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Research Article

Recent Advances in Caries Risk Assessment: A Review

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ABSTRACT
Effectively controlling and preventing dental caries requires precise risk assessment. Several tests, including the Snyder, Alban, swab, reductase, and Oricult tests, evaluate microbial activity and acid production, highlighting the significant role of the various microorganisms in the emergence of dental caries. The salivary buffer capacity test and various salivary tests, such as salivary reductase, Dentobuff, viscosity, and flow rate tests, evaluate the ability of saliva to protect against acid attacks. Advanced instruments like Cariogram, CAT, and CAMBRA integrate behavioral, microbiological, and clinical data to provide comprehensive risk assessments and help create customized preventive strategies. Other methods used to determine enamel strength and early cavity diagnosis include the Fosdisk calcium dissolution test, Dewar test, critical visual examination, and fluoride level monitoring. The function of bacteria in cavity formation is assessed by the intraoral cariogenicity test, and prior cavity experience is a valid predictor of future susceptibility. Electrical impedance is used by the Vanguard Electronic Caries Detector to identify early demineralization. When used in tandem, these methods enable detailed and individual assessments of cavity risk, which facilitates the development of targeted interventions and preventative measures. This comprehensive approach to caries risk assessment ensures early detection and effective treatment of dental caries, improving oral health outcomes. tooth professionals can enhance their preventive and treatment strategies by integrating different diagnostic instruments and techniques, which will ultimately reduce the incidence and consequences of tooth cavities.

Key words:- Alban test, Caries Risk Assessment Tool, Cariogram, Enamel demineralization, Salivary buffer capacity

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INTRODUCTION

Dental caries (DC) continues to be a common public health concern impacting individuals of all ages globally. The complex development of this process is influenced by a combination of microbial, dietary, and host factors, with the demineralization and remineralization cycles playing a central role (Zero et al., 2001). It is essential to comprehend these processes for successful caries management and prevention. Recent developments in evaluating caries risk are changing how professionals approach treatment by improving the precision of predicting risk and allowing for personalized prevention plans (Featherstone et al., 2021). These innovations are crucial for proactive dental care, which focuses on early intervention through accurate evaluations. Recognizing high-risk individuals and utilizing personalized therapies necessitates sophisticated forecasting instruments and improved management procedures (Rakshana et al. 2020). The incorporation of advanced technologies like saliva analysis and microbial testing has greatly enhanced our methods for preventing and treating caries (Maheswari et al., 2015). A thorough caries-risk evaluation for newborns, kids, and teenagers is recommended by the American Academy of Pediatric Dentistry's 2013 guideline. To properly customize prevention and management strategies, it recommends assessing variables like diet, oral hygiene, and socioeconomic status. Optimizing caries management requires early, personalized risk assessment (AAPD, 2013). Keeping up with these advancements is essential for enhancing caries treatment and enhancing patient results. This review emphasizes the significance of new tools and techniques in improving dental health care by exploring recent developments in caries risk assessment.

ETIOLOGY OF DENTAL CARIES

Dental caries is a dynamic process driven by bacteria that break down dietary carbohydrates, leading to mineral loss from enamel and dentin. Cariogenic bacteria like Lactobacillus species and Streptococcus mutans ferment carbohydrates into lactic acid, lowering the oral pH and promoting demineralization of tooth structures, which facilitates cavity formation (Featherstone et al., 2021; Zero et al., 2001). In contrast, saliva helps counteract this by providing calcium and phosphate ions that support remineralization, a process that rebuilds tooth minerals and is enhanced by salivary flow and fluoride (Twetman & Fontana, 2009). The balance between demineralization and remineralization influences dental health and caries risk. Modern caries risk assessment tools evaluate microbial counts, dietary habits, and natural remineralization processes to predict caries development and inform preventive and therapeutic strategies. Understanding these mechanisms is crucial for effective caries management and prevention (Featherstone et al., 2021; Vanobbergen et al., 2001). Key terms in caries risk assessment include:

♦ ***Cariogenic bacteria:*** Microbes that cause tooth decay by fermenting carbohydrates and releasing acids.

♦ ***Demineralization:*** Loss of minerals from the tooth enamel or dentin due to acidic conditions.

♦ ***Remineralization****:* Process by which minerals are redeposited into the tooth structure from saliva or other sources.

♦ ***Caries Risk Assessment****:* A systematic approach to evaluating the likelihood of a patient developing caries based on various risk factors, including microbial load, dietary habits, and fluoride exposure.

