Keywords
Congenital heart disease; oral health; dental caries; periodontal health; enamel defects; pediatric cardiology; oral health-related quality of life

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Association between Congenital Heart Diseases and Oral Health in Children: A Systematic Review

Abstract

Background: Worldwide, congenital heart disease (CHD) is the most common type of birth abnormality, with advancing medical care creating a growing population of survivors requiring comprehensive long-term management including oral health care. The relationship between CHD and oral health is multifaceted, potentially affecting dental caries, periodontal status, enamel development, and quality of life, while poor oral health may increase the risk of life-threatening infective endocarditis.

Objective: The objective of this systematic review was to thoroughly assess and compile the data currently available about the relationship between congenital heart disease and pediatric oral health outcomes, including dental caries experience, periodontal status, oral hygiene measures, enamel defects, oral health-related quality of life, barriers to dental care, and treatment needs.

Methods: A comprehensive search for papers published between January 2021 and January 2026 was done in PubMed/MEDLINE, Scopus, Web of Science, and Google Scholar. Included were observational and interventional studies that looked at the oral health outcomes of children with CHD between the ages of 0 and 18. Two reviewers independently selected the studies, extracted the data, and evaluated the quality using Joanna Briggs Institute standards. Because of the differences across the research, a narrative synthesis was carried out. …

Results: Seventeen studies from 11 countries, comprising 2,236 children with CHD and 4,485 controls, were included. Consistently poorer periodontal health was demonstrated across multiple studies, with significantly higher plaque indices, gingival indices, and oral hygiene scores in CHD children compared to controls. Enamel defects were substantially more prevalent in CHD populations (15.9-16.5%) versus controls (4.7%), with significant associations between hypoxic episodes and enamel anomalies. Dental caries findings were heterogeneous: approximately half of studies reported significantly higher caries experience in CHD children, while others found no significant differences. Treatment needs indices exceeded 85% with low care indices (10.8-12.4%), indicating critical gaps in restorative dental care access. Dental extractions comprised the majority (86%) of treatments under general anesthesia, with mean costs of $4,395 per procedure. Significant barriers included dental fear, parental knowledge deficits, and logistical challenges. Targeted oral hygiene education programs significantly improved parental knowledge and children's oral hygiene status.

Conclusions: Compared to their healthy classmates, children with congenital heart disease have noticeably worse dental health, particularly regarding periodontal status and enamel defects linked to hypoxic episodes. Despite heterogeneous caries findings, critically high treatment needs and low care indices reveal substantial gaps in dental care access. Interdisciplinary collaboration between pediatric cardiologists and dentists is essential to establish systematic referral pathways and early preventive interventions to improve both oral and systemic health outcomes in this vulnerable population.

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Introduction

The most common kind of birth defects worldwide is congenital heart disease (CHD), which includes a variety of structural and functional heart and great vessel abnormalities that occur during intrauterine development [1]. These anomalies range from simple lesions with minimal hemodynamic consequence to complex malformations requiring multiple surgical interventions and lifelong specialized care. Congenital heart defects (CHD) are the most common group of congenital birth defects worldwide. According to recent data from the Global Burden of Disease study, there were about 8.52 million prevalent cases and 0.55 million attributable fatalities in 2019 alone [2]. According to reports, the incidence of congenital heart disease (CHD) ranges from 4 to 50 per 1000 live births, with higher incidence rates observed in lower Socio-Demographic Index regions [3]. Furthermore, projections through 2050 suggest a significant rise in CHD prevalence, While death rates are predicted to continue their slow fall, especially in the 0–4 age range, there will be an increasing number of survivors who will need comprehensive long-term care, including dental treatment [2].

The remarkable advancements in pediatric cardiology, cardiac surgery, and intensive care over recent decades have dramatically altered the prognostic landscape for children born with CHD. Contemporary treatment outcomes have improved substantially, with most patients now reaching adulthood, creating a paradigm shift from palliative care to curative and life-long management approaches [4]. This growing population of CHD survivors faces unique health challenges beyond their primary cardiac condition, including increased susceptibility to various systemic and oral health complications. The oral cavity represents a critical interface between local and systemic health, particularly for individuals with compromised cardiac status, as oral diseases can serve as portals of entry for microorganisms capable of causing infective endocarditis—a life-threatening complication with in-hospital mortality rates approaching 16% [5]. Approximately 1.1 cases of infective endocarditis occur in patients with CHD for every 1000 patient-years, which is a much higher risk than in the general population [5].

Oral health and coronary heart disease have a complex and reciprocal interaction. Children with CHD may experience compromised oral health through several interconnected mechanisms. First, hemodynamic alterations, including chronic or intermittent hypoxia in cyanotic defects, can directly affect odontogenesis and enamel formation during critical developmental windows, predisposing to structural anomalies such as enamel hypoplasia and hypomineralization [6]. Second, the complex medical regimen often required for CHD management frequently includes sugar-containing medications that increase caries risk, as well as medications with xerostomic side effects such as diuretics and ACE inhibitors that reduce salivary flow and diminish its protective functions [7]. Third, the intense focus on cardiac management by parents and healthcare providers may inadvertently lead to relative neglect of oral hygiene practices and preventive dental care, with oral health being deprioritized amidst more immediately pressing medical concerns [6]. Fourth, children with CHD have higher rates of associated genetic syndromes and developmental disabilities that may independently affect oral health status and complicate dental management [7].

Multiple domains are involved in the oral symptoms and consequences of CHD. One of the main concerns is dental caries, with several research examining whether children with congenital heart disease (CHD) have a greater frequency of caries than their healthy peers. The results of a recent meta-analysis and systematic review of research published between 2014 and 2024 were inconsistent: while several individual studies demonstrated significantly higher caries experience in CHD children, particularly with advancing age, pooled meta-analyses showed no statistically significant differences in either DMFS scores (mean difference: 0.07 [95% CI: -0.13 to 0.27]; $p = 0.48$) or dmft scores (mean difference: 1.39 [95% CI: -1.05 to 3.83]; $p = 0.26$) [8]. This heterogeneity suggests that caries risk in CHD populations may be modified by geographic, socioeconomic, and healthcare access factors, and underscores the need for continued investigation with standardized methodologies [9].

Beyond dental caries, periodontal health emerges as a consistently significant concern in CHD populations. Multiple studies have documented higher plaque accumulation, gingival inflammation, and children with CHD had worse oral hygiene indices than healthy controls [6]. This finding carries particular clinical significance given the established relationship between periodontal disease and bacteremia. Even routine activities such as tooth brushing and chewing can induce bacteremia in the presence of gingival inflammation, with the incidence of bacteremia after tooth brushing reaching up to 23% [5]. In children with CHD, such bacteremia poses enhanced risk due to altered hemodynamics, endothelial damage from shear forces, and the presence of prosthetic materials or surgical repairs that serve as niduses for bacterial colonization [5]. According to reports, 14–20% of instances of infective endocarditis are related to oral infections, with gram-positive streptococci accounting for almost 50% of these infections [3].

