Eliminating sternal wound infections: Why every cardiac surgery program needs an I hate infections team

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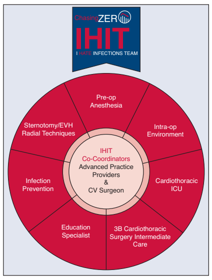
ABSTRACT

Objectives: The majority of studies examining deep sternal wound infection (DSWI) prevention focus on ameliorating 1 variable at a time. There is a paucity of data regarding the synergistic effects of combining clinical and environmental interventions. This article describes an interdisciplinary, multimodal approach to eliminate DSWIs at a large community hospital.

Methods: We developed a robust, multidisciplinary infection prevention team to evaluate and act in all phases of perioperative care to achieve a cardiac surgery DSWI rate of 0, named: the I hate infections team. The team identified opportunities for improved care and best practices and implemented changes on an ongoing basis.

Results: Patient-related interventions consisted of preoperative methicillin-resistant *Staphylococcus aureus* identification, individualized perioperative antibiotics, antimicrobial dosing strategies, and maintenance of normothermia. Operative-related interventions involved glycemic control, sternal adhesives, medications and hemostasis, rigid sternal fixation for high-risk patients, chlorhexidine gluconate dressings over invasive lines, and use of disposable health care equipment. Environment-related interventions included optimizing operating room ventilation and terminal cleaning, reducing airborne particle counts, and decreasing foot traffic. Together, these interventions reduced the DSWI incidence from 1.6% preintervention to 0% for 12 consecutive months after full bundle implementation.

Conclusions: A multidisciplinary team focused on eliminating DSWI identified known risk factors and implemented evidence-based interventions in each phase of care to ameliorate risk. Although the influence of each individual intervention on DSWI remains unknown, use of the bundled infection prevention approach reduced the incidence to 0 for the first 12 months after implementation. (JTCVS Techniques 2023;19:93-103)



The I hate infections team organizational structure.

CENTRAL MESSAGE

An interdisciplinary, multimodal approach by an infection prevention team that evaluates and acts in all phases of perioperative care can achieve a deep sternal wound infection rate of 0.

PERSPECTIVE

DSWI is a serious complication after median sternotomy and is associated with significant morbidity and mortality often causing rehospitalization and higher health care costs. A multidisciplinary team focused on infection prevention can identify and implement evidence-based strategies across all levels of care to ameliorate risk and reduce the DSWI incidence to zero.

Deep sternal wound infection (DWSI) is a serious complication after median sternotomy, affecting 0.25% to 5% of patients.[1] DSWI is associated with significant morbidity and has a mortality rate ranging from 10% to 50%.[1] Roughly 4.3% of cardiac surgery patients are readmitted for treatment of postoperative infections, including DSWI.[2] The Swedish National Study revealed that 80% of patients with DSWI had coronary revascularization either alone or in combination with other cardiac procedures.[3] In a recent study, patients readmitted within 30 days after cardiac surgery had significantly higher early (6 months) and late (60 months) mortality rates compared with those who did not require rehospitalization.[2] A DSWI is associated with increased health care costs of $111,175 compared with $7981 for a superficial sternal wound infection in the United States.[4]

Infection prevention research highlights ways hospital personnel and institutional policies may mitigate surgical site infection (SSI). The majority of studies examining

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Abbreviations and Acronyms

ACS	= American College of Surgeons
CHG	= chlorhexidine gluconate
CTICU	= cardiothoracic intensive care unit
DoOR Traffic	= decrease our operating room traffic
DSWI	= deep sternal wound infection
ERAS	= enhanced recovery after cardiac surgery
IHIT	= I hate infections team
IHI	= Institute for Healthcare Improvements
MRSA	= methicillin-resistant *Staphylococcus aureus*
SSI	= surgical site infections

DSWI prevention focus on ameliorating 1 variable at a time (Table 1). However, Konishi and colleagues[26] employed a multifaceted approach to decreasing the incidence of DSWI that targeted patient-related and intraoperative-related risk factors, such as preoperative methicillin-resistant *Staphylococcus aureus* (MRSA) screening and decolonization, decreasing the frequency of on-pump coronary artery bypass grafting procedures, allowing for higher intraoperative body temperatures, and using antimicrobial skin sealants. These combined measures significantly reduced the incidence of DSWI (0.2% vs 3.6%; $P < .0001$).[26] Unfortunately, there is a paucity of studies evaluating the effects of infection-related bundling addressing patient risk factors, intraoperative strategies, and environmental risk reduction. This article describes an interdisciplinary and multimodal approach to eliminating DSWI in patients undergoing adult cardiac surgery at a large community-based health system and its outcomes over a 12-month period.

FORMING A TEAM

Composition

In 2020, the cardiac surgery I hate infections team (IHIT) was formed in alignment with the hospital's Chasing Zero Initiative. IHIT worked in the framework of an existing enhanced recovery after cardiac surgery (ERAS) program.[27] The team consisted of the executive medical director, cardiac surgeons, key advanced practice providers, clinical pharmacists, perfusionists, infectious diseases physicians, infection prevention nurses, operating room personnel, anesthesia and nursing staff, and importantly our environmental services personnel (Figure 1).

