Nanotechnology Perceptions
ISSN 1660-6795
www.nano-ntp.com

Effectiveness Of Mouthwash-Containing Silver Nanoparticles On Oral Health: A Scoping Review

Reema H Aljubua[1], Rahul N Gaikwad[2], Rama A Alkhudhairy[1], Amjad M Alharbi[3]

[1]*Resident, Department of Community Dentistry and Oral Epidemiology, College of Dentistry, Qassim University, Buraydah, Saudi Arabia.*

[2]*Associate Professor, Department of Community Dentistry and Oral Epidemiology, College of Dentistry, Qassim University, Buraydah, Saudi Arabia.*

[3]*Assistant Professor, Department of Community Dentistry and Oral Epidemiology, College of Dentistry, Qassim University, Buraydah, Saudi Arabia.*

Corresponding author:

Reema H Aljubua
Resident, Department of Community Dentistry and Oral Epidemiology, College of Dentistry, Qassim University, Buraydah, Saudi Arabia

Background

The strong antibacterial characteristics of silver nanoparticles (AgNPs) have recently attracted a lot of interest in the field of dentistry. Mouthwashes containing AgNPs have been developed as potential alternatives to conventional antimicrobial agents for improving oral health. The purpose of this scoping study was to inventory the current data regarding the efficacy of AgNP-containing mouthwashes on various aspects of oral health.

Methods

Scopus, Web of Science, PubMed/MEDLINE, and others were scoured in an exhaustive search. Studies were included if they examined mouthwashes containing silver nanoparticles and their effects on any oral health outcomes. Data were extracted using a standardized form and synthesized narratively according to intervention characteristics and outcome measures.

Results

The inclusion criteria were met by eight research, including randomized controlled trials, in vivo animal studies, in vitro studies, and review articles published between 2021 and 2025. Silver nanoparticle mouthwashes demonstrated significant antimicrobial efficacy against oral pathogens, though generally less potent than chlorhexidine in comparative studies. When it came to preventing white spot lesions during orthodontic therapy, nano-silver mouthwash proved to be more efficient than chlorhexidine and fluoride. An animal model demonstrated encouraging wound healing results with a composition of 9.8 wt% silver nanoparticles. Formulations varied considerably in concentration, particle size, and composition, with emerging interest in plant-based synthesis approaches. Limited adverse effects were reported, though systematic assessment of safety was lacking in most studies.

Conclusion

Oral health uses of silver nanoparticle mouthwashes are promising, with particular promise for the prevention of white spot lesions during orthodontic treatment and post-surgical care. However, significant research gaps remain, including limited long-term safety data, heterogeneity in formulations, and sparse evidence in diverse populations. Further studies ought to prioritize standardized formulations, effectiveness over time, safety, and applications in specific patient populations to establish the role of these products in oral health management.

Keywords

Silver nanoparticles; Mouthwash; Oral health; Antimicrobial; Dental caries; Periodontal health; Scoping review

1. Introduction

Good oral health forms an essential part of general well-being and affects both life quality and medical expenses while influencing systemic health conditions. The effective management of the oral microbiome by controlling harmful bacterial populations is essential for achieving optimal oral health since these bacteria cause dental caries along with periodontal disease and oral infections. Antimicrobial mouthwashes have long been an important adjunct to mechanical plaque control methods, providing chemical means to reduce microbial load and prevent or treat various oral diseases [1].

Chlorhexidine stands as the premier antimicrobial choice in dental medicine because of its wide-ranging bacterial action and its capacity to adhere to oral tissues for lasting effects. However, its long-term use is associated with several adverse effects, including tooth staining, taste alteration, mucosal irritation, and potential for bacterial resistance [2]. The drawbacks associated with current antimicrobial agents have led researchers to investigate new alternatives that deliver similar efficacy while causing fewer side effects.

Nanotechnology has become a leading field within dentistry in recent years by providing innovative methods for preventing, diagnosing, and treating oral diseases. The strong antimicrobial properties of Silver nanoparticles (AgNPs) against diverse microorganisms like bacteria, fungi, and viruses have made them especially noteworthy [3]. The development of silver nanoparticles with improved properties became possible due to nanotechnology advancements because of their small size (1-100 nm) and high surface area-to-volume ratio which boosts their interaction with microbial membranes [4].

