

Efficacy of Dental Services for Reducing Adverse Events in Those Undergoing Insertion of Implantable Cardiovascular Devices



Main Points

- A search of the MEDLINE® database and professional society websites identified two primary research studies, four systematic reviews, and eight practice guidelines that addressed the benefits and harms of dental evaluation and treatment prior to the insertion of implantable cardiovascular devices other than surgically implanted prosthetic heart valves.
- Bleeding from tooth extractions may be less frequent if the extractions are performed prior to (rather than after) insertion of ventricular assist devices.
- The available evidence does not permit conclusions regarding the effect of pre-treatment dental care for preventing downstream infections related to any of these devices.
- Professional society guidelines endorse the provision of patient education on routine oral hygiene practices but have not recommended other pre-treatment dental care prior to insertion of these devices.
- Professional society guidelines recommend ongoing routine dental examinations for some patients treated with cardiovascular devices.



Background

Implantable devices are an important part of treatment regimens for serious cardiovascular disorders, and their use has steadily increased since the original development of vascular grafts and artificial heart valves in the 1950s. Implantable pacemakers were first used in the early 1960s, and a steady progression of increasingly sophisticated and effective devices have been introduced up until the present. Although relatively rare, infection of implanted devices can be a very serious complication, and prevention of infection is an important clinical priority.¹ Such infections are believed to be caused by seeding of the devices by bacteria that enter the body from other sites.²⁻⁴

Disorders of the teeth, gums, and their supporting structures are important threats to a person's overall health.⁵ The mouth is colonized with a large number of bacterial species, and several of these have been identified as being the source of infection in patients with underlying

structural defects of the heart, including prosthetic heart valves and other prosthetic materials.^{2, 4, 6, 7} The identification and targeted treatment of foci of infection of the mouth potentially can reduce the incidence of infection of implanted cardiovascular devices. Some implantable devices also require routine anticoagulation, with a corresponding increased risk of bleeding complications. Bleeding is a potential complication of dental procedures such as tooth extractions, and anticoagulation increases the probability of bleeding following these procedures.⁸

Dental evaluation and treatment are carried out by healthcare professionals, but financial barriers can impede access to dental services. In 2015, the percentage of people in the United States with no dental insurance was 29% overall and 62% for older adults.⁹ The number of people lacking dental insurance is triple the rate of those lacking medical insurance, and there are serious gaps in the U.S. safety net system for providing dental care to uninsured adults and children.¹⁰ Optimizing insurance coverage for necessary clinical and dental services is an important priority.¹¹

Programs overseen by the Centers for Medicare & Medicaid Services (CMS) are major components of the U.S. health insurance system. Medicaid and the Children's Health Insurance Program (CHIP) are administered by States under broad Federal guidelines. States are required to provide dental benefits to Medicaid and CHIP-enrolled children, but States choose whether to provide dental benefits for adults. Medicare generally does not cover most dental services. While the statutes that define Medicare policies do not permit payment for most types of dental care, they have allowed some exceptions when dental care is closely tied to the outcomes of complex medical procedures.¹² For example, in the CY 2023 Physician Fee Schedule Final Rule (87 FR 70198), CMS finalized a policy to permit payment for certain dental services, such as dental examinations, including necessary treatment, performed as part of a comprehensive workup prior to organ transplant surgery, or prior to cardiac valve replacement or valvuloplasty procedures, that are similarly inextricably linked to certain other covered medical services.¹³ However, this payment policy does not authorize payment for dental care administered to patients who receive implanted cardiac devices other than prosthetic valves.

The rationale for performing a thorough dental evaluation before implantation of cardiac devices is twofold. The first is that examination by a dentist can identify local sources of active infection, such as oral abscesses or infected teeth or gums. By then treating those foci, the bacterial load in the mouth can be reduced. The second rationale is to provide teaching to the patient on proper daily self-care of the teeth and gums through brushing and flossing. Such daily maintenance can minimize the overgrowth of pathogenic bacteria in the mouth and deter progression of dental disease that could contribute to transient bacteremia and seeding of the implanted device. Unless there is great urgency to insert the device, it can be safe and feasible to incorporate a dental examination, local treatment, and patient education components into one or two dental visits prior to the implantation procedure.¹⁴⁻¹⁶

We sought to assemble and evaluate the published evidence supporting the efficacy of specific types of dental care that are intended to reduce adverse event rates in patients who receive implanted cardiac devices other than surgical prosthetic valves. If the evidence base is judged to be sufficient, this information potentially can inform policy initiatives (including changes to Medicare payment policies) that can improve access to specific dental services for people with serious or life-threatening cardiac disorders. The primary question for this review is: *For those undergoing insertion of implantable cardiovascular devices, does dental care prior to the treatment improve adverse event rates and other relevant outcomes?*

Methods

The goal of this Rapid Response report was to identify evidence pertinent to the efficacy of dental evaluation prior to the insertion of certain kinds of medical devices used to treat cardiovascular conditions. The medical devices addressed in this report include:

- Ventricular assist devices
- Artificial pacemakers
- Implantable defibrillators
- Transcatheter artificial heart valves
- Synthetic vascular grafts and patches
- Coronary and vascular stents

We reviewed peer-reviewed literature and professional guidelines from the last 50 years to identify research and standards of practice on the need for and effectiveness of dental screening and pretreatment prior to the insertion of cardiovascular devices. A medical librarian with extensive experience conducting searches for systematic and rapid reviews developed and conducted a literature search of Ovid MEDLINE ALL in March 2023 (Appendix A). Our review of the search results focused on identifying primary research studies, systematic reviews, and clinical guidelines published by professional societies. We also scanned the reference lists of all included studies.

One team member reviewed each title and abstract. A comparison group (patients who did not receive pre-treatment dental care) was not a criterion for including a study. We excluded reports of small numbers of patients (such as case reports) and studies that reported on patients treated only with surgically implanted cardiac valves. We included systematic reviews that addressed the effectiveness of dental care prior to insertion of cardiovascular devices. Each study included at the abstract review stage was then reviewed in full text to determine its final suitability for inclusion in this report.

Any published papers on clinical practice guidelines pertaining to the use of implantable cardiac devices were identified in review of the MEDLINE search results. We also searched for practice guidelines through review of the literature references of all included primary studies and systematic reviews. To find additional relevant practice guidelines, we conducted a gray literature search using the websites of the [American College of Cardiology](#), [American Dental Association](#), [American Heart Association](#), [Centers for Disease Control and Prevention \(CDC\)](#), [Cochrane](#), [European Society of Cardiology](#), [Heart Rhythm Society](#), [National Heart Lung and Blood Institute \(NHLBI\)](#), [National Institute for Health and Care Excellence \(NICE\)](#), and [Society for Cardiovascular Angiography & Interventions](#). Because it is a repository of evidence syntheses on a variety of clinical topics, we also searched [Cochrane](#) for evidence summaries. All sites were searched for the following terms: dental, dentistry, oral, teeth, gingivitis, cavities, cavity, and caries. All results of these searches were reviewed at the title/abstract level, and any potentially relevant guidelines were then reviewed at the full-text level by one reviewer.

We evaluated each included primary research study for its study design, using the categories of randomized controlled trial (RCT), prospective cohort, retrospective cohort, or registry-based study. For studies that were not RCTs, we recorded whether the statistical analysis had used methods to adjust for confounding, such as matching or propensity score methods. For

systematic reviews, we summarized the date ranges of the search, the primary conclusions, and any strength of evidence assessments that were performed.

All reported patient outcomes in the included studies were recorded. We did not perform quantitative meta-analysis of the included primary research studies. Instead, we conducted a narrative synthesis of all included studies for this report.

Results

The literature search yielded 386 records. The review of titles, abstracts, and full-text yielded two primary research studies and four systematic reviews.¹⁷⁻²³ All of the included articles were published since 2017. One primary study¹⁷ was funded by the Japan Society for Promotion of Science; the other primary study¹⁸ reported no source of funding. One systematic review¹⁹ was funded by the American Dental Association; the other three systematic reviews reported no funding source.^{20, 22, 23} Table 1 summarizes the research designs, major results, and patient populations of the two included primary studies. No randomized controlled trials were identified, and the two included primary studies both had retrospective cohort designs. One study was conducted in the United States,¹⁸ and one was conducted in Japan.¹⁷ Neither study used statistical methods to control for confounding between the comparison groups.

The gray literature search identified 41 practice guidelines or recommendations, of which 19 addressed patient populations and devices relevant to the topic of this report (Appendix B).²⁴⁻⁴²

Both of the primary research studies^{17, 18} and two systematic reviews^{19, 23} examined the association between dental problems and clinical outcomes in patients who received ventricular assist devices (VADs). The primary research studies both had modest sample sizes (Table 1). Both studies examined rates of intraoral bleeding occurring after dental treatment and also after the implantation of VADs. The study conducted in Japan¹⁷ compared 17 patients who underwent tooth extractions prior to insertion of the VAD with 11 patients who underwent tooth extractions after the VAD insertion. Only bleeding that persisted after the day of the tooth extraction was counted as a bleeding complication, and the study did not report how long the patients were monitored for bleeding beyond the first postoperative day. The rate of bleeding was significantly ($p = 0.001$) lower in the group who had the dental procedure prior to VAD insertion (13% versus 67%). In the U.S. study,¹⁸ all 88 patients underwent dental examinations prior to VAD insertion and then were stratified by whether invasive dental treatment was required and performed. The patients were monitored for signs of bleeding during the 31 days following the initial dental evaluation. Of the patients who underwent dental treatment, the mean time between dental treatment and VAD insertion was 19.87 days, so anticoagulation regimens may have varied during the 31-day followup period. Intraoral bleeding was higher in the group who received dental treatment (7% rate). Because it did not include a comparison group of patients with similar dental disorders, this second study does not define whether the dental treatment affected rates of adverse events following VAD insertion.

