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REVIEW

Oral Health and Cardiovascular Disease
— A Scoping Review of Assessment Methods, Risk Factors, and Prognosis —

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Oral frailty, which encompasses decline in oral health and function with aging, has broader health implications. However, its specific role in individuals with cardiovascular disease (CVD) remains poorly understood. In this scoping review we investigated the prevalence, assessment tools, and potential intervention strategies for oral frailty in patients with CVD. We used the Population, Concept, and Context framework as follows: Population: Patients with CVD; Concept: Existing literature on oral frailty in the context of CVD; Context: Not restricted. Extracted data were synthesized qualitatively. From an initial pool of 3,199 studies, 70 were included in the final analysis, with a cumulative sample size of 891,450 individuals. Among the assessment tools for oral frailty, the number of teeth was the most commonly used measure in 39 studies, followed by the Decayed, Missing, Filled Index. Of the studies, 5 studies indicated that coronary artery disease and diabetes are risk factors for oral frailty, and 8 identified poor oral health as a predictor of cardiac events. However, no study clearly defined oral frailty in the context of CVD. Additionally, only 2 studies explored the relationship between oral health and physical frailty. This results of this review underscore the lack of a standardized definition for oral frailty in CVD. Although associations between oral health and prognosis were observed, further research is needed to clarify the definitions and explore causal relationships.

Key Words: Assessment tools; Cardiovascular disease; Oral frailty; Oral health; Outcomes

Oral frailty refers to the age-related decline in oral health and function, which has broader health implications.[1] It manifests in various ways, including difficulty in chewing or swallowing, dry mouth, tooth loss, and poor oral hygiene. Such changes may contribute to malnutrition, reduced social interaction, and decreased quality of life.[2] Oral frailty is also recognized as an early indicator and significant contributor to physical frailty,[3] often resulting in a complex interplay of malnutrition, sedentary behavior, and muscle weakness.[4] Despite its importance, a universally accepted diagnostic standard for oral frailty is lacking, leading to inconsistencies in its definition and assessment across studies. Previous studies have focused predominantly on community-dwelling older adults,[5–7] leaving a gap in understanding oral frailty in individuals with pre-existing health conditions.

In patients with cardiovascular disease (CVD), the relationship between oral health and CVD presents unique challenges.[8] Both conditions are complex and likely share risk factors such as systemic inflammation and bacterial spread from the mouth to the cardiovascular system.[9] A particularly direct link exists between oral health and infective endocarditis (IE), as inadequate oral hygiene practices and dental procedures can facilitate oral bacteria entering the bloodstream.[10] Thus, maintaining good oral hygiene is critical for IE prevention.[11] Additionally, oral impairments such as dental caries and periodontal disease may trigger chronic inflammation that adversely affects vascular endothe-

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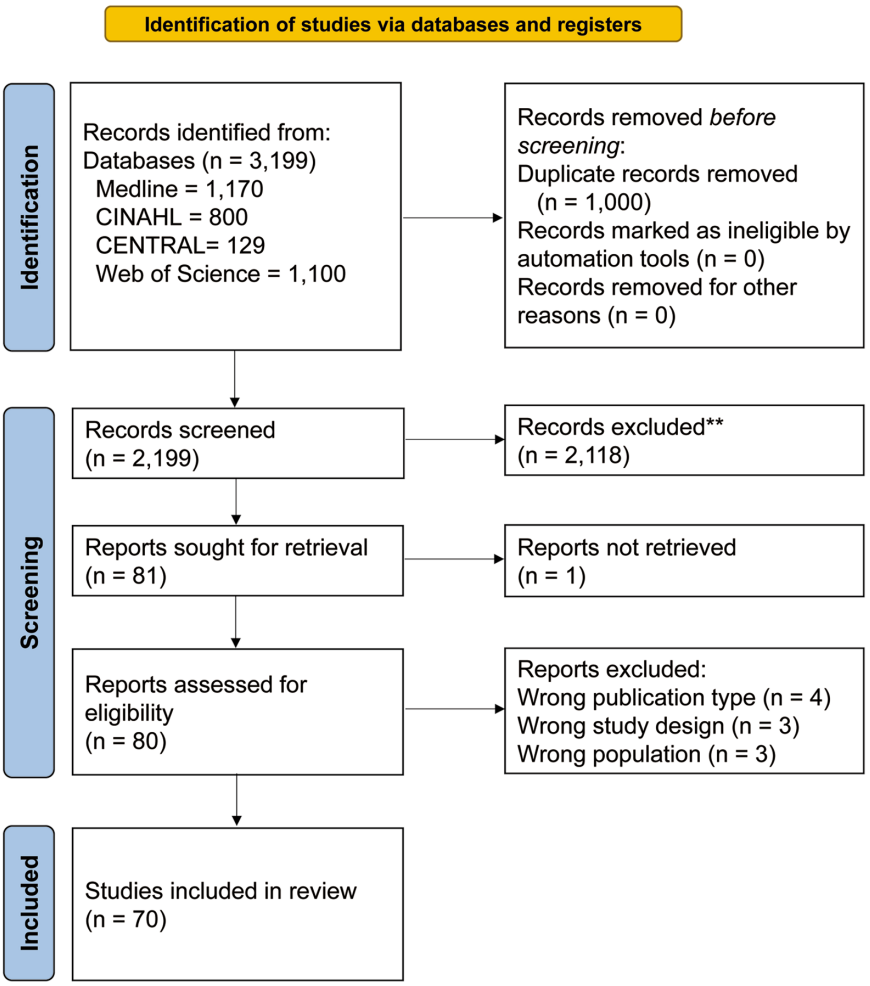


Figure. PRISMA flow diagram. *Consider, if feasible to do so, reporting the number of records identified from each database or register searched (rather than the total number across all databases/registers). **If automation tools were used, indicate how many records were excluded by a human and how many were exclude by automation tools. From: Page MJ, et al.[98] For more information, visit: http://www.prisma-statement.org/

lial function, further increasing the risk of cardiovascular complications.[8] Reports suggest that oral frailty is more prevalent in CVD patients than in the general older population, indicating a strong association with physical frailty.[12]

In this scoping review, we aimed to elucidate the multifaceted nature of oral frailty within the context of CVD, examining its characteristics, prevalence, assessment methodologies, and potential intervention strategies. Systematically mapping the existing literature, we aimed to clarify research gaps, paving the way for future studies that may significantly improve clinical outcomes and patient care strategies in this domain.