Using silver nanoparticles in mouthwashes could offer significant benefits for managing oral health. Silver nanoparticle-based mouthwashes present multiple benefits that include their wide-ranging antimicrobial impact and lower risk of side effects when compared to traditional mouthwash ingredients along with potential extra features like anti-inflammatory effects and wound healing support [5]. The rising threat of antimicrobial resistance has driven researchers to study new antimicrobial approaches including silver nanoparticles because their multiple attack methods against microbes could lower resistance development chances [6].

Research on the effectiveness of silver nanoparticle mouthwashes for oral health results shows inconsistency across studies due to differences in study design, population groups, mouthwash formulations, and measured outcomes. Researchers have not yet completed a comprehensive review mapping the existing evidence regarding oral health effects of silver nanoparticle mouthwashes. The absence of existing research demonstrates that a scoping review is needed to systematically collect, evaluate and combine evidence on this subject. This scoping review focuses on evaluating current evidence about the effectiveness of silver nanoparticle-containing mouthwashes for different oral health aspects. Specifically, this review aims to:

1. Examine the various formulations of silver nanoparticle mouthwash that researchers have investigated.
2. Examine the evidence regarding their effectiveness for different oral health outcomes
3. Compare their efficacy to conventional mouthwashes
4. Identify potential adverse effects or safety concerns
5. Identify research gaps in the existing evidence base to guide future scientific investigations.

   By comprehensively mapping the existing evidence on silver nanoparticle mouthwashes, this review will provide valuable insights for dental practitioners, researchers, and policymakers regarding the potential role of these products in oral health management. These findings support clinical decision-making while steering research directions in the promising field of dental public health.

2. Methods

2.1 Study Design

The methodological framework from Arksey and O'Malley (2005) [7] together with Levac et al.'s refinement provided the structure for conducting this scoping review. The scoping review methodological framework included refinements by Levac et al. (2010) [8] as well as contributions from the Joanna Briggs Institute published by Peters et al. (2020) [9]. The review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) guidelines established by Tricco et al. in 2018 [10]. The review process followed a protocol established before its commencement.

2.2 Research Questions

The main objective of this scoping review was to explore these research questions. This literature review investigates existing research evidence about how silver nanoparticles in mouthwashes affect oral health outcomes. 2. What specific oral health parameters are affected by AgNP-containing mouthwashes? 3. What are the reported antimicrobial effects of AgNP mouthwashes against oral pathogens? 4. What is the safety profile and potential adverse effects of AgNP mouthwashes? 5. What are the gaps in the present research regarding AgNP mouthwashes?

2.3 Search Strategy

The search strategy to find relevant studies was developed through consultation with a health sciences librarian. The following electronic databases were searched from inception to April 2025: The investigation included searches within PubMed/MEDLINE and Scopus, Web of Science and Embase databases with additional exploration of the Cochrane Library and Google Scholar. The search strategy combined terms related to silver nanoparticles (e.g., “silver nanoparticle", "AgNP”, “nano silver”), mouthwashes (e.g., “mouthwash", "mouth rinse”, “oral rinse"), and oral health (e.g., "oral health", "dental health", "periodontal", "plaque", "biofilm", "caries", "antimicrob”). Researchers also examined reference lists from included studies to find studies missed by the electronic search.

2.4 Eligibility Criteria

Research articles qualified for inclusion when they fulfilled the specified requirements.

2.4.1 Inclusion Criteria

- **Population**: Human subjects of any age, gender, or health status; in vitro studies involving oral microorganisms or biofilms
- **Intervention**: Mouthwashes or oral rinses containing silver nanoparticles as a primary or adjunctive ingredient
- **Comparators**: Conventional mouthwashes, placebo, no treatment, or other antimicrobial agents
- **Outcomes**: Any oral health outcomes including but not limited to antimicrobial efficacy against oral pathogens, plaque and biofilm reduction, gingival and periodontal health indices, halitosis reduction, caries prevention, and adverse effects or toxicity
- **Study Design**: Our research incorporated every study design from randomized controlled trials to systematic reviews as well as non-randomized trials, observational studies, case reports, and in vitro studies.
- **Type of Publication:** Theses and dissertations, conference proceedings, and peer-reviewed journals
- **The Language**: Publications written in English.
- **Time Frame**: No date restrictions

2.4.2 Exclusion Criteria

- Studies focusing solely on silver nanoparticles in dental materials other than mouthwashes (e.g., restorative materials, implant coatings)
- Studies examining silver compounds without nanoparticle formulation
- Animal studies without direct relevance to human oral health
- Opinion papers, editorials, or commentaries without original data
- Publications not available in English

- Duplicate publications or multiple reports of the same study

2.5 Selection of Studies

Two distinct phases formed the study selection process. Two reviewers independently evaluated the titles and abstracts of all retrieved records against the eligibility criteria during the initial phase. The research team received and evaluated full texts of studies that appeared eligible during the second phase. Reviewers resolved their disagreements through dialogue or by seeking input from an additional reviewer if required.