A systematic review¹⁹ sought studies examining the efficacy of dental care prior to either surgical cardiac valve replacement or VAD insertion. While the review identified six studies addressing valve replacement, it identified no relevant studies addressing VAD insertion. In its evaluation of the evidence on dental care prior to surgical valve replacement, this review found that evidence was inconsistent on whether dental care prior to surgical valve replacement

lowered rates of mortality, infectious endocarditis, postsurgical infection, or hospital length of stay.^{23, 43} Surgically implanted cardiac valves have mechanical characteristics similar to valves that are inserted using a transcatheter technique.²¹ A systematic review has examined strategies for preventing infectious endocarditis in patients who undergo transcatheter aortic valve implantation (TAVI).²⁰ It describes consensus on use of prophylactic antibiotics during the TAVI procedure but does not address evidence on the efficacy of dental care prior to the procedure.^{19, 21}

A systematic review²³ examined whether standardized protocols for dental evaluation have been defined for patients who will undergo VAD insertion. It found that only one published study had described a protocol. That study⁴³ was published in 2002, and no other studies have described adoption of its protocol for use prior to VAD insertion. Another systematic review²² searched for articles describing outcomes, guidelines, or protocols for dental care prior to a wide range of cardiovascular procedures. It included 44 publications in its analysis, but these included narrative reviews and letters to the editor as well as primary studies. Only two of the publications were primary studies examining dental care prior to cardiac procedures addressed in this review.^{44, 45} These studies reported the results of the dental evaluations but provided no data on clinical outcomes after the patients underwent vascular procedures. The systematic review concluded that there is some evidence supporting recommendations for pre-treatment dental care for surgical valve replacement and cardiac transplantation but no evidence supporting pre-treatment dental care prior to insertion of other cardiovascular devices.

Table 1. Table of included studies

Author, Year Country	Outcome	Design	Rate of Outcome in Dental Care Group	Rate of Outcome in Control Group	Total N	Cardiac Conditions	Cardiac Treatments	Key Findings
Mincer, 2022 ¹⁸ United States	Any intraoral bleeding	Retrospective cohort	7%	1%	88	End-stage heart failure and eligible for cardiac transplantation	VADs	All patients received pre-procedure dental evaluation. The two comparison groups were defined by whether dental treatment was or was not administered. Not all included patients received VADs. The bleeding rate was significantly ($p = 0.001$) higher in the dental treatment group.
Kobayashi, 2020 ¹⁷ Japan	Intraoral bleeding after tooth extraction	Retrospective cohort	13%	67%	28	Cardiomyopathies	VADs	Only patients who required tooth extraction were included and were stratified by whether the extraction occurred before or after insertion of the VAD. The bleeding rate was significantly ($p = 0.001$) lower in the group that had extraction prior to VAD insertion.

Abbreviation: VAD=ventricular assist device.

Our searches identified 19 practice guidelines or recommendations that address relevant cardiac conditions and procedures.²⁴⁻⁴² Of these, eight provide recommendations on the prevention of serious infection for patients with implantable cardiac devices and other cardiac conditions that are susceptible to serious infection (Appendix B).^{24, 27, 30-35} The cardiac conditions addressed in the guidelines include congenital heart disease, valvular heart disease, infective endocarditis, vascular graft infections, cardiac arrhythmias, heart failure, and other less common conditions.

Five guidelines were produced for the American Heart Association.^{24, 26, 29, 34, 35} Topics for these clinical practice guidelines were prevention of viridans group streptococcal infective endocarditis, management of cardiovascular implantable electronic device infections, and vascular graft infections. Three guidelines were produced jointly between the American College of Cardiology and the American Heart Association.^{32, 33, 38} Topics for these clinical practice guidelines were the management of patients with valvular heart disease and adults with congenital heart disease. Three guidelines were produced for a collaboration between the American College of Cardiology, the American Heart Association, and the Heart Rhythm Society.^{36, 37, 39} All of these addressed cardiac rhythm abnormalities. Two guidelines were produced for the European Society of Cardiology.^{25, 28} These addressed cardiac pacing and emergency management of patients with left ventricular assist devices (LVADs). One guideline addressing medical clearance for common dental procedures was produced for the American Academy of Family Physicians.³⁰ One guideline addressing heart failure was produced by a collaboration of the American Heart Association, the American College of Cardiology, and the Heart Failure Society of America.⁴² One guideline was produced jointly for the American College of Cardiology, the American Heart Association, and the North American Society for Pacing and Electrophysiology.⁴¹ This guideline addressed pacemaker implantation. One guideline on transcatheter mitral valve interventions was produced by the American Association for Thoracic Surgery, the American College of Cardiology, the Society for Cardiovascular Angiography and Interventions, and the Society for Thoracic Surgeons.⁴⁰ A guideline and a related evidence summary were produced for Cochrane and NICE in the UK.^{27, 31} These addressed antibiotic prophylaxis use for the prevention of infective endocarditis.

Authors of all of the guidelines cited a lack of clinical trial evidence on which to base their recommendations. Therefore, guideline writing groups identified case series, observational studies, and expert opinion as the basis for their recommendations. None of the guidelines recommend specific dental treatments prior to insertion of cardiovascular devices. However, four guidelines and an evidence summary called for improved oral health overall, and education and instruction of cardiac patients in routine oral health practices.^{27, 31-33, 35} Two guidelines also recommended regular or biannual dental examinations as a strategy for preventing infectious endocarditis.^{32, 35}



Discussion

To prepare this Rapid Response, a thorough search of the MEDLINE database compiled all relevant published studies through March 2023. The evidence base includes two primary research studies that have relatively small sample sizes and used retrospective cohort designs.^{17, 18} Both of these studies examined the relationship between dental procedures and bleeding occurrence among patients who receive ventricular assist devices. At this time, reduction of bleeding from dental work is the strongest evidence-based rationale for provision of dental care immediately prior to the insertion of VADs. Our MEDLINE search also identified one systematic review addressing dental care in patients who undergo insertion of transcatheter prosthetic heart valves and one other systematic review that synthesized evidence for surgically implanted prosthetic valves.^{19, 20} These reviews did not identify

strong evidence supporting the necessity of dental care (other than routine prophylactic antibiotics) prior to the valve procedures.

A frequently used category of implanted cardiac devices is artificial pacemakers and implantable defibrillators, of which more than one million are inserted worldwide every year.²⁸ A cross-sectional analysis using a large nationwide database in South Korea found that dental procedures following implantation of the devices are associated with new episodes of endocarditis.⁴⁶ However, our MEDLINE search identified no studies evaluating the efficacy of pre-insertion dental care for patients receiving these devices, and recently published guidelines do not include recommendations for such dental care.²⁸

Artificial materials are also used in the treatment of other vascular disorders. These devices include vascular stents and grafts. Our MEDLINE search identified no primary studies or systematic reviews on the efficacy of dental care for preventing complications in patients receiving these devices. Dental care has been addressed in a recently published clinical practice guideline that included the following position statement:

A variety of other prosthetic cardiovascular devices deserve comment. These include cardiovascular implantable electronic devices; septal defect closure devices (when there is complete defect closure); peripheral vascular grafts and patches, including those used for hemodialysis and coronary and other vascular stents; central nervous system ventriculoatrial shunts; vena caval filters; and pledgets. Infections of these devices are rare, and when they occur, most cases are caused by staphylococci. Therefore, AP [antibiotic prophylaxis] for a dental procedure in these patients is not suggested.³⁵

While this statement does not directly address dental care prior to procedures for implanting these devices, it implies that the efficacy of such dental care is likely to be low.

Cardiac transplantation is a definitive treatment for end-stage heart failure, and evidence supports the efficacy of pre-transplant dental evaluation and treatment for preventing complications following the transplant.^{22, 47} An important difference between heart transplantation and the use of artificial cardiovascular devices is that immunosuppressive drugs are used to prevent organ rejection after the transplant procedure. Impaired immunity increases the risk of serious infections that can lead to prolonged hospitalizations and patient morbidity.⁴⁸ Two comparative studies have examined the impact of pre-treatment dental care on the rate of serious infections in patients administered immunosuppressive drugs for treatment of malignancies, and both showed a significantly lower infection rate in the patients who had received pre-treatment dental care.^{14, 49} Immunosuppression may be an important mediating factor for demonstrating the efficacy of pre-treatment dental care in patients who receive various invasive treatments for their cardiac conditions.