Methods

A full detailed study protocol was published on the Open Science Framework (OSF; DOI 10.17605/OSF.IO/HKMGD), adhering to the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) extension for scoping reviews (PRISMA-ScR) statement[13] (**Supplementary Table 1**).

Eligibility Criteria

We used the Population, Concept, and Context (PCC) framework to define the inclusion criteria.

Population The study population comprised adults aged ≥18 years with any type of CVD, including ischemic heart disease (IHD), myocardial infarction, acute coronary syndrome (ACS), heart failure, and peripheral arterial disease.

Concept We reviewed existing literature on oral frailty in patients with CVD. The research questions were as follows:

1. To investigate the prevalence and assessment tools for oral frailty with CVD.
2. To investigate the risk factors for developing oral frailty in individuals with CVD.
3. To investigate prognosis in patients with oral frailty with CVD.
4. To investigate the relationship between oral and physical frailty in patients with CVD.

Context The study setting was unrestricted, allowing

for the inclusion of research from various settings, including but not limited to hospital care, community settings, and primary care. We included randomized trials and observational studies without restrictions on language, country of origin, sex, ethnicity, study location, and study date. Abstracts, letters, case series, and case reports were excluded.

Data Sources and Search Strategy

We conducted a comprehensive search across multiple databases, including MEDLINE via PubMed, the Cochrane Central Register of Controlled Trials (CENTRAL), CINAHL, and Web of Science (March 22, 2024). The search strategy used a combination of text words ('oral frailty,' 'cardiovascular diseases') and Medical Subject Headings (MeSH) terms to identify relevant studies. The search terms and strategies are detailed in **Supplementary Table 2**. We prioritized studies that utilized established oral frailty assessment tools, such as the Oral Frailty Index-8[6] and Oral Frailty 5-Item Checklist,[14] or those that measured factors associated with oral frailty, including number of remaining teeth,[12] oral dryness,[15] and impaired tongue function.[16]

Study Selection and Data Collection

We selected studies following the PRISMA flow diagram,[13] and used the PCC framework[17] to guide our review, focusing on patients with CVD, the concept of oral frailty, and an unrestricted context. Four authors worked in pairs. First, duplicate studies were excluded, all titles and abstracts were screened, and irrelevant studies were independently excluded. Papers that specifically focused on oral frailty in patients with CVD were carefully selected. The 2 teams then independently assessed the full text of the remaining studies and discussed them with author M. Okamura as necessary. Data were then transferred to the Review Manager software.[18]

Summarizing the Data

Data extraction was performed using standardized forms, capturing diagnostic information, study design, setting, patient demographics, sample size, oral frailty assessment tools, oral frailty prevalence, the relationship between physical and oral frailty, and prognosis. The extracted data were synthesized qualitatively, summarizing the assessment tools for oral frailty and its prevalence, association with physical frailty, and prognostic implications in individuals with CVD.

Results

Selection of Patients

From an initial pool of 3,199 studies, 1,000 duplicates were removed. In the first screening phase, 2,118 studies were excluded based on titles and abstracts. In the second screening phase, the full text of the remaining 80 studies was assessed, leading to the exclusion of 10 studies (wrong publication type [n=4], wrong study design [n=3], and wrong population [n=3]). The inter-rater reliability between reviewers during the screening process was "almost perfect" (κ=0.84). Ultimately, 70 studies were included in the final analysis.[12,19–87] The study selection process is presented in the PRISMA flow diagram (**Figure**).

Study Characteristics

The characteristics of the included studies and relevant participant information are summarized in **Supplementary Table 3**. The studies were published between 1989 and 2024, showing a gradual increase in publication volume over time. Notably, the majority (n=54, 77%) were published after 2010, highlighting the growing research interest in recent years. Geographically, Europe was the predominant region of publication (48.6%), followed by Asia (32.9%), and limited contributions from other regions. Regarding study settings, approximately 35% of the studies focused on hospitalized patients. Sample sizes ranged between 50 and 722,519 participants. Totally, the 70 studies included a cumulative sample size of 891,450 individuals, with 189,461 specifically diagnosed with CVD. Among studies focusing on specific CVD subtypes, IHD was the most frequently investigated, comprising 36% of the studies. Heart failure was examined in 25% of the studies, followed by arrhythmias (4%), large vessel disease (3%), and IE (5%).

Table 1. Summary of Oral Health Assessment Tools Extracted From the Review

Category	Subcategory	No. of papers
Comprehensive tool	DMF-index	13
	Total dental index	3
No. of teeth	No. of teeth	36
Dental caries	Dental caries	14
Denture use	Denture use	2
Self-care	Brush teeth daily	3
QOL	OHIP-14	3
Periodontal	Bleeding on Probing: BOP	23
	Probing Pocket Depth: PPD	26
	Clinical Attachment Level: CAL	28
	CPITN	5
Oral hygiene	Plaque index	18
	Hygiene index	1
	Oral Hygiene Index	1
	Oral health score	1
	ROAG	1
	OHAT	1
Saliva	Saliva	2
Muscle	Masseter thickness	1
	Other	1

CPITN, Community Periodontal Index of Treatment Needs; DMF, Decayed, Missing, and Filled Teeth; OHAT, Oral Health Assessment Tool; OHIP, Oral Health Impact Profile; ROAG, Revised Oral Assessment Guide.