Enamel defects and developmental dental anomalies represent another critical dimension of oral health in CHD children, with prevalence rates substantially exceeding those observed in healthy populations. Saraç and colleagues reported enamel defects in 16.5% of CHD-affected children compared to only 4.7% of healthy controls, with a significant association between lower oxygen saturation values and the presence of enamel defects [6]. This finding provides compelling evidence linking the hemodynamic consequences of CHD—specifically hypoxic episodes during critical periods of tooth development—to structural alterations in dental hard tissues. The clinical implications extend beyond esthetic concerns, as enamel defects create irregular surfaces that predispose to plaque retention and accelerate caries development, creating a cascade of oral health deterioration if not addressed preventively.

In infants with congenital heart disease, the effects of poor oral hygiene go beyond the mouth to affect systemic health, quality of life, and healthcare utilization. Oral health-related quality of life may be significantly compromised, affecting children's ability to eat, sleep, socialize, and participate in normal daily activities [3]. Furthermore, the economic burden of managing advanced dental disease in this population is substantial, with dental treatment under general anesthesia often necessitating extractions rather than conservative restorative approaches, and frequently requiring overnight hospitalization with associated costs and utilization of limited healthcare resources [3]. The goal of the current systematic review is to thoroughly assess and compile the evidence that is currently available regarding the relationship between congenital heart disease and oral health outcomes in the pediatric population. These outcomes include dental caries experience, periodontal status, oral hygiene practices, enamel defects and dental anomalies, oral health-related quality of life, obstacles to dental care, and treatment requirements.

Methodology

Protocol and Registration

To guarantee clear and comprehensive reporting, this systematic review was carried out in compliance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) criteria [10]. The study topic, search strategy, inclusion and exclusion criteria, data extraction techniques, and quality evaluation methodologies were all outlined in the review protocol, which was created before the search process started. Although the approach adhered to accepted best practices for performing systematic reviews in dentistry and medical research, official registration in a prospective registry like PROSPERO was not necessary because the study was a systematic review [11].

Research Question and Objectives

The PICO framework (Population, Intervention, Comparison, Outcomes) was used to develop the main research question that served as the basis for this systematic review: What is the relationship between the oral health outcomes (Outcome) of children with congenital heart disease (Population) and those of healthy children or normative data (Comparison)? The review's objective was to thoroughly assess and compile the available data regarding the relationship between congenital heart disease and a number of oral health parameters in the pediatric population, such as dental caries experience, periodontal status, oral hygiene practices, enamel defects and dental anomalies, oral health-related quality of life, obstacles to dental care, and treatment requirements [12].

Search Strategy and Information Sources

To find pertinent research published throughout a five-year span, from January 2021 to January 2026, a thorough literature search was carried out. The electronic databases PubMed/MEDLINE, Scopus, Web of Science, and Google Scholar were all searched. The search strategy included keywords and Medical Subject Headings (MeSH) terms associated with oral health ("oral health," "dental caries," "dental decay," "dmft," "DMFT," "periodontal disease," "gingivitis," "plaque index," "oral hygiene," "enamel defects," "dental anomalies," "oral health-related quality of life," and "OHRQoL") as well as congenital heart disease ("congenital heart disease," "congenital heart defect," "CHD," "congenital cardiac disease," "heart malformation") and oral health. Only English-language research with human subjects were included in the search. In order to find any more possibly suitable research that the automated database search was unable to find, the reference lists of the included studies and pertinent review articles were also manually examined [13].

Eligibility Criteria and Study Selection

Research that satisfied the following requirements was accepted: (1) included children and adolescents with congenital heart disease between the ages of 0 and 18; (2) evaluated one or more oral health outcomes, such as dental caries, periodontal status, oral hygiene, enamel defects, dental anomalies, oral health-related quality of life, or required dental treatment; (3) used observational study designs, such as cohort, cross-sectional, and case-control studies, or interventional studies with baseline data relevant to the research question; (4) provided clear definitions and validated measurement methods for oral health outcomes; (5) were authored in English and published between 2021 and 2026 in peer-reviewed journals. Excluded studies were those that: (1)focused on acquired heart disease rather than congenital heart disease; (2) included adult populations without separate pediatric data; (3) were letters to the editor, conference abstracts, case reports, and case series, or narrative reviews without original data; (4) did not provide sufficient data on oral health outcomes; or (5) were not available in full text.

For effective and blinded study selection, all obtained records were loaded into the Rayyan systematic review program (Qatar Computing Research Institute, Doha, Qatar). All identified records' titles and abstracts were evaluated by two impartial reviewers in accordance with the qualifying requirements. Rayyan's automatic duplication detection function was used to find and eliminate duplicate records. The full-text articles of possibly suitable studies were obtained and independently evaluated by the same two reviewers after title and abstract screening. At any point, any disputes about research eligibility were settled by consensus-building and debate, or, if required, by consulting a third reviewer. A PRISMA flow diagram was created and used to document the complete research selection procedure.

Data Extraction and Management

To methodically gather pertinent data from every included study, a uniform data extraction form was created in Microsoft Excel. Data from all qualifying papers was separately retrieved by two reviewers, and disagreements were settled by consensus and discussion. The following information was extracted: (1) study characteristics, such as author names, publication year, country of study, study design, and study setting; (2) participant characteristics: sample size (total, CHD group, control group), age range, gender distribution, and CHD classification or type; (3) oral health outcomes: quality of life measures related to oral health, parental knowledge and attitudes, treatment needs indices, dental caries indices (dmft, DMFT, dmfs, DMFS), plaque indices, gingival indices, oral hygiene indices, and the prevalence and types of enamel defects and dental anomalies; (4) key findings and conclusions reported by the study authors. For studies with missing or unclear data, corresponding authors were not contacted as the review was based on published data only, and missing information was recorded as "not mentioned" (NM) in the extraction tables.

Quality and Risk of Bias Assessment

The Joanna Briggs Institute's (JBI) suitable critical evaluation instruments were used to evaluate the included studies' methodological quality and bias risk. The JBI Checklist for Analytical Cross-Sectional Studies was used for cross-sectional, case-control, and descriptive studies. It assesses nine criteria: the inclusion criteria should be clearly defined; the study subjects and setting should be described in detail; exposure and outcome measurements should be valid and reliable; confounding factors should be identified and managed; and statistical analysis should be appropriate.

The JBI Checklist for Quasi-Experimental Studies, which evaluates factors like cause and effect clarity, participant similarity, the presence of a control group, outcome measurement, follow-up completeness, and statistical analysis appropriateness, was used for interventional studies without control groups. Each included study was evaluated separately by two reviewers, who rated each criterion as "yes" (low risk of bias), "no" (high risk of bias), "unclear" (unclear risk of bias), or "not applicable." Each study was given a low, moderate, or high overall risk of bias judgment based on the evaluation. Disagreements among reviewers were settled by consensus and discussion.

Data Synthesis and Analysis

A narrative synthesis methodology was used instead of meta-analysis due to the expected variability in study designs, demographics, outcome measures, and methodological methods. Dental caries experience, oral hygiene and periodontal condition, enamel defects and dental abnormalities, oral health-related quality of life and parental awareness, treatment requirements and economic burden, and other important oral health domains were used to arrange and present the data. The results were descriptively summarized within each domain. highlighting consistent patterns across studies as well as areas of heterogeneity and conflicting evidence. Where appropriate, the direction and magnitude of associations were described, and the strength of evidence was considered in light of the methodological quality and risk of bias of individual studies. The synthesis aimed to provide a comprehensive and balanced overview of the current evidence regarding the association between congenital heart disease and oral health in children, identifying gaps in knowledge and implications for clinical practice and future research.

