Pharmacological Evidence For The Oral Health Potential Of *Acorus Calamus*: A Scoping Review

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ABSTRACT

Background: *Acorus calamus contains diverse bioactive compounds with antimicrobial, antioxidant, and anti-inflammatory properties. However, evidence regarding its potential applications in oral health remains dispersed across various experimental models.This scoping review aimed to map the available evidence on the pharmacological potential of A. calamus in oral health and identify current research gaps.*

Methods: *A literature search was conducted in PubMed and ScienceDirect, supplemented by Google Scholar and manual reference screening. Original English-language studies published between January 2022 and July 2026 were included. Data on plant preparation, experimental model, pharmacological activity, principal findings, and relevance to oral health were extracted. Study selection followed the PRISMA-ScR framework.*

Results: *Twenty-three studies met the eligibility criteria. Most employed in vitro models, while only one combined laboratory investigations with a randomized clinical trial. The evidence consistently demonstrated antibacterial, antioxidant, and anti-inflammatory activities, with additional reports of antifungal, wound-healing, and oral formulation potential. Rhizome-derived preparations were the most frequently investigated. However, studies directly evaluating oral tissues, oral microorganisms, or clinical oral outcomes were limited, and substantial methodological heterogeneity was observed.*

Conclusion: *A. calamus demonstrates promising pharmacological properties with potential applications in oral healthcare. Nevertheless, clinical translation remains limited by the scarcity of oral-specific and clinical evidence. Further standardized preclinical studies and well-designed clinical trials are warranted to establish its safety, efficacy, and therapeutic value in dentistry.*

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INTRODUCTION

Oral health is maintained through a dynamic equilibrium among the resident microbiota, host responses, and the local tissue environment. Disruption of this balance may promote microbial dysbiosis, persistent inflammation, oxidative imbalance, and progressive tissue damage, thereby contributing to dental caries, periodontal disease, and other oral disorders[1,2] . When inadequately prevented or treated, these conditions may cause pain, impaired oral function, limitations in daily activities, and psychosocial consequences that ultimately reduce quality of life[3,4] . Oral diseases also remain a major global health burden, affecting approximately 3.69 billion people worldwide in 2021 [1] .

Oral diseases are complex because their development involves several interconnected biological processes. Biofilm accumulation and changes in microbial activity may activate host inflammatory responses, while persistent inflammation and oxidative stress can further promote tissue destruction and impair physiological repair[2,5]. Conventional management commonly includes antimicrobial, antiseptic, and anti-inflammatory agents. Although these interventions remain clinically important, repeated or inappropriate antimicrobial use may contribute to the selection and dissemination of antimicrobial resistance genes within the oral cavity[6]. These concerns have encouraged the investigation of medicinal plants as potential sources of adjunctive agents with antimicrobial, antibiofilm, anti-inflammatory, antioxidant, and tissue-supportive activities[6,7].

Acorus calamus, commonly known as sweet flag, Vacha, or jeringau, is an aromatic medicinal plant traditionally used in several Asian medical systems. Its leaves, roots, and rhizomes, as well as essential oils derived from the plant, contain diverse phytochemical constituents, including phenylpropanoids, terpenoids, flavonoids, and asarone-related compounds[8,9]. However, the phytochemical composition and biological activity of *A. calamus* may vary according to the plant part, chemotype, geographical origin, extraction method, concentration, and experimental model. This variability may limit direct comparisons and generalization of findings across studies.

Evidence related to oral applications has begun to emerge, including a recent study of an oral bioadhesive formulation containing *A. calamus* rhizome extract that was evaluated through laboratory testing and a randomized clinical trial involving orthodontic white spot lesions[11]. Nevertheless, the available findings remain dispersed across oral and non-oral experimental models, whereas existing reviews have mainly addressed the general ethnobotany, phytochemistry, and pharmacology of *A. calamus*[8,9].

The pharmacological evidence relevant to oral health has not been specifically mapped according to biological activity, plant preparation, experimental model, and degree of oral relevance. Therefore, this scoping review aimed to map the pharmacological evidence supporting the oral health potential of *A. calamus* and to identify the current limitations and research gaps affecting its potential application in oral healthcare.