Characteristics of the Oral Health Assessment Tools

None of the 70 included studies explicitly defined oral frailty within the context of CVD. Due to the lack of a consistent definition and assessment criteria, evaluating the prevalence of oral frailty was not feasible. However, various tools and measures were used for assessing oral health status, which could serve as proxies for identifying poor oral health. **Table 1** summarizes these assessment tools. The most frequently used measure was the number of remaining teeth, applied in 36 studies, followed by the Decayed, Missing, Filled (DMF) Index in 13 studies. Assessing periodontal health, bleeding on probing (BOP), probing pocket depth (PPD), and clinical attachment level (CAL) were used in

Table 2. Risk Factors for Oral Function Deterioration

Risk factor	Reference
CAD	Johansson et al. (2014)[36]
	Meurman et al. (2003)[85]
	Buhlin et al. (2005)[84]
DM	Aoyama et al. (2018)[28]
	Han et al. (2021)[62]
Age	Schulze et al. (2024)[20]
BMI (obesity)	Schulze et al. (2024)[20]
IE	Lockhart et al. (2023)[50]
Inflammatory markers	Meurman et al. (2003)[85]

BMI, body mass index; CAD, coronary artery disease; DM, diabetes mellitus; IE, infective endocarditis.

23, 26, and 28 studies, respectively. Oral hygiene was primarily assessed using the plaque index in 18 studies.

Risk Factors of Poor Oral Health

Table 2 summarizes the risk factors associated with poor oral health in individuals with CVD: 5 studies identified coronary artery disease (CAD) and diabetes as significant risk factors for poor oral health.[28,36,62,84,85] Notably, patients with CVD and diabetes had a 1.4-fold higher prevalence of periodontitis than those without diabetes.[62] Additionally, Schulze et al. demonstrated that aging and obesity correlated with poor periodontal status.[20] Multiple studies have reported increased oral function decline risk in individuals with CVD, particularly those with CAD.[36,84,85] Specifically, among patients with CAD, ACS was also found to be associated with increased signs of gingival inflammation prior to tooth loss.[37] Furthermore, elevated serum inflammatory markers were identified as risk factors for compromised dental indices.[85] However, the relationship between oral health and CVD appears to be bidirectional. Several studies have shown that poor oral health, including tooth loss, periodontal disease, and inadequate oral care habits, is associated with an increased IHD risk[25,41,63,70,75,77,78] Additionally, dental calculus and plaque were identified as IE risk factors,[50] whereas periodontal disease was linked to increased risks of heart failure.[46,60,73]

Impact of Poor Oral Health on Prognosis

A total of 8 studies investigated the effect of poor oral health on adverse cardiovascular events or long-term mortality rates in individuals with CVD. Although Johansson et al. found no significant association between baseline periodontal status and CAD-related endpoints during follow-up,[36] the remaining 7 studies demonstrated a link between poor oral health and less favorable outcomes[23,31,33,49,52,72,75] (**Table 3**). Tooth loss was associated with increased risk of major adverse cardiovascular events (MACE), cardiovascular death, and stroke.[33,52,72] Of note, inadequate oral hygiene practices, such as infrequent dental visits or inadequate brushing and flossing, were linked to a higher risk of new cardiovascular events.[31,49,75] Masseter muscle thickness, a perioral muscle, was found to be a better predictor of postoperative pneumonia and life expectancy.[23]

Table 3. Impact of Oral Health Decline on Long-Term Outcomes

Reference	Outcome	Factors
Ito et al. (2022)[23]	Death	Masseter muscle thickness
Reichert et al. (2016)[31]	MACE	BOP index >30%
		>10 missing teeth
		Frequency of brushing teeth
		Use of floss/interdental brushes
Vedin et al. (2016)[33]	MACE	Tooth loss
Hamaya et al. (2023)[52]		
Vedin et al. (2017)[72]		
Wagner et al. (2023)[49]	MACE	Absence of prior dental visits
Reichert et al. (2015)[75]	MACE	Use of dental floss
		Interdental brushes

BOP, bleeding on probing; MACE, major adverse cardiac event.

Discussion

Key Findings and Knowledge Gaps

This scoping review comprehensively examined the current state of research on oral frailty in individuals with CVD. Our findings revealed a critical knowledge gap: the lack of a universally accepted definition and assessment tool for oral frailty in this population. This absence of standardization hinders a deeper understanding of the relationship between oral frailty and CVD and impedes the development of targeted interventions.

Assessing Oral Frailty With CVD

Our results highlighted a significant challenge in the field of oral frailty within the context of CVD: the lack of a universally accepted definition and assessment tool. This aligns with previous reviews on oral health in older adults,[1] which also highlighted the heterogeneity in assessment variables and absence of a standardized concept of oral frailty. Inconsistent definitions may partly explain the conflicting results across studies, where some found no association between periodontal disease[34,82] and dental treatment,[86] and CVD, even as most studies suggested a strong link between declining oral function and CVD onset or exacerbation. Although oral frailty is a relatively new concept, validation using unified indicators is essential. Ideally, the oral frailty assessment includes evaluations of the oral environment, teeth, gingiva, mucosa, dentures, dexterity, and articulation.[88] Although comprehensive tools such as the Revised Oral Assessment Guide[89] and Oral Health Assessment Tool[90] are recommended, in our review their use was limited: only 1 study used each tool.[21,51] However, studies assessing only the number of remaining teeth yielded consistent results, particularly regarding the link between tooth count and angina pectoris or CAD severity.[70,78,82,86] Although tooth count may be a useful indicator of oral frailty in CVD, it represents only 1 aspect of oral function. A comprehensive tool incorporating multiple dimensions of oral health would likely offer a more accurate and nuanced understanding of oral frailty in this population.