Results:

The methodical procedure of finding and choosing studies for this review is depicted in the PRISMA flow diagram. 228 documents were found in the first database search; 104 duplicates were eliminated before screening. Following title and abstract screening, 74 records that did not fit the initial eligibility requirements were eliminated from the remaining 124 records. 29 full-text reports were evaluated for comprehensive eligibility out of the 50 reports that were requested to be retrieved, 21 of which were unsuccessful, Twelve reports were disqualified during the full-text evaluation for the following reasons:
Three were conference abstracts with insufficient data, two included incorrect demographics, and seven had incorrect outcomes unrelated to the research aim. In the end, 17 papers were included in this systematic review after meeting all inclusion criteria.

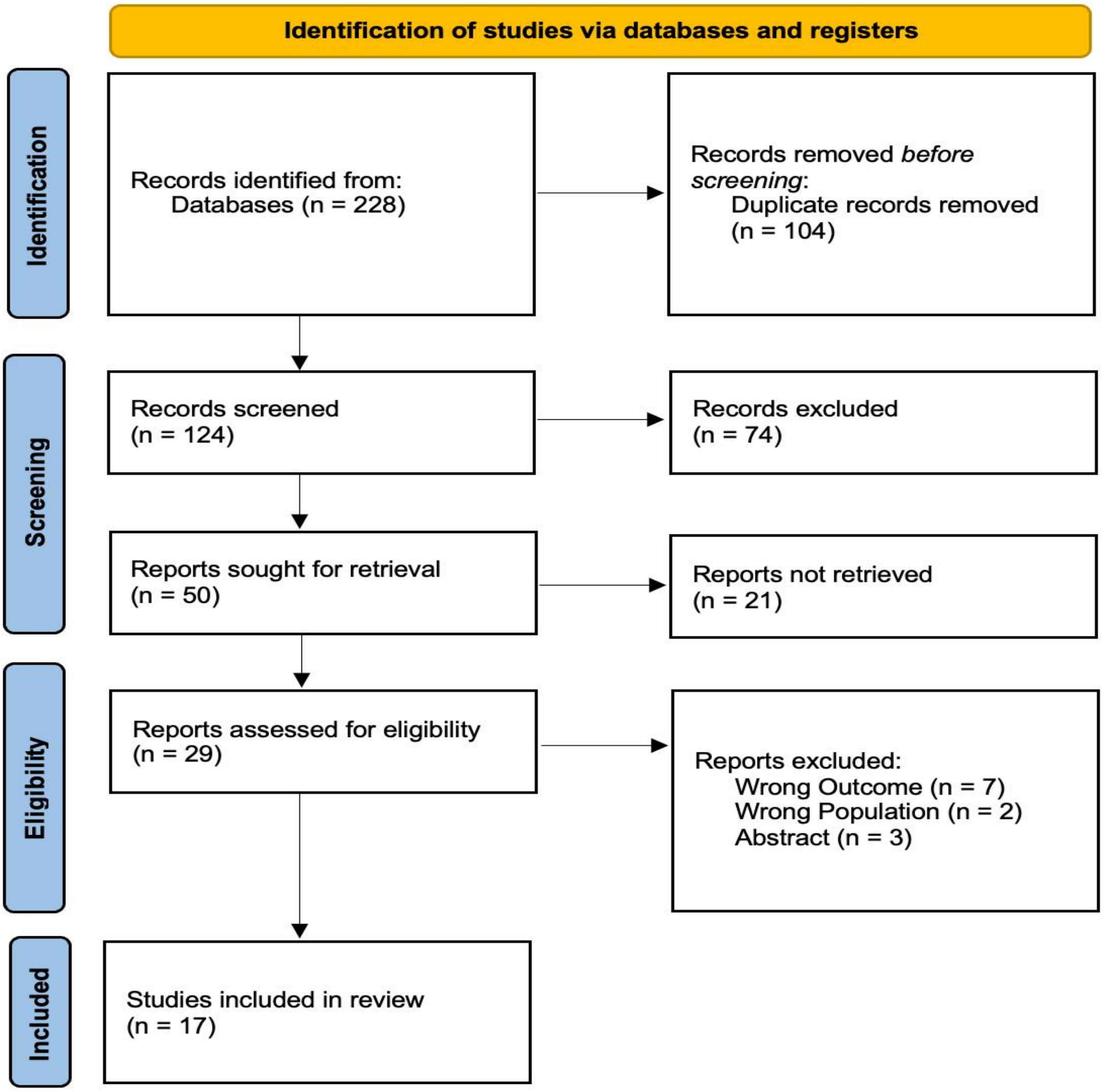

Figure 1: PRISMA Flow Diagram of Study Selection Process

Table 1 gives a thorough summary of the methodological and demographic aspects of the 17 included studies that looked at the relationship between children's dental health and congenital heart disease (CHD). The studies, which were released between 2021 and 2025, show a wide range of geographic locations, with the majority originating from Turkey [14,15,21,26,27,29], followed by India [18,25,28], Germany [17,30], and other countries including Australia [16], Finland [19], Malaysia [20], Iran [22], Kosovo [23], and Syria [24]. Regarding study design, cross-sectional studies were the most prevalent [14,17,18,20,23,26], complemented by case-control studies [22,24,29], descriptive studies [15,21], retrospective analyses [16,27], prospective interventional studies [28,30], and one practice-based follow-up study [19]. The sample sizes varied considerably, ranging from smaller studies with 20 participants per group [29] to large-scale investigations including up to 3356 controls [19] and 300 CHD patients [25]. The age ranges covered the entire pediatric spectrum from 6 months [15] to 18 years [15], with the majority of research concentrating on school-age kids between the ages of two and fourteen. Gender distribution was reported inconsistently, with some studies providing detailed information [16,17,20,21,24,26,27,28,29] while others did not mention it [14,15,18,19,22,23,25]. CHD classification varied across studies, with some utilizing cyanotic/acyanotic categorization [14,25], others employing severity-based [21] or hemodynamic-based classifications [15,19], and several not specifying the classification method used [16,17,18,20,22,23,24,26,27,28,29,30]. All studies appropriately included children diagnosed with CHD, with control groups consisting of healthy children in most comparative studies [14,15,17,18,19,20,22,23,24,26,29,30].

Table 2 synthesizes the principal oral health outcomes across the included studies, organized into five domains: dental caries experience, oral hygiene and gingival status, enamel defects and anomalies, parental knowledge, oral health-related quality of life (OHRQoL), and important findings. In relation to dental caries, the findings were heterogeneous: several studies reported significantly higher caries experience in CHD children compared to controls [17,18,24,25], with Hazarika et al. [18] documenting higher dmfs scores (5.93±10.22 vs. 3.41±6.19) and Bsesa et al. [24] finding significantly higher dmft in CHD patients (5.245 vs. 2.660, $p<0.05$). Conversely, other studies found no significant differences in caries indices [14,15,19,22,23,26], while Aksakal et al. [29] paradoxically reported lower caries scores in the CHD group. Oral hygiene and gingival status were consistently poorer among CHD children across multiple studies [14,15,20,21,24,25,26,29,30], with significantly higher plaque indices [14,26,30], gingival indices [15,20,21,24,26,29,30], and OHI-S scores [15,24]. Enamel defects and dental anomalies were prominently featured in several investigations, with Saraç et al. [15] reporting defects in 16.5% of CHD children versus 4.7% of controls, Bsesa et al. [24] revealing much greater hypocalcification (10.5% vs. 2%) and enamel opacities (8% vs. 2%), and Sethi et al. [25] finding dental anomalies in 9% of CHD patients, predominantly enamel opacities (8.0%). OHRQoL and parental knowledge assessments revealed important psychosocial dimensions: Mohammad et al. [20] identified significant barriers including dental fear and parental knowledge deficits, Rexhepi et al. [23] found that only 32.7% of parents were aware of preventive measures despite 68.7% knowing about IE risk, and Bsesa et al. [24] demonstrated significantly worse OHRQoL across all domains in CHD children. The key conclusions consistently emphasized the need for interdisciplinary collaboration [15,17,30], targeted preventive interventions [19,20,28], and recognition of CHD as a risk factor for compromised oral health [14,15,24,25].