Setting Goals

Once assembled, the team adopted the Institute for Healthcare Improvement's (IHI) Model.[28] The IHI Model incorporates W. Edwards Demings' Plan-Do-Study-Act model.[28] It poses 3 questions: "What are we trying to accomplish? How will we know that a change is an improvement? What changes can we make that will result in improvement?"[28] The team performed a literature review to identify applicable guidelines and current evidence-based SSI prevention methods (Table 2). A number of interventions from across the perioperative continuum were selected for the IHIT bundle. The interventions selected for implementation by IHIT are grouped by the risk factors

TABLE 1. Individual deep sternal wound infection prevention variables

Variable	Specifics
Reducing skin flora[5]	Chlorhexidine baths for infection control of multidrug-resistant organisms
Preoperative nasal MRSA screening[5,6]	Antibiotic selection, preoperative decolonization
Perioperative antibiotics[5,7-10]	Selection, coverage, concentration
Perioperative normothermia	Warming devices, room temperatures
Clean operating room environment[11-13]	Air quality, air turnover rates, temperature, cleanliness, foot traffic
Operating room door openings[11,14]	Airborne particle counts, staff movement, ventilation
Blood product transfusion[7]	Hemodilution, blood exposure
Sternal topical adhesives and medications[15,16]	Topical vancomycin, sterilization techniques, preventing dehiscence
Hypothermia prevention[17-19]	Airborne particles
Sternal closure method[20-23]	Figure-of-8, wire cerclage, rigid fixation
Using disposable equipment[24,25]	ECG leads, electrocautery pad chords
Intravenous line dressings	CHG-impregnated dressing, CHG-impregnated patch

MRSA, Methicillin-resistant *Staphylococcus aureus*; *ECG*, electrocardiogram; *CHG*, chlorhexidine gluconate.

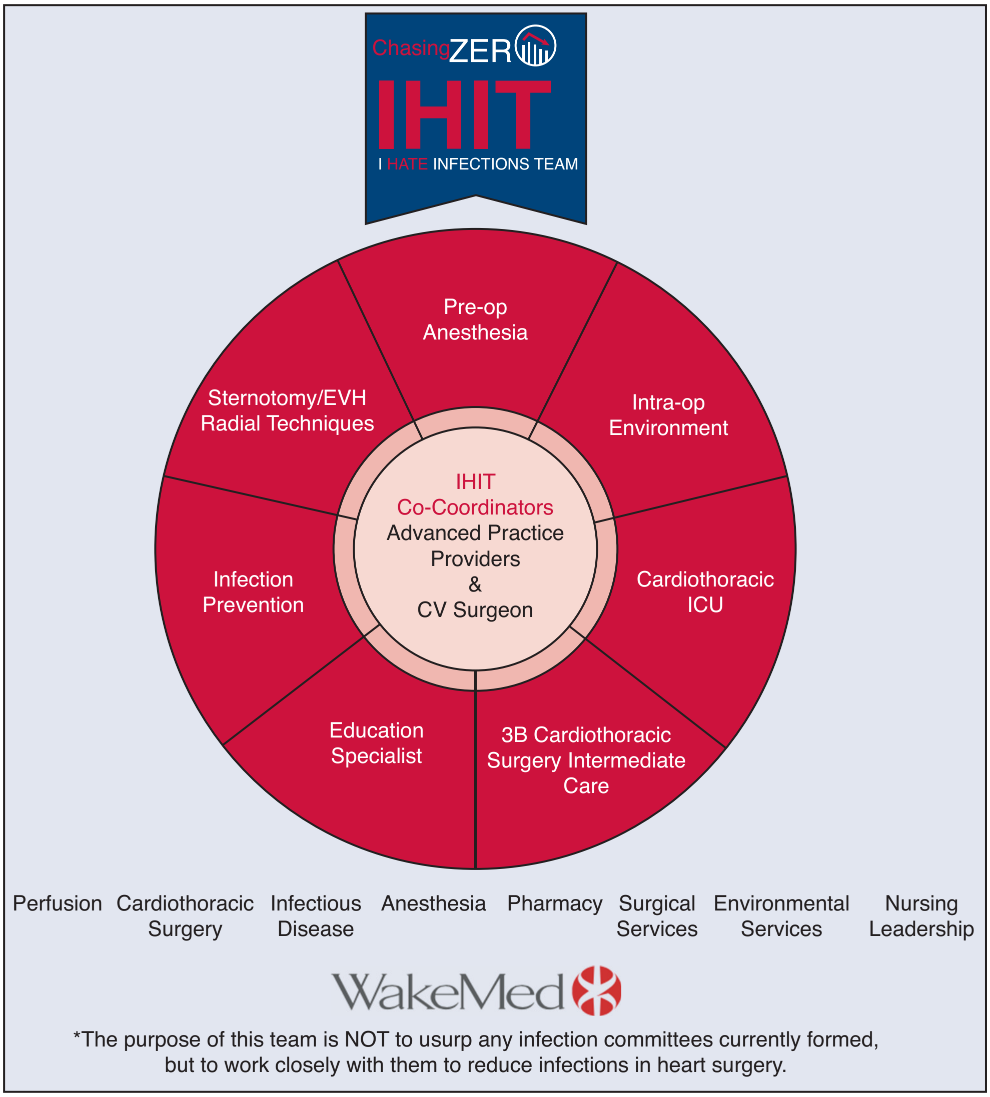

FIGURE 1. The I Hate Infections Team (*IHIT*) organizational structure. *ICU*, Intensive care unit; *CV*, cardiovascular.

they address: patient-related, environment-related, and operative-related (Figure 2). Changes were implemented on an ongoing basis. IHIT periodically assessed compliance, re-educated team members, and identified additional opportunities for improvement.

