GRADUATION PROJECT

Degree in Dentistry

SYSTEMATIC REVIEW: IS SALIVARY PH ASSOCIATED WITH DENTAL CARIES INCIDENCE IN ADULTS ?

Madrid, academic year 2025/2026

Identification number: 102

RESUMEN

Introducción: La caries dental continúa siendo una de las enfermedades bucodentales más prevalentes y resulta de la interacción de múltiples factores biológicos, conductuales y ambientales. La saliva desempeña un papel esencial en el mantenimiento del equilibrio oral, especialmente a través de su capacidad tampón y la regulación del pH. **Objetivo:** Evaluar la posible asociación entre el pH salival y la caries dental en población adulta. **Materiales y métodos:** Se realizó una revisión sistemática siguiendo las recomendaciones PRISMA. La búsqueda bibliográfica se llevó a cabo en PubMed, MEDLINE Complete y Google Scholar mediante ecuaciones de búsqueda predefinidas. Se incluyeron estudios realizados en adultos que analizaban la relación entre el pH salival y los índices de caries. Nueve estudios cumplieron los criterios de inclusión y fueron seleccionados para el análisis. **Resultados:** Los estudios, publicados entre 2012 y 2024, incluyeron un total de 2436 participantes. En la mayoría de los casos, se observó una tendencia que asociaba valores más bajos de pH salival con mayores índices de caries, especialmente en relación con el índice DMFT. Sin embargo, algunos estudios no mostraron asociaciones estadísticamente significativas, lo que sugiere cierta heterogeneidad en los resultados. **Conclusión:** El pH salival podría estar relacionado con la presencia de caries en adultos y representar un indicador útil en la evaluación del riesgo. No obstante, debido al carácter multifactorial de la enfermedad, debe interpretarse junto con otros factores clínicos y conductuales. Se requieren estudios longitudinales adicionales para confirmar esta relación y su aplicabilidad clínica.

PALABRAS CLAVE

Odontología; pH salival; Caries dental; Saliva; Adulto

ABSTRACT

Introduction: Dental caries remains one of the most prevalent oral diseases and results from a complex interaction between biological, behavioural, and environmental factors. Among these, saliva plays a fundamental role in preserving oral balance, particularly through its buffering action and regulation of pH levels. Variations in salivary pH may therefore influence the progression of carious lesions. **Objective:** This study aimed to investigate the relationship between salivary pH and dental caries in adult individuals. **Material and Methods:** A systematic review was carried out in accordance with PRISMA recommendations. Literature searches were conducted using PubMed, MEDLINE Complete, and Google Scholar with predefined search terms. Studies focusing on adult populations and evaluating salivary pH in relation to dental caries were selected. Nine studies fulfilled the inclusion criteria and were retained for analysis. **Results and Discussion:** The selected studies, published between 2012 and 2024, included a total of 2436 participants. Most of the evidence indicated a tendency for lower salivary pH values to be associated with higher caries indices, particularly DMFT scores. Nevertheless, not all studies demonstrated statistically significant results. Differences in methodology, sample characteristics, and measurement techniques may account for this variability. **Conclusion:** Salivary pH appears to be associated with dental caries in adults and may contribute to the evaluation of caries risk. However, given the multifactorial nature of the disease, it should be considered alongside other clinical and behavioural determinants. Further research, particularly longitudinal studies with standardized methodologies, is necessary to clarify this relationship and its potential application in clinical practice.

KEYWORDS

Dentistry ; Salivary pH; Dental caries; Saliva; Adult

TABLE OF CONTENTS

1. INTRODUCTION 1

1.1 Saliva 1

1.1.1. Production and secretion of saliva 1

1.1.2. Saliva composition 1

1.1.3. Function of Saliva 2

1.1.4. Individual and pathological variations in salivary characteristics 3

1.2. Dental Caries 3

1.2.1. Definition and epidemiology 3

1.2.2. Etiopathogenesis of dental caries 4

1.2.3. Structural and biochemical features of carious lesions 4

1.3. Salivary pH 5

1.3.1. Definition and physiological ranges 5

1.3.2. Mechanism of Salivary pH regulation 5

1.3.3. Factors influencing salivary pH 6

2. OBJETIVE 6

3. MATERIAL AND METHODS 7

3.1. PICO Research Question 7

3.2. Eligibility Criteria 8

3.3. Sources of Information 9

3.4. Search Strategy 9

3.5. Study Selection Process 10

3.6. Data extraction 11

4. RESULTS 11

4.1. Studies selection 11

4.2. Characteristics of the studies 13

4.3. Main findings 16

5. DISCUSION 17

5.1. Summary of main findings 17

5.2. Interpretation 18

5.3. Comparison with other studies 19

5.4. Limitations 21

5.5. Clinical implications and futur research 22

6. CONCLUSIONS 23

7. SUSTAINABILITY 23

8. REFERENCES 24

1. INTRODUCTION

1.1 Saliva

1.1.1. Production and secretion of saliva

Saliva is a clear and slightly acidic (pH= 6.0-7.0) biological fluid produced mainly by three major glands including the parotid gland, the submandibular and the sublingual gland, and the rest is produced by other minor glands in all of the buccal cavity (1). When the saliva is produced, it becomes mixed, in the buccal cavity, with others components such as crevicular fluid, desquamated epithelial cells, microorganism and food residues.

Different types of saliva can be identified according to the gland secreting it: For the parotid gland the secretion is a serous enzyme-rich fluid saliva. For the submandibular gland it is a mix of serous-mucous secretion. And for the sublingual gland, the secretion is predominantly mucous saliva. The minor glands secrete a continuous mucous lubrication and are localized on the lips, tongue, palate, and buccal mucosa.

The resting or unstimulated salivary vary from 0.25 to 0.35 mL/min. The amount of saliva produced can reach 1-3mL/min for the stimulated salivary flow (2). The production of saliva is stimulated by gustatory, olfactory, mechanical, visual stimuli as well as the circadian rhyhtm and mastication. Saliva is mainly regulated by the parasympathetic part of the autonomic nervous system which induced high volume flow, while sympathetic leads to a more viscous, protein rich saliva (3).

Alterations in the mechanisms of the secretion or glandular function result in hyposalivation or xerostomia, characterized by the decrease of the salivary flow (2).

1.1.2. Saliva composition

Saliva is mainly composed of water and the remaining by organic and inorganic components essential to oral homeostasis.

Organic components include enzymes such as α-amylase, lysozyme, peroxidase and lipase, as well as glycoproteins (mucins), lactoferrin and histatins. All of those are contributing to lubrication, digestion and antimicrobial defense as well secretory immunoglobulin A (sIgA) plays an important role in mucosal immunity by preventing bacterial adhesion to the enamel surface (4).