Table 3 uses the relevant Joanna Briggs Institute (JBI) critical evaluation criteria based on each study's methodological design to assess the risk of bias for each of the 17 included studies. The JBI Checklist for Analytical Cross-Sectional research was used for cross-sectional, case-control, and descriptive research, and the JBI Checklist for Quasi-Experimental Studies was used for interventional studies without control groups [28,30]. Selection bias, performance bias, detection bias, attrition bias, and reporting bias are the five primary domains that were assessed in the evaluation. Each of these domains was given a risk rating of low, moderate, or high, which led to an overall risk of bias judgment. Most of the studies showed a low overall risk of bias. [14,15,17,18,20,21,24,26,29], demonstrating strong methodological quality through suitable sample techniques, well-defined inclusion criteria, accurate and trustworthy result measurement, and sufficient statistical analysis. Standardized oral health assessment techniques, well-defined CHD populations, suitable control groups, and thorough reporting of results were common features of these investigations. Research with an overall risk of bias of moderate [16,19,22,23,25,27,28,30] exhibited concerns primarily in selection bias domains, including unclear sampling methods [16,22,23,25], potential confounding variables not adequately addressed [19,27], or performance bias related to the lack of blinding in interventional designs [28,30]. Additionally, some moderate-risk studies showed attrition bias concerns [19,28,30] due to incomplete follow-up or unclear reporting of participant flow. Notably, no studies were rated as high risk of bias, and all demonstrated low risk in detection and reporting bias domains, suggesting that outcome measurements were generally valid and findings were comprehensively reported.

Table 1: Demographic and Study Characteristics of Included Studies

Study (Author, Year) [Ref.]	Country	Study Design	Sample Size (CHD/Control)	Age Range (Years)	Gender Distribution (CHD Group)	CHD Classification	Key Inclusion Criteria
Sarac & Simsek Derelioglu, 2025 [14]	Turkey	Cross-sectional	108 / 111	5-14	NM	Cyanotic/Acyanotic	CHD-diagnosed children and healthy controls
Saraç et al., 2023 [15]	Turkey	Descriptive and correlational	217 / 364	0.5-18	NM	Shunt, Stenosis, Saturation values	Children with/without CHD
Nikolovski et al., 2023 [16]	Australia	Retrospective analysis	89 / 0	Mean 8.15	51.7% Male	NM	Children with CHD who had a dental GA procedure
Koerdt et al., 2022 [17]	Germany	Cross-sectional with matched	147 / Epidemiological control	3-17 (Mean 11)	55.1% Male	NM	Children with CHD

		control					
Hazarika et al., 2024 [18]	India	Cross-sectional	73 / 73	6-12	NM	Congenital heart disease (unspecified)	Children attending school with or without CHD
Karhumaa et al., 2021 [19]	Finland	Practice-based follow-up	215 / 3356	Up to 15	NM	Shunting, Stenotic, Complex	Patients with heart surgery who were born between 1997 and 1999
Mohammad et al., 2025 [20]	Malaysia	Cross-sectional	67 / 67	3-12	49.3% Male (within CHD group)	NM	Children with/without CHD
Taşdemir et al., 2024 [21]	Turkey	Descriptive	271 CHD / 30 Acquired	5-14	53.5% Male (total sample)	Severity (Mild, Moderate, Severe)	Children with congenital and acquired heart disease
Salehi et al., 2024 [22]	Iran	Case-control	28 / 28	3-6	42.9% Female (total sample)	NM	Children with/without CHD referred to Toubi Clinic
Rexhepi et al., 2022 [23]	Kosovo	Cross-sectional	80 / 60	3-15	NM	Congenital heart disease (unspecified)	Children with/without CHD
Bsesa et al., 2023 [24]	Syria	Case-control	200 / 100	4-12	56.5% Male (CHD group)	NM	Children with/without CHD
Sethi et al., 2025 [25]	India	Cross-sectional	300 / 0	2-16	NM	Cyanotic/Acyanotic	Children diagnosed with CHD
Yavsan et al., 2022 [26]	Turkey	Cross-sectional	75 / 75	3-6	46.7% Male (CHD group)	NM	Preschool children with/without CHD
Kolçakoğlu et al., 2024 [27]	Turkey	Retrospective	146 / 0	2-14	53.4% Male	NM	Children with CHD needing prophylaxis before CVS
Joy et al., 2025 [28]	India	Prospective interventional	93 / 0	2-14 (Mean 5.9)	62% Male	NM	Children with CHD and their parents
Aksakal et al., 2024 [29]	Turkey	Case-control	20 / 20	6-12	45% Male (CHD group)	NM	Children with/without CHD
Schulz-Weidner et al., 2021 [30]	Germany	Prospective interventional	107 / 101	2-6	NM	Congenital heart disease (unspecified)	Children with/without CHD

Table 2: Key Oral Health Findings in Children with Congenital Heart Disease

Study (Author, Year) [Ref.]	Dental Caries Experience	Oral Hygiene & Gingival Status	Enamel Defects & Anomalies	OHRQoL & Parental Knowledge	Key Conclusions Related to Oral Health in CHD
Sarac & Simsek Derelioglu, 2025 [14]	No significant diff. in dmft/DMFT vs. controls (p>0.05)	PI scores significantly higher in CHD group (p<0.001)	NM	NM	Children with CHD showed delayed dental age despite similar caries scores.
Saraç et al., 2023 [15]	Caries index scores similar to controls.	OHI-S (p<0.001) and gingivitis (p=0.047) higher in CHD.	Enamel defects: 16.5% in CHD, 4.7% in controls. Lower saturation (89±8.9) in those with defects (p=0.03).	NM	CHD children more prone to enamel defects and periodontal disease, linked to hypoxia.
Nikolovski et al., 2023 [16]	Extractions in 86% of GAs. 27% had history of dental infection.	NM	NM	NM	Dental extractions are the majority of treatment under GA, with significant health and economic burden.
Koerdt et al., 2022 [17]	38.8% had untreated caries. DMFT/dmft higher than healthy controls.	NM	NM	NM	>1/3 of children with CHD have dental condition needing rehab, requiring interdisciplinary cooperation.
Hazarika et al., 2024 [18]	Mean dmfs higher in CHD (5.93±10.22) vs. controls (3.41±6.19).	NM	NM	NM	Children with CHD have higher caries experience and poorer nutritional status.
Karhumaa et al., 2021 [19]	Caries prevalence did not differ from controls. Significant diff. in DT and DMFT by defect type at age 15.	NM	NM	High caries experience not associated with more preventive visits.	Need for OHP, especially by hygienists, in CHD. National dental visit obligations not always met.
Mohammad et al., 2025 [20]	dmft/DMFT assessed but not main comparative outcome.	Gingivitis scores significantly higher in CHD (p<0.001).	NM	CHD: never visited dentist (p=0.002), more afraid/anxious, parents lacked knowledge.	CHD children have significant oral health needs and face considerable barriers to dental care.
Taşdemir et al., 2024 [21]	Extensive caries in 75.7%. TNI: 85.8% (primary), 88.9% (permanent). CI: ~10-12%.	Mean PI 1.18±0.38; GI 0.69±0.53.	Enamel defects in 15.9%.	NM	High prevalence of untreated caries, gingivitis, and high treatment need, increasing IE risk.
Salehi et al., 2024 [22]	Mean dmft: 6.42±3.27 (CHD) vs. 5.92±2.9 (control) (p=0.492).	NM	NM	CHD showed better OHRQoL (FIS section, p=0.026) than healthy children.	dmft was higher (not significant) in CHD, but their OHRQoL was better, possibly due to less pain.
Rexhepi et al., 2022 [23]	Mean dmft: 6.7 (CHD), 5.62 (control). Mean	NM	NM	68.7% parents informed about IE risk, but only	No diff. in caries, but lack of parental knowledge about