Execution

The IHIT team conducted literature reviews on an ongoing basis while also participating in continuing educational opportunities such as infection prevention conferences. Literature topics for review were not compartmentalized by team member position; however, most members identified opportunities in their area of expertise. Opportunities for improvement were then brought forward at the bimonthly interdisciplinary Conference of Excellence meetings held by the heart and vascular service line. Ad hoc meetings were also conducted on an as-needed basis. At the forefront of IHIT was the initiative's champion, a long-tenured cardiac surgery physician assistant with passion and expertise in infection prevention. Interventions were made after the IHIT team identified corrective action or after a new process was trialed and supported by health system administration. Electronic medical record and standard work processes were then put in place to maintain these IHIT interventions appropriately. The Institutional Review Board of WakeMed Health and Hospitals did not approve this study given that the research design was focused on literature review and environmental quality initiatives. Patient written consent for the publication of the study was not received due to the absence of use or inclusion of any patient information.

Patient-related interventions	• Preoperative MRSA identification • Individualized perioperative antibiotics • Antimicrobial dosing strategies • Normothermia maintenance
Environment-related interventions	• Proper OR ventilation • OR professional cleaning • Reducing airborne particle counts • Decreasing OR foot traffic
Operative-related interventions	• Glycemic control • Sternal adhesives and medications • Rigid sternal plating for high risk patients • Use of disposable healthcare equipment • Use of CHG dressings over invasive lines

FIGURE 2. The interventions made by the I Hate Infections Team (IHIT) grouped by the risk factors they address. *MRSA*, Methicillin-resistant *Staphylococcus aureus*; *OR*, operating room: *CHG*, chlorhexidine gluconate.

DSWI incidence has been historically recorded. Neither the method of surveillance nor the definition of DSWI has changed over the course of this study. We define DSWI as an infection involving the muscle, bone, or mediastinum within 90 days of surgery, consistent with the Society of Thoracic Surgeons database classification.

IDENTIFYING ADDRESSABLE FACTORS

Patient-Related Risk Factors

There are numerous established risk factors for developing DSWI.[1,2] Patients with prolonged hospital stays before surgery, those who undergo urgent or emergency procedures, as well as those undergoing redo surgeries are at risk for developing DSWI.[1] Additional patient-related risk factors include hyperglycemia, hypothermia, renal dysfunction with or without hemodialysis, nasal and skin colonization with specific pathogens, chronic obstructive pulmonary disease, female sex, obesity, older age, peripheral arterial disease, heart failure, and left ventricular dysfunction.[1,2,30]

Skin flora is another risk factor that can be proactively modified. *S aureus* is a commensal organism found on human skin and nasal passages. It predisposes patients to surgical site infections including DSWI.[24] The American College of Surgeons (ACS) recommends testing all patients for intranasal MRSA colonization. Although routine perioperative antibiotics such as first and second-generation cephalosporins cover methicillin-sensitive isolates, they are not effective against MRSA. Despite use of evidence-based regimens to reduce skin bioburden like preoperative nasal MRSA screening and chlorhexidine (CHG) baths or showers the evening before surgery, our institution still experienced DSWI at a rate consistent with national averages.[5,20]

Avoiding unnecessary hypothermia, defined perioperatively as a core temperature below 36 °C, is important in preventing surgical site infections, including DSWI. Hypothermia leads to vasoconstriction, which decreases blood flow and oxygen delivery to the tissues, impairs coagulation, and reduces antibiotic concentrations at surgical sites.

TABLE 2. Guidelines referenced by the I hate infections team

Guideline	Organization
Surgical Site Infection Guidelines, 2016[5]	American College of Surgeons and Surgical Infection Society
2019 merican Society of Heating, Refrigerating and Air-Conditioning Engineers Handbook—HVAC Applications: Health Care Facilities[29]	American Society of Heating, Refrigerating, and Air Condition Engineers
Practice Guideline Series: Antibiotic Prophylaxis in Cardiac Surgery, Parts I and II[8,10]	The Society of Thoracic Surgeons
Anesthetic Gases: Guidelines for Workplace Exposures	Occupational Health & Safety Administration
ISO 14644-1:2015	International Standards Organization

ISO, International Standards Organization

Mitigating Intraoperative-Related Risk Factors

Operative risk factors associated with DSWI include use of bilateral internal thoracic arteries as coronary artery bypass conduits, excessive electrocautery, hyperglycemia, contaminated equipment, blood product transfusion, sternal closure technique, and prolonged operative, aortic cross-clamp, and/or cardiopulmonary bypass pump times.[1]

Some of these risk factors are modifiable. Hyperglycemia is associated with excess morbidity and mortality in adult critically ill patients, in particular infection, and can be ameliorated with endocrine management teams and insulin protocols. Approximately 60% to 90% of cardiac surgery patients develop perioperative stress hyperglycemia.[31] Patients without diabetes developing stress hyperglycemia have a 4-fold increase in complications and a 2-fold increase in death.[31] Intraoperative hyperglycemia has also been associated with excess morbidity and mortality for patients undergoing cardiopulmonary bypass. A meta-analysis demonstrated that intensive insulin therapy titrated to achieve blood glucose values from 70 to 200 mg/dL significantly reduced infection rates compared with higher target ranges. There were no differences in the incidence of hypoglycemia between treatment groups.