COMPONENTS OF CARIES RISK ASSESSMENT

❒ **Identification of high-risk individuals:** Recognizing patients at high risk is essential for the management and prevention of dental cavities. Risk assessment tools classify patients by their probability of getting cavities, directing specific interventions. These instruments assess aspects like diet, clinical findings, and oral care. In the field of pediatric dentistry, utilizing advanced risk models that consider both clinical and non-clinical data improves early detection and treatment. Early evaluation of caries risk in primary teeth can anticipate the occurrence of cavities in permanent teeth, highlighting the significance of initial assessment (Vanobbergen et al., 2001; Moca et al., 2021). Thorough risk assessments in children and teenagers lead to tailored prevention plans, enhancing the precision and efficiency of treatment (AAPD, 2023; Suchetha et al., 2022).

❒ **Factors influencing caries risk:** The chance of getting tooth decay depends on biological and behavioral factors, such as cavity-causing bacteria like Mutans Streptococci and Lactobacilli, as well as diets rich in fermentable sugars (Zero et al., 2001). The flow of saliva, exposure to fluoride, and socioeconomic status all have an impact on susceptibility. Decreased saliva production raises the likelihood of decay, whereas fluoride boosts enamel strength and improves resistance to decay. Access to dental care and knowledge about oral hygiene are influenced by one's socioeconomic status (Maheswari et al., 2015; Rakshana et al. 2020). Diagnostic techniques such as clinical evaluations and microbiological tests are employed to assess these factors (Senneby et al., 2015; Cagetti et al., 2018; Doméjean-Orliaguet et al. 2006). Thorough risk evaluations, suggested by the American Academy of Pediatric Dentistry (2023), assist in customizing prevention and management approaches.

❒ **Significance of individualized assessment:** Creating personalized assessments of cavities risk is essential for crafting efficient, individualized treatment plans. Customizing evaluations based on individual requirements leads to appropriate preventive and therapeutic treatments, improving patient results. Baseline models for assessing caries risk, as discussed by Vanobbergen et al. (2001), forecast future caries occurrence and underscore the importance of tailored strategies. Technological developments, like machine learning, greatly enhance risk forecasts and preventative healthcare strategies (Sadegh-Zadeh et al., 2022). Personalized caries management considers oral hygiene, diet, saliva production, fluoride exposure, and socioeconomic status to develop specific risk profiles for customized interventions. Personalized assessments also improve patient understanding and involvement, as educated patients are more inclined to adhere to preventative measures, decreasing chances of cavities and promoting lasting oral well-being. Through the incorporation of sophisticated evaluation techniques and various risk elements, dental experts could enhance patient results and oral health in general (Vanobbergen et al., 2001; Sadegh-Zadeh et al., 2022; Zukanović, 2013).

CLASSIFIFCATION OF CARIES RISK ASSESSMENT

The assessment of caries risk can be roughly divided into multiple categories, each of which focuses on distinct factors that influence the total risk. Behavioral aspects, socioeconomic issues, salivary defense mechanisms, tooth defense mechanisms, microbiological factors, and recent developments in evaluation techniques are some of these themes.

Table 1: Comprehensive Factors and Methods in Caries Risk Assessment and Management

Domain	Factors/Methods
Microbial Factors	**Mutans Streptococci Detection** - Plaque/Toothpick method - Tongue blade method - Replicate test - Dipslide method **Lactobacilli Detection** - Laboratory method - Chairside method
Salivary Defense	- Salivary flow rate and buffering capacity - Antibacterial components in saliva
Tooth Defense	- Fluoride exposure and concentration in enamel - Tooth morphology and structure
Behavioral Factors	- Dietary habits (sugar intake) - Oral hygiene practices
Socioeconomic Factors	- Access to dental care - Socioeconomic status
Recent Advancements	- CAT (Caries Assessment Tool) - CAMBRA (Caries Management by Risk Assessment) - Cariogram - Machine learning approaches for caries risk assessment in children - Salivary nitric oxide levels as a biomarker

MICROBIAL TESTS FOR MUTANS STREPTOCOCCI DETECTION

Plaque/Toothpick Method: The toothpick/plaque method is a useful strategy for identifying Mutans Streptococci (MS) in dental plaque because of its affordability and ease of use in both clinical and research contexts. The process includes:

→ **Sample collection:** Plaque can be removed with a sterile toothpick from the tooth surface, gingival border, and interdental spaces, among other areas of the oral cavity. By doing this, a thorough and representative sample of the oral microbiota is guaranteed.

→ **Culturing:** The gathered plaque is then placed on a selective culture medium, such as blood agar or trypticase soy agar, and incubated in an anaerobic environment to encourage the growth of multiple sclerosis.

→ **Identification:** The colonies are inspected for typical MS traits after incubation, including as colony morphology, Gram staining features, and biochemical tests like sucrose fermentation.