Inorganic constituents consist of sodium, potassium, calcium, phosphate, chloride and bicarbonate ions. Calcium and phosphate are essential for remineralization of enamel while bicarbonate is the major buffer to neutralize acid. Bicarbonate-carbonic system is the most dominant buffering mechanism followed by phosphate and protein systems. When salivary flow is stimulated bicarbonate concentration rises, leading to a higher salivary pH and improved buffering capacity (5).

1.1.3. Function of Saliva

Through multiple physiological and biochemical functions saliva fullfils a major role in maintaining oral and systemic health.

1)Mechanical cleansing: Saliva contributes to continuous cleansing of the oral cavity, removing food debris, desquamated cells and microbial aggregates. This cleaning action reduces bacterial colonization and plaque accumulation (6).

2)Lubrication: Mucins and glycoproteins form a thin mucosal layer that facilitates mastication, speech and swallowing while protecting oral soft tissues from mechanical trauma (3).

3)Antimicrobial and antiviral defense: Enzymes such as lysozyme, lactoferrin and peroxidase will help to reduce microbial proliferation, sIgA neutralizes pathogens, histatins and defensins exhibit antifungal activity (4,6).

4)Buffering and acid-base balance: By neutralizing dietary and bacterial acids, saliva helps maintaining the plaque pH above the critical demineralization threshold (~5,5) and prevent enamel dissolution (6)

5)Remineralization: The salivary reservoir of calcium, phosphate, and fluoride ions plays a major role by supporting enamel remineralization and inhibiting lesion progression (6).

By executing these combined actions, saliva maintains homeostasis in the oral ecosystem, preserving tissue integrity and contributing to caries prevention.

1.1.4. Individual and pathological variations in salivary characteristics

The amount and quality of saliva differ significantly between individuals and can be affected by various intrinsic and extrinsic factors, such as genetics, age, sex, hydration, medication, diet, stress and disease.

Age-related changes often include reduced flow rate and alterations in protein content, whereas differences linked to sex have been noted in both flow and composition as a result of hormonal changes (7). Pharmacological factors, especially anticholinergics, antidepressants and antihypertensives frequently reduce salivary secretion.

Pathological states like Sjögren's syndrome, diabetes mellitus or glandular damage from radiation can severely alter salivary gland function (2). A persistent reduction in salivary flow compromises buffering, antimicrobial defense and remineralization leading to a dysbiosis of the oral microbiome.

Salivary dysbiosis can be defined as a disturbance in the equilibrium between protective and pathogenic microbial species, such as Streptococcus mutans (8), that can arise whenever there are changed to one or more salivary characteristics (flow rate, composition or pH). This imbalance can enhance the proliferation of acidogenic (bacteria producing acid) and aciduric (bacteria proliferating in acid) bacteria, favoring the development of caries and other oral pathologies.

1.2. Dental Caries

1.2.1. Definition and epidemiology

Caries is one of the most common chronic bacterial diseases affecting humans, characterized by a progressive demineralization and destruction of the hard dental tissues (enamel, dentin, cementum) caused by acids produced by bacteria (2).

The process of caries formation is not a straight but is instead a balance between demineralization (loss of mineral content due to acid exposure) and remineralization (restoration of minerals facilitated by saliva) (5). It can affect people of every age group, but its occurence is especially high among adults, making it a significant public health concern.

1.2.2. Etiopathogenesis of dental caries

Four fundamentals points of the pathogenesis of dental caries can be identified that are the host, the microorganisms, diet and time.

Dental caries develop within the dental biofilm, a complex community of microorganisms situated in a extracellular polysaccharide matrix produced by bacterial metabolism and salivary elements. The biofilm adheres to tooth surfaces, creating a microenvironment where pH and oxygen gradients promote specific microbial growth (9).
Within this ecosystem, specific bacteria, especially *Streptococcus Mutans, Steptococcus sobrinus and Lactobacillus species* play a predominant role. These microorganisms are acidogenic (produce acid from carbohydrates) and aciduric (develop in low pH conditions) making them central to the carious process (8,9).

When fermentable carbohydrates such as sucrose, glucose and fructose are ingested, bacteria within the plaque metabolize them, producing organic acids (mainly lactic, acetic and formic acids). This results in a rapid decrease in plaque pH, sometimes reaching values as low as 4.3. Once the local pH drops below the critical pH threshold of approximately 5.5, enamel hydroxyapatite crystals begin to dissolve (7,10).

If the acidic exposure continues and saliva cannot neutralize or restore missing minerals, enamel demineralization progresses toward dentin, eventually forming a cavitary lesion.

The development of caries is currently recognized as a microbial dysbiosis, a disturbance of the usual ecological balance in the oral microbiome. In healthy condition, the oral biofilm includes both acid-producing and alkaline-producing bacteria (like *Streptococcus sanguinis and Streptococcus salivarius*) that help in maintaining pH homeostasis by metabolizing arginine and urea into ammonia (11).

1.2.3. Structural and biochemical features of carious lesions

Caries lesions progress through distinct histological stages, representing the complex interaction between mineral loss and restoration.

1)Initial (non cavitary) lesions: Defined by surface demineralization below an intact enamel surface, clinically observable as a white spot.
2)Cavitary lesions: When surface integrity is compromised, bacteria infiltrate deeper into enamel, accelerating mineral dissolution and collagen degradation.
3)Dentin involvement: The dentin-enamel junction provides less resistance. The lesion spreads in dentin, accompanied by bacterial invasion, collagen degradation and inflammatory pulp response (12).

1.3. Salivary pH

1.3.1. Definition and physiological ranges

Salivary pH indicates the concentrations of hydrogen ions in saliva that represents the acid-base equilibrium of the oral cavity. It plays a crucial role in maintaining oral homeostasis by affecting the integrity of tooth structures, the composition of the oral microbiota and the activity of salivary enzymes (2,6).

In healthy people, the resting salivary pH usually varies around 7, influenced by flow rate, glandular origin and time of the day. Stimulated saliva is generally more alkaline (pH 7.0-8.0) because of increased bicarbonate concentration and improved buffering capacity (6). On the other hand, the pH of the dental plaque can drop below 5.5 following sugar intake, triggering enamel demineralization.

1.3.2. Mechanism of Salivary pH regulation

Three buffering systems mainly regulate the salivary pH:
1)The bicarbonates-carbonic acid system, which is the most important and active, responsable for rapid neutralization of acids during stimulation (6).
2) The phosphate buffer system, more effective at low flow rates and resting conditions (2,10).
3) Salivary proteins such as histatins, and carbonic anhydrase VI help stabilize the pH and inhibit the precipitation of calcium salts (13).

The concentration of bicarbonate rises more or less in a linear manner with the rate of salivary flow, improving saliva's capacity to neutralize acid (14). When bacterial metabolism produces

acids, the bicarbonate system quickly responds to restore neutrality. This recovery follows the Stephan curve, which describes the fall and subsequent rise of pH in dental plaque after sugar exposure (12). The rate and magnitude of this recovery are an important indicator of a person's risk for caries, a faster recovery implies a reduced duration of demineralization.