Topical adhesives and medications applied to the sternum before cardiac surgery can influence the incidence of infection by interfering with sterilization techniques. Bone wax was in the past believed to reduce bleeding and sternal wound infections, but more recent data suggest the opposite may be true.[20,30] Bone wax also inhibits bone union, increasing the risk of sternal dehiscence.[20,30] Alternative sternal applications may be more efficacious and safer. Vancomycin slurry paste, when applied to the cut edges of a sternum, may reduce superficial and DSWI.[15,16] A large single-center study failed to confirm this finding but the overall incidence of DSWI was <1%; thus, it may have been underpowered. In summary, use of vancomycin paste has not been associated with harm and may improve outcomes.[15] Additionally, several observational studies have demonstrated an association between blood product transfusion and DSWI although data from a randomized controlled trial is conflicting.[7]

The method of sternal closure may reduce risk. Traditional wire cerclage using parasternal or transsternal wires can potentially cut through the very bone to which they are applied.[20,30] When compared with transsternal closure, 1 report suggested a figure-of-8 approach may reduce DSWI and superficial sternal wound infections.[20] Rigid sternal fixation with plates may provide even more benefit by eliminating micromovements of the osteotomy edges. Allen and colleagues'[21] prospective, single-blinded, multicenter randomized controlled trial of 226 patients showed better sternal healing and nonunion rates at 3 and 6 months in those who underwent rigid fixation compared with wire cerclage. Moreover, there were decreased sternal complication rates at 6 months and a trend toward decreased infection.[21] A randomized controlled trial demonstrated improved bone healing with rigid plate fixation as assessed by radiography.[22] A meta-analysis that included unmatched observational studies concluded sternal plate fixation may improve survival, decrease hospital length of stay, and other complications compared with wire cerclage in patients at high risk.[23]

Central intravenous access is an important tool for invasive hemodynamic monitoring and preferred route for vasopressor infusions. Antibiotic-impregnated dressings are often placed over the insertion sites to prevent central line-associated bloodstream infections. A recent study evaluated a CHG-impregnated dressing vs a CHG-impregnated patch applied at central line insertion sites. There was no significant difference in central line-associated bloodstream infections rates between the 2 groups.[32] However, they noted the CHG-impregnated dressings were easier to apply and had statistically significantly less dressing interruptions compared with the CHG-impregnated patch.[32]

Reusable equipment has the potential to introduce bacteria into surgical sites if it is not properly cleaned or if design prohibits thorough and complete disinfection. This is particularly true of telemetry wires that may be colonized with bacteria known to cause DSWI. Studies have demonstrated the presence of enterococci, including vancomycin-resistant *Enterococcus*, as well as *Escherichia coli* and other gram-negative rods on telemetry wires despite cleaning. The Descriptive Evaluation of EKG Telemetry Pathogens study showed 69% of remote telemetry monitoring systems in medical units were colonized despite standard cleansing methods.[24] Twenty-four percent were still colonized ($P < .001$) after instituting a sanitization protocol utilizing 0.52% sodium hypochlorite wipes (Dispatch, Clorox).[24] Lankiewicz and colleagues[25] showed similar data with 77% of clean reusable electrocardiogram leads being contaminated with bacteria. Switching to disposable electrocardiogram leads was associated with a 25% reduction in sternal wound infections over a 90-day period in Medicare patients. Another potential benefit of this change is the reduction in nursing time spent cleaning the reusable leads.[33]

Environment-Related Risk Factors

The majority of nonpatient risk factor-related SSIs arise from contamination during surgery.[30] Direct contamination can occur from gloves, hands, or hard-to-clean equipment.[11] Indirect contamination can occur from particulate matter such as respiratory droplets and dust.[11] Environmental elements, including operating room air quality, air turnover rates, poor ventilation, higher amounts of airborne contaminants, temperature, cleanliness, and foot traffic may contribute to the development of DSWI and other SSIs.[5,11]

Ventilation systems help prevent contamination of surgical fields.[12,13] Studies have revealed the presence of both methicillin-sensitive and MRSA, *Staphylococcus epidermidis*, coagulase-negative *Staphylococcus*, *Enterobacter*, *Acinetobacter*, and *Pseudomonas*.[11] The American Society of Heating, Refrigerating, and Air Conditioner Engineers' ventilation requirements for operating rooms specifies there must be a minimum of 4 outdoor air exchanges per hour, a minimum of 20 air changes per hour, 20% to 60% relative humidity, and design temperature of 20 to 24°C.[29] The amount of particulate matter in the air can be measured via air particulate counts done with specialized equipment, or by using a microbiological approach using agar plates and counting colony forming units.[11,34] Prior studies have demonstrated that UV light cleaning of operating rooms may decrease hospital-acquired infection transmission.