2.6 Data Extraction

The research team created a standardized data extraction form grounded in their review objectives which they tested using a selection of included studies. The following data were extracted from each included study: The research characteristics extracted from each study included author names, publication year, country of origin, study design, sample size, population characteristics, and study duration.- Intervention details (silver nanoparticle concentration, size, formulation details, frequency and duration of use, administration protocol) - Comparator details (type, formulation, administration protocol) - Outcome measures (primary and secondary outcomes assessed, measurement methods, assessment timepoints) - Results (findings related to antimicrobial efficacy, plaque/biofilm reduction, gingival/periodontal health, other oral health outcomes, statistical significance, effect sizes) - Safety and adverse effects (reported adverse effects, safety assessments, tolerability) - Study limitations (limitations reported by authors, risk of bias assessment, quality assessment). A single reviewer conducted data extraction while a second reviewer verified the results to confirm their accuracy and completeness.

2.7 Data Analysis and Synthesis

Due to the diverse nature of study designs, populations, interventions, and outcomes the analysis utilized a narrative synthesis approach. Studies were categorized based on intervention type (e.g., concentration, particle size, formulation) and outcome measures. The effectiveness of silver nanoparticle mouthwashes was analyzed for different oral health parameters, and comparisons with conventional mouthwashes were synthesized when available. The review identified patterns and trends along with evidence gaps which were discussed in detail. The examination of evidence quality depended upon the study design along with sample size and methodological rigor in relation to risk of bias.

3. Results

3.1 Selection of Studies

The search approach produced 10 records from databases and identified 2 more records from additional sources. Following the elimination of duplicate entries we screened 10 unique records to determine eligibility.

We selected 8 studies for full-text review after title and abstract screening because they all fulfilled the inclusion criteria and were included in the final analysis. Figure 1 contains the PRISMA flow diagram which illustrates the study selection process.

3.2 Characteristics of Included Studies

Research on silver nanoparticle mouthwashes recently emerged in scientific literature as demonstrated by the publication dates from 2021 to 2025 of the eight included studies. The research incorporated different study designs which consisted of three randomized controlled trials, one in vivo animal study, two in vitro studies, and two review articles. Research efforts took place in multiple countries such as Saudi Arabia, India, Iran and additional locations showing worldwide interest in this research field.

3.2.1 Study Populations

The human studies included various populations: - Children [11] - Orthodontic patients [12, 13] - General adult populations (limited representation)

Sample sizes in the clinical trials ranged from 42 to 80 participants, with study durations ranging from 4 days to 6 months. One animal study used 60 rabbits to evaluate wound healing and antimicrobial effects [14].

3.2.2 Silver Nanoparticle Mouthwash Formulations

The included studies investigated various silver nanoparticle mouthwash formulations:

1. **Concentration variations**:
   - 9.8 wt% silver nanoparticle suspension with 400 ppm concentration [14]
   - Commercial formulations (NanOlife – [12])
   - Unspecified concentrations in other studies
2. **Particle size**:
   - 5 nm average size [14]
   - Unspecified in most studies
3. **Formulation components**:
   - Synthetic mouthwash containing water, glycerin, nano-silver suspension, and sodium saccharine [14]
   - Plant-based formulations:
     - Moringa oleifera reinforced with silver nanoparticles (5% concentration)
     - Ulvan-reduced silver nanoparticles
4. **Administration protocols**:
   - Varied across studies, with limited standardization
   - The period users engaged with the product spanned from 4 days to 6 months.