	DMFT: 4.1 (CHD), 3.47 (control) (p>0.05).			32.7% aware of prophylactic measures.	OHP was evident.
Bsesa et al., 2023 [24]	dmft higher in CHD (5.245 vs. 2.660, p<0.05). No diff. in DMFT.	OHI (5.95 vs. 1.87) and PMGI (1.68 vs. 1.17) higher in CHD (p<0.05).	Enamel opacities (8% vs. 2%) and hypocalcification (10.5% vs. 2%) higher in CHD.	All four domains of OHRQoL were significantly worse in CHD children.	CHD children have poorer oral health on multiple measures and a lower OHRQoL.
Sethi et al., 2025 [25]	Caries prevalence: 56.7%. Mean DMFT: 0.6±1.6.	Debris Index: 0.8±0.9; Calculus Index: 0.3±0.6.	Dental anomalies: 9% (enamel opacities 8.0%, hypodontia 0.7%).	NM	Children with CHD have poor oral health overall.
Yavsan et al., 2022 [26]	Caries and missing teeth higher in CHD (p>0.05). Filled teeth higher in control (p<0.05).	PI and GI higher in CHD (p>0.05).	NM	OHRQoL was lower in CHD, but not statistically significant (p>0.05).	High caries and plaque in both groups. OHRQoL was lower in CHD children, though not significant.
Kolçakoğlu et al., 2024 [27]	Pre-rehab DMFT/dmft correlated with number of caries (r=0.95, p=0.01).	NM	NM	NM	Extraction is the predominant approach in oral rehabilitation for children with CHD.
Joy et al., 2025 [28]	NM (interventional)	Baseline: only 22.5% had good OH. Silness-Loe plaque index: 1.25.	NM	Baseline: 17.2% parents had adequate knowledge; 5.4% had satisfactory practices.	Baseline data confirms poor parental KAP and poor oral hygiene in children with CHD.
Aksakal et al., 2024 [29]	CHD group had significantly lower caries scores than control.	CHD group had significantly higher GI scores than control.	NM	NM	Oral hygiene (gingival health) was worse in CHD, even with lower caries.
Schulz-Weidner et al., 2021 [30]	NM (interventional)	Baseline: CHD children had significantly poorer QHI, GI, GHI (p<0.05) vs. controls.	NM	NM	Baseline data confirms poorer oral hygiene in CHD children compared to healthy peers.

Table 3: Risk of Bias Assessment of Included Studies Using Appropriate Tools

Study (Author, Year) [Ref.]	Assessment Tool	Selection Bias	Performance Bias	Detection Bias	Attrition Bias	Reporting Bias	Overall Risk of Bias
Sarac & Simsek Derelioglu, 2025 [14]	JBI Checklist	Low	Low	Low	Low	Low	Low
Saraç et al., 2023 [15]	JBI Checklist	Low	Low	Low	Unclear	Low	Low
Nikolovski et al., 2023 [16]	JBI Checklist	Moderate	Moderate	Low	Low	Low	Moderate
Koerdt et al., 2022 [17]	JBI Checklist	Low	Low	Low	Low	Low	Low
Hazarika et al., 2024 [18]	JBI Checklist	Low	Low	Low	Low	Low	Low

Karhumaa et al., 2021 [19]	JBI Checklist	Moderate	Low	Low	Moderate	Low	Moderate
Mohammad et al., 2025 [20]	JBI Checklist	Low	Low	Low	Low	Low	Low
Taşdemir et al., 2024 [21]	JBI Checklist	Low	Low	Low	Low	Low	Low
Salehi et al., 2024 [22]	JBI Checklist	Moderate	Low	Low	Low	Low	Moderate
Rexhepi et al., 2022 [23]	JBI Checklist	Moderate	Low	Low	Low	Low	Moderate
Bsesa et al., 2023 [24]	JBI Checklist	Low	Low	Low	Low	Low	Low
Sethi et al., 2025 [25]	JBI Checklist	Moderate	Low	Low	Low	Low	Moderate
Yavsan et al., 2022 [26]	JBI Checklist	Low	Low	Low	Low	Low	Low
Kolçakoğlu et al., 2024 [27]	JBI Checklist	Moderate	Moderate	Low	Low	Low	Moderate
Joy et al., 2025 [28]	JBI Checklist for Quasi-Experimental	Low	Moderate	Low	Moderate	Low	Moderate
Aksakal et al., 2024 [29]	JBI Checklist	Low	Low	Low	Low	Low	Low
Schulz-Weidner et al., 2021 [30]	JBI Checklist for Quasi-Experimental	Low	Moderate	Low	Moderate	Low	Moderate

Discussion

The current systematic review provides a thorough assessment of the relationship between congenital heart disease (CHD) and oral health outcomes in children by synthesizing data from 17 research published between 2021 and 2025. Our findings reveal a complex and multifaceted relationship, characterized by consistently poorer periodontal health and higher prevalence of enamel defects among CHD children, alongside heterogeneous findings regarding dental caries experience. These findings complement and build upon earlier meta-analyses and systematic reviews in this area.

The findings of a recent systematic review and meta-analysis by Moussa et al. [31], which included studies published between 2014 and 2024 comparing oral health status between children with and without CHD using DMF/dmf indices, are consistent with the heterogeneity in dental caries findings found in our review. There were no statistically significant differences in DMFS scores (mean difference: 0.07 [95% CI: -0.13 to 0.27]; p = 0.48) or dmft scores (mean difference: 1.39 [95% CI: -1.05 to 3.83]; p = 0.26), according to their meta-analysis, which included 12 articles in qualitative synthesis and 4 in quantitative synthesis [31][32]. The authors came to the conclusion that although a number of research indicated that children with congenital heart disease would be at a higher risk of dental caries, especially as they become older, the differences were not consistently seen in all studies and age groups [33]. This conclusion is in line with our findings, which showed that children with CHD had significantly greater caries experiences in around half of the analyzed studies [17,18,24,25], whereas other studies revealed no significant differences. [14,15,19,22,23,26], and one study paradoxically reported lower caries scores in the CHD group [29].