1.3.3. Factors influencing salivary pH

The pH varies due to physiological, pathological and behavioral factors.

-Physiological factors: salivary pH varies during the day according to the circadian rhythms. It tends to be lower during sleep and higher during daytime activity when flow is stimulated by eating and speaking (15). Changes associated with age may diminish buffering capacity, while eating patterns, particularly regular carbohydrate consumption, can affect baseline pH levels.

-Pathological factors: Systemic conditions like diabetes mellitus, kidney failure, autoimmune diseases (like Sjögren's syndrome) and radiation related salivary dysfunction are known to alter pH through changes in secretion rate or ionic composition (2,16). Medication that have anticholinergic properties, along with dehydration and stress can worsen these changes.

-Behavioral factors: Lifestyle habits such as smoking, drinking alcohol and regularly consuming acidic foods and drinks can lower the salivary pH (15). But proper hydration and chewing stimulation often raise pH levels by increasing salivary flow and bicarbonate secretion.

The salivary pH is essential for preserving oral balance, while there is extensive evidence linking pH to caries, the precise relationship between salivary pH and the occurence of dental caries in adults is not fully established. This uncertainty highlights the necessity of doing a systematic review.

2. OBJETIVE

To determine whether adults with a decrease of salivary pH in resting saliva have a greater incidence of dental caries than adults with a salivary pH that remains within the normal range.

3. MATERIAL AND METHODS

3.1. PICO Research Question

The research question guiding this review was structured using the PICO framework, which is widely used to ensure clarity and precision in the formulation of clinical research questions. This approach allowed for a clear identification of the key components of the study and supported the development of a focused and consistent search strategy. It also facilitated a structured and transparent approach to study selection and data extraction throughout the review process.

The Population (P) of interest included adult individuals aged 18 years and older. This selection was made in order to specifically explore the relationship between salivary pH and dental caries within adult populations, while avoiding potential variations associated with pediatric subjects. This distinction is important, as caries patterns and salivary characteristics may differ significantly between children and adults.

The Intervention (I) corresponded to the level of salivary pH measured under resting conditions. Only studies using validated and clinically accepted measurement methods, such as digital pH meters, pH indicator strips, or electrode-based systems, were considered in order to ensure the accuracy and reliability of the reported values. This criterion was essential to maintain consistency and comparability across the included studies.

The Comparator (C) consisted of individuals presenting salivary pH values within the normal physiological range. This comparison allowed for the evaluation of potential differences in caries occurrence depending on variations in salivary acidity. It also provided a reference point for interpreting deviations from normal salivary conditions.

The Outcome (O) of interest was the presence or incidence of dental caries, assessed using commonly accepted clinical indices such as DMFT, DMFS, ICDAS, or equivalent diagnostic criteria. This structured framework provided a clear and consistent basis for the selection, analysis, and interpretation of the studies included in this review, thereby strengthening the overall methodological coherence of the study.

PICO Question: Does adults whose present a decrease of salivary pH in resting saliva cause a greater incidence of dental caries than in adults with a salivary pH that remains within the normal range ?

3.2. Eligibility Criteria

In order to ensure a consistent and relevant selection of studies, a set of predefined eligibility criteria was applied throughout the screening process. Only studies conducted on human participants aged 18 years or older were considered suitable for inclusion, as the objective of this review was to specifically explore the association between salivary pH and dental caries within adult populations. This distinction was essential, given that both salivary characteristics and caries progression may differ depending on age.

Eligible studies were required to include an assessment of salivary pH under resting conditions. These measurements had to be obtained using recognized and clinically accepted techniques, such as digital pH meters, indicator strips, or electrode-based devices, in order to ensure that the reported values were reliable and comparable across different studies.

In addition, only studies that evaluated dental caries using established clinical indices were retained. These included commonly used diagnostic systems such as DMFT, DMFS, ICDAS, or equivalent methods, allowing for a more consistent interpretation of caries outcomes across the selected literature.

To maintain an adequate level of scientific quality, only articles published in peer-reviewed journals were included. Furthermore, a publication period ranging from 2000 to 2026 was applied in order to focus on relatively recent evidence while still capturing a sufficient number of relevant studies.

Studies that did not meet these criteria were excluded during the selection process. In particular, studies involving children or adolescent populations were not considered, as they fell outside the scope of the present review. Likewise, secondary literature such as systematic reviews, meta-analyses, narrative reviews, case reports, conference abstracts, editorials, and letters were excluded, since the aim was to analyze primary research data.

Finally, experimental studies conducted in vitro or on non-human models were also excluded, as their findings cannot be directly extrapolated to clinical conditions in humans. The application of these criteria contributed to a more focused and methodologically consistent selection of studies aligned with the research objective.

3.3. Sources of Information

The search for relevant literature was conducted using three main electronic databases: PubMed, Google Scholar, and MEDLINE Complete. These sources were selected to ensure a comprehensive, reliable, and well-balanced coverage of the available scientific literature and to identify studies examining the relationship between salivary pH and dental caries in adult populations.

Each database contributed differently to the search process. PubMed provided access to a large number of high-quality peer-reviewed biomedical articles, while MEDLINE Complete allowed the identification of additional indexed studies within a broader medical and clinical context. Google Scholar was used as a complementary source in order to retrieve potentially relevant publications not indexed in traditional biomedical databases.

This combined and systematic approach helped to minimize the risk of missing relevant studies and ensured a more exhaustive and reliable identification of the available evidence. It also allowed for the inclusion of studies from different scientific backgrounds and research designs, thereby strengthening the overall robustness and comprehensiveness of the literature search.

3.4. Search Strategy

A structured search strategy was developed in order to identify relevant studies addressing the relationship between salivary pH and dental caries in adult populations. This strategy combined the use of Medical Subject Headings (MeSH) with free-text terms, allowing for a more comprehensive and flexible identification of relevant literature. Boolean operators such as “AND” and “OR” were applied to appropriately combine the different keywords. The search equations were adapted for each database to account for their specific indexing systems and search functionalities.

In PubMed, a more detailed and targeted search equation was used, focusing on title and abstract fields in order to improve the specificity of the results. The following combination of terms was applied: ((salivary pH[Title/Abstract] OR saliva pH[Title/Abstract] OR ((saliva[Title/Abstract] OR salivary[Title/Abstract]) AND pH[Title/Abstract])) AND (dental caries[Title/Abstract] OR caries[Title/Abstract] OR DMFT[Title/Abstract] OR

ICDAS[Title/Abstract])). This approach aimed to ensure that the retrieved studies were directly relevant to the research topic.