→ **Significance:** The suitability for a variety of contexts stems from its capacity to reliably indicate the presence of cariogenic bacteria with a minimum of tools and knowledge (Rakshana et al., 2020; Tranæus et al., 2005).

Tongue blade method: Another method for identifying MS is the tongue blade method, which concentrates on taking a sample from the dorsum of the tongue, which frequently has high bacterial burdens. The process entails:

→ **Sample collection:** The tongue's surface is gently scraped with a sterile tongue blade to get a sample that contains both saliva and plaque.

→ **Culturing:** After that, the sample is placed on a selective medium made to encourage MS growth and is incubated under the right anaerobic circumstances.

→ **Identification:** Following incubation, the shape and Gram staining properties of MS colonies are used to assess the growth.

→ **Significance:** Important for determining the distribution of bacteria in various dental areas, supporting a more thorough evaluation of caries risk (Zero et al., 2001; Senneby et al., 2015).

Replicate test: Through the collection of numerous samples from the same location, the repeat test lowers sampling mistakes and increases the accuracy of MS detection. The process consists of:

→ **Sample collection:** The same oral site, such as the tooth surface or gingival margin, is sampled multiple times using sterile instruments (e.g., swabs or toothpicks).

→ **Culturing:** To guarantee MS growth in anaerobic environments, each sample is grown independently on specific media.

→ **Culturing:** Each culture plate's ensuing growth is examined to verify the presence of MS, and consistency is ensured by comparing the outcomes across samples.

→ **Significance:** By confirming that the detection of MS is not the result of sampling variability, the duplicate test improves the validity of caries risk estimates (Suneja et al., 2017; Cagetti et al., 2018).

Dipslide test: This method provides quantitative and qualitative information on the quantities of bacteria in saliva and plaque and is a quantitative tool for identifying MS. This method is a valuable tool for clinical monitoring and longitudinal investigations because of its quantitative capability and ease of use. The procedure includes:

→ **Sample Collection:** A pre-coated slide or strip is dipped into a saliva or plaque sample collected from the patient. This slide is designed to adhere to MS and other bacteria present in the sample.

→ **Culturing:** The dipslide is then incubated in an anaerobic environment, facilitating the growth of MS on its coated surface.

→ **Identification:** Post-incubation, the slides are examined, and the number of MS colonies is quantified. This quantification provides a direct measure of the bacterial load, useful for monitoring changes over time (Gao et al., 2010; Fontana et al., 2006).

METHOD FOR STREPTOCOCCUS MUTANS DETECTION

Laboratory methods: Advanced approaches are used in these methods to accurately identify and quantify cariogenic bacteria, specifically Mutans Streptococci (MS). The key methods include the following:

→ **Microbiological culturing:** This conventional technique uses selective culture medium, such as Mitis Salivarius Bacitracin (MSB) agar, to isolate MS from dental plaque or saliva samples. According to Suneja et al. (2017), the process entails cultivating the material on MSB agar, incubation under anaerobic conditions, and identifying MS colonies based on their distinctive shape and Gram staining.

→ **Polymerase chain reaction (PCR):** One molecular method for identifying and measuring MS DNA is PCR. DNA is extracted from the sample, certain genes linked to multiple sclerosis are amplified, and gel electrophoresis or real-time PCR are used to analyze the results. According to Young et al., 2013, this technique has a high sensitivity and specificity for detecting MS.

→ **Enzyme linked immunosorbent assay (ELISA):** ELISA uses antibodies that bind selectively to MS antigens to detect MS. The sample is first incubated with a particular antibody, and then it is treated with a secondary antibody that has been conjugated to an enzyme. Next, quantitative information on MS levels is obtained by measuring the enzyme-substrate reaction (Featherstone et al., 2021).

Chairside methods: Chairside techniques are intended for quick identification of MS during regular dental consultations. These techniques provide ease of use and quick outcomes:

→ **Saliva testing kits:** These kits detect the presence of MS in saliva samples using reagents. Saliva is collected, combined with a reagent, and color changes characteristic of multiple sclerosis are observed. These tests are appropriate for clinical settings since they are easy to use and yield results in a matter of minutes (Rakshana et al., 2020).

→ **Rapid immunoassays:** MS is identified by chairside immunoassays that use lateral flow devices and certain antibodies. After applying the sample to the apparatus, a visible line on the test strip indicates the presence of MS. Chairside caries risk assessment can benefit from this method's speed and visual results (Zero et al., 2001).

Survey methods: These involve collecting and analyzing samples from larger populations to assess caries risk and prevalence:

→ **Epidemiological surveys:** These surveys gather saliva or dental plaque from a population through sample techniques. After that, the samples are examined in a lab setting using methods like PCR and microbiological culturing to determine the frequency and distribution of MS in the general population (Vanobbergen et al., 2001).