METHODS

Data Search

This scoping review used secondary data obtained from previously published studies. PubMed and ScienceDirect were searched as the main databases. Supplementary searches were performed using Google Scholar and by screening the reference lists of eligible studies and relevant reviews to identify potentially eligible studies not

retrieved through the main database searches. The search strategy was designed to identify studies evaluating the pharmacological activities of *A. calamus* and their potential relevance to oral health. The core search string was: “Acorus calamus” AND (antibacterial OR antifungal OR antibiofilm OR antioxidant OR anti-inflammatory OR “wound healing” OR oral). The search terms were adapted to the search functions and syntax of each database. Additional records were assessed according to the same eligibility criteria and were deduplicated against the records retrieved from PubMed and ScienceDirect.

The literature search covered articles published between January 2022 and July 2026 and was completed in July 2026. Duplicate records were removed before title and abstract screening. Potentially eligible records subsequently underwent full-text assessment according to the predefined eligibility criteria. The study-selection process is presented in a PRISMA-ScR flow diagram[10].

Data were charted in a standardized spreadsheet. The pharmacological activities reported in the included studies were recorded and grouped into antibacterial, antifungal, antibiofilm, antioxidant, anti-inflammatory, wound-healing, and oral-formulation activities. Information regarding the plant part, preparation or extraction method, experimental model, main findings, and potential relevance to oral health was also collected. Methodological characteristics potentially affecting the interpretation of the findings were descriptively recorded. No formal risk-of-bias tool was applied because of the heterogeneity of the included study designs.

Inclusion and Exclusion Criteria

Original research articles were included if they were published between January 2022 and July 2026, written in English, available in full text, and focused on *A. calamus* and its pharmacological activities with potential relevance to oral health. *In vitro, in vivo, and clinical studies were eligible for inclusion.* Studies investigating oral microorganisms, oral tissues, dental structures, oral formulations, or clinical oral outcomes were included as direct oral evidence. Studies using non-oral models were included when they evaluated antibacterial, antifungal, antibiofilm, antioxidant, anti-inflammatory, or wound-healing activities relevant to oral health.

Review articles, editorials, protocols, conference abstracts, and other non-original publications were excluded. Studies investigating other *Acorus* species, phytochemical composition without pharmacological testing, pharmacological effects without clear relevance to oral health, and multicomponent formulations in which the contribution of *A. calamus* could not be distinguished were also excluded.

RESULTS

Study Selection

The main database searches identified 77 records, comprising 43 records from PubMed and 34 records from ScienceDirect. After the removal of 17 duplicate records, 60 records remained for title and abstract screening. Of these, 43 were excluded because they did not meet the predefined eligibility criteria. The remaining 17 articles were assessed in full text, and one article was excluded because it evaluated a multicomponent nanocomposite in which the independent contribution of *A. calamus* could not be distinguished. Therefore, 16 studies identified through the main database searches were included.

Supplementary searching through Google Scholar and the reference lists of eligible studies and relevant reviews identified nine additional potentially relevant articles. Two articles were excluded: one because the full text was not

published in English and another because it evaluated an *A. calamus*-mediated nanoparticle preparation in which the independent pharmacological contribution of the plant could not be distinguished. Seven additional studies were consequently included, resulting in a total of 23 studies included in the scoping review. The study-selection process is presented in Figure 1.

Characteristic of the Included Studies

The 23 included studies were published between 2022 and 2026[11–32]. Fifteen studies predominantly used *in vitro* experimental methods, seven included animal models, and one employed a two-phase design combining laboratory investigation with a randomized clinical trial. The experimental evidence was therefore predominantly preclinical, with only one study evaluating an intervention in human participants[11]. The included studies evaluated antibacterial, antifungal, antibiofilm, antioxidant, anti-inflammatory, wound-healing, tissue repair, and oral-formulation activities.

Most studies investigated rhizome-derived preparations, whereas fewer evaluated leaves, aerial parts, or roots. The preparations included crude extract, solvent fractions, essential oils, isolated phytochemical constituent, reduced graphene oxide preparations, PLGA-encapsulated extracts, and an oral bioadhesive formulation.

Antibacterial activity was assessed using agar – diffusion, minimum inhibitory concentration, time-kill, membrane-permeability, biofilm-inhibition, and antibiotic-potentiation assays [11,12,16,18,21,25,26,29,31,33]. Several studies reported inhibition of Gram-positive and Gram-negative bacteria, disruption of bacterial membrane integrity, enhancement of membrane permeability, inhibition of biofilm formation, or potentiation of conventional antibiotics

Antifungal evidence was more limited and was mainly derived from testing plant extracts alone or in combination with conventional antifungal agents[18].