For MEDLINE Complete, the search strategy was adapted to a simplified structure while maintaining the key concepts of the research question. The equation included terms related to salivary pH, dental caries, and adult populations, and was formulated as follows: (salivary pH OR saliva pH OR salivary) AND (dental caries OR caries OR DMFT) AND (adults). This allowed for the identification of additional studies that might not have been captured through PubMed alone.

In Google Scholar, a broader search strategy was intentionally applied in order to capture potentially relevant studies not indexed in traditional biomedical databases. The search equation used was: (salivary pH OR saliva OR salivary) AND (dental caries OR tooth decay OR caries OR DMFT OR ICDAS) AND (adults OR adult). This wider approach helped to complement the database search and ensured a more exhaustive coverage of the available literature.

3.5. Study Selection Process

The study selection process was carried out in a structured and sequential manner and was divided into three main phases in order to ensure a consistent and rigorous selection of the relevant studies.

The first phase consisted of title screening. During this step, all identified records were reviewed based on their titles in order to exclude studies that were clearly unrelated to the research question. This initial screening allowed for a rapid reduction of the number of articles while maintaining a broad inclusion strategy.

The second phase involved abstract screening. At this stage, the abstracts of the remaining studies were carefully examined to assess their relevance and to determine whether they met the predefined inclusion criteria. Only studies that appeared potentially eligible and directly related to the topic were retained for further evaluation.

The third phase consisted of full-text evaluation. The selected articles were thoroughly reviewed in full, and each study was assessed in detail according to the inclusion and exclusion criteria. This final step ensured that only the most relevant and methodologically appropriate studies were included in the systematic review.

3.6. Data extraction

The data extracted from each included study were selected to ensure a structured and consistent analysis, in accordance with the variables presented in the results table. For each study, general characteristics such as study identification (author and year of publication) and sample size, expressed as the number of participants, were recorded. The mean age of participants, when available, was also collected to better describe the study populations.

Methodological aspects were carefully documented, including the technique used to measure salivary pH, as well as the corresponding pH values or groups defined within each study. In addition, the type of caries index used (such as DMFT, DMFS, ICDAS, or equivalent) was extracted, along with the reported values associated with these indices.

Particular attention was paid to identifying statistical associations between salivary pH and dental caries, as this was a key element in answering the research question. The magnitude of the observed effect, when reported, was also taken into account to better interpret the relevance of the results.

In addition, the sample size of each study, expressed as a percentage of the total population included in the review, was calculated to reflect its relative contribution to the body of evidence. Finally, the main results of each study were summarized according to their relevance to the systematic review.

4. RESULTS

4.1. Studies selection

The literature search process resulted in the identification of a total of 1,514 records across the selected databases, with the majority of studies retrieved from PubMed. In order to ensure a more comprehensive search, additional sources were also explored, leading to the identification of three extra articles from other databases, including Google Scholar (n = 2) and MEDLINE Complete (n = 1).

Following this initial identification phase, a set of predefined filters was applied in order to refine the results. These filters included restrictions to studies conducted on human subjects, publications available in English, and articles published within the time frame from 2000 to 2026. After applying these criteria, the number of relevant records was reduced to 634, which were then considered for further evaluation.

A preliminary screening of titles and abstracts was subsequently performed to assess the relevance of each study in relation to the research objective. This step led to the exclusion of 604 articles that did not meet the inclusion criteria or were not directly related to the topic of interest.

The remaining 30 studies were then retrieved and examined in full text to determine their eligibility. During this stage, 21 articles were excluded for various reasons, including the absence of salivary pH measurements, lack of appropriate caries assessment indices, inclusion of non-adult populations, or study designs that did not correspond to the objectives of this review, such as review articles or in vitro studies.

Ultimately, a total of nine studies fulfilled all the predefined inclusion criteria and were therefore included in this systematic review.

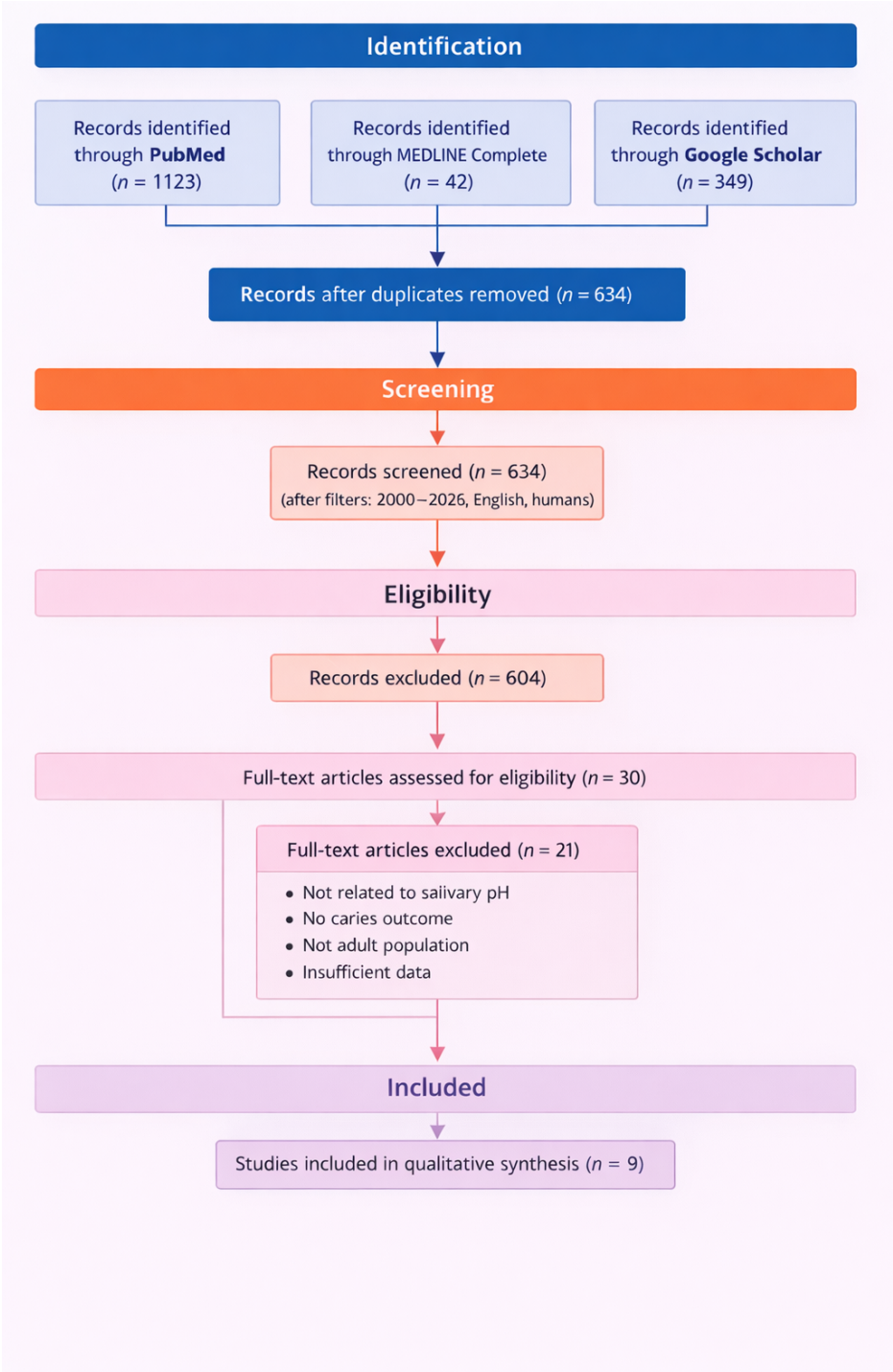


Figure 1. PRISMA 2020 flow diagram illustrating the study selection process (17)