3.2.3 Comparators

Most studies compared silver nanoparticle mouthwashes with one or more of the following: - Chlorhexidine mouthwash (0.2% or 2.0%) - Fluoride mouthwash - Placebo mouthwash - No treatment (negative control)

3.2.4 Outcome Measures

The included studies assessed a range of oral health outcomes:

1. **Antimicrobial efficacy**:
   – Microbial counts (total and specific pathogens)
   – Colony-forming unit (CFU) counts
2. **Plaque and biofilm parameters**:
   – Plaque Index
3. **Gingival and periodontal health**:
   – Gingival Index
   – Gingival Bleeding Index
   – Pocket Probing Depth
4. **Caries-related parameters**:
   – White spot lesions (WSLs)
   – Salivary pH
5. **Wound healing**:
   – Wound area measurements
   – Healing progression

3.3 Effectiveness of Silver Nanoparticle Mouthwashes

3.3.1 Antimicrobial Efficacy

All studies that assessed antimicrobial outcomes demonstrated significant antimicrobial effects of silver nanoparticle mouthwashes:

- Maher et al. (2022) reported that AgNPs mouthwash effectively reduced cariogenic microbial counts in children [11].
- Raghav et al. (2025) found that silver nanoparticle mouthwash significantly reduced microbial counts of Streptococcus spp. in orthodontic patients, although it was less effective than chlorhexidine [12].
- Moaddabi et al. (2022) demonstrated significant reduction in CFU counts with 9.8 wt% silver nanoparticle mouthwash in an animal model, comparable to the effects of 2.0% chlorhexidine [14].

- The experimental research demonstrated Moringa oleifera mouthwash with silver nanoparticles possesses significant antimicrobial capabilities against Staphylococcus aureus and Streptococcus mutans [18].
- Th Research into mouthwash formulations containing silver nanoparticles showed promising antiviral activity against SARS-CoV-2 which suggests possible wider antimicrobial applications [16].

Comparative analysis showed that while silver nanoparticle mouthwashes demonstrated significant antimicrobial efficacy compared to placebo or no treatment, chlorhexidine generally showed superior antimicrobial effects in most studies. Raghav et al. (2025) [12] specifically noted that while SNP mouthwash reduced microbial counts, it could not decrease them to baseline levels, whereas CHX mouthwash decreased counts below baseline.

3.3.2 Plaque and Biofilm Reduction

Silver nanoparticle mouthwashes consistently demonstrated significant plaque reduction across studies:

- Maher et al. (2022) reported effective plaque reduction with AgNPs mouthwash in children [11].
- Raghav et al. (2025) showed that SNP mouthwash reduced plaque index in orthodontic patients but could not decrease it to baseline levels, while CHX mouthwash decreased plaque index below baseline [12].

The pattern for plaque reduction was similar to that observed for antimicrobial efficacy, with silver nanoparticles showing significant effects but generally less pronounced than chlorhexidine.

3.3.3 Gingival and Periodontal Health

Evidence on gingival health parameters was more limited:

- Raghav et al. (2025) reported that SNP mouthwash was effective in reducing gingival index but less effective than CHX [12].
- Orthodontic patients experienced limited effectiveness from both silver nanoparticle mouthwashes and chlorhexidine mouthwashes for Gingival Bleeding Index and Pocket Probing Depth.

3.3.4 Caries Prevention and Remineralization

Two studies provided evidence on caries-related parameters:

- study by Ali et al.(2021) showed nanosilver mouthwash outperformed CHX and fluoride mouthwash in reducing white spot lesions throughout orthodontic treatment. The WSL mean for the nanosilver group showed significant lower values compared to both CHX and fluoride groups at 90 and 180 days of evaluation with p-values below 0.05 [13].
- Maher et al. (2022) reported improved salivary pH with AgNPs mouthwash, which may contribute to caries prevention through reduced enamel demineralization [11].

These findings suggest that silver nanoparticle mouthwashes may have particular advantages for preventing early carious lesions, potentially outperforming conventional mouthwashes in this specific application.

3.3.5 Wound Healing

Moaddabi et al. (2022) provided the only evidence on wound healing effects [14]:

- The 9.8 wt% silver nanoparticle mouthwash significantly improved wound healing after incision in the lateral border of the tongue in rabbits.
- The wound area showed marked reduction across all experimental groups ($p < 0.001$) and significant inter-group differences emerged by the fourth day after surgery ($p < 0.001$).
- The synthetic silver nanoparticle mouthwash displayed similar antibacterial properties and wound-healing capabilities as chlorhexidine.

These findings suggest potential applications for silver nanoparticle mouthwashes in post-surgical oral care.

3.3.6 Safety and Adverse Effects

Reporting of adverse effects was limited across studies. None of the included studies reported significant adverse effects associated with silver nanoparticle mouthwashes, but systematic assessment and reporting of potential side effects were generally lacking. The potential advantages of silver nanoparticle mouthwashes over chlorhexidine in terms of reduced side effects (e.g., staining, taste alteration) were suggested but not comprehensively evaluated.