→ **Population-based screening:** This method uses defined protocols to screen large groups for the existence of MS. The information gathered aids in identifying high-risk populations and creating focused preventative strategies. This approach offers insightful information about caries risk at the population level (Featherstone et al., 2021).

Selective methods: These methods are designed to isolate and identify MS from mixed bacterial populations:

→ **Selective media:** Certain methods, like cultivating on MSB agar, selectively encourage the growth of MS while suppressing the growth of other bacteria. According to Maheswari et al., 2015, selective culturing makes it possible to separate MS from complicated microbial ecosystems.

→ **Biochemical tests:** Based on metabolic byproducts, selective biochemical tests can distinguish MS from other bacteria. To verify the existence of MS, these tests are combined with specific media (Featherstone et al., 2021).

Adherences methods: These focus on the ability of MS to adhere to the tooth surfaces which is essential for the development of caries.

→ **Adhesion assays:** These assays use techniques like microtiter plate assays to quantify MS's adhesion to dental enamel or other substrates. MS is grown on a substrate, unbound bacteria are washed, and adherent bacteria are quantified using spectrophotometric or colorimetric methods (Gao et al., 2010).

→ **Immunofluorescence microscopy:** This method allows a microscope to view the adhesion of MS to tooth surfaces by using fluorescently tagged antibodies. According to Suneja et al. (2017), it offers comprehensive data on the quantity and spatial distribution of adherent MS.

MICROBUIAL TESTS FOR LACTOBACILLI DETECTION

Laboratory methods

→ **Microbiological culturing:** Lactobacilli are frequently isolated from saliva samples or dental plaque using culturing procedures. To do this, a sample is inoculated onto a selective medium, like Rogosa agar, which promotes Lactobacilli growth while suppressing the growth of other bacteria. Colonies are distinguished by their shape and Gram staining properties during anaerobic incubation (Featherstone et al., 2021; Reich et al., 1999; Anusavice, 2001).

→ **Polymerase chain reaction (PCR):** Lactobacilli are frequently isolated from saliva samples or dental plaque using culturing procedures. To do this, a sample is inoculated onto a selective medium, like Rogosa agar, which promotes Lactobacilli growth while suppressing the growth of other bacteria. Colonies are distinguished by their shape and Gram staining properties during anaerobic incubation incubation (Featherstone et al., 2021; Reich et al., 1999; Anusavice, 2001).

→ **Enzyme-Linked Immunosorbent assay (ELISA):** Using antibodies that are specific to Lactobacilli antigens, this can be used to identify Lactobacilli. A sample is first incubated with a particular antibody, and then it is treated with a secondary antibody that has been conjugated to an enzyme. A detectable color shift is the result of the enzyme-substrate reaction, which suggests the presence of Lactobacilli (Suneja et al., 2017; Tellez et al., 2013).

Chairside methods

→ **Saliva testing kits:** Reagents that react with lactobacilli in saliva samples are used in chairside kits for the detection of lactobacilli. Saliva is combined with a reagent during the process, and color changes that show the presence of Lactobacilli are monitored. These kits are easy to use in clinical settings and offer prompt findings (Rakshana & Shanmugavel, 2020; Petersson & Twetman, 2015).

→ **Rapid immunoassays:** These assays identify Lactobacilli in samples of saliva or plaque by using lateral flow devices. After applying the sample to the apparatus, a visible line on the test strip indicates the presence of lactobacilli. According to Zero et al. (2001), this approach is quick and appropriate for chairside caries risk assessment (Zero et al., 2001; Bader et al., 2005).

CARIES ACTIVITY TESTS

→ **Snyder test:** This test assesses the caries risk by evaluating the acid production capability of oral bacteria. During this experiment, saliva is combined with Snyder's medium, which includes glucose and bromcresol green. Glucose functions as a fermentable carbohydrate for acid-producing bacteria, while bromcresol green serves as a pH indicator. The blend is left to incubate at a temperature of 37 degrees Celsius for a period of 24 to 48 hours. In the presence of cariogenic bacteria like Mutans Streptococci and Lactobacilli, glucose is fermented into lactic acid, reducing the pH levels and resulting in a change in color from green to yellow. A color change to yellow in less than one day shows increased caries activity and a high chance of cavities from notable acid production. On the other hand, a lack of color change or a delay in color change indicates decreased caries activity, indicating a healthier, less acidic mouth. The Snyder test is an important tool for evaluating the risk of tooth decay, giving information on bacteria levels, and allowing for specific preventative actions. Its simple nature and efficiency make it the top option for early detection and treatment of caries risk (Zero, Fontana & Lennon, 2001; American Academy of Pediatric Dentistry, 2023; Suchetha et al., 2022; Maheswari et al., 2015).