Oral Health and CVD

Our review, including primarily case-control studies with healthy controls, consistently demonstrated a decline in oral function among patients with CVD. This deterioration encompassed a reduction in the number of remaining teeth and compromised oral hygiene, and extended to peri-

odontal health and overall quality of life, underscoring the critical role of oral care in CVD management. Although numerous studies reported an association between poor oral health and MACE, the relationship between oral function deterioration and CVD onset appears multifaceted, likely mediated by a complex interplay of factors beyond biology alone. Social and psychological factors can adversely affect both oral and cardiovascular health.[91,92] Additionally, education level and health literacy may play crucial roles in shaping an individual's oral health behaviors and ability to manage CVD.[93,94] Further research is needed to clarify the complex pathways through which these factors influence the relationship between oral health and CVD and thus identify potential intervention points. A recent study has suggested that oral bacteria may increase Alzheimer's disease risk through tooth loss,[95] raising the possibility that cognitive function influences CVD recurrence and self-management. Oral health may be closely linked to the broader concept of frailty, which includes physical, mental/cognitive, and social dimensions. This interplay between oral health and various aspects of frailty underscores the need for a holistic approach to CVD care, integrating oral and physical health with cognitive and social well-being. Usmani et al. recently published a scoping review on the effect of oral healthcare interventions on CVD, reinforcing the importance of the oral–cardiovascular link.[96] Although they focused on preventive interventions, our study adds to this growing body of evidence by specifically examining oral health assessment methods, risk factors, and prognosis in patients with established CVD. However, this review did not examine specific mechanisms, but the role of periodontal pathogens and host immune responses in linking oral health with CVD warrants mention. Inflammation triggered by periodontal pathogens could lead to bone resorption via osteoclast activation,[97] and elevated antibody titers against these bacteria might reflect a systemic inflammatory burden associated with CVD. Further research into these mechanisms is needed.

Study Limitations

First, due to the nature of this scoping review, we did not search for specific mechanisms linking oral health with CVD. Future studies should focus on these aspects to elucidate the detailed biological pathways linking oral health decline to CVD. Second, because this was a scoping review, our search strategy, which was comprehensive in covering various aspects of oral health using the MeSH term "Oral Health", might have missed some studies. Furthermore, future research should focus on the relationship between these specific parameters and CVD outcomes to develop more targeted interventions for managing oral frailty in this population.

Conclusions

This scoping review highlighted the crucial interplay between oral health and CVD. Poor oral function was associated with less favorable CVD outcomes, emphasizing the importance of oral care in CVD management. However, lacking standardized definitions and assessment tools for oral frailty in patients with CVD precluded a meta-analysis, limiting firm conclusions about its effect on long-term prognosis. Future research should prioritize establishing a clear definition of oral frailty in CVD cases, developing validated assessment tools, and defining a core outcome set to facilitate standardized reporting and comparisons across studies.

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Conflicts of Interest

None.

References

1. Dibello V, Zupo R, Sardone R, Lozupone M, Castellana F, Dibello A, et al. Oral frailty and its determinants in older age: A systematic review. *Lancet Healthy Longev* 2021; **2:** e507–e520, doi:10.1016/s2666-7568(21)00143-4.
2. Iwasaki M, Hirano H. Decline in oral function and its management. *Int Dent J* 2022; **72:** s12–s20, doi:10.1016/j.identj.2022.06.010.
3. Minakuchi S, Tsuga K, Ikebe K, Ueda T, Tamura F, Nagao K, et al. Oral hypofunction in the older population: Position paper of the Japanese Society of Gerodontology in 2016. *Gerodontology* 2018; **35:** 317–324, doi:10.1111/ger.12347.
4. Hoogendijk EO, Afilalo J, Ensrud KE, Kowal P, Onder G, Fried LP. Frailty: Implications for clinical practice and public health. *Lancet* 2019; **394:** 1365–1375, doi:10.1016/s0140-6736(19)31786-6.
5. Tani A, Mizutani S, Oku S, Yatsugi H, Chu T, Liu X, et al. Association between oral function and physical pre-frailty in community-dwelling older people: A cross-sectional study. *BMC Geriatr* 2022; **22:** 726, doi:10.1186/s12877-022-03409-5.
6. Tanaka T, Takahashi K, Hirano H, Kikutani T, Watanabe Y, Ohara Y, et al. Oral frailty as a risk factor for physical frailty and mortality in community-dwelling elderly. *J Gerontol A Biol Sci Med Sci* 2018; **73:** 1661–1667, doi:10.1093/gerona/glx225.
7. Iwasaki M, Watanabe Y, Motokawa K, Shirobe M, Inagaki H, Motohashi Y, et al. Oral frailty and gait performance in community-dwelling older adults: Findings from the Takashimadaira study. *J Prosthodont Res* 2021; **65:** 467–473, doi:10.2186/jpr.JPR_D_20_00129.
8. Gianos E, Jackson EA, Tejpal A, Aspry K, O'Keefe J, Aggarwal M, et al. Oral health and atherosclerotic cardiovascular disease: A review. *Am J Prev Cardiol* 2021; **7:** 100179, doi:10.1016/j.ajpc.2021.100179.
9. Macedo Paizan ML, Vilela-Martin JF. Is there an association between periodontitis and hypertension? *Curr Cardiol Rev* 2014; **10:** 355–361, doi:10.2174/1573403x10666140416094901.
10. Del Giudice C, Vaia E, Liccardo D, Marzano F, Valletta A, Spagnuolo G, et al. Infective endocarditis: A focus on oral microbiota. *Microorganisms* 2021; **9:** 1218, doi:10.3390/microorganisms9061218.
11. Lockhart PB, Brennan MT, Thornhill M, Michalowicz BS, Noll J, Bahrani-Mougeot FK, et al. Poor oral hygiene as a risk factor for infective endocarditis-related bacteremia. *J Am Dent Assoc* 2009; **140:** 1238–1244, doi:10.14219/jada.archive.2009.0046.
12. Ogawa M, Satomi-Kobayashi S, Yoshida N, Tsuboi Y, Komaki K, Nanba N, et al. Relationship between oral health and physical frailty in patients with cardiovascular disease. *J Cardiol* 2021; **77:** 131–138, doi:10.1016/j.jjcc.2020.07.016.
13. 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:** 467–473, doi:10.7326/m18-0850.
14. Tanaka T, Hirano H, Ikebe K, Ueda T, Iwasaki M, Shirobe M, et al. Oral frailty five-item checklist to predict adverse health outcomes in community-dwelling older adults: A Kashiwa cohort study. *Geriatr Gerontol Int* 2023; **23:** 651–659, doi:10.1111/ggi.14634.
15. Hiltunen K, Saarela RKT, Kautiainen H, Roitto HM, Pitkälä KH, Mäntylä P. Relationship between Fried's frailty phenotype and oral frailty in long-term care residents. *Age Ageing* 2021; **50:** 2133–2139, doi:10.1093/ageing/afab177.
16. Satake A, Kobayashi W, Tamura Y, Oyama T, Fukuta H, Inui A, et al. Effects of oral environment on frailty: Particular rele-