After implantation of cardiovascular devices, there is an ongoing risk of device infection,⁷ and prophylactic antibiotics have often been recommended for patients who undergo subsequent dental procedures.³ This Rapid Response was not scoped to evaluate primary research studies on the efficacy of prophylactic antibiotics, but our guideline review highlighted a long-standing controversy in the field regarding which patients should and should not be provided a course of prophylactic antibiotics prior to dental treatment. Historically, prophylactic antibiotics were used for the majority of patients perceived to be at risk for infective endocarditis. In the last 15 years, NICE, in the UK, has recommended ceasing all such prophylaxis,³¹ while others have focused on identifying which patients may actually benefit from this practice.^{27, 33, 35} Most guideline writing groups now agree that only those patients at highest

risk of developing infective endocarditis should be given prophylaxis prior to elective dental interventions,^{27, 32, 35} yet there is still professional debate as to which patients are actually high risk.

Dental care can include a fairly broad range of dental services as part of pre-treatment dental programs. Practice guidelines addressing pre-treatment dental care for patients with cancer have advocated a combination of services that include thorough examinations, immediate treatment of serious abnormalities, and patient education.^{50, 51} However, it has not been possible to determine which of the components of the dental programs had greater or lesser impact. Systematic reviews addressing both ventricular assist devices and hematological cancers^{23, 52} noted the lack of consistency across studies in the specific components of recommended patient evaluation and dental treatments. However, the recommended regimens have generally included physical examinations by a dentist, plaque removal, other treatments that are targeted at local foci of infection, and training of patients on daily dental hygiene.

This Rapid Response has addressed bleeding and infectious outcomes whose incidence or severity potentially can be reduced by an episode of pre-treatment dental care. While the current evidence base has limitations, it does provide guidance on when dental care may be beneficial in the care of people with certain types of cardiovascular disorders that are treated with artificial devices. The linkages between dental care and treatment with implantable cardiovascular devices (and the benefits of linking such care) are summarized in Appendix C. While the evidence of efficacy for dental care prior to device insertion is limited to a narrow segment of the devices (VADs and transcatheter artificial heart valves), clinical practice guidelines suggest that ongoing oral hygiene regimens and routine dental examinations after the implantation procedures can be beneficial.



References

1. Kouijzer JJP, Noordermeer DJ, van Leeuwen WJ, et al. Native valve, prosthetic valve, and cardiac device-related infective endocarditis: A review and update on current innovative diagnostic and therapeutic strategies. *Front Cell Dev Biol*. 2022;10:995508. doi: <https://dx.doi.org/10.3389/fcell.2022.995508>. PMID: 36263017.
2. Chirillo F, Faggiano P, Cecconi M, et al. Predisposing cardiac conditions, interventional procedures, and antibiotic prophylaxis among patients with infective endocarditis. *Am Heart J*. 2016 09;179:42-50. doi: <https://dx.doi.org/10.1016/j.ahj.2016.03.028>. PMID: 27595678.
3. Bumm CV, Folwaczny M. Infective endocarditis and oral health-a Narrative Review. *Cardiovasc*. 2021 Dec;11(6):1403-15. doi: <https://dx.doi.org/10.21037/cdt-20-908>. PMID: 35070809.
4. Khaledi M, Sameni F, Afkhami H, et al. Infective endocarditis by HACEK: a review. *J Cardiothorac Surg*. 2022 Aug 19;17(1):185. doi: <https://dx.doi.org/10.1186/s13019-022-01932-5>. PMID: 35986339.
5. Kane SF. The effects of oral health on systemic health. *Gen Dent*. 2017 Nov-Dec;65(6):30-4. PMID: 29099363.
6. Suzuki Y, Daitoku K, Minakawa M, et al. Infective endocarditis with congenital heart disease. *Jpn J Thorac Cardiovasc Surg*. 2006 Jul;54(7):297-300. PMID: 16898644.
7. Di Filippo S, Delahaye F, Semiond B, et al. Current patterns of infective endocarditis in congenital heart disease. *Heart*. 2006 Oct;92(10):1490-5. PMID: 16818488.
8. Yagyu T, Kawakami M, Ueyama Y, et al. Risks of postextraction bleeding after receiving direct oral anticoagulants or warfarin: a retrospective cohort study. *BMJ Open*. 2017 Aug 21;7(8):e015952. doi: <https://dx.doi.org/10.1136/bmjopen-2017-015952>. PMID: 28827248.
9. Manski RJ, Rohde MA. Dental Services: Use, Expenses, Source of Payment, Coverage and Procedure Type, 1996–2015: Research Findings No. 38. Rockville, MD: Quality AfHRA; 2017. https://meps.ahrq.gov/mepsweb/data_files/publications/rf38/rf38.pdf
10. National Institutes of Health. Oral Health in America: Advances and Challenges. Bethesda (MD); 2021. <https://www.nidcr.nih.gov/research/oralhealthinamerica>.
11. Kufra K, Forman M, Swisher-McClure S, et al. Pre-Radiation dental considerations and management for head and neck cancer patients. *Oral Oncol*. 2018 01;76:42-51. doi: <https://dx.doi.org/10.1016/j.oraloncology.2017.11.023>. PMID: 29290285.
12. Centers for Medicare and Medicaid Services. Medicare Dental Coverage. <https://www.cms.gov/Medicare/Coverage/MedicareDentalCoverage>. Accessed on 01/22/2023.
13. Centers for Medicare and Medicaid Services. Medicare and Medicaid Programs; CY 2023 Payment Policies Under the Physician Fee Schedule and Other Changes to Part B Payment and Coverage Policies; Medicare Shared Savings Program Requirements; Implementing Requirements for Manufacturers of Certain Single-dose Container or Single-use Package Drugs To Provide Refunds With Respect to Discarded Amounts; and COVID–19 Interim Final Rules. In: Department of Health and Human Services, editor: Federal Register; 2022.
14. Watson EE, Metcalfe JE, Kreher MR, et al. Screening for Dental Infections Achieves 6-Fold Reduction in Dental Emergencies During Induction Chemotherapy for Acute Myeloid Leukemia. *JCO Oncol Pract*. 2020 11;16(11):e1397-e405. doi: <https://dx.doi.org/10.1200/OP.20.00107>. PMID: 32609586.
15. National Cancer Institute. Oral Complications of Chemotherapy and Head/Neck Radiation (PDQ(R)): Health Professional Version. PDQ Cancer Information Summaries. Bethesda (MD); 2002. [Oral Complications of Chemotherapy and Head/Neck Radiation \(PDQ®\)–Health Professional Version - NCI \(cancer.gov\)](https://www.cancer.gov/pdq/cancer/oral_complications_of_chemotherapy_and_head_neck_radiation/health_professional_version).
16. Mincer RC, Zahr RH, Chung EM, et al. Pre-Cardiac Dental Treatment Does Not Increase the Risk of Adverse Events. *J Oral Maxillofac Surg*. 2022 Jan;80(1):22-8. doi: <https://dx.doi.org/10.1016/j.joms.2021.07.005>. PMID: 34363765.