→ **Alban test:** This test evaluates the chance of developing tooth decay by assessing the level of acid produced by oral bacteria in saliva. A saliva sample is combined with a solution containing glucose and the pH indicator bromcresol green. Glucose is a fermentable carbohydrate, whereas bromcresol green is used to identify pH variations. Following incubation at 37°C, cariogenic bacteria such as Mutans Streptococci and Lactobacilli convert glucose into lactic acid, decreasing the pH and resulting in a change in color from green to yellow. A quick change in color suggests a higher presence of acid-producing bacteria and an increased likelihood of cavities (Young & Featherstone, 2013; Suneja et al., 2017). On the other hand, if there is no or minimal color change, it may indicate lower acid production and a reduced risk of cavities, which points to a healthier oral condition. The Alban test is a useful and effective method for pinpointing people with a greater chance of developing cavities. It helps in focusing on preventive and treatment plans. Its value in clinical and research environments is due to its simplicity and reliability (Young & Featherstone, 2013; Maheswari et al., 2015; Vanobbergen et al., 2001)

→ **Swab test:** The swab test evaluates the risk of cavities by obtaining a dental plaque sample using a sterile swab and cultivating it in specific media that encourage the proliferation of bacteria that cause cavities such as Mutans Streptococci and Lactobacilli. This technique separates and measures these bacteria, giving us a better understanding of the microbial surroundings in the mouth (Rakshana & Shanmugavel, 2020). A high presence of cavity-causing bacteria signals an increased likelihood of developing cavities because of the acidic environment produced by their metabolism (Featherstone et al., 2021; Suchetha et al., 2022). Recognizing elevated levels of these bacteria assists dental experts in customizing preventative and therapeutic strategies, improving caries control and treatment (Zero et al., 2001; Suneja et al., 2017). The swab test is essential for thorough assessment of caries risk, helping with prompt and efficient treatments (Suneja et al., 2017; American Academy of Pediatric Dentistry, 2023).

→ **Reductase test:** This test finds acid-producing bacteria in saliva to determine the risk of dental caries. In this experiment, a solution containing a redox indicator which changes color when reduced by bacterial metabolism is introduced to a saliva sample. A color shift indicates the presence of acidogenic bacteria if the bacteria in the sample lower the indicator (Suneja et al., 2017). A discernible change in color signifies a higher concentration of these bacteria, which raises the possibility of tooth decay. This test is useful for assessing the metabolic activity of bacteria and early detection of those who are more susceptible to cavities (Featherstone et al., 2021; Suchetha et al., 2022).

→ **Oricult test:** This test measures the risk of caries by rapidly identifying cariogenic bacteria in plaque or saliva. After incubation, a color shift on a test strip containing chemicals confirms the presence of these microorganisms. This color shift indicates a high level of caries activity, which helps with early detection and preventative care. Because of its simple and quick methodology, the test is useful in both clinical and home environments (Featherstone et al., 2021; Rakshana & Shanmugavel, 2020; Suneja et al., 2017).

→ **Salivary buffer capacity test:** This test evaluates saliva's ability to neutralize acids made by cariogenic bacteria, which is essential for preventing dental cavities. A saliva sample is combined with a buffered solution for the test, and the pH change is monitored. Significant pH drops are indicative of inadequate buffering capacity, which raises the risk of dental cavities since saliva is unable to neutralize acids. This sudden reduction in pH indicates an acidic environment that is favorable to dental damage. The test is necessary to evaluate the protective function of saliva and to determine whether individuals may need further preventive steps (Young & Featherstone, 2013; Featherstone et al., 2021; Rakshana & Shanmugavel, 2020).

MICROBIAL TESTS FOR LACTOBACILLI DETECTION

→ **Laboratory methods:** Determining Lactobacilli is essential for microbiome analysis and caries risk assessment. Culture-dependent methods, like cultivating saliva samples on MRS agar, encourage the growth of Lactobacilli and allow the identification of colonies through their shape and biochemical characteristics. Although dependable, this approach might be laborious, requiring multiple days to provide outcomes (Suneja et al., 2017; Zero et al., 2001). Rapid and highly sensitive detection can be achieved by molecular techniques such as polymerase chain reaction (PCR), which amplify genetic sequences of Lactobacilli. Small quantities of bacteria can be found in saliva samples thanks to real-time PCR's increased sensitivity and ability to quantify bacterial levels (Godovanets & Kotelban, 2022; Rakshana & Shanmugavel, 2020). These methods are essential to comprehending caries-related microbial profiles and assessing antibacterial therapies (Suneja et al., 2017; Zero et al., 2001).