Airborne particle counts within operating suites have been attributed to the number of intraoperative staff present, staff movement, ventilation, and number of door openings.[11] Door openings are primarily attributed to nursing and non-nursing operating room staff, anesthesia providers, and visitors who are not involved in the procedure.[14] Elliot and colleagues[35] reported an average of 54 door openings per hour in cardiac surgery cases compared with 33 per hour during general surgery cases. The most common reason for door openings was supply retrieval.[35] Birgand and colleagues'[14] multicenter observational study during 34 orthopedic and 25 cardiac surgeries demonstrated a statistically significant increase in $\log_{10}$ 0.3 μm particle and microbial air counts in cases with more door openings. From beginning to end of cardiac procedures, the median number of door openings per hour of the case was 23.4, with a range of 19.7 to 30.[14] The average time the doors were open during each cardiac case was 13.1 minutes, equivalent to 7.3% of the surgery duration.[14] Each door opening increases the likelihood of intraoperative surgical site contamination and SSI.[14]

Convection patient warmers are commonly used on patients in operating rooms to prevent or mitigate hypothermia; however, there are concerns that these devices may not only harbor bacteria and dust but mobilize infectious particles that could potentially seed wounds.[17,18] Their internal fans can disturb air flow currents in an operating room, causing dust, debris, and/or bacteria to settle on the sterile field.[19]

INTERVENTIONS AND IMPLEMENTATION

Mitigating Modifiable Patient-Related Risk Factors

The ACS's preoperative MRSA bundle, which includes CHG baths and nasal decolonization with mupirocin, is designed to limit surgical wound infections; however, it is less effective if all components are not completed.[5] Regardless of the swab results, all preoperative patients are given intranasal mupirocin twice daily for 5 days based on current ACS recommendations.[5] Although use of a universal decolonization strategy has not been shown to reduce infections in noncarriers of *S aureus*, targeted decolonization is difficult to operationalize because it is most effective when doses are completed before surgery.[6] Because the interval between preadmission testing for outpatients or cardiac catheterization for inpatients and cardiac surgery is short, many patients do not complete 10 doses of mupirocin before surgery, putting colonized patients at risk for developing MRSA DSWI.

Our institution screens all nonemergency cardiac surgery patients for intranasal MRSA colonization with either a culture-based or polymerase chain reaction test, depending on the urgency of the procedure. The MRSA screen is used to guide periprocedural antibiotic selection, regardless of whether or not the mupirocin course is completed preoperatively. MRSA-negative patients receive cefazolin, a first-generation cephalosporin, with activity against common gram-positive and gram-negative pathogens associated with SSIs.[8] To optimize pharmacokinetics and pharmacodynamics, a weight-based dose undiluted cefazolin is given as an intravenous push just before incision. Intraoperative doses of cefazolin are repeated every 4 hours during surgery per guideline recommendations.[5] IHIT altered the standard cefazolin-dosing based on newer literature suggesting higher plasma concentrations at skin closure are associated with lower rates of SSI.[9] Beginning in January 2021, patients prescribed perioperative cefazolin received an additional 1 g at the time of closure to ensure higher antibiotic levels in the skin before closure. Antibiotics are given for 24 hours after surgery. In addition to cefazolin for both gram-positive and gram-negative coverage, MRSA-positive patients receive perioperative vancomycin, which is active in vitro against MRSA.[7,10] Emergency cases or patients for whom MRSA results are not available are treated as if they are MRSA-colonized.

All perioperative care team members were educated and engaged in keeping patients warm from operating room to the cardiothoracic intensive care unit (CTICU). CTICU management audited all patients for adherence to the normothermia protocol. Preoperative temperatures are generally measured axillary or oral, intraoperatively with invasive catheters, and postoperatively with axillary or oral route or in some cases by remaining vascular or bladder catheters. If a patient was found to be hypothermic postoperatively, IHIT assessed whether or not the relevant patient warmers in the operating room were functioning appropriately, whether or not room temperatures were appropriate, and whether or not accurate patient temperatures were being achieved.

Mitigating Intraoperative-Related Risk Factors

To combat intraoperative hyperglycemia, we targeted an intraoperative blood glucose level from 110 to 180 mg/dL utilizing insulin infusions for all patients by standardized nomogram. With regard to cardiopulmonary bypass, to reduce the risk of hemodilution, our perfusionists had previously worked to optimize the perfusion circuits to achieve the smallest possible extracorporeal volumes and minimize blood exposure to the circuit by reducing the length. They continue to work on hematocrit optimization in the setting of goal-directed perfusion practice.

Before the implementation of IHIT, we occasionally employed the use of sterile bone wax to augment hemostasis at the osteotomy site. Now by IHIT consensus, the use of bone wax was eliminated. IHIT employs rigid sternal fixation for those patients most likely to experience nonunion as determined by the surgeon and multidisciplinary team seeking to optimize value and risk for each patient in this manner. The decision for rigid sternal fixation was patient and surgeon-specific and not protocolized. Key factors weighing toward consideration of rigid sternal fixation included the following: bilateral internal thoracic artery harvest, poorly controlled diabetes mellitus, chronic obstructive pulmonary disease, body habitus, and amputee status. Wire cerclage was also surgeon-dependent and involved a combination of stainless-steel single and double-strand wires in simple and figure-of-8 configurations to fit patient anatomy. Braided cables or other multifilament cerclage options were not used.