vance of tongue pressure. *Clin Interv Aging* 2019; **14:** 1643–1648, doi:10.2147/cia.S212980.
17. Peters M, Godfrey CM, Mcinerney P, Soares CB, Khalil H, Parker D. The Joanna Briggs Institute reviewers' manual 2015: Methodology for JBI scoping reviews. The Joanna Briggs Institute, 2015.
18. Harrison H, Griffin SJ, Kuhn I, Usher-Smith JA. Software tools to support title and abstract screening for systematic reviews in healthcare: An evaluation. *BMC Med Res Methodol* 2020; **20:** 7, doi:10.1186/s12874-020-0897-3.
19. Terano K, Motoi T, Nagata E, Oho T. Association of remaining tooth number with postoperative respiratory complications in heart valve surgery patients. *Int J Dent Hyg* 2024; **22:** 394–400, doi:10.1111/idh.12673.
20. Schulze A, Kwast S, Pökel C, Busse M. Assessment of the relationship between periodontitis and cardiac parameters in patients with early chronic heart failure: A cross-sectional study. *J Funct Morphol Kinesiol* 2024; **9:** 52, doi:10.3390/jfmk9010052.
21. Uemura Y, Shibata R, Ishikawa S, Takemoto K, Murohara T, Watarai M. The association between oral health status and physical function in elderly patients with acute heart failure. *Clin Exp Dent Res* 2024; **10:** e824, doi:10.1002/cre2.824.
22. Barbosa De Accioly Mattos M, Bernardo Peixoto C, Geraldo de Castro Amino J, Cortes L, Tura B, Nunn M, et al. Coronary atherosclerosis and periodontitis have similarities in their clinical presentation. *Front Oral Health* 2023; **4:** 1324528, doi:10.3389/froh.2023.1324528.
23. Ito E, Ohki T, Nakagawa H, Toya N. The masseter muscle thickness is a predictive marker for postoperative pneumonia after endovascular aneurysm repair. *Surg Today* 2022; **52:** 1591–1598, doi:10.1007/s00595-022-02506-7.
24. Szerszeń M, Górski B, Kowalski J. Clinical condition of the oral cavity in the adult polish population below 70 years of age after myocardial infarction: A case-control study. *Int J Environ Res Public Health* 2022; **19:** 7265, doi:10.3390/ijerph19127265.
25. Lazureanu PC, Popescu FG, Stef L, Focsa M, Vaida MA, Mihaila R. The influence of periodontal disease on oral health quality of life in patients with cardiovascular disease: A cross-sectional observational single-center study. *Medicina (Kaunas)* 2022; **58:** 584, doi:10.3390/medicina58050584.
26. Schmalz G, Eisner M, Binner C, Wagner J, Rast J, Kottmann T, et al. Oral health-related quality of life of patients after heart transplantation and those with heart failure is associated with general health-related quality of life: A cross-sectional study. *Qual Life Res* 2020; **29:** 1621–1630, doi:10.1007/s11136-020-02439-z.
27. Garbade J, Rast J, Schmalz G, Eisner M, Wagner J, Kottmann T, et al. Oral health and dental behaviour of patients with left ventricular assist device: A cross-sectional study. *ESC Heart Fail* 2020; **7:** 1273–1281, doi:10.1002/ehf2.12636.
28. Aoyama N, Suzuki JI, Kobayashi N, Hanatani T, Ashigaki N, Yoshida A, et al. Japanese cardiovascular disease patients with diabetes mellitus suffer increased tooth loss in comparison to those without diabetes mellitus: A cross-sectional study. *Intern Med* 2018; **57:** 777–782, doi:10.2169/internalmedicine.9578-17.
29. Kumar A, Rai A. Oral health status, health behaviour and treatment needs of patients undergoing cardiovascular surgery. *Braz J Cardiovasc Surg* 2018; **33:** 151–154, doi:10.21470/1678-9741-2017-0137.
30. Aoyama N, Suzuki JI, Kobayashi N, Hanatani T, Ashigaki N, Yoshida A, et al. Associations among tooth loss, systemic inflammation and antibody titers to periodontal pathogens in Japanese patients with cardiovascular disease. *J Periodontal Res* 2018; **53:** 117–122, doi:10.1111/jre.12494.
31. Reichert S, Schulz S, Benten AC, Lutze A, Seifert T, Schlitt M, et al. Periodontal conditions and incidence of new cardiovascular events among patients with coronary vascular disease. *J Clin Periodontol* 2016; **43:** 918–925, doi:10.1111/jcpe.12611.
32. Górski B, Nargiełło E, Grabowska E, Opolski G, Górska R. The association between dental status and risk of acute myocardial infarction among Poles: Case-control study. *Adv Clin Exp Med* 2016; **25:** 861–870, doi:10.17219/acem/58866.
33. Vedin O, Hagström E, Budaj A, Denchev S, Harrington RA, Koenig W, et al. Tooth loss is independently associated with poor outcomes in stable coronary heart disease. *Eur J Prev Cardiol* 2016; **23:** 839–846, doi:10.1177/2047487315621978.
34. Zanella SM, Pereira SS, Barbisan JN, Vieira L, Saba-Chujfi E, Haas AN, et al. Periodontal disease, tooth loss and coronary heart disease assessed by coronary angiography: A cross-sectional observational study. *J Periodontal Res* 2016; **51:** 221–227, doi:10.1111/jre.12301.
35. Kodovazenitis G, Pitsavos C, Papadimitriou L, Vrotsos IA, Stefanadis C, Madianos PN. Association between periodontitis and acute myocardial infarction: A case-control study of a non-diabetic population. *J Periodontal Res* 2014; **49:** 246–252, doi:10.1111/jre.12101.
36. Johansson CS, Ravald N, Pagonis C, Richter A. Periodontitis in patients with coronary artery disease: An 8-year follow-up. *J Periodontol* 2014; **85:** 417–425, doi:10.1902/jop.2013.120730.
37. Ziebolz D, Priegnitz A, Hasenfuss G, Helms HJ, Hornecker E, Mausberg RF. Oral health status of patients with acute coronary syndrome: A case control study. *BMC Oral Health* 2012; **12:** 17, doi:10.1186/1472-6831-12-17.
38. Bokhari SA, Khan AA, Ansari JA, Alam R. Tooth loss in institutionalized coronary heart disease patients of Punjab Institute of Cardiology, Lahore, Pakistan. *J Epidemiol Glob Health* 2012; **2:** 51–56, doi:10.1016/j.jegh.2011.11.004.
39. Vashurin IV, WagnerVD, Gurevich K, Gurevich MV. Oral health and heart failure. *Cardiovasc Ther Prev* 2012; **11:** 69–72, doi:10.15829/1728-8800-2012-1-69-72.
40. Linden GJ, McClean K, Young I, Evans A, Kee F. Persistently raised C-reactive protein levels are associated with advanced periodontal disease. *J Clin Periodontol* 2008; **35:** 741–747, doi:10.1111/j.1600-051X.2008.01288.x.
41. Holmlund A, Holm G, Lind L. Severity of periodontal disease and number of remaining teeth are related to the prevalence of myocardial infarction and hypertension in a study based on 4,254 subjects. *J Periodontol* 2006; **77:** 1173–1178, doi:10.1902/jop.2006.050233.
42. Andriankaja OM, Genco RJ, Dorn J, Dmochowski J, Hovey K, Falkner KL, et al. The use of different measurements and definitions of periodontal disease in the study of the association between periodontal disease and risk of myocardial infarction. *J Periodontol* 2006; **77:** 1067–1073, doi:10.1902/jop.2006.050276.
43. Geerts SO, Legrand V, Charpentier J, Albert A, Rompen EH. Further evidence of the association between periodontal conditions and coronary artery disease. *J Periodontol* 2004; **75:** 1274–1280, doi:10.1902/jop.2004.75.9.1274.
44. Janket SJ, Qvarnström M, Meurman JH, Baird AE, Nuutinen P, Jones JA. Asymptotic dental score and prevalent coronary heart disease. *Circulation* 2004; **109:** 1095–1100, doi:10.1161/01.Cir.0000118497.44961.1e.
45. Montebugnoli L, Servidio D, Miaton RA, Prati C, Tricoci P, Melloni C. Poor oral health is associated with coronary heart disease and elevated systemic inflammatory and haemostatic factors. *J Clin Periodontol* 2004; **31:** 25–29, doi:10.1111/j.0303-6979.2004.00432.x.
46. López R, Oyarzún M, Naranjo C, Cumsille F, Ortiz M, Baelum V. Coronary heart disease and periodontitis: A case control study in Chilean adults. *J Clin Periodontol* 2002; **29:** 468–473, doi:10.1034/j.1600-051x.2002.290513.x.
47. Häyrinen-Immonen R, Ikonen TS, Lepäntalo M, Lindgren L, Lindqvist C. Oral health of patients scheduled for elective abdominal aortic correction with prosthesis. *Eur J Vasc Endovasc Surg* 2000; **19:** 294–298, doi:10.1053/ejvs.1999.0984.
48. Schmalz G, Hennecke A, Haak R, Kottmann T, Garbade J, Binner C, et al. Secondary analysis of potential associations between oral health and infection-related parameters in patients with severe heart failure: Results of a German cohort. *BMC Cardiovasc Disord* 2023; **23:** 573, doi:10.1186/s12872-023-03612-1.
49. Wagner AK, D'Souza M, Bang CN, Holmstrup P, Blanche P, Fiehn NE, et al. Treated periodontitis and recurrent events after first-time myocardial infarction: A Danish nationwide cohort study. *J Clin Periodontol* 2023; **50:** 1305–1314, doi:10.1111/jcpe.13853.
50. Lockhart PB, Chu V, Zhao J, Gohs F, Thornhill MH, Pihlstrom B, et al. Oral hygiene and infective endocarditis: A case control study. *Oral Surg Oral Med Oral Pathol Oral Radiol* 2023; **136:** 333–342, doi:10.1016/j.oooo.2023.02.020.
51. Matsuo H, Yoshimura Y, Fujita S, Maeno Y, Tanaka S. Association of poor oral health with increased incidence of dysphagia and impaired improvement in nutritional status among patients with acute heart failure: A prospective cohort study. *Eur Geriatr Med* 2023; **14:** 879–888, doi:10.1007/s41999-023-00810-0.
52. Hamaya R, Yonetsu T, Aoyama N, Shiheido-Watanabe Y, Tashiro A, Niida T, et al. Contribution of periodontal health in cardiovascular secondary prevention: Analyses on hospitalized patients in cardiology units. *J Clin Periodontol* 2023; **50:** 708–716, doi:10.1111/jcpe.13792.
53. Pejcic A, Kostic M, Marko I, Obradovic R, Minic I, Bradic-Vasic M, et al. Tooth loss and periodontal status in patients with car-