→ **Chairside methods:** Methods for identifying Lactobacilli provide easy-to-use answers in medical situations. Chairside diagnostics can be performed quickly and effectively with dip slide procedures, which entail submerging a slide coated with selective media into a saliva sample (Suneja et al., 2017; Celik et al., 2012). For quick, accurate findings in only one visit, commercial lactobacilli test kits employ colorimetric or enzymatic reactions (Zero et al., 2001). These techniques are useful for making quick decisions about treatment and caries risk assessment (Suneja et al., 2017).

CARIES ACTIVITY TESTS

→ **Snyder test:** In this test, glucose agar is inoculated with saliva, and the color change that results from Lactobacilli fermenting glucose and generating acid is measured. While a delayed or absent color change denotes lesser caries activity, a rapid color change indicates high activity. This test evaluates the risk of caries and the cariogenic potential of oral microbiota (Featherstone et al., 2021).

→ **Alban test:** Using saliva samples, this test measures the amount of acid produced in glucose-rich media to assess the risk of dental caries. A quick pH drop is a sign of excessive acid production by cariogenic bacteria, which raises the risk of caries. According to Featherstone et al. (2021) this technique offers a useful evaluation of the bacterial propensity to produce dental caries.

→ **Swab test:** Oral samples are collected with a sterile swab, cultured in specific media, and incubated to detect Lactobacilli growth. High Lactobacilli counts indicate increased caries risk, providing insights into microbial load and caries potential. This method effectively assesses the risk of developing dental caries (Featherstone et al., 2021).

→ **Reductase test:** When saliva and a redox indicator are combined in a medium, the metabolic activity of Lactobacilli is revealed via a color shift. A discernible alteration in hue signifies elevated bacterial activity and heightened susceptibility to caries, offering valuable information about microbiological activity and possible carious lesions (Rakshana & Shanmugavel, 2020).

→ **Oricult test:** Using a selective medium, the Oricult test finds Lactobacilli in saliva; growth patterns of these bacteria indicate the likelihood of dental caries. Increased caries risk is suggested by higher bacterial numbers. In clinical settings, this rapid, user-friendly technique is useful for determining the risk of caries (Featherstone et al., 2021).

→ **Salivary buffer capacity test:** This test measures pH changes after mixing saliva with a buffer solution. A rapid pH drop indicates poor buffering capacity and higher caries risk, reflecting saliva's reduced ability to neutralize acid from cariogenic bacteria (Suneja et al., 2017).

Table 2: Comparison of Caries Activity Tests

Test	Description	Indicates	Reference
Snyder Test	Uses glucose agar inoculated with saliva; color change from Lactobacilli fermentation is measured.	Caries risk and cariogenic potential.	Featherstone et al., 2021
Alban Test	Measures acid production in glucose-rich media from saliva samples.	Acid production by cariogenic bacteria; caries risk.	Featherstone et al., 2021
Swab Test	Oral samples cultured to detect Lactobacilli growth.	Microbial load and caries potential.	Featherstone et al., 2021
Reductase Test	Combines saliva with a redox indicator to reveal Lactobacilli metabolic activity through color change.	Bacterial activity and caries susceptibility.	Rakshana & Shanmugavel, 2020
Oricult Test	Selective medium detects Lactobacilli in saliva; growth patterns indicate caries risk.	Caries risk based on Lactobacilli numbers.	Featherstone et al., 2021
Salivary Buffer Capacity Test	Measures pH changes after mixing saliva with a buffer solution.	Buffering capacity and caries risk.	Suneja et al., 2017

COMPREHENSIVE CARIES RISK ASSESSMENT TOOLS

→ **Cariogram:** The Cariogram is a thorough risk assessment tool that assesses caries risk by combining clinical, microbiological, and behavioral data. For a comprehensive risk assessment, it integrates dental exam findings, bacterial levels, dietary practices, and fluoride exposure. With the tool's graphical display, which indicates the percentage influence of different risk factors on the overall risk score, physicians may easily identify important risk contributors. This graphic format is useful in developing customized preventive strategies and effectively communicating risk to patients so they can understand their caries risk and make informed decisions about their oral health (Vanobbergen et al., 2001; Maheswari et al., 2015; Featherstone et al., 2021).

→ **Caries Risk Assessment Tool (CAT):** By examining several variables, such as plaque levels, dietary practices, fluoride use, and prior cavity experiences, this assesses the risk of cavities. It divides people into groups according to risk level low, moderate, or high by assigning them a numerical score. Through the consideration of cariogenic bacteria presence, socioeconomic level, and dental hygiene, the CAT offers a comprehensive risk assessment that facilitates focused interventions. This methodical approach improves clinical decision-making and helps create customized treatment regimens, which improves caries control and patient-specific care (Zero et al., 2001; Maheswari et al., 2015).