3.4 Quality Assessment

In general, the evidence was of a moderate quality. Strengths included the presence of several randomized controlled trials with appropriate comparators. Limitations included relatively small sample sizes, heterogeneous interventions with limited standardization of formulations, and limited long-term follow-up. Risk of bias was not systematically reported in most studies.

4. Discussion

The scoping review explored existing evidence about how mouthwashes with silver nanoparticles impact different oral health aspects. Research developments show a broadening knowledge base about silver nanoparticle mouthwashes with proven antimicrobial effectiveness applicable to specific oral health treatments. The review exposed notable variability in formulations and methodologies which produced different outcomes along with crucial gaps in the existing evidence base.

4.1 Antimicrobial Properties and Mechanisms of Action

The demonstrated antimicrobial effectiveness of silver nanoparticle mouthwashes in the studied research matches existing knowledge about silver nanoparticles' antimicrobial characteristics. Multiple mechanisms lead to antimicrobial outcomes from silver nanoparticles which encompass bacterial cell membrane disruption alongside bacterial enzyme inhibition and reactive oxygen species generation [15]. The multi-target mechanism may extend broadspectrum protection against multiple oral bacteria while also decreasing antimicrobial resistance risks which conventional treatments increasingly face [6].

The studies showed that silver nanoparticle mouthwashes had significant antimicrobial effects versus placebo or no treatment, but chlorhexidine proved more effective than silver nanoparticles in most comparative studies for reducing microbial counts. The superior performance of chlorhexidine matches expectations because of its documented strong antimicrobial effectiveness and long-lasting action [2]. The research demonstrates silver nanoparticle mouthwashes outperform chlorhexidine and fluoride in preventing white spot lesions during orthodontic treatment which implies their clinical usefulness could be especially advantageous for certain applications or patient groups [13].

The research review by Molena et al., 2022 [16] suggests silver nanoparticle mouthwashes possess potential antiviral properties against SARS-CoV-2 which makes this area ripe for future research studies. Since the oral cavity plays an essential role in transmitting viruses and oral infections become increasingly recognized as manifestations of viral diseases mouthwashes with antiviral properties might provide substantial public health benefits beyond basic oral hygiene.

4.2 Formulation Considerations

The variation of silver nanoparticle mouthwash formulas between research studies underscores the requirement for standardized methods in formulation and evaluation processes [17]. The effectiveness and safety of silver nanoparticle formulations depend greatly on particle size and concentration levels as well as the chosen delivery system. The lack of comprehensive parameter reporting in numerous studies prevents researchers from establishing definitive conclusions about the best formulation characteristics.

The research by Moaddabi et al. (2022) [14] that detailed particle size (5 nm) and concentration (9.8 wt%) stands as a significant resource for exploring the link between formulation components and clinical results. Future formulation development can benefit from their results which show this formulation possesses strong antimicrobial effects and wound healing properties.

Studies on Moringa oleifera and Ulvan-based formulations demonstrate the development of eco-friendly silver nanoparticle synthesis methods which indicate an increased focus on sustainable and biocompatible manufacturing solutions. Plant compounds demonstrate enhanced effects when combined with their natural antimicrobial or anti-inflammatory properties [18]. Further investigation is required to determine how these formulations perform in terms of comparative efficacy as well as their stability and safety.

4.3 Clinical Applications and Target Populations

Our review reveals multiple potential clinical uses for mouthwashes containing silver nanoparticles.

1. **Prevention of white spot lesions during orthodontic treatment:** Nano-silver mouthwash has shown better results than chlorhexidine and fluoride for preventing white spot lesions [13]. Orthodontic treatment patients face a higher risk of enamel

demineralization because oral hygiene difficulties arise which necessitates effective preventive approaches. This effect functions through antimicrobial activity against cariogenic bacteria and possible impacts on remineralization processes that need additional research.

2. **Post-surgical oral care**: The wound healing effects demonstrated by Moaddabi et al. (2022) [14] suggest potential applications in post-surgical settings. In oral surgical procedures where managing infection risk and speeding up recovery are critical needs the combined advantages of antimicrobial protection and accelerated wound healing become especially useful.
3. **Pediatric applications:** AgNPs mouthwash demonstrates potential to suppress harmful oral bacteria and enhance salivary pH levels in pediatric patients [11]. Silver nanoparticle mouthwashes present a potential alternative for caries prevention in young children due to fluoride ingestion concerns and chlorhexidine taste issues but require additional research on safety and acceptability.
4. **Patients with contraindications to conventional mouthwashes:** Silver nanoparticle mouthwashes serve as an alternative antimicrobial solution for patients allergic to chlorhexidine or those who face staining or taste issues, but their long-term effectiveness requires additional research.