diovascular disease in the Serbian population: A randomized prospective study. *Int J Dent Hyg* 2023; **21:** 317–327, doi:10.1111/idh.12663.
54. Nagy FT, Gheorghita D, Dharmarajan L, Braunitzer G, Achim A, Ruzsa Z, et al. Oral health of patients undergoing percutaneous coronary intervention: A possible link between periodontal disease and in-stent restenosis. *J Pers Med* 2023; **13:** 760, doi:10.3390/jpm13050760.
55. Matsuyama Y, Jürges H, Listl S. Causal effect of tooth loss on cardiovascular diseases. *J Dent Res* 2023; **102:** 37–44, doi:10.1177/00220345221120164.
56. Struppek J, Schnabel RB, Walther C, Heydecke G, Seedorf U, Lamprecht R, et al. Periodontitis, dental plaque, and atrial fibrillation in the Hamburg City Health Study. *PLoS One* 2021; **16:** e0259652, doi:10.1371/journal.pone.0259652.
57. Schmalz G, Binner C, Eisner M, Wagner J, Rast J, Kottmann T, et al. Oral health-related quality of life in patients with heart failure and left ventricular assist devices-results of a cross-sectional study. *Clin Oral Investig* 2021; **25:** 5879–5887, doi:10.1007/s00784-021-03893-w.
58. Molania T, Malekzadeh Shafaroudi A, Taghavi M, Ehsani H, Moosazadeh M, Haddadi A, et al. Oral health-related quality of life (OHRQoL) in cardiovascular patients referring to Fatima Zahra Hospital in Sari, Iran. *BMC Oral Health* 2021; **21:** 391, doi:10.1186/s12903-021-01756-0.
59. Lăzureanu PC, Popescu F, Tudor A, Stef L, Negru AG, Mihăilă R. Saliva pH and flow rate in patients with periodontal disease and associated cardiovascular disease. *Med Sci Monit* 2021; **27:** e931362, doi:10.12659/msm.931362.
60. Ziebolz D, Binner C, Reuschel F, Eisner M, Wagner J, Kottmann T, et al. Comparison of periodontal parameters between patients with ischemic and dilative cardiomyopathy. *BMC Cardiovasc Disord* 2021; **21:** 304, doi:10.1186/s12872-021-02111-5.
61. Pinnamaneni SP, Kumar S, Abrol S, Brar RS, Khudare PA, Gautam N. Assessment of knowledge, attitude, and practice about oral health in patients with cardiovascular diseases: An original study. *J Pharm Bioallied Sci* 2021; **13:** S344–S347, doi:10.4103/jpbs.JPBS_733_20.
62. Han SJ, Son YJ, Kim BH. Association between diabetes mellitus and oral health status in patients with cardiovascular diseases: A nationwide population-based study. *Int J Environ Res Public Health* 2021; **18:** 4889, doi:10.3390/ijerph18094889.
63. Gor I, Nadeem G, Bataev H, Dorofeev A. Prevalence and structure of periodontal disease and oral cavity condition in patients with coronary heart disease (prospective cohort study). *Int J Gen Med* 2021; **14:** 8573–8581, doi:10.2147/ijgm.S330724.
64. Omori C, Ekuni D, Ohbayashi Y, Miyake M, Morita M. Quasi-Randomized trial of effects of perioperative oral hygiene instruction on inpatients with heart diseases using a behavioral six-step method. *Int J Environ Res Public Health* 2019; **16:** 4252, doi:10.3390/ijerph16214252.
65. Carasso S, Amy DPB, Kusniec F, Ghanim D, Sudarsky D, Kinany W, et al. Dental screening prior to valve interventions: Should we prepare transcatheter aortic valve replacement candidates for "surgery"? *Int J Cardiol* 2019; **294:** 23–26, doi:10.1016/j.ijcard.2019.07.081.
66. Binner C, Wagner J, Schmalz G, Eisner M, Rast J, Kottmann T, et al. Insufficient oral behaviour and the high need for periodontal treatment in patients with heart insufficiency and after heart transplantation: A need for special care programs? *J Clin Med* 2019; **8:** 1668, doi:10.3390/jcm8101668.
67. Mendonca DD, Furtado MV, Sarmento RA, Nicoletto BB, Souza GC, Wagner TP, et al. Periodontitis and tooth loss have negative impact on dietary intake: A cross-sectional study with stable coronary artery disease patients. *J Periodontol* 2019; **90:** 1096–1105, doi:10.1002/jper.19-0036.
68. Suzuki H, Matsuo K, Okamoto M, Nakata H, Sakamoto H, Fujita M. Preoperative periodontal treatment and its effects on postoperative infection in cardiac valve surgery. *Clin Exp Dent Res* 2019; **5:** 485–490, doi:10.1002/cre2.212.
69. Folwaczny M, Wilberg S, Bumm C, Hollatz S, Oberhoffer R, Neidenbach RC, et al. Oral health in adults with congenital heart disease. *J Clin Med* 2019; **8:** 1255, doi:10.3390/jcm8081255.
70. Lee H, Kim HL, Jin KN, Oh S, Han YS, Jung DU, et al. Association between dental health and obstructive coronary artery disease: An observational study. *BMC Cardiovasc Disord* 2019; **19:** 98, doi:10.1186/s12872-019-1080-9.
71. Sanchez P, Everett B, Salamonson Y, Redfern J, Ajwani S, Bhole S, et al. The oral health status, behaviours and knowledge of patients with cardiovascular disease in Sydney Australia: A cross-sectional survey. *BMC Oral Health* 2019; **19:** 12, doi:10.1186/s12903-018-0697-x.