4.2. Characteristics of the studies

The main characteristics and results of the included studies are summarized in Table 1 :

Study	Sample (number of people)	Age in years	pH method	Ph value/ groups	Caries Index	Caries/ index values	Statistical associations	Sample weight (%)	Strength of the effect detected	Results of the studies
Al-Abdaly 2020 (18)	750	20–50 years	pH strips	M:7.15→7.83 ; F: 6.72→6.77	DMFT	M: 7.1→8.4 ; F: 8.2→9.8	DMFT ↑ with age (p=0.001); pH ↑ with age in males (p=0.035)	30.8%	High (pH strip but compensate by a big sample : 750 adults)	Neutral
Szkaradkiewicz-Karpinska 2024 (11)	61	20–40 years	Digital pH meter + combined electrode	7.19±0.15 (CF); 7.12±0.20 (low); 6.69±0.17 (moderate); 6.57±0.19 (high)	DMFT	0; 6.4±1.3; 10.9±1.8; 19.2±3.6	pH significantly lower in moderate/high caries	2.5%	High (good pH detection with 61 adults)	Favorable
Dukić et al., 2013 (15)	140	26–51 years	pH indicator paper	Unstimulated: pH 5–7: Alcoholics 67 (96%); Controls 50 (72%). pH >7: Alcoholics 3 (4%); Controls 20 (28%).	DMFT	Alcoholics: 14.40 ± 6.08; Controls: 13.44 ± 4.48	Group pH distributions differ (alcoholics lower pH). pH category did not significantly affect DMFT (p>0.05).	5.7%	Moderate (pH indicator paper)	Neutral
Karnik 2015 (19)	60	18–37 years	Digital pH meter	Pregnant: 6.56±0.35; Non-pregnant: 6.86±0.42	DMFT	Pregnant: 7.97±4.82; Non-pregnant: 8.23±5.52	Significant negative correlation (p=0.002; p=0.01)	2.5%	High (60 adults with digital pH meter)	Favorable

Rahiotis et al., 2021 (20)	87	20–40 years	GC Saliva-Check Buffer (color strip)	Low/acidic: pH < 6.6 (n=37) ; Normal: pH > 6.8 (n=50)	DMFT	(D1) Low: 17.89 ± 7.84 ; Normal: 16.26 ± 5.67 (D3) Low: 15.68 ± 8.41 ; Normal: 14.14 ± 6.47	Low pH associated with higher DMFT at D1 only	3.6%	Moderate (color strip)	Favorable
Jawed 2012 (21)	700	26–65 years	Digital pH meter	7.18±0.98 ; 5.99±0.24	DMFT	10.54±3.38 ; 14.25±1.88	pH lower and DMFT higher in diabetics ($p<0.001$)	28.7%	High (Sample of 700 adults with digital pH meter)	Favorable
Foglio-Bonda 2019 (22)	120	~50 years	Digital pH meter	6.75±0.34 ; 6.86±0.24	DMFT	11.93±7.14 ; 12.23±6.37	No correlation	4.9%	High (Sample of 120 adults with digital pH meter)	Neutral
Glavina 2023 (23)	87	Adults (18 years old or more)	pH indicator paper	pSS: 6.00; dcSSc: 6.25; Controls: 7.00	DMFT	23.74; 28.50; 20.00	Lower pH and higher DMFT in disease groups ($p<0.001$); no direct correlation test	3.6%	Moderate (pH paper)	Favorable
Hosseini-Yekani 2018 (24)	431	20–60 years	Digital pH meter	6.07±0.91 ; 5.99±1.04	DMFT	12.99±6.74; 15.86±7.08	Each increase of 1 pH unit → decrease of approximately 1 DMFT unit	17.7%	High (431 adults and digital pH meter)	Favorable

Table 1. Results of included studies

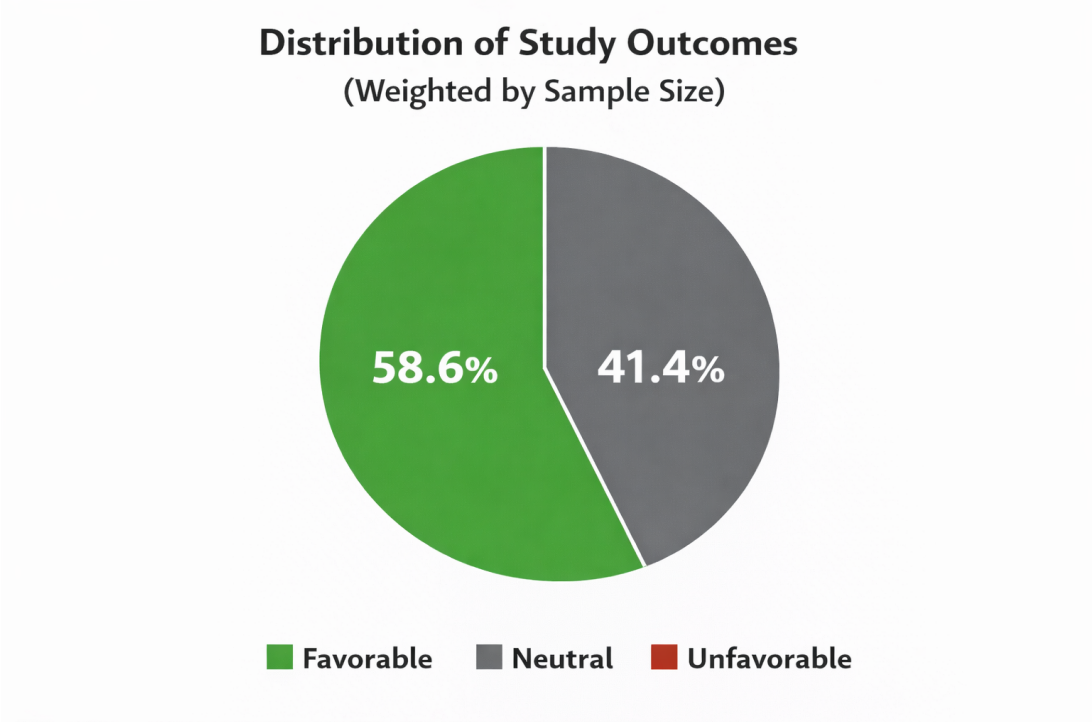


Figure 2. Distribution of study outcomes (favourable, neutral, unfavourable) weighted by total sample size across the included studies.