Variations in research design, sample characteristics, geographic location, healthcare systems, and methodological approaches to caries evaluation are some of the possible causes of the inconsistent caries findings. Interestingly, research from poor nations like Syria [24] and India [18,25] tended to show more noticeable variations in caries experience between children with CHD and healthy children. This might be because of inequalities in availability to oral health education and preventative dental treatment. The significance of taking contextual variables into account when assessing oral health outcomes in CHD populations is highlighted by this regional variance. Furthermore, the age-dependent nature of caries development may contribute to heterogeneity, as suggested by Moussa et al. [31], who observed that differences became more apparent in older children, possibly due to cumulative exposure to risk factors over time.

In contrast to the inconsistent caries findings, our review revealed remarkably consistent evidence regarding poorer periodontal health in children with CHD. Multiple studies demonstrated significantly higher plaque indices [14,26,30], gingival indices [15,20,21,24,26,29,30], and oral hygiene index-simplified (OHI-S) scores [15,24] among CHD children compared to healthy controls. Saraç et al. [15] reported significantly higher OHI-S scores ($p < 0.001$) and gingivitis findings ($p = 0.047$) in their large cohort of 217 CHD children compared to 364 healthy controls.

Similarly, Mohammad et al. [20] found significantly higher gingivitis scores in CHD children ($p < 0.001$), while Schulz-Weidner et al. [30] showed that at baseline, children with CHD had substantially lower Quigley-Hein plaque index (QHI), gingival index (GI), and gingival hyperplasia index (GHI) ($p < 0.05$). These results are consistent with the controlled study by Cantekin et al. [35], which demonstrated that children with congenital cardiac disease typically had poorer oral health and should be targeted for vigorous preventive dental care, and with previous research by Pourmoghaddas et al. [34], who reported higher dental decay and periodontitis in pediatric patients with CHD. Poorer periodontal health in children with congenital heart disease may be caused by a number of factors, such as the inability to maintain proper oral hygiene because of repeated hospitalizations, parental attention on cardiac treatment at the cost of dental hygiene, and possible drug side effects on gingival tissues [15,20].

The much increased occurrence of enamel abnormalities and dental malformations in children with CHD is one of our review's most notable findings. Saraç and associates. [15] reported enamel defects in 16.5% of CHD children compared to only 4.7% of healthy controls, with a significant association between lower oxygen saturation values and the presence of enamel defects (mean saturation 89 ± 8.9 in those with defects versus 95 ± 4.2 in those without; $p = 0.03$). Taşdemir et al. [21] observed enamel defects in 15.9% of their CHD cohort, while Bsesa et al. [24] found that children with CHD had considerably greater hypocalcification (10.5% vs. 2%) and enamel opacities (8% vs. 2%) than controls. Sethi and associates. [25] found that 9% of patients with congenital heart disease had dental abnormalities, with enamel opacities/hypoplasia accounting for the majority (8.0%), followed by hypodontia (0.7%) and fusion (0.3%). These results support previous studies by Halperson et al. and Franco et al. [36], who showed that children with CHD have a greater prevalence of enamel abnormalities than healthy children [37], who linked enamel defects in CHD patients to hypoxic episodes during tooth development. The etiological relationship between CHD and enamel defects is biologically plausible, as amelogenesis is a highly sensitive process that can be disrupted by systemic disturbances, including hypoxia, malnutrition, and hemodynamic instability during critical periods of tooth development [15,38]. Saraç et al. [15] provided direct evidence for this mechanism by demonstrating that children with enamel defects had significantly lower oxygen saturation values, suggesting that chronic or intermittent hypoxia may compromise enamel formation.

In this research, obstacles to dental treatment and oral health-related quality of life (OHRQoL) emerged as significant psychosocial factors. In comparison to healthy controls, Bsesa et al. [24] found that children with congenital heart disease (CHD) had substantially worse OHRQoL in all four dimensions of the Child Oral Health-Related Quality of Life Questionnaire (COHRQoL), including oral symptoms, functional limits, emotional well-being, and social well-being. However, Salehi et al [22] found that while dmft scores were higher (though not statistically significant) in CHD children, their OHRQoL as measured by the ECOHIS was better in the family impact scale (FIS) section ($p = 0.026$), suggesting that parents of CHD children may have different perceptions or expectations regarding oral health impacts. Regarding barriers to care, Mohammad et al. [20] found several important issues, such as increased dental anxiety and terror ($p < 0.001$), difficult behavior during dental procedures ($p < 0.001$), parents' ignorance of where to get dental care ($p = 0.005$), and time limits when taking kids to dental clinics ($p = 0.014$). A significant knowledge-to-practice gap was highlighted by Rexhepi et al. [23], who discovered that although 68.7% of parents of children with congenital heart disease were aware of the danger of infective endocarditis during dental procedures, only 32.7% were aware of particular preventative measures. These results are consistent with studies conducted by Rai et al [39], who demonstrated a need for improvement in parental knowledge regarding oral health measures, especially concerning the risk of odontogenic bacteria and infective endocarditis. The clinical significance of these findings cannot be overstated, as poor oral health in CHD children may increase the risk of bacteremia and infective endocarditis [40,41]. Parahitiyawa et al. [42] emphasized that odontogenic bacteremia can occur even during routine daily activities such as tooth brushing, underscoring the importance of maintaining optimal oral health regardless of dental treatment frequency.

The high treatment needs and economic burden associated with dental care in CHD children were highlighted by several studies. Taşdemir et al. [21] revealed that 75.7% of the children in their cohort had severe caries, and there were no caries-free children according to the International Caries Detection and Assessment System II (ICDAS II) index. While the treatment Index (CI) was only 12.4% for primary teeth and 10.8% for permanent teeth, the Treatment Needs Index (TNI) was remarkably high at 85.8% for primary teeth and 88.9% for permanent teeth, showing a serious lack of access to restorative dental treatment [21]. Nikolovski et al. [16] assessed the financial burden and discovered that, with a mean cost of $4395.14 per surgery and a mean hospital stay of 1.43 days, tooth extractions accounted for the majority (86%) of treatments given under general anesthesia for infants with congenital heart disease. Children who showed signs of face swelling, which indicated postponed dental treatment and the development of odontogenic infections, had far greater costs [16]. Kolçakoğlu et al. [27] similarly found that extraction was the predominant approach in oral rehabilitation for children with CHD, rather than endodontic or deep restorative treatments, reflecting the severity of dental disease at presentation. These results highlight the need of early preventative measures and routine dental surveillance in order to avert the need for costly and time-consuming general anesthetic procedures, which pose extra dangers for children with impaired heart function [43].