Antioxidant activity was commonly evaluated using DPPH, ABTS, FRAP, hydrogen-peroxide-scabenging, reducing-power, or cell-based oxidative-stress assays[10,12,15,18,21–23,25,29,30].

Anti-inflammatory activity was evaluated using protein-denaturation assays, measurements of inflammatory cytokines and oxidative-stress biomarkers, molecular-pathway analyses, and animal models of acute or chronic inflammation[12–15,19,20,23,30].

Wound healing and tissue-repair activities were investigated in rabbit and rat skin-injury models[15,28] These studies assessed outcomes such as wound contraction, epithelial restoration, collagen organization, inflammatory or repair-associated mediators. However, these finding were derived from non-oral tissues and were therefore classified as supportive evidence rather than direct evidence of oral wound healing.

Two studied provided direct oral-health-related evidence. D'souza et al. evaluated hydroponically grown roots and soil-grown rhizomes against *S. mutans* and other bacterial species[21]. Suma et al. developed an oral bioadhesive formulation containing *A. calamus* rhizome extract and evaluated its antimicrobial and remineralization-related performance through laboratory testing and a randomized clinical trial involving orthodontic white spot lesions[11]. Most remaining studies were classified as supportive non-oral pharmacological evidence because they evaluated biological activities relevant to oral disease mechanisms without using oral tissues, oral disease models, or clinical oral outcomes.

The main characteristic of included studies, including the plant part, preparation, study model,

pharmacological activity, principal findings, and degree of oral relevance, are summarized in **Table1.**

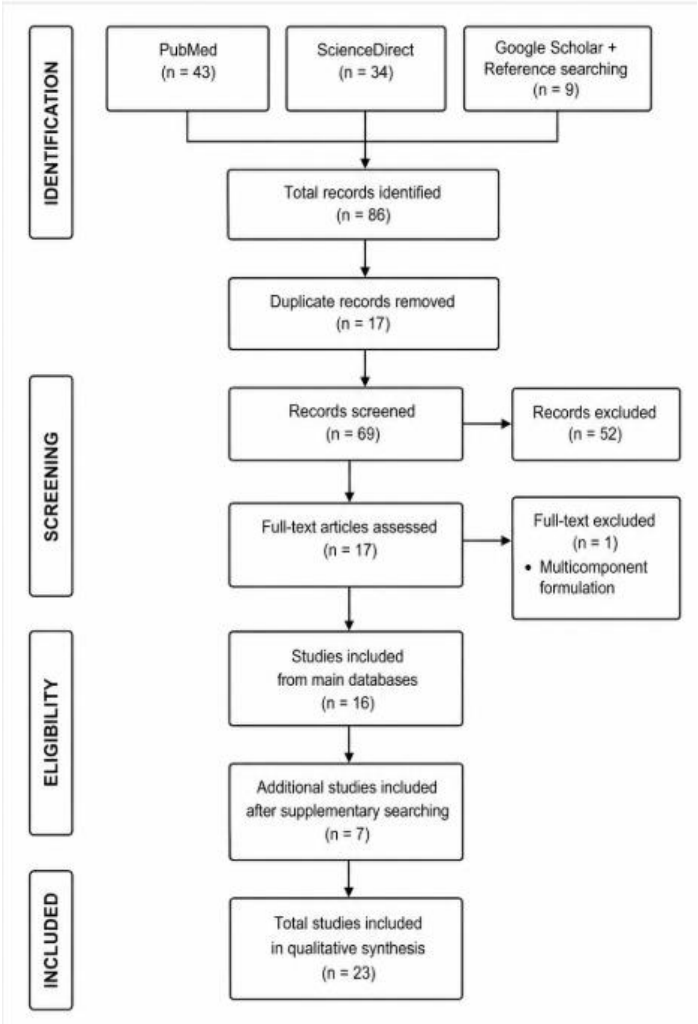

Figure 1. In the diagram, records are shown on PRIMSMA. Our initial search shows a total of 77 potential articles. Due to duplication, 17 articles were eliminated. Screening by titles, abstract and keyword on full text was conducted and founds 60 articles from this process based on inclusion criteria. Due to eligibility criteria, 44 articles were excluded. Seven additional articles included from supplementary searching. For the final, there were 23 articles decided for final synthesis.