IHIT found that practitioners were inconsistent with antimicrobial patch application techniques. IHIT found that the CHG-impregnated (3M) dressing was not only easier to apply but that it was also more economical. Following this change, audits showed 100% of dressings were applied correctly.

The placement of leads and other devices were targeted preoperatively to avoid the anticipated surgical sites. Our institution trialed and ultimately switched to disposable leads. Additionally, reusable electrocautery pad chords were replaced with a disposable version to decrease the risk of bioburden spread.

Mitigating Environment-Related Risk Factors

Although there are no standard limits for particle or colony forming units counts, IHIT sought to reduce particulate matter as much as possible.[13,34] Ventilation ductwork in operating rooms was identified as another opportunity for improvement. Scrub sink faucet aerator tips were replaced and put on a regular cleaning and replacement plan because these were identified as possible contamination points if not regularly changed out and maintained.

Use of disinfecting UV light to enhance terminal cleaning of the operating room at the end of each day was noted to be suboptimal. Barriers to UV light use were identified via discussion with EVS personnel. These barriers included beliefs that UV use was prohibited around certain perfusion-related machines, intravenous fluids left in the operating room, and insufficient UV lights to accomplish terminal cleaning of all operating rooms on a nightly basis due to time constraints. This resulted in staff education and the purchase of additional UV light machines. There was a steady increase in usage of UV light after remediation and education with 100% compliance in all operating rooms achieved.

Outside of operating rooms, terminally cleaned ICU rooms were targeted to prevent potential contamination of fresh surgical sites and invasive devices. Cloth ICU room privacy curtains were replaced with a disposable version to reduce risk of bioburden cross-contamination and facilitate cleaning both in the ICU and in the preoperative patient bays in the preoperative holding area.

The IHIT team started the Decrease Our Operating Room Traffic (DoOR Traffic) initiative to limit movement into and out of operating rooms. The baseline number of door openings was established by observing 2 CABG surgeries and 8 other surgical procedures. Staff began door counts during set up of the sterile field and ended the counts after wound closure. To capture potential pathogens associated with operating room traffic and personnel, agar plates were placed in each operating room. Control agar plates were placed inside the operating room after the room was terminally cleaned and were recovered before the next surgical procedure. After baseline data was collected, operating room staff were asked to limit unnecessary entry into active cases and strategically implement mitigation measure to reduce traffic. Par levels of supplies were optimized. Surgeons and schedulers verified that cases were posted accurately to ensure that appropriate equipment carts were placed in rooms and extra inventory was minimized. Sizeable STOP sign stickers were placed on the doors of each operating room (Figure 3). After implementation, door opening counts and agar plate studies were repeated. The DoOR Traffic initiative resulted in an approximated 63% reduction in operating room traffic from an average of 310 to 114 door openings and a marked visual reduction in aerosolized bacterial particles were noted on the blood agar plates (Figure 4). This image proved a powerful tool to galvanize support for IHIT across each phase of cardiac

FIGURE 3. The Decrease Our Operating Room Traffic initiative STOP sign that was placed on the door of each operating room to limit movement into and out of the operating room.

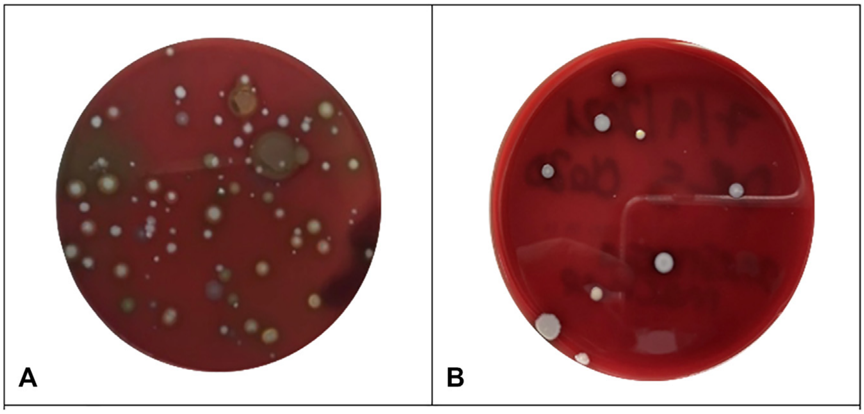

FIGURE 4. Agar plates placed inside the operating room before and after implementation of the Decrease Our Operating Room Traffic initiative (DoOR Traffic) initiative. A, Microorganism growth on a control agar plate before DoOR Traffic Initiative implementation. B, Microorganism growth on an experimental agar plate after DoOR Traffic Initiative implementation.

surgical care. As a result of convection patient warmers potentially disturbing airflow currents, alternative devices capable of controlling body temperature with less airborne risk were identified by IHIT; thus, intraoperative convection warmers were replaced with water temperature-controlled heater-coolers.