17. Kobayashi Y, Imai Y, Mizutani S, et al. Opportune Time of Tooth Extraction in Individuals Requiring Ventricular Assist Device Implantation: A Retrospective Cohort Study. *J Oral Maxillofac Surg.* 2020 Nov;78(11):1921.e1-e9. doi: <https://dx.doi.org/10.1016/j.joms.2020.05.019>. PMID: 32574607.
18. Mincer RC, Zahr RH, Chung EM, et al. A retrospective chart review evaluating pre-operative dental extractions on patients with end-stage heart failure undergoing advanced surgical cardiac therapies. *Oral Surg Oral Med Oral Pathol Oral Radiol.* 2022 Dec;134(6):702-7. doi: <https://dx.doi.org/10.1016/j.oooo.2022.05.016>. PMID: 36229366.
19. Lockhart PB, DeLong HR, Lipman RD, et al. Effect of dental treatment before cardiac valve surgery: Systematic review and meta-analysis. *J Am Dent Assoc.* 2019 09;150(9):739-47.e9. doi: <https://dx.doi.org/10.1016/j.adaj.2019.04.024>. PMID: 31439203.
20. Ostergaard L, Lauridsen TK, Iversen K, et al. Infective endocarditis in patients who have undergone transcatheter aortic valve implantation: a review. *Clin Microbiol Infect.* 2020 Aug;26(8):999-1007. doi: <https://dx.doi.org/10.1016/j.cmi.2020.01.028>. PMID: 32036048.
21. Russo M, Taramasso M, Guidotti A, et al. The evolution of surgical valves. *Cardiovascular Medicine.* 2017 12/20/2017;20(12):285-92. doi: <https://doi.org/10.4414/cvm.2017.00532>.
22. Cotti E, Arrica M, Di Lenarda A, et al. The perioperative dental screening and management of patients undergoing cardiothoracic, vascular surgery and other cardiovascular invasive procedures: A systematic review. *Eur J Prev Cardiol.* 2017 03;24(4):409-25. doi: <https://dx.doi.org/10.1177/2047487316682348>. PMID: 28094561.
23. Javed F, Khan J, Youssef M, et al. Dental management of patients with congestive heart failure before and after implantation of ventricular assist devices: linking the missing protocol. *Scand Cardiovasc J.* 2020 Aug;54(4):206-11. doi: <https://dx.doi.org/10.1080/14017431.2020.1742368>. PMID: 32188268.
24. Baddour LM, Epstein AE, Erickson CC, et al. Update on cardiovascular implantable electronic device infections and their management: a scientific statement from the American Heart Association. *Circulation.* 2010 Jan 26;121(3):458-77. doi: <https://dx.doi.org/10.1161/CIRCULATIONAHA.109.192665>. PMID: 20048212.
25. Ben Gal T, Ben Avraham B, Milicic D, et al. Guidance on the management of left ventricular assist device (LVAD) supported patients for the non-LVAD specialist healthcare provider: executive summary. *Eur J Heart Fail.* 2021 Oct;23(10):1597-609. doi: <https://dx.doi.org/10.1002/ehf.2327>. PMID: 34409711.
26. Fordyce CB, Katz JN, Alviar CL, et al. Prevention of Complications in the Cardiac Intensive Care Unit: A Scientific Statement From the American Heart Association. *Circulation.* 2020 Dec;142(22):e379-e406. doi: <https://dx.doi.org/10.1161/CIR.0000000000000909>. PMID: 33115261.
27. Rutherford SJ, Glenny AM, Roberts G, et al. Antibiotic prophylaxis for preventing bacterial endocarditis following dental procedures. *Cochrane Database Syst Rev.* 2022 May 10;5(5):CD003813. doi: <https://dx.doi.org/10.1002/14651858.CD003813.pub5>. PMID: 35536541.
28. Glikson M, Nielsen JC, Kronborg MB, et al. 2021 ESC Guidelines on cardiac pacing and cardiac resynchronization therapy. *Eur Heart J.* 2021 Sep 14;42(35):3427-520. doi: <https://dx.doi.org/10.1093/eurheartj/ehab364>. PMID: 34455430.
29. Gopinathannair R, Cornwell WK, Dukes JW, et al. Device Therapy and Arrhythmia Management in Left Ventricular Assist Device Recipients: A Scientific Statement From the American Heart Association. *Circulation.* 2019 May 14;139(20):e967-e89. doi: <https://dx.doi.org/10.1161/CIR.0000000000000673>. PMID: 30943783.
30. Herrick KR, Terrio JM, Herrick C. Medical Clearance for Common Dental Procedures. *Am Fam Physician.* 2021 Nov 1;104(5):476-83. PMID: 34783493.

31. National Institute for Health and Care Excellence. Prophylaxis Against Infective Endocarditis: Antimicrobial Prophylaxis Against Infective Endocarditis in Adults and Children Undergoing Interventional Procedures. London: 2008. <https://www.ncbi.nlm.nih.gov/pubmed/21656971>
32. Nishimura RA, Otto CM, Bonow RO, et al. 2017 AHA/ACC Focused Update of the 2014 AHA/ACC Guideline for the Management of Patients With Valvular Heart Disease: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. *J Am Coll Cardiol*. 2017 Jul 11;70(2):252-89. doi: <https://dx.doi.org/10.1016/j.jacc.2017.03.011>. PMID: 28315732.
33. Warnes CA, Williams RG, Bashore TM, et al. ACC/AHA 2008 Guidelines for the Management of Adults with Congenital Heart Disease: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (writing committee to develop guidelines on the management of adults with congenital heart disease). *Circulation*. 2008 Dec 2;118(23):e714-833. doi: <https://dx.doi.org/10.1161/CIRCULATIONAHA.108.190690>. PMID: 18997169.
34. Wilson WR, Bower TC, Creager MA, et al. Vascular Graft Infections, Mycotic Aneurysms, and Endovascular Infections: A Scientific Statement From the American Heart Association. *Circulation*. 2016 Nov 15;134(20):e412-e60. doi: <https://dx.doi.org/10.1161/CIR.0000000000000457>. PMID: 27737955.
35. Wilson WR, Gewitz M, Lockhart PB, et al. Prevention of Viridans Group Streptococcal Infective Endocarditis: A Scientific Statement From the American Heart Association. *Circulation*. 2021 05 18;143(20):e963-e78. doi: <https://dx.doi.org/10.1161/CIR.0000000000000069>. PMID: 33853363.
36. Epstein AE, DiMarco JP, Ellenbogen KA, et al. 2012 ACCF/AHA/HRS focused update incorporated into the ACCF/AHA/HRS 2008 guidelines for device-based therapy of cardiac rhythm abnormalities: a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines and the Heart Rhythm Society. *J Am Coll Cardiol*. 2013 Jan 22;61(3):e6-75. doi: <https://dx.doi.org/10.1016/j.jacc.2012.11.007>. PMID: 23265327.
37. Kusumoto FM, Schoenfeld MH, Barrett C, et al. 2018 ACC/AHA/HRS Guideline on the Evaluation and Management of Patients With Bradycardia and Cardiac Conduction Delay: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines and the Heart Rhythm Society. *Circulation*. 2019 Aug 20;140(8):e382-e482. doi: <https://dx.doi.org/10.1161/CIR.0000000000000028>. PMID: 30586772.
38. Antman EM, Anbe DT, Armstrong PW, et al. ACC/AHA guidelines for the management of patients with ST-elevation myocardial infarction: A report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee to Revise the 1999 Guidelines for the Management of patients with acute myocardial infarction). *J Am Coll Cardiol*. 2004 Aug 4;44(3):E1-E211. doi: <https://dx.doi.org/10.1016/j.jacc.2004.07.014>. PMID: 15358047.
39. Al-Khatib SM, Stevenson WG, Ackerman MJ, et al. 2017 AHA/ACC/HRS guideline for management of patients with ventricular arrhythmias and the prevention of sudden cardiac death: Executive summary: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines and the Heart Rhythm Society. *Heart Rhythm*. 2018 Oct;15(10):e190-e252. doi: <https://dx.doi.org/10.1016/j.hrthm.2017.10.035>. PMID: 29097320.
40. Bonow RO, O'Gara PT, Adams DH, et al. Multisociety expert consensus systems of care document 2019 AATS/ACC/SCAI/STS expert consensus systems of care document: Operator and institutional recommendations and requirements for transcatheter mitral valve intervention: A Joint Report of the American Association for Thoracic Surgery, the American College of Cardiology, the Society for Cardiovascular Angiography and Interventions, and the Society of Thoracic Surgeons. *Catheter Cardiovasc Interv*. 2020 Apr 1;95(5):866-84. doi: <https://dx.doi.org/10.1002/ccd.28671>. PMID: 31841613.

41. Gregoratos G, Abrams J, Epstein AE, et al. ACC/AHA/NASPE 2002 guideline update for implantation of cardiac pacemakers and antiarrhythmia devices: summary article. A report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (ACC/AHA/NASPE Committee to Update the 1998 Pacemaker Guidelines). *J Cardiovasc Electrophysiol*. 2002 Nov;13(11):1183-99. doi: <https://dx.doi.org/10.1046/j.1540-8167.2002.01183.x>. PMID: 12475117.
42. Heidenreich PA, Bozkurt B, Aguilar D, et al. 2022 AHA/ACC/HFSA Guideline for the Management of Heart Failure: A Report of the American College of Cardiology/American Heart Association Joint Committee on Clinical Practice Guidelines. *J Am Coll Cardiol*. 2022 May 3;79(17):e263-e421. doi: <https://dx.doi.org/10.1016/j.jacc.2021.12.012>. PMID: 35379503.
43. Lund JP, Drews T, Hetzer R, et al. Oral surgical management of patients with mechanical circulatory support. *Int J Oral Maxillofac Surg*. 2002 Dec;31(6):629-33. doi: <https://dx.doi.org/10.1054/ijom.2002.0228>. PMID: 12521320.
44. Silvay G. Day admission for thoracic aortic surgery. *HSR Proc Intensive Care Cardiovasc Anesth*. 2010;2(1):40-2. PMID: 23440073.
45. Stansby G, Byrne MT, Hamilton G. Dental infection in vascular surgical patients. *Br J Surg*. 1994 Aug;81(8):1119-20. doi: <https://dx.doi.org/10.1002/bjs.1800810812>. PMID: 7953335.
46. Kim JY, Park SJ, Lee SH, et al. Risk of infective endocarditis associated with invasive dental procedures in patients with cardiac rhythm devices. *Europace*. 2022 Dec 09;24(12):1967-72. doi: <https://dx.doi.org/10.1093/europace/euac086>. PMID: 35696285.
47. Meyer U, Weingart D, Deng MC, et al. Heart transplants--assessment of dental procedures. *Clin Oral Investig*. 1999 Jun;3(2):79-83. PMID: 10803115.
48. Kuderer NM, Dale DC, Crawford J, et al. Mortality, morbidity, and cost associated with febrile neutropenia in adult cancer patients. *Cancer*. 2006 May 15;106(10):2258-66. doi: <https://dx.doi.org/10.1002/cncr.21847>. PMID: 16575919.
49. Greenberg MS, Cohen SG, McKittrick JC, et al. The oral flora as a source of septicemia in patients with acute leukemia. *Oral Surg Oral Med Oral Pathol*. 1982 Jan;53(1):32-6. PMID: 6948251.
50. Elad S, Raber-Durlacher JE, Brennan MT, et al. Basic oral care for hematology-oncology patients and hematopoietic stem cell transplantation recipients: a position paper from the joint task force of the Multinational Association of Supportive Care in Cancer/International Society of Oral Oncology (MASCC/ISOO) and the European Society for Blood and Marrow Transplantation (EBMT). *Support Care Cancer*. 2015 Jan;23(1):223-36. doi: <https://dx.doi.org/10.1007/s00520-014-2378-x>. PMID: 25189149.
51. Yarom N, Shapiro CL, Peterson DE, et al. Medication-Related Osteonecrosis of the Jaw: MASCC/ISOO/ASCO Clinical Practice Guideline. *J Clin Oncol*. 2019 Sep 1;37(25):2270-90. doi: <https://dx.doi.org/10.1200/JCO.19.01186>. PMID: 31329513.
52. Abed H, Alhabshi M, Alkhayal Z, et al. Oral and dental management of people with myelodysplastic syndromes and acute myeloid leukemia: A systematic search and evidence-based clinical guidance. *Spec Care Dentist*. 2019 Jul;39(4):406-20. doi: <https://dx.doi.org/10.1111/scd.12384>. PMID: 31087570.