→ **CAMBRA (Caries Management by Risk Assessment):** This system integrates clinical observations, microbiological data, and behavioral patterns to provide an advanced framework for controlling and assessing individual caries risk. This all-inclusive method creates individualized treatment programs targeted at lowering caries risk by using specific data, such as dental history, bacterial levels, fluoride use, and dietary preferences. When it comes to monitoring treatment outcomes, making treatment decisions, and modifying programs in response to variations in caries risk, CAMBRA plays a crucial role. It assists healthcare providers in customizing plans to meet the needs of each patient and enhance results for both preventive and restorative therapy. CAMBRA improves caries management and promotes effective long-term treatment plans by offering a comprehensive and flexible risk assessment (Zero et al., 2001; Vanobbergen et al., 2001; Sadegh-Zadeh et al., 2022).

Table 3:- Comparison of Caries Risk Assessment Tools: CAT vs. CAMBRA [Lesmana et al., 2022; Ramos-Gomez & Ng, 2011).

Feature	CAT (Caries Assessment Tool)	CAMBRA (Caries Management by Risk Assessment)
Description	A risk assessment tool for predicting caries risk in children.	A comprehensive protocol for caries management based on risk assessment.
Focus	Predominantly used for assessing caries risk in pediatric patients.	Covers broader aspects including preventive and therapeutic interventions.
Assessment Criteria	Considers clinical, behavioral, and biological factors.	Includes clinical examination, patient history, and salivary tests.
Risk Factors	Microbial factors, dietary habits, and oral hygiene practices.	Microbial factors, fluoride exposure, diet, and socio-economic status.
Risk Prediction	Uses a scoring system to categorize risk levels.	Provides a detailed risk profile and tailored management strategies.
Application	Used mainly for identifying high-risk children and predicting future caries.	Aimed at managing caries based on individual risk profiles.
Recent Advancements	Incorporates data for precise risk categorization	Emphasizes personalized care and integrates with advanced diagnostic tools.

SALIVARY TESTS

→ **Salivary reductase test:** This measures the activity of reductase enzymes in saliva, reflecting bacterial metabolic activity. During the procedure, saliva is combined with a redox indicator, and the resulting color change indicates the level of reductase activity (Rakshana & Shanmugavel, 2020). This test is significant as it provides valuable insight into the microbial activity within the oral cavity. High levels of reductase activity correlate with increased caries risk, making this test a useful tool for assessing caries risk and guiding preventive strategies (Suneja et al., 2017).

→ **Dentobuff test:** This assesses saliva's buffering capacity by measuring pH changes after saliva is mixed with a buffer solution; a significant pH drop indicates low buffering capacity (Suneja et al., 2017). This reduced buffering capacity suggests a higher risk of carious lesions due to impaired acid neutralization. Thus, the Dentobuff test is useful for evaluating the protective function of saliva in neutralizing acids and preventing tooth decay (Rakshana & Shanmugavel, 2020).

→ **Salivary viscosity:** This is assessed using rheological instruments or observational methods, where high viscosity indicates thicker saliva (Suneja et al., 2017). Increased viscosity can impair saliva's protective functions, contributing to a higher caries risk. Therefore, this test is useful for assessing saliva quality and its impact on oral health (Featherstone et al., 2021).

→ **Salivary flow rate test:** This test measures the rate of saliva production by collecting saliva over a set period and calculating the flow rate (Suneja et al., 2017). A reduced salivary flow rate can lead to a higher risk of carious lesions due to decreased oral clearance and buffering capacity. Therefore, this test is crucial for identifying individuals at risk due to salivary deficiencies (Featherstone et al., 2021).

ADDITIONAL CARIES RISK ASSESSMENT METHODS

→ **Fosdisk Calcium Dissolution Test:** This evaluates saliva's capacity to control calcium levels, an essential function for dental health. The test entails putting a disk coated in calcium in the mouth and timing how quickly the calcium dissolves. Better caries resistance is shown by a slower dissolving rate, which reflects the salivary buffering capacity in action. This test assesses the degree to which saliva preserves enamel and guards against demineralization brought on by acid. The Fosdisk test assists in identifying those with low salivary function who may be more susceptible to tooth decay by offering insights into salivary function and its role in cavity prevention (Rakshana & Shanmugavel, 2020).