Outcomes

In the 12 months since implementation, our incidence of DSWI fell from 1.6% to 0% (Figure 5). Although our mission was to eliminate DSWI, superficial sternal wound infections were also tracked and as a byproduct, the incidence also fell to 0%. These efforts may have resulted in secondary benefits of infection prevention such as decreased morbidity and mortality; however, that was not quantified and was deemed beyond the scope of this piece. The IHIT approach has led individuals in each phase of care to take a deep dive into best practice in their area and through that effort has uncovered shortcomings and opportunities to achieve many small gains resulting in a big win for our patients.

DISCUSSION

In an effort to proactively strive for a cardiac surgery DSWI rate of 0, our system developed a robust, multidisciplinary infection prevention team called the IHIT to identify

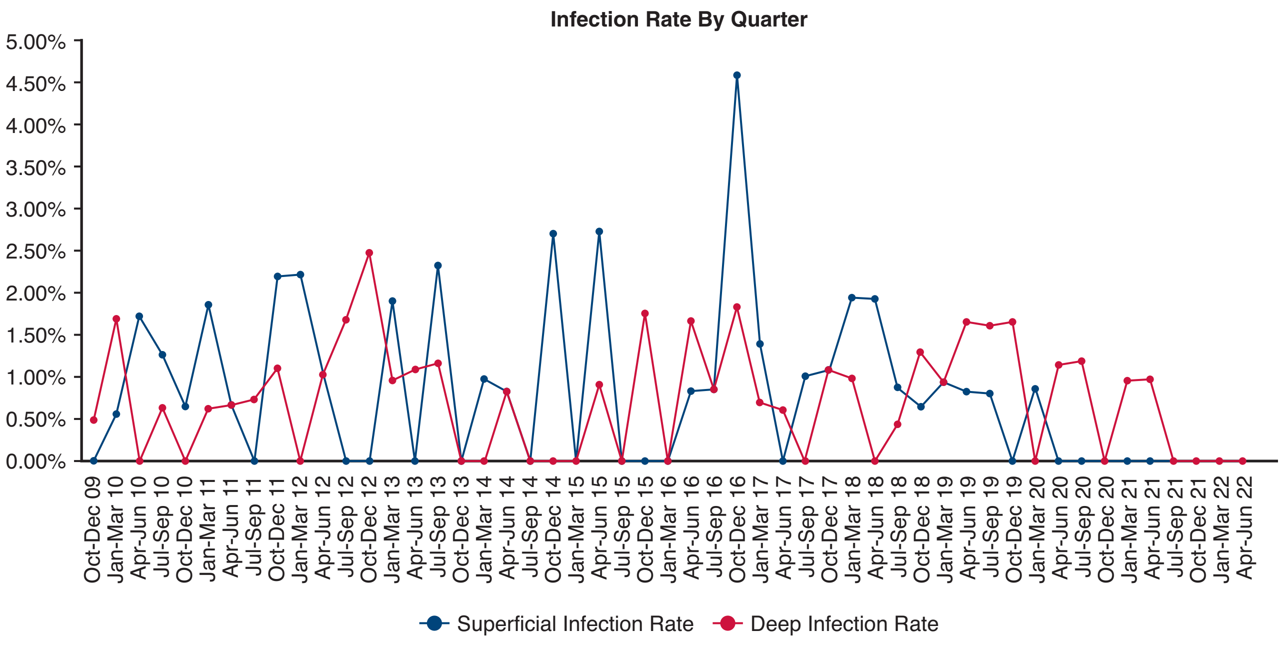

FIGURE 5. Quarterly results of deep sternal wound infection incidence leading up to the I hate infections team intervention and 12 months after implementation. The *x*-axis represents time reported in quarterly intervals. The *y*-axis shows infection rate.