Table 1. Characteristics of the Included Studies on Acorus calamus

Author (Year)	Main focus	Pharmacological activity
S. S. et al. 2026[34]	Oral bioadhesive formulation for orthodontic white spot lesions	Antimicrobial; remineralization
Haran et al. 2024[12]	*A. calamus* leaf extract against *P. aeruginosa* and *S. aureus*	Antioxidant; anti-inflammatory; antibacterial
Bai et al. 2023[13]	Alpha-asarone and allergic inflammation	Anti-inflammatory
Bari et al. 2026[14]	Rhizome extract in experimental arthritis	Anti-inflammatory; analgesic
Wu et al. 2026[15]	Extract treatment for radiation-induced skin injury	Wound healing; tissue repair
Al-Mijalli et al. 2025[16]	Volatile compounds and antibacterial mechanism	Antibacterial
Argentino et al. 2025[17]	Plant-derived extracts and antioxidant effects	Antioxidant
Booth et al. 2025[18]	Medicinal plants and antimicrobial activity	Antimicrobial; toxicity
Datchanamurthy et al. 2023[19]	Rhizome extract in experimental animal models	Anti-inflammatory; antinociceptive
Kisku & Sulakhiya 2024[20]	Essential oil activity using in silico/in vitro methods	Antioxidant; anti-inflammatory
D'Souza et al. 2026[21]	Root systems and antimicrobial activity	Antibacterial
Keshamma 2022[22]	Rhizome phytochemical screening	Antioxidant
Huang et al. 2024[23]	Anti-inflammatory compounds from rhizome	Anti-inflammatory
Chaubey et al. 2023[24]	Chemical composition of different accessions	Antioxidant
Ali et al. 2024[25]	Rhizome phytochemicals and antibacterial activity	Antibacterial
Kongkham et al. 2024[26]	Rhizome extract and bacterial membrane effects	Antibacterial
Assaggaf et al. 2024[27]	Essential-oil mixture containing *A. calamus*	Antioxidant
Abbas et al. 2023[28]	Extract applied to surgical wounds in rabbits	Wound healing
Sethumadhavan et al. 2022[29]	Bio-templated reduced graphene oxide	Antibacterial
Zaheri Abdevand et al. 2025[30]	Ethanolic extract in allergic asthma model	Anti-inflammatory
Aiman et al. 2026[31]	Essential oil and antibiotic combination	Antioxidant; antimicrobial
Sytykiewicz et al. 2025[32]	Essential-oil composition and antioxidant potential	Antioxidant
Kongkham & Hariprasad 2025[33]	PLGA-encapsulated *A. calamus* extract	Antibacterial; antibiotic potentiation

Risk of Bias

Considerable methodological heterogeneity was observed across the included studies regarding plant parts, extraction methods, preparation techniques, doses, experimental models, and outcome measures, limiting direct comparison of the reported pharmacological activities.

Botanical authentication, voucher-specimen documentation, chemotype identification, and quantitative standardization of active constituents were inconsistently reported. Although several studies characterized essential oils or isolated bioactive compounds, the concentrations of α-asarone and β-asarone were not consistently quantified, which may have influenced the reported pharmacological activities and safety profiles.

DISCUSSION

Phytochemical Constituents of *Acorus calamus* Leaves

The pharmacological potential of Acorus calamus is attributed to its diverse phytochemical composition. Across the included studies, α-asarone and β-asarone were consistently identified as the major phenylpropanoid compounds, particularly in rhizome extracts and essential oils. Other frequently reported constituents included flavonoids, phenolic compounds, tannins, terpenoids, alkaloids, and saponins, all of which are associated with various biological activities [25,32,33].

Phytochemical composition varied according to the plant part, extraction solvent, and cultivation conditions. Rhizomes generally contained higher concentrations of α-asarone and β-asarone, whereas leaves were richer in phenolic compounds and flavonoids. In addition, hydroponically cultivated roots were reported to

Experimental models and extraction methods, the included studies consistently reported

Most of the included evidence was generated using *in vitro* assays or non-oral animals models. Chemical antioxidant assays, protein-denaturation test, agar-diffusion methods, and molecular docking were useful for preliminary pharmacological screening but could not independently establish clinical efficacy. Several studies also lacked comprehensive cytotoxicity, dose0response, long-term safety, or formulation-stability assessments. Only one included study used a randomized clinical design, and direct evidence involving oral tissues, dental structure, oral biofilm, or clinical oral outcomes remained limited [11].