Funding, Authors, and Disclosures

Investigators:

David H. Hickam, M.D., M.P.H.

Cathy J. Gordon, M.P.H.

Charlotte E. Armstrong, B.A.

Robin Paynter, M.L.I.S.

Acknowledgments: The authors thank Dr. Jonathan Treadwell, who served as Associate Editor for this review.

This report is based on research conducted by the Scientific Resource Center for the Agency for Healthcare Research and Quality (AHRQ) Effective Health Care Program under contract to AHRQ, Rockville, MD (Contract No. 75Q80122C00002). The findings and conclusions in this document are those of the authors, who are responsible for its contents; the findings and conclusions do not necessarily represent the views of AHRQ. Therefore, no statement in this report should be construed as an official position of AHRQ or of the U.S. Department of Health and Human Services.

This Rapid Response was prepared by the AHRQ Evidence-based Practice Center (EPC) Program using streamlined literature review methods to assist end-users in making specific decisions in a limited timeframe. To shorten timelines, reviewers made strategic choices about which processes to abridge compared to a comprehensive systematic review. The adaptations made for expediency may limit the certainty and generalizability of the findings from the review.

None of the investigators have any affiliations or financial involvement that conflicts with the material presented in this report.

The information in this report is intended to help healthcare decision makers—patients and clinicians, health system leaders, and policymakers, among others—make well-informed decisions and thereby improve the quality of healthcare services. This report is not intended to be a substitute for the application of clinical judgment. Anyone who makes decisions concerning the provision of clinical care should consider this report in the same way as any medical reference and in conjunction with all other pertinent information, i.e., in the context of available resources and circumstances presented by individual patients.

This report is made available to the public under the terms of a licensing agreement between the author and the Agency for Healthcare Research and Quality. Most AHRQ documents are publicly available to use for noncommercial purposes (research, clinical or patient education, quality improvement projects) in the United States, and do not need specific permission to be reprinted and used unless they contain material that is copyrighted by others. Specific written permission is needed for commercial use (reprinting for sale, incorporation into software, incorporation into for-profit training courses) or for use outside of the U.S. If organizational policies require permission to adapt or use these materials, AHRQ will provide such permission in writing.

AHRQ or U.S. Department of Health and Human Services endorsement of any derivative products that may be developed from this report, such as clinical practice guidelines, other quality enhancement tools, or reimbursement or coverage policies, may not be stated or implied.

Role of the Funding Source: Funding for this review was provided by AHRQ. The funding source assigned the topic and provided comments on draft manuscripts but was not involved in data collection, analysis, manuscript preparation, or addressing comments from reviewers.

AHRQ appreciates appropriate acknowledgment and citation of its work. Suggested language for acknowledgment: This work was based on an evidence report, Efficacy of Dental Services for Reducing Adverse Events in Those Undergoing Insertion of Implantable Cardiovascular Devices, by the Scientific Resource Center for the AHRQ EPC Program.

Suggested citation: Hickam DH, Gordon CJ, Armstrong CE, Paynter R. Efficacy of Dental Services for Reducing Adverse Events in Those Undergoing Insertion of Implantable Cardiovascular Devices. Rapid Response. (Prepared by the Scientific Resource Center under Contract No. 75Q80122C00002.) AHRQ Publication No. 23-EHC020. Rockville, MD: Agency for Healthcare Research and Quality; July 2023. DOI: <https://doi.org/10.23970/AHRQEPCRAPIDDENTALCARDIO>. Posted final reports are located on the Effective Care Program [search page](#).

Afterword

Recognized for excellence in conducting comprehensive systematic reviews, the Agency for Healthcare Research and Quality (AHRQ) Evidence-based Practice Center (EPC) Program is developing a range of rapid evidence products to assist end-users in making specific decisions in a limited timeframe.

To shorten timelines, reviewers make strategic choices about which review processes to abridge. However, the adaptations made for expediency may limit the certainty and generalizability of the findings from the review, particularly in areas with a large literature base. Transparent reporting of the methods used and the resulting limitations of the evidence synthesis are extremely important.

AHRQ expects that these rapid evidence products will be helpful to health plans, providers, purchasers, government programs, and the healthcare system as a whole. Transparency and stakeholder input are essential to the Effective Health Care Program.

If you have comments on this report, they may be sent by mail to the Task Order Officer named below at: Agency for Healthcare Research and Quality, 5600 Fishers Lane, Rockville, MD 20857, or by email to epc@ahrq.hhs.gov.

Robert Otto Valdez, Ph.D., M.H.S.A.
Director
Agency for Healthcare Research and Quality

Craig A. Umscheid, M.D., M.S.
Director
Evidence-based Practice Center Program
Center for Evidence and Practice Improvement
Agency for Healthcare Research and Quality

Therese Miller, Dr.P.H.
Acting Director
Center for Evidence and Practice Improvement
Agency for Healthcare Research and Quality

Christine S. Chang, M.D., M.P.H.
Task Order Officer
Associate Director
Evidence-based Practice Center Program
Center for Evidence and Practice Improvement
Agency for Healthcare Research and Quality

Appendix A. MEDLINE Search Strategy

Search performed on March 9, 2023:

Ovid MEDLINE ALL 1946 to March 08, 2023

1 Heart Failure/su or Angioplasty, Balloon, Coronary/ or Atherectomy, Coronary/ or Cardiac Surgical Procedures/ or exp Coronary Artery Bypass/ or Arterial Switch Operation/ or Cardiomyoplasty/ or exp Heart Arrest, Induced/ or Heart Bypass, Right/ or Fontan Procedure/ or Heart Massage/ or Heart Transplantation/ or Heart-Lung Transplantation/ or Maze Procedure/ or Myocardial Revascularization/ or Angioplasty, Balloon, Coronary/ or Atherectomy, Coronary/ or exp Coronary Artery Bypass/ or Transmyocardial Laser Revascularization/ or Norwood Procedures/ or Pericardial Window Techniques/ or Pericardiectomy/ or Pericardiocentesis/ or Percutaneous Coronary Intervention/ or ((arter* or cardia* or cardio* or coronary or heart).hw. and su.fs.) (477123)

2 (arter* or atria\$1 or CABG or cardia* or cardio* or coronary or heart*).ti,kf. (1619523)

3 Cardiac Resynchronization Therapy Devices/ or Defibrillators, Implantable/ or Heart, Artificial/ or Heart-Assist Devices/ or Pacemaker, Artificial/ (66879)

4 (((arter* or vascular) adj2 stent*) or defibrillat* or pacemaker\$1 or pace-maker\$1 or "ventricular assist*").ti,kf. (51579)

5 or/1-4 (1837393)

6 (Dental Prophylaxis/ or Dental Scaling/ or Periodontal Debridement/ or Periodontal Diseases/ or Root Planing/) and (Perioperative Care/ or Perioperative Period/ or Preoperative Care/ or Preoperative Period/) (69)

7 ((dental or periodont* or "oral care" or "oral disease*" or "oral health" or "oral hygiene" or "oral infection*" or teeth or tooth) and (advance or ahead or before or caries or cavity or cavities or early or initial* or "medically necessary" or prehabilitation or preliminary or periimplant or "peri-implant*" or preimplant* or "pre-implant*" or perioperat* or "peri-operat*" or preoperat* or "pre-operat*" or preparat* or periprocedur* or "peri-procedur*" or post* or preprocedur* or "pre-procedur*" or perisurg* or "peri-surg*" or presurg* or "pre-surg*" or peritherap* or "peri-therap*" or pretherap* or "pre-therap*" or peritransplant* or "peri-transplant*" or pretransplant* or "pre-transplant*" or peritreat* or peri-treat* or pretreat* or "pre-treat*" or preventive or prior or prophyl* or screen* or time* or timing or undergoing)).ti,kf. (41360)