4.3. Main findings

Nine studies met the inclusion criteria and were included in the final analysis. These studies were published between 2012 and 2024 and involved a total of 2,436 adults.

Sample sizes varied considerably between studies, ranging from 60 to 750 participants, and age from 18 to 65 years old.

Different methods were used to measure salivary pH, for exemple digital pH meters, pH indicator papers, pH strips, and commercial chairside saliva tests, such as the GC Saliva-Check Buffer. Although there is methodological differences, most studies measured unstimulated salivary pH.

Dental caries were primarily assessed by using the DMFT index, some studies also used different diagnostic thresholds, such as D1 and D3 levels (20), to assess caries severity. In all included studies, mean salivary pH values ranged from approximately 5.99 to 7.83, depending on the characteristics of the populations studied.

Several studies have reported an inverse relationship between salivary pH and dental caries. Lower salivary pH values were generally associated with higher DMFT, indicating a higher prevalence of dental caries. For example, the study by Szkaradkiewicz-Karpinska (2024) showed that salivary pH decreased progressively as the severity of caries increased (11). Similarly, Hosseini-Yekani (2018) reported that each increase of one pH unit was associated with a decrease of approximately one unit in the DMFT index (24).

A similar trend was observed in the study of Jawed (2012), which found significantly lower salivary pH values and higher DMFT scores in diabetic participants compared to non-diabetics (21).

However, not all studies found a statistically significant association. Foglio-Bonda (2019) reported no significant correlation between salivary pH and caries index values (22), while Dukić et al. (2013) observed differences in salivary pH between groups but found no significant influence of pH categories on DMFT scores (15).

Overall, most of the included studies suggest that lower salivary pH may be associated with higher caries indices, even through the strength of this relationship varies depending on the study design, the population examined, and the methodology used.

5. DISCUSION

5.1. Summary of main findings

The results of this review suggest that salivary pH may be associated with the development of dental caries in adult populations. Most of the included studies reported an inverse relationship between salivary pH and caries indices such as the DMFT, indicating that lower salivary pH values tend to be associated with a higher incidence of dental caries. However, this association was not consistently observed across all studies, with some authors reporting no statistically significant correlations between salivary pH and caries indices.

Overall, the available data suggest a general trend toward a link between salivary pH and dental caries, although the strength of this relationship appears to vary depending on the

characteristics of the studied population and the methodological design of the studies. Differences in sample size, age distribution, and underlying health status may contribute to the variability observed between studies. Furthermore, variations in the methods used to assess salivary pH and caries indices may influence the comparability of the results.

These results indicate that while salivary pH may play an important role in the oral environment, it should be interpreted with caution and considered alongside other clinical and biological factors involved in the development of dental caries.

5.2. Interpretation

The observed link between lower salivary pH and increased dental caries can be explained by saliva's role in maintaining oral homeostasis. Saliva helps buffer the acids produced by bacterial metabolism and helps maintain a neutral pH in the oral environment. When salivary pH decreases, the risk of enamel demineralization increases, promoting the development of dental caries. Furthermore, acidic oral conditions favor the proliferation of acidogenic and aciduric bacteria, such as Streptococcus mutans, which are strongly associated with the onset and progression of dental caries (8,9,11).

More specifically, when the pH of the oral environment falls below the critical threshold of approximately 5.5, demineralization of the enamel surface begins, leading to mineral loss from the tooth structure (7,10). Under normal conditions, saliva contributes to remineralization through the presence of calcium and phosphate ions, as well as buffering systems such as bicarbonates(6). However, under persistently acidic conditions, this balance between demineralization and remineralization is disrupted, promoting the progression of lesions.

Additionally, salivary flow rate and buffering capacity play a key role in regulating oral pH. A decrease in salivary flow rate or buffering capacity can further exacerbate acidic conditions, thus increasing susceptibility to dental caries. It is also important to consider that dental caries is a multifactorial disease, influenced not only by salivary pH, but also by factors such as dietary habits, frequency of sugar consumption, oral hygiene practices, host-related characteristics, hydration status, and circadian rhythms. This variability suggests that a single measurement may not fully reflect the long-term oral environment of an individual. (2,7,15).

Overall, salivary pH can be considered a relevant element in the cariogenic process, but it should not be viewed in isolation. Its role must be understood within a broader framework involving multiple biological and environmental influences that interact within the oral cavity.

In clinical practice, this suggests that a single pH measurement may not be sufficient to accurately assess caries risk. A more reliable evaluation requires integrating salivary pH with other parameters, such as salivary flow, buffering capacity, and patient-related factors.

5.3. Comparison with other studies

The results obtained in this study are generally consistent with those reported in previous studies on the relationship between salivary parameters and dental caries. Several publications have suggested that conditions that can alter the composition or function of saliva may indirectly influence the risk of caries. For example, studies evaluating patients with systemic diseases such as asthma or diabetes have reported alterations in salivary characteristics and higher caries indices compared to healthy individuals (25,26). These observations support the idea that changes in the oral environment may contribute to the development of dental caries.

Lifestyle factors have also been described as potential contributors to changes in salivary properties. Research focusing on tobacco use, including smoking and the use of smokeless tobacco, has reported a reduction in salivary pH and alterations in salivary flow (27,28). Such changes can affect the protective role of saliva, leading to conditions that promote bacterial activity and enamel demineralization.

The results of larger studies examining salivary biomarkers in dental caries confirm this relationship. These studies highlight that several salivary variables, including pH, buffering capacity, and salivary flow rate, are often associated with differences in caries prevalence. However, they also emphasize that this relationship is complex and can vary depending on the population and study protocols (29,30).

Recent research also suggests that dental caries may share common risk factors with other oral diseases. For example, studies exploring the link between caries and periodontal disease indicate that both may be influenced by similar environmental and behavioral determinants,

including oral hygiene practices, the composition of the microbial biofilm, and lifestyle habits (31).

These results support the hypothesis that salivary pH plays an important role in maintaining oral homeostasis and may be a significant factor influencing the development and progression of dental caries.

Moreover, several recent systematic reviews and meta-analyses have further emphasized the importance of salivary parameters in assessing caries risk, highlighting that changes in salivary composition can be particularly relevant in certain patient populations, notably those with systemic diseases or lifestyle-related risk factors (30,31). These studies suggest that, while salivary pH is an important indicator of the oral environment, it should not be considered in isolation but rather interpreted in conjunction with other key salivary factors such as buffering capacity and salivary flow rate, which together contribute to maintaining the overall protective function of saliva.