These methodological differences should be considered when interpreting the reported pharmacological activities and their potential translation into preventive or therapeutic applications in oral healthcare.

contain abundant bioactive metabolites, indicating that cultivation methods may influence the chemical composition and biological properties of A. calamus [25,32].

Collectively, these phytochemicals contribute to the antioxidant, antimicrobial, and anti-inflammatory activities of A. calamus. Although the contribution of individual compounds remains unclear, the available evidence suggests that its pharmacological effects are more likely mediated by synergistic interactions among multiple bioactive constituents, supporting its potential as a phytotherapeutic agent for oral health applications [8,12,32].

Modulation of Inflammatory Signaling Pathways

Growing evidence suggests that the anti-inflammatory activity of Acorus calamus is mediated through the modulation of key inflammatory signaling pathways. Despite differences in reduced

production of pro-inflammatory mediators and attenuation of oxidative stress.

These effect have been associated with suppression of the NF-κB and MAPK pathways, resulting in decreased expression of cyclooxygenase-2 (COX-2), inducible nitric oxide synthase (iNOS), and other inflammatory mediators. In addition, activation of antioxidant defenses may reduce intracellular reactive oxygen species (ROS), thereby limiting oxidative stress that amplifies inflammatory responses. Collectively, these findings indicate that A. calamus exerts anti-inflammatory effects through the coordinated regulation of inflammatory and oxidative stress pathways rather than a single molecular target [8,12,27].

These molecular mechanisms are particularly relevant to oral health because persistent activation of NF-κB and MAPK contributes to cytokine production, connective tissue degradation, and alveolar bone loss during the progression of gingivitis and periodontitis. Therefore, the anti-inflammatory and antioxidant activities of A. calamus provide a pharmacological basis for its potential use as an adjunctive natural agent in managing inflammatory oral diseases [7,11,26].

Despite these promising findings, the available evidence remains predominantly preclinical. Most mechanistic studies were conducted using in vitro or non-oral experimental models, and only a limited number investigated oral tissues or clinical oral outcomes. Furthermore, variations in plant materials, extraction methods, and experimental protocols may influence the reported biological activities. Consequently, further studies using standardized A. calamus preparations, oral-specific experimental models, and well-designed clinical trials are needed to confirm these mechanisms and their clinical relevance in oral healthcare [8,11]. **Figure 3.**

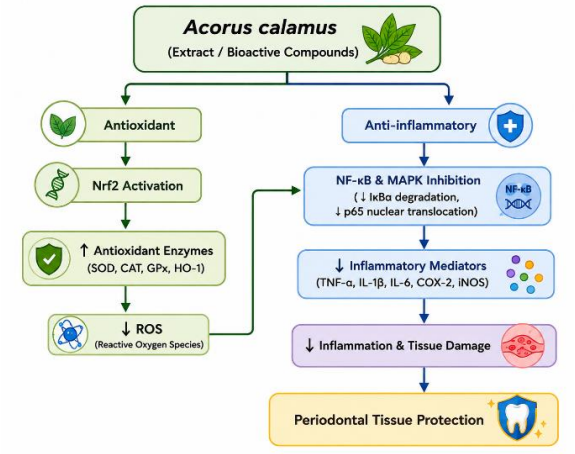

Figure 3. Proposed molecular mechanisms underlying the anti-inflammatory activity of Acorus calamus. The antioxidant activity of A. calamus may activate the Nrf2 pathway, resulting in increased endogenous antioxidant enzyme expression and reduced intracellular ROS. Concurrently, inhibition of the NF-κB and MAPK pathways may suppress the expression of pro-inflammatory mediators, including TNF-α, IL-1β, IL-6, COX-2, and iNOS, thereby reducing inflammatory responses and potentially protecting periodontal tissues. The proposed mechanism represents a conceptual summary synthesized from the included studies.

Potential Applications in Oral Health The pharmacological properties of Acorus calamus, particularly its antibacterial, antioxidant, and anti-inflammatory activities, suggest its potential as a phytotherapeutic agent for oral healthcare. These biological effects are relevant to the prevention and management of oral diseases, including dental caries and periodontal diseases. However, direct evidence remains limited, with only a few studies investigating oral microorganisms or oral formulations. Notably, an oral bioadhesive containing A. calamus rhizome extract demonstrated promising remineralization effects in patients with orthodontic white spot lesions, while another study reported antibacterial activity against Streptococcus mutans [11,12].