8 ((dental or periodont* or "oral care" or "oral disease*" or "oral health" or "oral hygiene" or "oral infection*" or teeth or tooth) adj5 (advance or ahead or before or caries or cavity or cavities or early or initial* or "medically necessary" or prehabilitation or preliminary or periimplant or "peri-implant*" or preimplant* or "pre-implant*" or perioperat* or "peri-operat*" or preoperat* or "pre-operat*" or preparat* or periprocedur* or "peri-procedur*" or post* or preprocedur* or "pre-procedur*" or perisurg* or "peri-surg*" or presurg* or "pre-surg*" or peritherap* or "peri-therap*" or pretherap* or "pre-therap*" or peritransplant* or "peri-transplant*" or pretransplant* or "pre-transplant*" or peritreat* or peri-treat* or pretreat* or "pre-treat*" or preventive or prior or prophyl* or screen* or time* or timing or undergoing)).ab. (63593)

9 or/6-8 (89857)

10 and/5,9 (882)

11 10 not ((exp Animals/ not Humans/) or (animal model* or bitch\$2 or bovine or canine or capra or cat or cats or cattle or cow\$1 or dog\$1 or equine or ewe\$1 or feline or goat\$1 or hamster\$1 or horse\$1 or invertebrate\$1 or macaque\$1 or mare\$1 or mice or monkey\$1 or mouse or murine or nonhuman or non-human or ovine or pig or pigs or porcine or primate\$1 or rabbit\$1 or rat\$1 or rattus or rhesus or rodent* or sheep or simian or sow\$1 or vertebrate\$1 or zebrafish).ti. or ("case report\$1" or comment).ti.) (815)

12 limit 11 to english language (740)

13 12 not (case reports or comment or editorial or letter or news).pt. (647)

14 13 and ((meta-analysis or "systematic review").pt. or (meta-anal* or metaanal* or ((evidence or review or scoping or systematic or umbrella) adj3 (review or synthesis))).ti.) (34)
 15 13 and ((controlled clinical trial or randomized controlled trial).pt. or (control* or random* or trial*).ti,ab,kf.) (212)
 16 15 not 14 (200)
 17 13 and (Case-Control Studies/ or Cohort Studies/ or Comparative Study/ or Controlled Before-After Studies/ or Cross-Sectional Studies/ or Epidemiologic Studies/ or exp Evaluation Studies as Topic/ or Follow-Up Studies/ or Historically Controlled Study/ or Interrupted Time Series Analysis/ or Longitudinal Studies/ or Prospective Studies/ or Retrospective Studies/ or ("case-control" or cohort\$1 or "before-after" or ((comparative or epidemiologic or evaluation) adj3 study) or cross-sectional or follow-up or (historic* adj4 control*) or "interrupted time" or longitudinal\$2 or prospective\$2 or retrospective\$2).ti.) (260)
 18 17 not (14 or 16) (148)

Supplemental search performed on March 28, 2023

Ovid MEDLINE ALL 1946 to March 27, 2023

1 heart septal defects/ or aortopulmonary septal defect/ or truncus arteriosus, persistent/ or endocardial cushion defects/ or heart septal defects, atrial/ or foramen ovale, patent/ or lutebacher syndrome/ or heart septal defects, ventricular/ or double outlet right ventricle/ (32819)
 2 ((atrial or ventricular) adj "septal defect*).ti,ab,kf. (24288)
 3 or/1-2 (42677)
 4 (Dental Prophylaxis/ or Dental Scaling/ or Periodontal Debridement/ or Periodontal Diseases/ or Root Planing/ and (Perioperative Care/ or Perioperative Period/ or Preoperative Care/ or Preoperative Period/ (69)
 5 ((dental or periodont* or "oral care" or "oral disease*" or "oral health" or "oral hygiene" or "oral infection*" or teeth or tooth) and (advance or ahead or before or caries or cavity or cavities or early or initial* or "medically necessary" or prehabilitation or preliminary or periimplant or "peri-implant*" or preimplant* or "pre-implant*" or perioperat* or "peri-operat*" or preoperat* or "pre-operat*" or preparat* or periprocedur* or "peri-procedur*" or post* or preprocedur* or "pre-procedur*" or perisurg* or "peri-surg*" or presurg* or "pre-surg*" or peritherap* or "peri-therap*" or pretherap* or "pre-therap*" or peritransplant* or "peri-transplant*" or pretransplant* or "pre-transplant*" or peritreat* or peri-treat* or pretreat*" or "pre-treat*" or preventive or prior or prophyl* or screen* or time* or timing or undergoing)).ti,kf. (41477)
 6 ((dental or periodont* or "oral care" or "oral disease*" or "oral health" or "oral hygiene" or "oral infection*" or teeth or tooth) adj5 (advance or ahead or before or caries or cavity or cavities or early or initial* or "medically necessary" or prehabilitation or preliminary or periimplant or "peri-implant*" or preimplant* or "pre-implant*" or perioperat* or "peri-operat*" or preoperat* or "pre-operat*" or preparat* or periprocedur* or "peri-procedur*" or post* or preprocedur* or "pre-procedur*" or perisurg* or "peri-surg*" or presurg* or "pre-surg*" or peritherap* or "peri-therap*" or pretherap* or "pre-therap*" or peritransplant* or "peri-transplant*" or pretransplant* or "pre-transplant*" or peritreat* or peri-treat* or pretreat*" or "pre-treat*" or preventive or prior or prophyl* or screen* or time* or timing or undergoing)).ab. (63769)
 7 or/4-6 (90105)
 8 and/3,7 (36)
 9 8 not ((exp Animals/ not Humans/) or (animal model* or bitch\$2 or bovine or canine or capra or cat or cats or cattle or cow\$1 or dog\$1 or equine or ewe\$1 or feline or goat\$1 or hamster\$1 or horse\$1 or invertebrate\$1 or macaque\$1 or mare\$1 or mice or monkey\$1 or mouse or murine or nonhuman or non-human or ovine or pig or pigs or porcine or primate\$1 or rabbit\$1 or rat\$1 or rattus or rhesus or rodent* or sheep or simian or sow\$1 or vertebrate\$1 or zebrafish).ti. or ("case report\$1" or comment).ti.) (29)
 10 limit 9 to english language (27)

11 10 not (case reports or comment or editorial or letter or news).pt. (13)
 12 11 and ((meta-analysis or "systematic review").pt. or (meta-anal* or metaanal* or ((evidence or review or scoping or systematic or umbrella) adj3 (review or synthesis))).ti.) (1)
 13 11 and ((controlled clinical trial or randomized controlled trial).pt. or (control* or random* or trial*).ti,ab,kf.) (2)
 14 13 not 12 (1)
 15 11 and (Case-Control Studies/ or Cohort Studies/ or Comparative Study/ or Controlled Before-After Studies/ or Cross-Sectional Studies/ or Epidemiologic Studies/ or exp Evaluation Studies as Topic/ or Follow-Up Studies/ or Historically Controlled Study/ or Interrupted Time Series Analysis/ or Longitudinal Studies/ or Prospective Studies/ or Retrospective Studies/ or ("case-control" or cohort\$1 or "before-after" or ((comparative or epidemiologic or evaluation) adj3 study) or cross-sectional or follow-up or (historic* adj4 control*) or "interrupted time" or longitudinal\$2 or prospective\$2 or retrospective\$2).ti.) (3)
 16 15 not (12 or 14) (2)

Appendix B. Relevant Guideline Recommendations

Table B-1. Relevant guideline recommendations

Organization(s)	Title	Year	Population	Recommendation(s)	Stated Recommendation Strength ^a
American Heart Association (AHA) ³⁵	Prevention of Viridans Group Streptococcal infective endocarditis	2021	Implanted cardiac devices	<p>Antibiotic prophylaxis for dental procedures is recommended for: Surgical or transcatheter prosthetic valve, devices for repair of cardiac valves, ventricular assist devices, unrepaired cyanotic congenital heart disease, prosthetic materials or conduits to repair heart defects, valvulopathies in transplanted hearts.</p> <p>Antibiotic prophylaxis for dental procedures is not recommended for: Implantable electronic devices such as pacemakers, septal defect closure devices, peripheral vascular grafts and patches, coronary artery stents, other vascular stents, ventriculoatrial shunts, vena cava filters, pledgets.</p> <p>Maintenance of good oral health and regular dental care are much more important to prevent IE than antibiotic prophylaxis for a dental procedure. We suggest that patients have biannual dental examinations when such care is available.</p> <p>Because routine daily activities result in transient VGS bacteremia at a much higher frequency than a single dental procedure, optimizing oral health has a major impact on preventing VGS IE. Ideally, patients should receive biannual dental care.</p>	Not provided in document
American Academy of Family Physicians ³⁰	Medical Clearance for Common Dental Procedures	2021	Prosthetic heart valves, heart valve repairs, infectious endocarditis, congenital heart disease, cardiac transplant	<p>The AHA recommends considering antibiotic prophylaxis only when dento-gingival manipulations are planned for selected patients at highest risk of complications (Table 2). Patients can consider delaying elective dental procedures for six weeks after myocardial infarction or bare-metal stent placement or six months after drug-eluting stent placement.</p> <p>Patients are considered at low cardiac risk when undergoing dental procedures if they have no active cardiac conditions and can perform at least 4 metabolic equivalents.</p>	Not provided in document