72. Vedin O, Hagström E, Östlund O, Avezum A, Budaj A, Flather MD, et al. Associations between tooth loss and prognostic biomarkers and the risk for cardiovascular events in patients with stable coronary heart disease. *Int J Cardiol* 2017; **245:** 271–276, doi:10.1016/j.ijcard.2017.07.036.
73. Esfahanian V NA, Rafiei E, Rafiei E, Akbarian E. Relationship between chronic periodontal diseases and acute myocardial infarction. *J Isfahan Dent Sch* 2017; **13:** 57–65.
74. Vedin O, Hagström E, Gallup D, Neely ML, Stewart R, Koenig W, et al. Periodontal disease in patients with chronic coronary heart disease: Prevalence and association with cardiovascular risk factors. *Eur J Prev Cardiol* 2015; **22:** 771–778, doi:10.1177/2047487314530660.
75. Reichert S, Schlitt A, Beschow V, Lutze A, Lischewski S, Seifert T, et al. Use of floss/interdental brushes is associated with lower risk for new cardiovascular events among patients with coronary heart disease. *J Periodontal Res* 2015; **50:** 180–188, doi:10.1111/jre.12191.
76. Sikka M, Sequeira PS, Acharya S, Bhat M, Rao A, Nagaraj A. Poor oral health in patients with coronary heart disease: A case-control study of Indian adults. *N Z Med J* 2011; **124:** 53–62.
77. Buhlin K, Mäntylä P, Paju S, Peltola JS, Nieminen MS, Sinisalo J, et al. Periodontitis is associated with angiographically verified coronary artery disease. *J Clin Periodontol* 2011; **38:** 1007–1014, doi:10.1111/j.1600-051X.2011.01775.x.
78. Fadel HT, Al-Kindy KA, Mosalli M, Heijl L, Birkhed D. Caries risk and periodontitis in patients with coronary artery disease. *J Periodontol* 2011; **82:** 1295–1303, doi:10.1902/jop.2011.100655.
79. Nicolosi LN, Lewin PG, González N, Jara L, Rubio Mdel C. Association between oral health and acute coronary syndrome in elderly people. *Acta Odontol Latinoam* 2011; **24:** 229–234.
80. Bokhari SA, Khan AA, Khalil M, Abubakar MM, Mustahsen UR, Azhar M. Oral health status of CHD and non-CHD adults of Lahore, Pakistan. *J Indian Soc Periodontol* 2011; **15:** 51–54, doi:10.4103/0972-124x.82273.
81. Willershausen B, Kasaj A, Willershausen I, Zahorka D, Briseño B, Blettner M, et al. Association between chronic dental infection and acute myocardial infarction. *J Endod* 2009; **35:** 626–630, doi:10.1016/j.joen.2009.01.012.
82. Stenman U, Wennström A, Ahlqwist M, Bengtsson C, Björkelund C, Lissner L, et al. Association between periodontal disease and ischemic heart disease among Swedish women: A cross-sectional study. *Acta Odontol Scand* 2009; **67:** 193–199, doi:10.1080/00016350902776716.
83. Völzke H, Schwahn C, Hummel A, Wolff B, Kleine V, Robinson DM, et al. Tooth loss is independently associated with the risk of acquired aortic valve sclerosis. *Am Heart J* 2005; **150:** 1198–1203, doi:10.1016/j.ahj.2005.01.004.
84. Buhlin K, Gustafsson A, Ahnve S, Janszky I, Tabrizi F, Klinge B. Oral health in women with coronary heart disease. *J Periodontol* 2005; **76:** 544–550, doi:10.1902/jop.2005.76.4.544.
85. Meurman JH, Janket SJ, Qvarnström M, Nuutinen P. Dental infections and serum inflammatory markers in patients with and without severe heart disease. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2003; **96:** 695–700, doi:10.1016/j.tripleo.2003.08.017.
86. Frisk F, Hakeberg M, Ahlqwist M, Bengtsson C. Endodontic variables and coronary heart disease. *Acta Odontol Scand* 2003; **61:** 257–262, doi:10.1080/00016350310005510.
87. Mattila KJ, Nieminen MS, Valtonen VV, Rasi VP, Kesäniemi YA, Syrjälä SL, et al. Association between dental health and acute myocardial infarction. *BMJ* 1989; **298:** 779–781, doi:10.1136/bmj.298.6676.779.
88. Watanabe Y, Okada K, Kondo M, Matsushita T, Nakazawa S, Yamazaki Y. Oral health for achieving longevity. *Geriatr Gerontol Int* 2020; **20:** 526–538, doi:10.1111/ggi.13921.
89. Andersson P, Hallberg IR, Renvert S. Inter-rater reliability of an oral assessment guide for elderly patients residing in a rehabilitation ward. *Spec Care Dentist* 2002; **22:** 181–186, doi:10.1111/j.1754-4505.2002.tb00268.x.
90. Chalmers JM, King PL, Spencer AJ, Wright FA, Carter KD. The oral health assessment tool: Validity and reliability. *Aust Dent J* 2005; **50:** 191–199, doi:10.1111/j.1834-7819.2005.tb00360.x.
91. Xu W, Fang L, Bai H, Ke K, Li W, Huang H, et al. The influence of psychological factors on coronary heart disease: A review of the evidence and implications for psychological interventions. *Medicine (Baltimore)* 2023; **102:** e34248, doi:10.1097/md.0000000000034248.