The available evidence supports further investigation of A. calamus for incorporation into oral healthcare products, such as mouthwashes, toothpastes, periodontal gels, and local drug-delivery systems. Nevertheless, standardized extraction methods, formulation optimization, and well-designed preclinical and clinical studies are still required to establish its safety, efficacy, and clinical applicability in dentistry [8].

Research Gaps and Future Perspectives

Despite the promising pharmacological properties of Acorus calamus, several limitations hinder its translation into oral healthcare applications. Most available evidence is derived from in vitro studies, whereas in vivo and clinical investigations remain limited. Moreover, only a few studies have specifically evaluated oral pathogens, oral tissues, or clinical oral outcomes, restricting the applicability of current findings to dental practice [8,11].

Another major limitation is the heterogeneity of the available evidence. Variations in plant parts, extraction methods, phytochemical composition, experimental models, and outcome measures complicate direct comparisons and may influence the reported biological activities. Future research should therefore prioritize extract standardization and comprehensive phytochemical characterization to improve reproducibility and comparability across studies [8,12].

Future investigations should also focus on oral-specific applications by using gingival fibroblasts, periodontal ligament cells, oral epithelial cells, multispecies oral biofilms, and experimental models of gingivitis or periodontitis. In addition, well-designed clinical trials are required to establish the safety, efficacy, optimal dosage, and long-term performance of A. calamus-based oral healthcare products, thereby supporting their translation into evidence-based dental practice [8,12].

Strengths and Limitations

This review provides a comprehensive overview of recent evidence regarding the pharmacological activities of Acorus calamus that may be relevant to oral health. By synthesizing studies published between 2022 and 2026, it highlights current research trends, identifies potential therapeutic applications, and summarizes the available evidence from experimental and clinical investigations. The use of a structured search strategy and predefined eligibility criteria further strengthens the transparency of the review process.

Nevertheless, several limitations should be acknowledged. Only English-language publications from selected databases were included, which may have resulted in the omission of relevant studies. The included articles also showed considerable methodological heterogeneity with respect to plant materials, extraction techniques, experimental models, and outcome measures, limiting direct comparison across studies. Finally, because most of the available evidence originated from preclinical

investigations, the clinical applicability of the findings should be interpreted with caution.

CONCLUTION

This scoping review demonstrates that Acorus calamus possesses a diverse pharmacological profile that may support its application in oral healthcare. The available evidence consistently highlights its antibacterial, antioxidant, and anti-inflammatory activities, while limited studies also suggest potential roles in wound healing and oral formulation development. These biological effects are supported by a wide range of phytochemical constituents, particularly α-asarone, β-asarone, flavonoids, phenolic compounds, terpenoids, tannins, alkaloids, and saponins.

Despite these promising findings, the current evidence remains predominantly preclinical, and direct investigations involving oral tissues or clinical oral outcomes are still limited. Variations in plant materials, extraction methods, and experimental protocols further complicate comparisons across studies and emphasize the need for greater methodological standardization. Future research should prioritize oral-specific experimental models, standardized phytochemical characterization, and well-designed clinical trials to clarify the safety, efficacy, and clinical applicability of A. calamus in dentistry. Overall, the present evidence supports A. calamus as a promising phytotherapeutic candidate for future oral healthcare research, although additional high-quality studies are required before routine clinical use can be recommended.

USE OF AI TOOLS DECLARATION

The authors used ChatGPT (OpenAI) exclusively to assist with language editing, grammatical refinement, and improvement of sentence clarity during manuscript preparation. The literature search, study selection, data extraction, critical appraisal, interpretation of findings, and final manuscript writing were conducted independently by the authors. The authors assume full responsibility for the accuracy, originality, and scientific integrity of the content presented in this manuscript.

AUTHOR CONTRIBUTION

K.D.R., N.E.K., F.P.R.P., and G.C. contributed to the conceptualization of the study, literature search, study selection, data extraction, data synthesis, preparation of figures and tables, and manuscript drafting. A.O.S. supervised the study, provided scientific guidance, critically reviewed and revised the manuscript, and approved the final version for publication. All authors have read and approved the final manuscript.

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CONFLICT OF INTEREST

The authors declare that there are no financial, personal, professional, or institutional conflicts of interest related to this study.

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