The current evidence base fails to adequately represent certain populations such as elderly individuals, patients with periodontal disease, and immunocompromised patients and this lack of representation constitutes a significant research gap. Patients facing difficulties with plaque management along with those experiencing higher oral infection risks would gain the most from using effective antimicrobial mouthwashes.

4.4 Safety Considerations and Research Gaps

The evidence base suffers from limited adverse effect reporting across studies. The lack of reported adverse effects gives hope but systematic evaluation and documentation of potential side effects remain essential to confirm silver nanoparticle mouthwash safety. Theoretical research highlights possible cytotoxicity and tissue accumulation concerns of silver nanoparticles as well as environmental effects [19], but such findings remain unexamined specifically for oral use cases.

Long-term research remains an essential missing component in this field. Most included studies had relatively short follow-up periods (days to 6 months), which may be insufficient to detect delayed adverse effects or evaluate long-term efficacy. Additionally, the optimal duration and frequency of use remain unclear, with limited evidence to guide clinical protocols.

Cost-effectiveness considerations were notably absent from the included studies. Given that silver nanoparticle formulations may be more expensive to produce than conventional mouthwashes, economic evaluations would be valuable for informing implementation decisions, particularly in public health contexts.

4.5 Strengths and Limitations of the Review

Among the many merits of this scoping review are its thorough search methodology, rigorous screening procedures, and data extraction procedures, and a narrative synthesis that identifies patterns, trends, and gaps across the included studies. The inclusion of diverse study designs allowed for a broad mapping of the current evidence base, consistent with the objectives of a scoping analysis.

The emerging nature of this research field has resulted in a limited number of studies included in the analysis. The variation found in research formulations and methods alongside differing results prevented quantitative analysis from being conducted and restricted definitive conclusions regarding comparative effectiveness.

4.6 Implications for Practice and Research

The results from this study reveal multiple important applications for dental practice and areas for future research:

4.6.1 Practice Implications

- Silver nanoparticle mouthwashes show promise as alternatives to conventional mouthwashes, particularly for specific applications like preventing white spot lesions in orthodontic treatments as well as managing oral care after surgical procedures.
- The current evidence supports their antimicrobial efficacy, though generally to a lesser extent than chlorhexidine for most applications.
- Given the limited evidence on long-term safety and optimal protocols, clinicians should exercise caution in recommending these products and consider them primarily for short-term use or specific indications where conventional approaches are contraindicated or have shown limited efficacy.

4.6.2 Research Implications

- Future studies should include larger randomized controlled trials with standardized formulations and extended follow-up periods to establish long-term safety and efficacy.
- Future studies should systematically assess and report potential adverse effects, including local and systemic effects.
- Research on optimal formulation parameters (concentration, particle size, delivery system) would help establish evidence-based guidelines for product development.
- Studies in diverse populations, including elderly individuals, patients with periodontal disease, and immunocompromised patients, would address important gaps in the current evidence base.
- Economic evaluations comparing silver nanoparticle mouthwashes with conventional alternatives would inform implementation decisions.
- Mechanistic studies exploring the precise modes of action against oral pathogens and potential effects on remineralization processes would enhance understanding of their therapeutic potential.

5. Conclusion

The research presents a complete evaluation of existing studies about silver nanoparticle-infused mouthwashes' impact on oral health. Our findings indicate that silver nanoparticle mouthwashes demonstrate promising antimicrobial properties against oral pathogens and potential benefits for various oral health applications. Research indicates specific effectiveness for mouthwashes containing silver nanoparticles to prevent white spot lesions in orthodontic patients, promoting wound healing after oral surgical procedures, and reducing cariogenic microbial counts in children.

While silver nanoparticle mouthwashes generally showed less potent antimicrobial effects than chlorhexidine in most comparative studies, they may offer advantages in terms of reduced side effects and specific applications where conventional mouthwashes have limitations. The emergence of plant-based or "green" synthesis approaches for silver nanoparticles represents an innovative direction that may enhance biocompatibility and sustainability.

However, significant research gaps remain. The heterogeneity in formulations across studies highlights the need for standardization in concentration, particle size, and delivery systems. Long-term safety data are limited, with most studies having relatively short follow-up periods. Systematic assessment and reporting of potential adverse effects are lacking in the current literature. Additionally, evidence in diverse populations, including elderly individuals, patients with periodontal disease, and immunocompromised patients, is sparse.