Organization(s)	Title	Year	Population	Recommendation(s)	Stated Recommendation Strength ^a
American College of Cardiology(ACC)/ American Heart Association ³²	2017 AHA/ACC Focused Update of the 2014 AHA/ACC Guideline for the Management of Patients with Valvular Heart Disease A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines	2017	Transcatheter prosthetic valves, prosthetic valve materials (annuloplasty rings, chords), transcatheter aortic valve replacement	<p>2.4.2. IE Prophylaxis: Recommendation</p> <p>Prophylaxis against IE is reasonable before dental procedures that involve manipulation of gingival tissue, manipulation of the periapical region of teeth, or perforation of the oral mucosa in patients with the following:</p> <ol style="list-style-type: none"> 1. Prosthetic cardiac valves, including transcatheter implanted prostheses and homografts. 2. Prosthetic material used for cardiac valve repair, such as annuloplasty rings and chords. 3. Previous IE <p>“Persons at risk of developing bacterial IE should establish and maintain the best possible oral health to reduce potential sources of bacterial seeding. Optimal oral health is maintained through regular professional dental care and the use of appropriate dental products, such as manual, powered, and ultrasonic toothbrushes; dental floss; and other plaque-removal devices.”</p>	C-LD
American Heart Association ³⁴	Vascular Graft Infections, Mycotic Aneurysms, and Endovascular Infections A Scientific Statement from the American Heart Association	2016	Vascular grafts, endovascular devices, or stents may	<p>Prevention of Infections of Vascular Grafts or Endovascular Devices and Stents</p> <p>The administration of antimicrobial agents for the prevention of infection of vascular grafts, endovascular devices, or stents may be considered as primary or secondary prophylaxis. Primary prophylaxis refers to the administration of antimicrobial prophylactic therapy to prevent perioperative infections. Secondary prophylaxis refers to the administration of antimicrobial therapy intended to prevent infection as a result of transient bacteremia associated with an invasive procedure, such as a dental procedure.</p> <p>The AHA does not recommend antimicrobial prophylaxis for prevention of vascular graft or endovascular graft infection in patients who undergo a dental procedure or in uninfected patients who undergo a urologic or gastrointestinal tract procedure.</p>	B, C

Organization(s)	Title	Year	Population	Recommendation(s)	Stated Recommendation Strength ^a
Cochrane ²⁷	Antibiotic prophylaxis for preventing bacterial endocarditis following dental procedures	2022	Adults or children at risk of endocarditis	<p>There is general agreement that there is little scientific evidence to support the effectiveness of antibiotic prophylaxis for the prevention of bacterial endocarditis. This lack of evidence has led to variations in guideline recommendations with regard to who should or should not be prescribed antibiotic prophylaxis and who is or is not considered high risk for bacterial endocarditis</p> <p>However, one area where most guidelines are in agreement is with regard to the need for regular dental surveillance to promote good oral hygiene, thus reducing the need for invasive dental procedures and subsequently reducing the risk of bacterial endocarditis.</p>	Very low quality
American Heart Association/Heart Rhythm Society ²⁴	Update of Cardiovascular Implantable Electronic Device Infections and their Management	2010	Patients who require a device to support heart rhythm or suppress unfavorable rhythms	<p>The scientific statement does not endorse antibiotic prophylaxis for dental procedures in patients who have had implantation of electronic devices:</p> <p>“There is little, if any, scientific justification for administration of antibiotic prophylaxis for invasive procedures, although there is a wide range of opinions. A review of the literature from 1950 to 2007 for publications on CIED infections reveals more than 140 articles, none of which report hematologic infection from dental, gastrointestinal, genitourinary, dermatologic, or other procedures. The predominance of staphylococci as pathogens in CIED infections rather than oral flora suggests that antibiotic prophylaxis for dental procedures is of little or no value. In the rare event of a device infection due to an oral pathogen, it is most likely to have arisen from a bacteremia from a common daily event such as toothbrushing or chewing food. Therefore, there is currently no scientific basis for the use of prophylactic antibiotics before routine invasive dental, gastrointestinal, or genitourinary procedures to prevent CIED infection.”</p> <p>The scientific statement does not make other recommendations for dental procedures in patients who will undergo implantation of electronic devices.</p>	C

Organization(s)	Title	Year	Population	Recommendation(s)	Stated Recommendation Strength ^a
American College of Cardiology/American Heart Association ³³	ACC/AHA 2008 Guidelines for the Management of Adults With Congenital Heart Disease A Report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Writing Committee to Develop Guidelines on the Management of Adults with Congenital Heart Disease)	2008	Adults with Congenital Heart Disease (ACHD), IE, prosthetic cardiac valves, complex CHD	<p>1.5.2. Recommendations for Psychosocial Issues Class I</p> <p>3. Additional health maintenance screening and information should be offered to ACHD patients as indicated during each visit to their ACHD healthcare provider, including the following:</p> <p>d. General medical/dental preventive care (e.g., smoking cessation, weight loss/maintenance, hypertension/lipid screening, oral care, and substance abuse counseling). Class IIa</p> <p>1. Antibiotic prophylaxis before dental procedures that involve manipulation of gingival tissue or the periapical region of teeth or perforation of the oral mucosa is reasonable in patients with CHD with the highest risk for adverse outcome from IE, including those with the following indications:</p> <p>a. Prosthetic cardiac valve or prosthetic material used for cardiac valve repair. (Level of Evidence: B)</p> <p>b. Previous IE. (Level of Evidence: B)</p> <p>1.6. Recommendations for Infective Endocarditis Class IIa</p> <p>1. Antibiotic prophylaxis before dental procedures that involve manipulation of gingival tissue or the periapical region of teeth or perforation of the oral mucosa is reasonable in patients with CHD with the highest risk for adverse outcome from IE, including those with the following indications:</p> <p>a. Prosthetic cardiac valve or prosthetic material used for cardiac valve repair. (Level of Evidence: B)</p>	C, B
National Institute for Health and Care Excellence (NICE) ³¹	Prophylaxis against infective endocarditis: antimicrobial prophylaxis against infective endocarditis in adults and children undergoing interventional procedures Clinical guideline	2008	Adults and children undergoing interventional procedures	<p>Prophylaxis against IE</p> <p>1.1.3 Antibiotic prophylaxis against IE is not recommended routinely:</p> <ul style="list-style-type: none"> • for people undergoing dental procedures <p>1.1.4 Chlorhexidine mouthwash should not be offered as prophylaxis against IE to people at risk of IE undergoing dental procedures. [2015]</p>	Not provided in document

Organization(s)	Title	Year	Population	Recommendation(s)	Stated Recommendation Strength ^a
American Heart Association/American College of Cardiology/Heart Failure Society of America (HFSA) ⁴²	2022 AHA/ACC/HFSA Guideline for the Management of Heart Failure: A Report of the American College of Cardiology/American Heart Association Joint Committee on Clinical Practice Guidelines	2022	Not applicable	The guideline document does not make recommendations for dental procedures in patients who will undergo implantation of electronic devices	Not applicable
American College of Cardiology/American Heart Association/ North American Society for Pacing and Electrophysiology(NASPE) ⁴¹	ACC/AHA/NASPE 2002 Guideline Update for Implantation of Cardiac Pacemakers and Anti-arrhythmia Devices: Summary Article A Report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (ACC/AHA/NASPE Committee to Update the 1998 Pacemaker Guidelines)	2022	Not applicable	The guideline document does not make recommendations for dental procedures in patients who will undergo implantation of electronic devices.	Not applicable
European Society of Cardiology(ESC) ²⁵	Guidance on the management of LVAD supported patients for the non-LVAD specialist healthcare provider: executive summary	2021	Patients with LVAD implants in the emergency department	The guideline document does not make recommendations for dental procedures in patients who will undergo implantation of electronic devices Guidance covers multiple emergent issues in this patient population and provides specific protocols on the patient's "...pathway from the ambulance to the emergency department...."	Not applicable

Organization(s)	Title	Year	Population	Recommendation(s)	Stated Recommendation Strength ^a
European Society of Cardiology ²⁸	2021 ESC Guidelines on cardiac pacing and cardiac resynchronization therapy	2021	Patients who require a device to support heart rhythm or suppress unfavorable rhythms	The guideline document does not make recommendations for dental procedures in patients who will undergo implantation of electronic devices.	Not applicable
American Heart Association ²⁶	Prevention of Complications in the CICU: A Scientific Statement from the American Heart Association	2020	Preventing HAI in CICU	<p>The guideline document does not make recommendations for dental procedures in patients who will undergo implantation of electronic devices</p> <p>HAIs include CAUTI, CLABSI, VAP, infection with MDR pathogens, and surgical site infections occurring with MCS. Although there are no CICU-specific guidelines available to inform best practice HAI prevention, guidance on the prevention of healthcare-associated infections is reviewed herein with a focus on CICU populations.</p>	Not applicable
American Heart Association ²⁹	Device Therapy and Arrhythmia Management in Left Ventricular Assist Device Recipients	2019	Patients with end-stage heart failure	The scientific statement does not endorse any specific aspects of dental care for patients undergoing implantation of left ventricular assist devices.	Not applicable
American Association for Thoracic Surgery/The American College of Cardiology/The Society for Cardiovascular Angiography and Interventions/The Society for Thoracic Surgeons ⁴⁰	Multi-society expert consensus systems of care document 2019 AATS/ACC/SCAI/STS expert consensus systems of care document: Operator and institutional recommendations and requirements for transcatheter mitral valve intervention	2019	Not applicable	The guideline document does not make recommendations for dental procedures in patients who will undergo implantation of electronic devices.	Not applicable