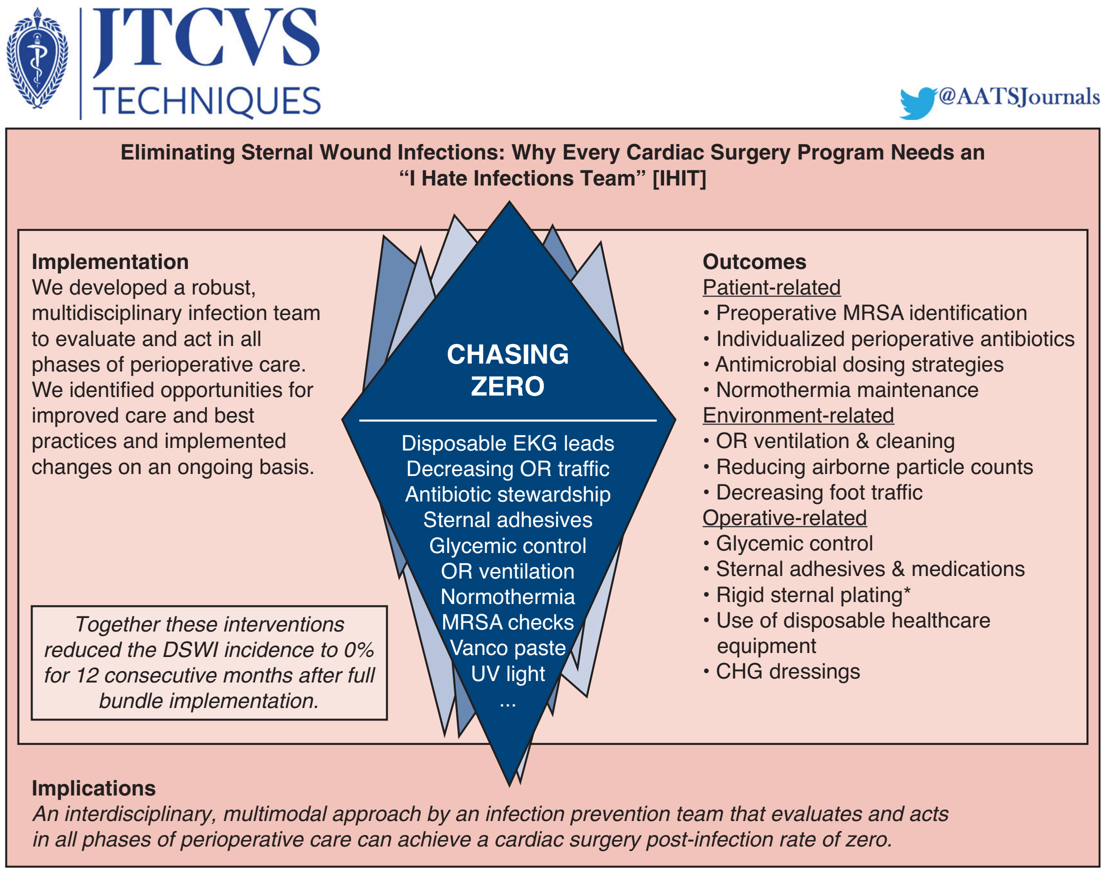

FIGURE 6. Pertinent interventions and outcomes. The iceberg image in the center depicts many, but not all, of the interventions made and represents that no action in particular tipped the iceberg, and the individual influence of each variable is unknowable. *IHIT*, I hate infections team; *MRSA*, methicillin-resistant *Staphylococcus aureus*; *EKG*, electrocardiogram; *OR*, operating room; *DSWI*, deep sternal wound infection; *UV*, ultraviolet light; *CHG*, chlorhexidine gluconate.

best practices in all phases of perioperative care. There are a substantial number of variables and pathway etiologies that can lead to DSWI. Our categorical initiatives toward operating room cleanliness and traffic, a shift to sterile disposable equipment, and a focus on reducing patient bioburden and antibiotic stewardship were altogether successful in this effort. Few studies explored outcomes associated with multiple interventions. To our knowledge, IHIT was the first multidisciplinary group to bundle patient- and operative-related interventions with environmental changes.

Implementing an evidence-based, bundled effort toward infection prevention aligns with the ERAS Cardiac Surgery objective of improving perioperative outcomes. Our IHIT has been working with other operating room clusters and service lines on infection prevention strategies and implementation, specifically the DoOR Traffic initiative. Opportunities for improvement in pediatric surgery have been identified, including sterile technique and the anesthesia work environment, as well as adopting the ERAS bundle. Moving forward, audits will be conducted, regardless of patient infection status, to ensure IHIT compliance. We will continue scheduled quarterly meetings to empower leaders in the setting of post-pandemic staff turnover.

Unfortunately, a shortcoming of implementing a set of bundled set interventions is that the influence of each variable on the incidence of DSWI is unknowable (Figure 6). Our IHIT leadership believes the most low-hanging fruit to be the elimination of bone wax and the implementation instead of vancomycin paste to augment hemostasis of the sternal edges and reducing door openings during surgical procedures (DoOR Traffic initiative). Our IHIT bundle was employed at a single center. Other institutions that implement an infection prevention bundle in a larger patient population may fail to achieve a similar magnitude of benefit. Data have been presented as the number of infections per the number of procedures, combatting potential cofounders of decreased or increased procedure numbers. However, it is still possible there are other cofounders contributing to infection decrease that we are unaware of. Despite these potential limitations, we remain optimistic that adoption of the IHIT approach and process will positively influence patient outcomes. It certainly has led to a more cohesive team effort and system-thinking regarding infection prevention. Expenses associated with IHIT implementation were variable and included an increased cost for disposable equipment and the need in some instances for additional equipment.

Before embarking on an initiative to reduce DSWI at other health systems, we recommend a multidisciplinary audit of current institutional processes. Creating a gap analysis of current and best practices can help identify areas needing improvement. We recommend focusing on the often-neglected environmental risk factors for SSIs. This effort allowed IHIT to uncover many opportunities for improvement. Lastly, we recommend continuous assessments of the influence of interventions, scheduled audits to ensure best-practice adherence, and identification of new opportunities for improvement.

CONCLUSIONS

As part of WakeMed's Chasing Zero Infections campaign, a multidisciplinary IHIT was created. The goal was to eliminate DSWI in our adult cardiac surgery population. The team assessed current perioperative infection prevention measures and reviewed various SSI prevention literature. The team adopted the IHI Improvement Model, which incorporates W. Edwards Demings' Plan-Do-Study-Act cycle to evaluate rapid change.[5] Initiatives focused on reducing patient bioburden, optimizing perioperative antibiotics, using disposable equipment, and operating room cleanliness. This bundle was successful in achieving a postsurgical DSWI rate of 0 during the first 12 months after implementation. This cumulation of incremental gains demonstrates why every cardiac surgery program needs an IHIT.

Conflict of Interest Statement

The authors reported no conflicts of interest

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