It is also important to consider that the influence of salivary pH on dental caries can vary from one individual to another. Variations in individual susceptibility, including differences in oral microbiota composition, host immune response, genetic predisposition, and dietary habits, can significantly alter the impact of salivary pH on the cariogenic process. These inter-individual differences could partly explain why some studies report strong and statistically significant associations, while others fail to demonstrate a clear relationship between salivary pH and caries indices.

Furthermore, the interaction between salivary pH and other oral health conditions suggests that dental caries must be understood within a broader ecological and dynamic framework. The constant balance between demineralization and remineralization processes, microbial activity within the dental biofilm, and host-related factors all play a crucial role in the onset and progression of the disease (8,9). In this context, variations in salivary pH may act as a contributing factor influencing this balance rather than as a direct and isolated cause of dental caries.

Overall, these results underscore the need for a comprehensive and integrative approach to caries risk assessment, combining salivary analysis with clinical examination, behavioral

assessment, and patient-specific risk factors to improve both preventive strategies and the long-term management of dental caries.

5.4. Limitations

Several limitations should be considered when interpreting the results of this review. First most of the studies included in this review were observational and cross-sectional, which do not allow for establishing a causal link between salivary pH and dental caries. Another limitation is the heterogeneity of the studies in terms of sample size, population characteristics, and methods used to measure salivary pH, such as digital pH meters, pH strips, or commercial saliva test kits. These methodological differences may affect the comparability of results between studies.

Also the relatively small number of studies included in this review may limit the generalizability of the results and while the selected studies provide valuable information, a larger number of well-designed studies would be needed to strengthen the available data set.

In addition, heterogeneity in the assessment of dental caries across studies represents a potential source of bias. While most studies relied on the DMFT index, differences in thresholds and diagnostic criteria may influence the reported prevalence of caries and limit direct comparisons between studies.

It should also be noted that potential confounding factors were not systematically controlled for in all included studies. Variables such as dietary habits, frequency of sugar consumption, oral hygiene practices, and socioeconomic status may have influenced the observed associations between salivary pH and dental caries.

Finally, the cross-sectional design of most of the included studies does not allow for the assessment of temporal relationships between variations in salivary pH and the development of dental caries therefore, longitudinal studies would be necessary to better understand the direction and causality of this association.

5.5. Clinical implications and futur research

Despite these limitations, the results of this study suggest that salivary pH could be a relevant factor in the oral environment and could contribute to the assessment of caries risk in adult patients. Monitoring salivary parameters and more precisely pH, could therefore be a useful tool in preventive dentistry and for identifying individuals at high risk of developing dental caries. However, further well-designed longitudinal and controlled studies are needed to better understand the relationship between salivary pH and dental caries and to determine whether salivary pH could be used as a reliable clinical indicator for caries risk assessment.

From a clinical perspective, integrating salivary analysis into routine dental examinations could provide additional information about a patient's oral environment and contribute to a more personalized approach to caries prevention. Chairside saliva testing could facilitate the early detection of patients with salivary abnormalities and enable the implementation of targeted preventive measures.

Combining salivary pH assessment with other clinical parameters, such as caries history, dietary habits, and oral hygiene practices, could improve the accuracy of caries risk assessment. This multifactorial approach would allow clinicians to better tailor preventive and therapeutic strategies to each patient.

Future research should also focus on standardizing methods for measuring salivary pH and other salivary parameters to improve the comparability of results between studies. Further research into the interaction between salivary pH, the oral microbiota, and host-related factors could also lead to a better understanding of the mechanisms underlying the development of dental caries.

Ultimately, a more comprehensive understanding of salivary factors could contribute to the development of more effective and personalized preventive strategies in modern dentistry.

6. CONCLUSIONS

The objective was achieved, as adults presenting lower resting salivary pH values tend to exhibit a higher incidence of dental caries compared to individuals whose salivary pH remains within the normal physiological range.

7. SUSTAINABILITY

In dentistry, sustainable healthcare increasingly emphasizes prevention and early risk identification to reduce the long-term impact of oral diseases. In this context, approaches that promote early detection and limit disease progression can contribute to more effective and responsible clinical practice.

The results of this review highlight the potential value of salivary pH as an easily accessible and non-invasive parameter that can help identify individuals with a greater predisposition to dental caries. Its use in routine dental assessments could facilitate earlier intervention and encourage preventive management rather than restorative treatments.

By promoting early identification of at-risk patients, such strategies can reduce the need for complex and invasive procedures, often associated with higher costs, increased clinical time, and greater material usage. This focus on prevention contributes to a more balanced use of healthcare resources.

The use of simple chairside assessments, such as salivary pH measurement, can improve patient understanding and encourage behavioural changes related to diet and oral hygiene.

Integrating salivary indicators into clinical practice supports a preventive and long-term approach to oral health care. This approach aligns with Sustainable Development Goal 3 (Good Health and Well-being) and reinforces more sustainable dental care practices (32).

8. REFERENCES

1. Ghannam MG, Singh P. Anatomy, Head and Neck, Salivary Glands. En: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2025; http://www.ncbi.nlm.nih.gov/books/NBK538325/ PubMed PMID: 30855909.

2. Cunha-Cruz J, Scott J, Rothen M, Mancl L, Lawhorn T, Brossel K, et al. Salivary characteristics and dental caries. J Am Dent Assoc. 2013;144(5):e31-40. doi:10.14219/jada.archive.2013.0159

3. Zaheer S, Kew B, Louca C, Hafizi S, Sarkar A, Mutahar M. Short-term effects of sweetened acidic beverages consumption on human saliva: Colloidal properties and protein composition. Hwang G, editor. PLOS One. 2025;20(9):e0330023. doi:10.1371/journal.pone.0330023

4. Klenotová M, Matějka P. SERS analysis of saliva and its key components: The effects of various collection methods, sample dilution, excitation wavelengths, and enhancing substrates. Vib Spectrosc. 2025;138:103787. doi:10.1016/j.vibspec.2025.103787

5. Stookey GK. The effect of saliva on dental caries. J Am Dent Assoc. 2008;139:11S-17S. doi:10.14219/jada.archive.2008.0347

6. Kaur A, Kwatra K, Kamboj P. Evaluation of non-microbial salivary caries activity parameters and salivary biochemical indicators in predicting dental caries. J Indian Soc Pedod Prev Dent. 2012;30(3):212. doi:10.4103/0970-4388.105013

7. Potra Cicalău GI, Ciavoi G, Scrobota I, Venter ID, Ganea MF, Ghitea MC, et al. Salivary pH Modulation and Antimicrobial Properties of Oregano-Oil Jelly in Relation to Menstrual and Menopausal Status. Nutrients. 2025;17(15):2480. doi:10.3390/nu17152480