92. Khayyam-Nekouei Z, Neshatdoost H, Yousefy A, Sadeghi M, Manshaee G. Psychological factors and coronary heart disease. *ARYA Atheroscler* 2013; **9:** 102–111.
93. Kanejima Y, Shimogai T, Kitamura M, Ishihara K, Izawa KP. Impact of health literacy in patients with cardiovascular diseases: A systematic review and meta-analysis. *Patient Educ Couns* 2022; **105:** 1793–1800, doi:10.1016/j.pec.2021.11.021.
94. Kelli HM, Mehta A, Tahhan AS, Liu C, Kim JH, Dong TA, et al. Low educational attainment is a predictor of adverse outcomes in patients with coronary artery disease. *J Am Heart Assoc* 2019; **8:** e013165, doi:10.1161/jaha.119.013165.
95. Fang WL, Jiang MJ, Gu BB, Wei YM, Fan SN, Liao W, et al. Tooth loss as a risk factor for dementia: Systematic review and meta-analysis of 21 observational studies. *BMC Psychiatry* 2018; **18:** 345, doi:10.1186/s12888-018-1927-0.
96. Usmani W, de Courten M, Hanna F. Can oral health care be a gateway to improve cardiovascular disease? A scoping review. *Front Oral Health* 2024; **5:** 1364765, doi:10.3389/froh.2024.1364765.
97. Hienz SA, Paliwal S, Ivanovski S. Mechanisms of bone resorption in periodontitis. *J Immunol Res* 2015; **2015:** 615486, doi:10.1155/2015/615486.
98. 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; **372:** n71, doi:10.1136/bmj.n71.

Supplementary Files

Please find supplementary file(s);
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