→ **Dewar Test:** This test measures the susceptibility of dental enamel to demineralization by immersing extracted enamel samples in acidic solutions and assessing mineral loss. It provides valuable insights into enamel resistance to acid attacks, which is crucial for caries susceptibility. The test is instrumental in evaluating fluoride treatments and other preventive measures that enhance enamel strength. Results guide the development of targeted prevention strategies and the improvement of dental products designed to fortify enamel. Additionally, it aids researchers in assessing the efficacy of various treatments, supporting evidence-based dental care and helping predict cavity risk and implement appropriate preventive measures (Featherstone et al., 2021).

→ **Critical Visual Examination:** Using this procedure, teeth are thoroughly examined for carious lesions, with special attention paid to discolouration, changes in surface texture, and other indications of decay. The ability of the examiner to spot early carious lesions that might not be seen using other techniques depends on their skill and acute observation. Early detection by visual inspection is essential for implementing timely preventive actions including fluoridating teeth, making dietary adjustments, and improving oral hygiene habits. According to Zero et al. (2001), this method is particularly helpful in clinical settings without access to sophisticated diagnostic instruments since it guarantees that patients receive critical care and prompt intervention based on visual assessment.

FLUORIDE LEVELS AS A MEASURE OF TOOTH RESISTANCE

Assessing fluoride levels in saliva and enamel is key to evaluating fluoride's effectiveness in cavity prevention. This involves collecting saliva samples and analyzing them using ion-selective electrodes or spectrophotometric methods. Techniques like enamel biopsy and surface microhardness tests are used to measure fluoride deposition on teeth directly. Higher fluoride levels in saliva and enamel generally indicate better caries protection, as fluoride helps remineralize and prevent enamel demineralization. Monitoring these levels is crucial for assessing the success of fluoride treatments, including fluoridated water, toothpaste, and professional applications. This evaluation helps tailor preventive measures and supports public health efforts in cavity prevention (American Academy of Pediatric Dentistry, 2023).

INTROAORAL CARIOGENECITY TEST

The intraoral cariogenicity test requires the introduction of cariogenic bacteria like Streptococcus mutans into the mouth to evaluate their effects on tooth enamel. This exam usually includes administering a bacterial solution to certain tooth sections with the assistance of protective barriers to separate these areas. The assessment tests how well the bacteria stick to enamel, create biofilms, and generate acids leading to enamel erosion. Enamel demineralization and carious lesions are evaluated using visual inspection, pH measurement, and microscopic analysis. This examination is vital for comprehending how bacteria lead to cavity formation, allowing for personalized prevention techniques and the creation of specific treatments to lessen microbial-induced cavities (Suchetha et al., 2022).

PAST CARIES EXPERIENCE AS AN INDICATOR

By evaluating risk based on a person's dental history, prior dental decay is a significant predictor of subsequent tooth decay. To predict future vulnerability, this study looks at the frequency, location, and severity of previous caries. A higher risk of fresh decay is indicated by a history of severe or frequent cavities. This technique, which is essential to models of caries risk assessment, helps to customize treatment and prevention plans. Clinicians can effectively lower the risk of cavities in the future by improving fluoride treatments and improving oral hygiene recommendations based on prior decay trends (Zero et al., 2001; Rakshana & Shanmugavel, 2020; Suneja et al., 2017; Cagetti et al., 2018).

VANGUARD ELECTRONIC CARIES DETECTOR

By monitoring variations in the electrical resistance of the tooth tissue, the Vanguard electronic caries detector detects early carious lesions. It measures conductivity with a probe; decreased resistance is a sign of demineralization, which is a condition that precedes cavities. By utilizing the unique electrical characteristics of demineralized enamel and dentin in contrast to healthy tooth structures, this method enables early diagnosis prior to the appearance of visible symptoms (Vanobbergen et al., 2001). The tool is useful for preventative dentistry since it allows for minimally invasive early intervention. Early caries detection allows dentists to improve remineralization and fluoride treatments, which improves caries management and patient outcomes (Suneja et al., 2017; Sadegh-Zadeh et al., 2022).

CONCLUSION

Therefore, integrating sophisticated caries risk assessment approaches has a great deal of potential to enhance oral health outcomes. Robust frameworks for assessing and managing caries risk are provided by contemporary methods including microbiological testing for Lactobacilli and Mutans Streptococci, as well as by comprehensive instruments like CAT, CAMBRA, and Cariogram. These techniques support early detection and tailored intervention plans, which are in line with modern preventive dentistry ideas. The significance of using these advancements in standard clinical practice is further highlighted by the capacity to carefully monitor microbial activity and environmental factors contributing to caries formation. The accuracy and usefulness of caries risk assessment instruments are expected to improve with continued study and technology developments in the sector, leading to more efficient and customized dental treatment plans in the end.

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