8. Santos HS de B, Do T, Parolo CCF, Poloni J de F, Maltz M, Arthur RA, et al. Streptococcus mutans Gene Expression and Functional Profile in Root Caries: An RNA-Seq Study. Caries Res. 2022;56(2):116-28. doi:10.1159/000524196

9. Marsh PD. Dental plaque as a biofilm and a microbial community – implications for health and disease. BMC Oral Health. 2006;6(S1):S14. doi:10.1186/1472-6831-6-S1-S14

10. Cieplik F, Rupp CM, Hirsch S, Muehler D, Enax J, Meyer F, et al. Ca2+ release and buffering effects of synthetic hydroxyapatite following bacterial acid challenge. BMC Oral Health. 2020;20(1):85. doi:10.1186/s12903-020-01080-z

11. SZKARADKIEWICZ-KARPINSKA AK, ZABA C, TEZYK A, GRECZKA G, SZKARADKIEWICZ A. Salivary glucose levels and pH in healthy adults with dental caries. J Physiol Pharmacol. 2024;525-31. doi:10.26402/jpp.2024.5.06

12. Catunda RQ, Altabtbaei K, Flores-Mir C, Febbraio M. Pre-treatment oral microbiome analysis and salivary Stephan curve kinetics in white spot lesion development in orthodontic patients wearing fixed appliances. A pilot study. BMC Oral Health. 2023;23(1):239. doi:10.1186/s12903-023-02917-z

13. Souza TRD, Zancope BR, De Sousa ET, Parisotto TM, Rocha Marques M, Nobre Dos Santos M. Sucrose rinse modulates the salivary behavior of carbonic anhydrase VI and its buffering capacity: a longitudinal study in 4 to 6.5-year-old children. PeerJ. 2024;12:e17429. doi:10.7717/peerj.17429

14. Bechir F, Pacurar M, Tohati A, Bataga SM. Comparative Study of Salivary pH, Buffer Capacity, and Flow in Patients with and without Gastroesophageal Reflux Disease. Int J Environ Res Public Health. 2021;19(1):201. doi:10.3390/ijerph19010201

15. Dukić W, Trivanović Dobrijević T, Katunarić M, Lešić S. Caries Prevalence in Chronic Alcoholics and the Relationship to Salivary Flow Rate and pH. Cent Eur J Public Health. 2013;21(1):43-7. doi:10.21101/cejph.a3796

16. Van Santen JS, Assy Z, Laine ML, Vissink A, Kroese FGM, Pringle S, et al. The intra-oral variation of salivary ions. Clin Oral Investig. 2025;29(11):515. doi:10.1007/s00784-025-06597-7

17. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ. 2021;n71. doi:10.1136/bmj.n71

18. Al-Abdaly MMAA, Assiry AIM. The Impact of Salivary pH Value and Dental Caries Index on Periodontal Status among Adult Age Groups of Patients from Aseer Region, Saudi Arabia. Open J Stomatol. 2020;10(07):199-209. doi:10.4236/ojst.2020.107019

19. Karnik A, Pagare S, Krishnamurthy V, Vahanwala S, Waghmare M. Determination of salivary flow rate, pH, and dental caries during pregnancy: A study. J Indian Acad Oral Med Radiol. 2015;27(3):372. doi:10.4103/0972-1363.170454

20. Rahiotis C, Mitropoulos P, Kakaboura A. Comparative Evaluation of Chair-Side Saliva Tests According to Current Dental Status in Adult Patient. Dent J. 2021;9(1):10. doi:10.3390/dj9010010

21. Jawed M, Khan RN, Shahid SM, Azhar A. Protective Effects of Salivary Factors in Dental Caries in Diabetic Patients of Pakistan. Exp Diabetes Res. 2012;2012:1-5. doi:10.1155/2012/947304

22. FOGLIO-BONDA PL, ROCCHETTI V. Salivary pH and flow rate in menopausal women. 2019. doi:10.26355/eurrev_201902_16977

23. Glavina A, Božić I, Parat K, Perković D, Biočina-Lukenda D, Martinović Kaliterna D, et al. Salivary Flow Rate and Oral Status in Patients with Primary Sjögren's Syndrome and Diffuse Cutaneous Systemic Sclerosis: A Cross-Sectional Study. Diagnostics. 2023;13(6):1057. doi:10.3390/diagnostics13061057

24. Hosseini-Yekani A, Nadjarzadeh A, Vossoughi M, Reza JZ, Golkari A. Relationship between Physicochemical Properties of Saliva and Dental Caries and Periodontal Status among Female Teachers Living in Central Iran. J Int Soc Prev Community Dent. 2018;8(1):48-55. doi:10.4103/jispcd.JISPCD_391_17

25. Fathima R, Shenoy R, Jodalli PS, Sonde L, Mohammed IP. Evaluation of Salivary Parameters and Oral Health Status Among Asthmatic and Nonasthmatic Adult Patients Visiting a Tertiary Care Hospital. Cureus. 2019. doi:10.7759/cureus.5957

26. Seethalakshmi C. Correlation of Salivary pH, Incidence of Dental Caries and Periodontal Status in Diabetes Mellitus Patients: A Cross-sectional Study. J Clin Diagn Res. 2016. doi:10.7860/JCDR/2016/16310.7351

27. Singh M, Ingle N, Kaur N, Yadav P, Ingle E. Effect of long-term smoking on salivary flow rate and salivary pH. J Indian Assoc Public Health Dent. 2015;13(1):11. doi:10.4103/2319-5932.153549

28. Al-Ak'hali MS, Halboub ES, Mujam OH, Alahmar NM, Jerah SA, Mutawwam FA. Salivary parameters among Arabian snuff (Shammah) users. Saudi Med J. 2017;38(12):1201-6. doi:10.15537/smj.2017.12.20973

29. Zhou G, Shu X, Long Y, Cao Y, Wang J, Liao G, et al. Dental caries and salivary alterations in patients with type 2 diabetes: A systematic review and meta-analysis. J Dent. 2024;150:105321. doi:10.1016/j.jdent.2024.105321

30. Hegde MN, Attavar SH, Shetty N, Hegde ND, Hegde NN. Saliva as a biomarker for dental caries: A systematic review. J Conserv Dent. 2019. PubMed PMID: 30820074; PubMed Central PMCID: PMC6385571.

31. Li Y, Xiang Y, Ren H, Zhang C, Hu Z, Leng W, et al. Association between periodontitis and dental caries: a systematic review and meta-analysis. Clin Oral Investig. 2024;28(6):306. doi:10.1007/s00784-024-05687-2

32. Weeks WB, Weinstein JN, Lavista JM. All Sustainable Development Goals Support Good Health and Well-Being. Int J Public Health. 2023;68:1606901. doi:10.3389/ijph.2023.1606901