Numerous interventional studies have shown the potential for focused therapies to enhance oral health outcomes in children with congenital heart disease. Despite their worse baseline status compared to healthy controls, Schulz-Weidner et al. [30] demonstrated that a structured preventive oral hygiene program (POHP) administered over six months significantly improved all oral hygiene parameters (QHI, GI, and GHI) in children with congenital heart disease (CHD) ($p < 0.05$). Joy and associates [28] demonstrated that a mobile application-based oral hygiene education program, combined with conventional methods and weekly telephonic reinforcement, significantly improved parental knowledge (from 17.2% to 85%, $p < 0.001$), attitudes (from 15% to 89.2%, $p < 0.001$), and practices (from 5.4% to 79.5%, $p < 0.001$), as well as children's oral hygiene (median Silness and Loe plaque index decreasing from 1.25 to 0.875, $p < 0.001$). An ongoing randomized educational intervention trial in Finland [44] aims to provide further evidence on whether early information, counseling, Providing assistance to families impacted by significant congenital heart disease can raise awareness of the value of maintaining dental health and stop the emergence of dental caries and other poor oral health conditions. The hypothesis that better information leads to better oral health outcomes, which in turn reduces dental procedures, dental anxiety, and the need for general anesthesia, is supported by the preliminary evidence from our review [28,30].

Limitations

When analyzing the results, it is important to recognize the many limitations of this systematic study. First, we were unable to do a meta-analysis because to the heterogeneity among the included studies in terms of design, sample characteristics, age ranges, CHD categorization methods, and outcome variables; therefore, a narrative synthesis technique was required. While all studies utilized standardized indices for caries assessment (dmft/DMFT), variations in examiner calibration, diagnostic thresholds, and reporting methods may have introduced measurement bias. Second, the cross-sectional design predominant among included studies [14,17,18,20,23,26] precludes establishment of causal relationships between CHD and oral health outcomes, as temporal associations cannot be determined. Third, potential confounding variables such as socioeconomic status, dietary habits, fluoride exposure, and access to dental care were not consistently controlled for across studies, which may have influenced observed associations. Moussa et al. [31] Confounding bias was a worry when significant characteristics like socioeconomic level or dental hygiene practices were not taken into account, as was also recognized in their systematic analysis. Fourth, there was a bias in the research' geographic dispersion toward Turkey [14,15,21,26,27,29] and India [18,25,28], potentially limiting generalizability to populations with different healthcare systems, cultural practices, and disease prevalence patterns. Fifth, publication bias may have influenced our findings, because research showing positive correlations may have a higher chance of publication than research showing null results. Sixth, the removal of papers written in languages other than English would have resulted in linguistic bias and perhaps left out pertinent research from non-English speaking nations. Seventh, a few of the included studies were classified as having a moderate risk of bias, indicating that their quality varied [16,19,22,23,25,27,28,30] primarily due to concerns in selection bias domains, including unclear sampling methods, potential confounding variables not adequately addressed, or performance bias related to lack of blinding in interventional designs. Finally, the focus on dental caries as the primary outcome in many studies may have underemphasized other important oral health parameters such as periodontal status, enamel defects, and oral microbiome composition, which our review suggests are significantly affected in CHD children.

Conclusions

Compared to their healthy classmates, children with congenital heart disease have noticeably worse dental health, particularly regarding periodontal status and enamel defects linked to hypoxic episodes. Dental caries findings were heterogeneous, yet treatment needs indices exceeding eighty-five percent with low care indices reveal critical gaps in restorative dental care access. Affected children face multiple barriers including dental fear, parental knowledge deficits, and logistical challenges. The economic burden of dental treatment under general anesthesia, predominantly extractions rather than preventive care, underscores the urgent need for early intervention. Targeted oral hygiene education programs can significantly improve outcomes. Interdisciplinary collaboration between pediatric cardiologists and dentists is essential to establish systematic referral pathways, ensure regular dental surveillance, and ultimately improve both oral and systemic health outcomes in this vulnerable population.

References

1. Ye E, Wu E, Tang T, La X. Global, regional, and national burdens of congenital heart anomalies from 1990 to 2021, and projections to 2050. Frontiers in Pediatrics. 2025 Aug 18;13:1601620.
2. Kang L, Cao G, Jing W, Liu J, Liu M. Global, regional, and national incidence and mortality of congenital birth defects from 1990 to 2019. European Journal of Pediatrics. 2023 Apr;182(4):1781-92.
3. Tasdemir T, Erbas Unverdi G, Ballikaya E, Aypar E, Aykan HH, Karagoz T, Uzamıs Tekcicek M. Evaluation of Oral Health status and treatment needs of children with congenital and acquired heart disease. Journal of Clinical Medicine. 2024 Jul 11;13(14):4060.
4. Ma K, He Q, Dou Z, Hou X, Li X, Zhao J, Rao C, Feng Z, Sun K, Chen X, He Y. Current treatment outcomes of congenital heart disease and future perspectives. The Lancet Child & Adolescent Health. 2023 Jul 1;7(7):490-501.