Long-term safety and effectiveness profiles require future research to conduct larger randomized controlled trials with standardized formulations and more extended follow-up periods. Research investigations into the exact mechanisms of action together with cost-effectiveness assessments against traditional treatments will deepen our knowledge about the possible application of these products in oral health care.

In conclusion, silver nanoparticle mouthwashes represent a promising approach in dental public health, with potential to address some limitations of conventional antimicrobial agents. However, more robust evidence is needed before definitive clinical recommendations can be made. As research in this field continues to evolve, dental practitioners should consider the current evidence in the context of individual patient needs and specific clinical scenarios, while researchers should address the identified gaps to advance our understanding of these innovative products.

References

1. Marsh PD. Controlling the oral biofilm with antimicrobials. J Dent. 2010;38 Suppl 1:S11-5.
2. James P, Worthington HV, Parnell C, Harding M, Lamont T, Cheung A, et al. Chlorhexidine mouthrinse as an adjunctive treatment for gingival health. Cochrane Database Syst Rev. 2017;3:CD008676.
3. Noronha VT, Paula AJ, Durán G, Galembeck A, Cogo-Müller K, Franz-Montan M, et al. Silver nanoparticles in dentistry. Dent Mater. 2017;33(10):1110-26.
4. Rai M, Yadav A, Gade A. Silver nanoparticles as a new generation of antimicrobials. Biotechnol Adv. 2009;27(1):76-83.

5. Besinis A, De Peralta T, Handy RD. The antibacterial effects of silver, titanium dioxide and silica dioxide nanoparticles compared to the dental disinfectant chlorhexidine on Streptococcus mutans using a suite of bioassays. Nanotoxicology. 2015;9(1):1-16.
6. Durán N, Durán M, de Jesus MB, Seabra AB, Fávaro WJ, Nakazato G. Silver nanoparticles: a new view on mechanistic aspects on antimicrobial activity. Nanomedicine. 2016;12(3):789-99.
7. Arksey H, O'Malley L. Scoping studies: towards a methodological framework. Int J Soc Res Methodol. 2005;8(1):19-32.
8. Levac D, Colquhoun H, O'Brien KK. Scoping studies: advancing the methodology. Implement Sci. 2010;5:69.
9. Peters MDJ, Godfrey C, McInerney P, Munn Z, Tricco AC, Khalil H. Chapter 11: Scoping Reviews. In: Aromataris E, Munn Z, editors. JBI Manual for Evidence Synthesis. JBI; 2020.
10. Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, et al. PRISMA extension for scoping reviews (PRISMA-ScR): checklist and explanation. Ann Intern Med. 2018;169(7):467-73.
11. Maher M, Fathi M, Elsayed M, Alaa M, Elsheikh M. Effectiveness of mouthwash-containing silver nanoparticles on cariogenic microorganisms, plaque index, and salivary pH in a group of Saudi children. Open Dent J. 2022;16:e187421062209090.
12. Raghav P, Khera AK, Bisht S. Comparative evaluation of antimicrobial properties of silver nanoparticles and chlorhexidine mouthwashes on the colonization of microflora and oral health during orthodontic treatment: a double-blind randomized controlled trial. Dental Press J Orthod. 2025;30(1):e2524112.
13. Ali A, Ismail H, Amin K. Effect of nanosilver mouthwash on prevention of white spot lesions in patients undergoing fixed orthodontic treatment: a randomized double-blind clinical trial. J Dent Sci. 2021;16(1):249-55.
14. Moaddabi A, Soltani P, Rengo C, Molaei S, Mousavi SJ, Mehdizadeh M, et al. Comparison of antimicrobial and wound-healing effects of silver nanoparticle and chlorhexidine mouthwashes: an in vivo study in rabbits. Odontology. 2022;110(3):577-83.
15. Dakal TC, Kumar A, Majumdar RS, Yadav V. Mechanistic basis of antimicrobial actions of silver nanoparticles. Front Microbiol. 2016;7:1831.
16. Molena KF, Martins CROG, Oliveira CAF, Feres MFN, Queiroz AM. Silver nanoparticles in mouthwashes against infection caused by SARS-CoV-2: a scoping review. Braz Dent Sci. 2022;25(2):e3721.
17. Rai MK, Deshmukh SD, Ingle AP, Gade AK. Silver nanoparticles: the powerful nanoweapon against multidrug-resistant bacteria. J Appl Microbiol. 2015;112(5):841-52.
18. Keat CL, Aziz A, Eid AM, Elmarzugi NA. Biosynthesis of nanoparticles and silver nanoparticles. Bioresour Bioprocess. 2015;2:47.
19. Hadrup N, Lam HR. Oral toxicity of silver ions, silver nanoparticles and colloidal silver: a review. Regul Toxicol Pharmacol. 2014;68(1):1-7.