Organization(s)	Title	Year	Population	Recommendation(s)	Stated Recommendation Strength ^a
American College of Cardiology/American Heart Association/Heart Rhythm Society (HRS) ³⁷	2018 ACC/AHA/HRS guideline on the evaluation and management of patients with bradycardia and cardiac conduction delay	2018	Patients with bradycardia requiring pacemaker therapy	The guideline document does not make recommendations for dental procedures in patients who will undergo implantation of electronic devices	Not applicable
American Heart Association/American College of Cardiology/Heart Rhythm Society ³⁹	2017 AHA/ACC/HRS Guideline for Management of Patients With Ventricular Arrhythmias and the Prevention of Sudden Cardiac Death	2017	Not applicable	The guideline document does not make recommendations for dental procedures in patients who will undergo implantation of electronic devices.	Not applicable
American College of Cardiology/American Heart Association/Heart Rhythm Society ³⁶	2012 ACCF/AHA/HRS Focused Update Incorporated into the ACCF/AHA/HRS 2008 Guidelines for Device-Based Therapy of Cardiac Rhythm Abnormalities	2013	Patients with cardiac rhythm disorders who may require pacemaker or implantable cardioverter-defibrillator therapy	The guideline document does not make recommendations for dental procedures in patients who will undergo implantation of electronic devices	Not applicable
American College of Cardiology/American Heart Association ³⁸	ACC/AHA Guidelines for the Management of Patients With ST-Elevation Myocardial Infarction	2004	Not applicable	The guideline document does not make recommendations for dental procedures in patients who will undergo implantation of electronic devices.	Not applicable

^aFor detailed explanations of the stated strength of each recommendation, please see the cited guideline.

Abbreviations: ACC=American College of Cardiology; ACHD=adults with congenital heart disease; AHA=American Heart Association; CAUTI=catheter-associated urinary tract infection; CHD=congenital heart disease; CICU=cardiovascular intensive care unit; CIED=cardiovascular implantable electronic device; CLABSI=central line-associated bloodstream infection; ESC=European Society of Cardiology; HAI=healthcare-associated infections; HFSA=Heart Failure Society of America; HRS=Heart Rhythm Society; IE=infectious endocarditis; LVAD=left ventricular assist device; MCS=mechanical circulatory support; MDR=multi-drug resistant; NASPE=North American Society for Pacing and Electrophysiology; SCAI=Society for Cardiovascular Angiography and Interventions; STS=Society for Thoracic Surgeons; VAP=ventilator-associated pneumonia; VGS=viridans group streptococcal.

Note: Reference numbers in Appendix B correspond to those in the main text of this report.

Appendix C. Linkages Between Certain Medical and Dental Services

Table C-1. Linkages between certain medical and dental services

Study Name	Citation	E1: Standard of Care Requires Dental Services	E2: Improved Healing/Quality of Surgery/Reduced Likelihood of Readmission	E3: Improved Clinical Outcomes and Success of Medical Procedure	E4: Improvement in Quality and Safety Outcomes (i.e., Fewer Readmissions; More Rapid Healing; Quicker Discharge)	Additional Comments
Prevention of Viridans Group Streptococcal (VGS) infective endocarditis (IE)	Wilson, 2021 ³⁵	“Current scientific data suggest that maintaining good oral health care in patients at risk of or from VGS IE has a major impact on preventing bacteremia with VGS from routine daily activities such as toothbrushing. Because routine daily activities result in transient VGS bacteremia at a much higher frequency than a single dental procedure, optimizing oral health has a major impact on preventing VGS IE. Ideally, patients should receive biannual dental care. Often, because of lack of insurance or affordability, access to regular dental care is limited for some patients. This is especially important in those patients at risk of the highest adverse outcome from VGS IE. The writing group recognizes the importance of connecting patients with a social worker or other services to facilitate access to dental care and assistance with insurance for dental coverage.”	VGS IE is a potentially devastating, often fatal condition affecting this patient population. Evidence indicates that prevention efforts such as routine oral care, patient education and AP in certain high-risk groups may reduce morbidity and mortality.	Not applicable	Not applicable	“We continue to recommend VGS IE prophylaxis only for categories of patients at highest risk for adverse outcome while emphasizing the critical role of good oral health and regular access to dental care for all. Randomized controlled studies to determine whether antibiotic prophylaxis is effective against VGS IE are needed to further refine recommendations.”

Study Name	Citation	E1: Standard of Care Requires Dental Services	E2: Improved Healing/Quality of Surgery/Reduced Likelihood of Readmission	E3: Improved Clinical Outcomes and Success of Medical Procedure	E4: Improvement in Quality and Safety Outcomes (i.e., Fewer Readmissions; More Rapid Healing; Quicker Discharge)	Additional Comments
2017 AHA/ACC Focused Update of the 2014 AHA/ACC Guideline for the Management of Patients with Valvular Heart Disease A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines	Nishimura, 2017 ³²	"Persons at risk of developing bacterial IE should establish and maintain the best possible oral health to reduce potential sources of bacterial seeding. Optimal oral health is maintained through regular professional dental care and the use of appropriate dental products, such as manual, powered, and ultrasonic toothbrushes; dental floss; and other plaque-removal devices."	Not applicable	Not applicable	Not applicable	"Patients with transcatheter prosthetic valves and patients with prosthetic material used for valve repair, such as annuloplasty rings and chords, were specifically identified as those to whom it is reasonable to give IE prophylaxis. This addition is based on observational studies demonstrating the increased risk of developing IE and high risk of adverse outcomes from IE in these subgroups."
Antibiotic prophylaxis for preventing bacterial endocarditis following dental procedures (Review)	Rutherford 2022 ²⁷	There is general agreement that there is little scientific evidence to support the effectiveness of antibiotic prophylaxis for the prevention of bacterial endocarditis. This lack of evidence has led to variations in guideline recommendations with regard to who should or should not be prescribed antibiotic prophylaxis and who is or is not considered high risk for bacterial endocarditis. However, one area where most guidelines are in agreement is with regard to the need	Not applicable	Not applicable	Not applicable	"All guidelines including NICE and those from the United States, Europe and Australia agree that regular dental surveillance is essential to promote good oral hygiene, reduce the need for invasive dental procedures and reduce the risk of infective endocarditis. Around 40% of cases of infective endocarditis are caused by oral bacteria. Although these may enter the circulation

Study Name	Citation	E1: Standard of Care Requires Dental Services	E2: Improved Healing/Quality of Surgery/Reduced Likelihood of Readmission	E3: Improved Clinical Outcomes and Success of Medical Procedure	E4: Improvement in Quality and Safety Outcomes (i.e., Fewer Readmissions; More Rapid Healing; Quicker Discharge)	Additional Comments
		for regular dental surveillance to promote good oral hygiene, thus reducing the need for invasive dental procedures and subsequently reducing the risk of bacterial endocarditis.				during invasive dental procedures there is also evidence that transient bacteraemia with oral organisms occurs during daily activities such as chewing food and tooth brushing. The size and frequency of the bacteraemia are significantly greater in those with poor oral hygiene."
Clinical Practice Guideline	Baddour, 2010 ²⁴	"The predominance of staphylococci as pathogens in CIED infections rather than oral flora ⁹⁸ suggests that antibiotic prophylaxis for dental procedures is of little or no value in the rare event of a device infection due to an oral pathogen, it is most likely to have arisen from a bacteremia from a common daily event such as toothbrushing or chewing food."	Not applicable	Not applicable	Not applicable	Antimicrobial prophylaxis is not recommended for dental or other invasive procedures not directly related to device manipulation to prevent CIED infection.
Retrospective cohort study on rates of clinically important bleeding after tooth extractions	Kobayashi, 2020 ¹⁷	Not applicable	Not applicable	Not applicable	The study compared a group of patients who underwent tooth extraction prior to insertion of VADs to a group of patients who underwent tooth extraction after insertion of such	A VAD requires intensive anticoagulation to prevent blood clotting triggered by the device. It is clinically logical that anticoagulation would increase the risk of bleeding caused by some dental

Study Name	Citation	E1: Standard of Care Requires Dental Services	E2: Improved Healing/Quality of Surgery/Reduced Likelihood of Readmission	E3: Improved Clinical Outcomes and Success of Medical Procedure	E4: Improvement in Quality and Safety Outcomes (i.e., Fewer Readmissions; More Rapid Healing; Quicker Discharge)	Additional Comments
					devices. The bleeding rate was significantly (p = 0.001) lower in the group that had extraction prior to VAD insertion.	procedures. This study supports the strategy to perform necessary dental procedures prior to insertion of a VAD.

Abbreviations: AP=antibiotic prophylaxis; CIED=cardiovascular implantable electronic device; IE=infectious endocarditis; NICE=National Institute for Health and Care Excellence; VAD=ventrivalar assist devices; VGS=viridans groups streptococcal.

Note: references numbers in Appendix C correspond to those in the main text of this report.