5. Moussa C, Savard G, Estrade L, Bourgi R, Kharouf N, Denis F, Daou MH. Dental health in children with congenital heart defects: a systematic review and meta-analysis. Journal of Clinical Medicine. 2024 Nov 21;13(23):7022.
6. Saraç F, Derelioğlu SŞ, Şengül F, Laloğlu F, Ceviz N. The evaluation of oral health condition and oral and dental care in children with congenital heart disease. Journal of Clinical Medicine. 2023 May 25;12(11):3674.
7. University of Washington School of Dentistry. Medical Professionals Treating Children with Congenital Cardiac Disorders: Oral Health Fact Sheet. Seattle: UW School of Dentistry; 2025. Available from: https://dental.washington.edu/dept-oral-med/special-needs/medical-professionals-treating-children-with-congenital-cardiac-disorders/
8. Moussa C, Savard G, Estrade L, Bourgi R, Kharouf N, Denis F, Daou MH. Dental health in children with congenital heart defects: a systematic review and meta-analysis. Journal of Clinical Medicine. 2024 Nov 21;13(23):7022.
10. Moussa C, Savard G, Estrade L, Bourgi R, Kharouf N, Denis F, Daou MH. Dental health in children with congenital heart defects: a systematic review and meta-analysis. Journal of Clinical Medicine. 2024 Nov 21;13(23):7022.
11. 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
12. Moher D, Liberati A, Tetzlaff J, Altman DG; PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. PLoS Med. 2009;6(7):e1000097. doi:10.1371/journal.pmed.1000097
13. Higgins JPT, Thomas J, Chandler J, Cumpston M, Li T, Page MJ, Welch VA, editors. Cochrane Handbook for Systematic Reviews of Interventions. Version 6.3. Cochrane; 2022. Available from: www.training.cochrane.org/handbook
14. Lefebvre C, Glanville J, Briscoe S, Littlewood A, Marshall C, Metzendorf MI, Noel-Storr A, Rader T, Shokraneh F, Thomas J, Wieland LS. Searching for and selecting studies. Cochrane handbook for systematic reviews of interventions. 2019 Sep 23:67-107.
15. Saraç F, Derelioğlu SŞ. Assessment of growth & development, dental caries, and dental development in children with congenital heart disease. Journal of Clinical Pediatric Dentistry. 2025 May 1;49(3).
16. Saraç F, Derelioğlu SŞ, Şengül F, Laloğlu F, Ceviz N. The evaluation of oral health condition and oral and dental care in children with congenital heart disease. Journal of Clinical Medicine. 2023 May 25;12(11):3674.
17. Nikolovski J, Chapman EE, Widmer RP, Ayer JG. Investigating the scope and costs of dental treatment provided under general anaesthesia among children with congenital heart disease. Journal of Paediatrics and Child Health. 2023 Jul;59(7):885-9.
18. Koerdt S, Hartz J, Hollatz S, Heiland M, Neckel N, Ewert P, Oberhoffer R, Deppe H. Prevalence of dental caries in children with congenital heart disease. BMC pediatrics. 2022 Dec 12;22(1):711.
19. Hazarika SJ, Jnaneswar A, Jha K. A Comparative Assessment of Dental Caries Experience in Relation to Nutritional Status among 6–12-Year-Old School-Going Children and Those with Congenital Heart Disease in Bhubaneswar City. International Journal of Clinical Pediatric Dentistry. 2024 Jan;17(1):1.
20. Karhumaa H, Lämsä E, Vähänikkilä H, Blomqvist M, Pätilä T, Anttonen V. Dental caries and attendance to dental care in Finnish children with operated congenital heart disease. A practice based follow-up study. European Archives of Paediatric Dentistry. 2021 Aug;22(4):659-65.
21. Mohammad H, Shoaib LA, Dziaruddin N, Zahari N. Oral health needs and barriers to care in children with congenital heart disease. Journal of Clinical Pediatric Dentistry. 2025 Nov 1;49(6):82-92.
22. Tasdemir T, Erbas Unverdi G, Ballikaya E, Aypar E, Aykan HH, Karagoz T, Uzamıs Tekcicek M. Evaluation of Oral Health status and treatment needs of children with congenital and acquired heart disease. Journal of Clinical Medicine. 2024 Jul 11;13(14):4060.
23. Salehi M, Molania T, Tabarestani A, Mollaei M, Moosazadeh M, Sadeghi-Lotfabadi A, Javan F, Nahvi A. Comparison of the Dmft Index and Oral Health-Related Quality of Life in 3 to 6-Year-Old Children with Congenital Heart Disease and Healthy Children. Journal of Mazandaran University of Medical Sciences. 2024 Feb 10;33(230):153-9.
24. Rexhepi A, Latifi-Xhemajli B, Kutllovci T, Bajrami S, Ahmeti D. Caries experience and knowledge about oral health importance among children with congenital heart diseases in Kosovo. Pesquisa Brasileira em Odontopediatria e Clínica Integrada. 2022 Dec 5;22:e210056.
25. Bsesa SS, Srour S, Dashash M. Oral health-related quality of life and oral manifestations of Syrian children with congenital heart disease: a case-control study. BMC Oral Health. 2023 May 23;23(1):316.
26. Sethi M, Sood S, Sharma N, Singh A, Sharma P, Kukshal P. Oral health status and dental anomalies among children with congenital heart disease in contemporary times. Special Care in Dentistry. 2025 May;45(3):e12815.
27. Yavsan ZS, Tosun G, Sert A. Oral health-related quality of life of preschool-aged Turkish children with congenital heart disease. Dental and Medical Problems. 2022;59(4):503-8.
28. Kolçakoğlu K, Korkut Dİ, Yücel G, Kızılcı E. Dental approaches in children with congenital heart disease treated under general anesthesia for oral rehabilitation. Medicina Oral, Patología Oral y Cirugía Bucal. 2024 May 25;29(4):e451.
29. Joy A, Gopichandran L, Venkatesan L, Gupta SK, Bansal K, Mathur VP, Handa A. Impact of mobile application-based oral hygiene education on parental knowledge, attitudes, practices, and oral

hygiene of children with congenital heart disease. Annals of Pediatric Cardiology. 2025 Jul 1;18(4):365-74.

30. Aksakal SD, Guven Y, Topcuoglu N, Kulekci G, Aktoren O. Assessment of oral bacteria potentially associated with the mobile microbiome in children with congenital heart disease. Journal of Clinical Pediatric Dentistry. 2024 Mar 1;48(2).
31. Schulz-Weidner N, Logeswaran T, Jux C, Schlenz MA, Krämer N, Bulski JC. Evaluation of the effectiveness of an interdisciplinary preventive oral hygiene program for children with congenital heart disease. International Journal of Environmental Research and Public Health. 2021 Mar 28;18(7):3497.
32. Moussa C, Savard G, Estrade L, Bourgi R, Kharouf N, Denis F, Daou MH. Dental Health in Children with Congenital Heart Defects: A Systematic Review and Meta-Analysis. J Clin Med. 2024;13(23):7022. doi:10.3390/jcm13237022
33. SAJADI FS, TORABINEJAD MH, TORABINEJAD F. Oral and dental health and related factors in children with congenital heart disease: A preliminary study.
34. Yavsan ZS, Tosun G, Sert A. Oral health-related quality of life of preschool-aged Turkish children with congenital heart disease. Dental and Medical Problems. 2022;59(4):503-8.
35. Pourmoghaddas Z, Meskin M, Sabri M, Tehrani MH, Najafi T. Dental caries and gingival evaluation in children with congenital heart disease. International journal of preventive medicine. 2018 Jan 1;9(1):52.
36. Cantekin K, Cantekin I, Torun Y. Comprehensive dental evaluation of children with congenital or acquired heart disease. Cardiology in the Young. 2013 Oct;23(5):705-10.
37. Franco E. Dental disease, caries related microflora and salivary of childre. N wit. H sev. Ere congenital cardiac sease: an ep dem ologlcal and oral microbial survey. Dent. 1996;18:228-35.
38. Halperson E, Shafir S, Fux-Noy A, Ram D, Eventov-Friedman S. Developmental defects of enamel in children born preterm. Frontiers in Pediatrics. 2022 Oct 13;10:1019586.
39. Seow WK. Developmental defects of enamel and dentine: challenges for basic science research and clinical management. Australian dental journal. 2014 Jun;59:143-54.
40. Schulz-Weidner N, Logeswaran T, Schlenz MA, Krämer N, Bulski JC. Parental awareness of oral health and nutritional behavior in children with congenital heart diseases compared to healthy children. International journal of environmental research and public health. 2020 Oct;17(19):7057.
41. Wilson W, Taubert KA, Gewitz M, Lockhart PB, Baddour LM, Levison M, Bolger A, Cabell CH, Takahashi M, Baltimore RS, Newburger JW. Prevention of infective endocarditis: guidelines from the American heart association: a guideline from the American heart association rheumatic fever, endocarditis, and Kawasaki disease committee, council on cardiovascular disease in the young, and the council on clinical cardiology, council on cardiovascular surgery and anesthesia, and the quality of care and outcomes research interdisciplinary working group. Circulation. 2007 Oct 9;116(15):1736-54.
42. Knirsch W, Nadal D. Infective endocarditis in congenital heart disease. European journal of pediatrics. 2011 Sep;170(9):1111-27.
43. Parahitiyawa NB, Jin LJ, Leung WK, Yam WC, Samaranayake LP. Microbiology of odontogenic bacteremia: beyond endocarditis. Clinical microbiology reviews. 2009 Jan;22(1):46-64.
44. Ghasemi Shayan R, Fatollahzadeh Dizaji M, Sajjadian F. Surgical and postoperative management of congenital heart disease: a systematic review of observational studies. Langenbeck's Archives of Surgery. 2025 Mar 31;410(1):113.
45. Karikoski E, Sarkola T, Blomqvist M. Oral health behavior during early childhood in children with major congenital heart defects. International Journal of Paediatric Dentistry. 2023 May;33(3):278-88.