Tables and Figures

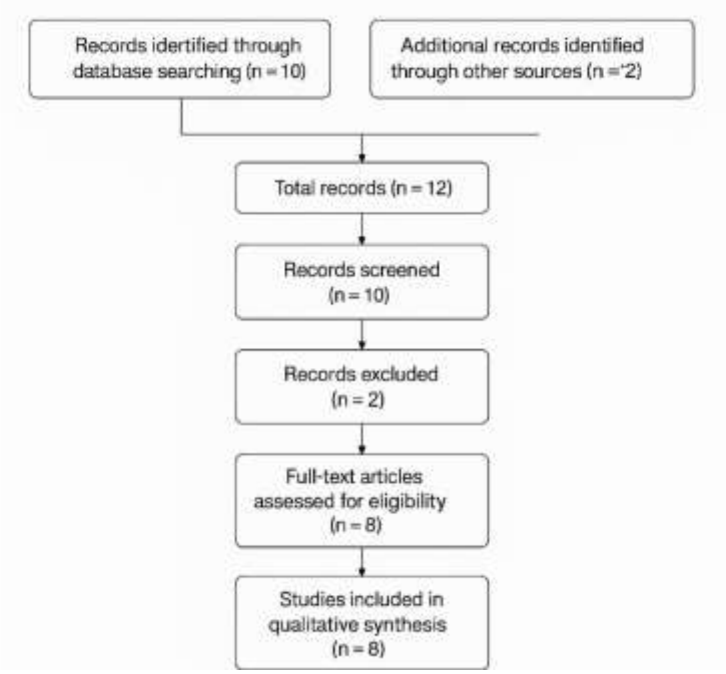

Figure 1: PRISMA Flow Diagram for Study Selection

Table 1: Characteristics of Included Studies

Study	Country	Design	Population	Sample Size	Intervention	Comparator	Key Outcomes
Maher et al. (2022) [11]	Saudi Arabia	RCT	Children	Not specified	AgNPs mouthwash	Chlorhexidine	Cariogenic microbial count, dental plaque, salivary pH
Raghav et al. (2025) [12]	India	4-arm RCT	Orthodontic patients	80 (20 per group)	NanOlife (SNP)	0.2% CHX, Placebo, No mouthwash	Microbial count, Plaque Index, Gingival Index, Gingival Bleeding

							Index, Pocket Probing Depth
Moaddabi et al. (2022) [14]	Iran	In vivo animal study	Rabbits	60	9.8 wt% AgNP mouthwash	Synthetic mouthwash without AgNPs, 2.0% CHX, No mouthwash	CFU counts, wound healing
Ali et al. (2021) [13]	Iran	RCT	Orthodontic patients	42 (14 per group)	Nano-silver mouthwash	CHX, Fluoride	White spot lesions

Table 2: Summary of Effectiveness by Outcome Measure

Outcome Measure	Silver Nanoparticle Mouthwash Effectiveness	Comparison to Conventional Mouthwashes
Antimicrobial Efficacy	Significant reduction in microbial counts	Generally less effective than CHX but significantly better than placebo/control
Plaque Reduction	Significant plaque reduction	Similar pattern to antimicrobial efficacy
Gingival Health	Effective in reducing gingival index	Less effective than CHX
White Spot Lesions	Significant reduction in WSLs	More effective than both CHX and fluoride
Wound Healing	Significant improvement in wound healing	Comparable to CHX
Salivary pH	Improved salivary pH	Comparable to CHX

Table 3: Research Gaps and Future Directions

Research Gap	Recommendation
Formulation standardization	Establish optimal concentration, particle size, and delivery systems
Long-term safety	Conduct studies with extended follow-up periods

Adverse effects reporting	Implement systematic assessment and reporting of side effects
Population diversity	Include elderly, periodontal disease patients, immunocompromised individuals
Mechanism of action	Conduct mechanistic studies on antimicrobial and remineralization effects
Cost-effectiveness	Perform economic evaluations compared to conventional alternatives
Clinical protocols	Develop evidence-based guidelines for duration and frequency of use