Specific Care Question

In patients undergoing surgery, what intraoperative or postoperative surgical care bundles prevent surgical site infections (SSI)?

Recommendations Based on Current Literature (Best Evidence) Only

A strong recommendation is made to use a postoperative bundle to decrease SSI, however no recommendation can be made for which elements to include in the bundle based on an expert review of the current literature by the Department of EBP. The overall certainty in the evidence is very low[a]. While the most effective individual bundle elements were not measured, the evidence supports the use of bundles to reduce SSIs. Implementation and compliance were major determinants of bundle success and were reported to have a profound beneficial effect on SSI rates (Manivanna et al., 2018; Zywot et al., 2017*). When there is a lack of scientific evidence, standard work should be developed, implemented, and monitored.*

Literature Summary

Background. An SSI is an infection that occurs after surgery, at the surgical site and can be a superficial infection involving the skin only or a more serious infection involving organs or implanted material (Center for Disease Control, 2010). SSIs are the most common hospital-acquired infection and occur in almost 2% of all surgeries (Anderson et al., 2017). Acquiring an SSI results in significant morbidity for patients and costs to the healthcare system (Caruso et al., 2019). The reported average cost of an SSI ranged from $25,000 to more than $90,000 (Berríos-Torres et al., 2017). Efforts to reduce SSIs in the pediatric population include implementation of SSI-reduction bundles and national networks sharing interventions (Children's Hospitals' Solutions for Patient Safety, 2019). Extensive literature on the efforts to reduce SSIs in adults has been published (Güenaga, Matos, & Wille-Jørgensen, 2011; Zywot, Lau, Stephen Fletcher, & Paul, 2017). Unfortunately, literature for the pediatric population has been limited (Rangel et al., 2015). This review will summarize identified literature to answer the specific care question.

Study characteristics. The search for suitable studies was completed on February 24, 2020. N. Price, MD reviewed the 143 titles and/or abstracts found in the search and identified[b] 44 single studies believed to answer the question. After an in-depth review of the single studies[c], 19 answered the question, one systematic review (Zywot et al., 2017) and 18 single studies (Agarwal et al., 2018; Caruso et al., 2019; Chiwera, Wigglesworth, McCoskery, Lucchese, & Newsholme, 2018; Delgado-Corcoran et al., 2017; Elia-Guedea et al., 2017; Fisher et al., 2016; Frenette, Sperlea, Tesolin, Patterson, & Thirion, 2016; Gould, Hennessey, Kiernan, Safier, & Herman, 2016; Harris et al., 2017; Kles et al., 2015; Lindblom et al., 2015; Losh et al., 2017; McGee et al., 2019; Nordin et al., 2017; Rubeli et al., 2019; Russell et al., 2018; Schriefer et al., 2017; Schweizer et al., 2015). Studies included pediatric and adult patients who underwent different types of surgeries including: (a) cardiac, (b) gastrointestinal, (c) spine, and (d) joint replacement. The study interventions included preoperative, intraoperative, and/or postoperative bundles. The most common intra and postoperative bundles are listed below. See Table 1 for a complete list of bundle elements by study.

Most Common Bundle Elements

Intraoperative Bundle.

- *Intraoperative hair removal
- *Intraoperative skin prep
- *Intraoperative antibiotic timing
- *Intraoperative antibiotic type
- *Intraoperative antibiotic dose and redosing
- De-cluttering of theatre and cleanliness checklists
- Segregation of scrub nurse trolleys
- Regulating movement in the operating theater
  - Limit medical and nursing students, pharmaceutical suppliers
  - Limit movement in and out of theater
  - Encouraging clean hallways for entrance to the theater, and dirty hallways for exiting the theater
  - Keeping theater doors closed during the operation
  - Correct use of personal protective equipment (PPE)
- *Instrument, gown, and gloves changed prior to closing
- Antibiotic impregnated suture

- Surgeons' hair on head and face completely covered
- Double gloved or exchanged every two hours
- High-risk patients prewarmed using warming blankets, thermal gowns, and thermal hats

*Bundles items used in pediatric surgery populations

Postoperative Bundle.

- *Sterile technique for surgical dressing changes
- *Standardization of dressing changes
- *Standardization of wound care protocols
- *Standardized antibiotic timing and dosing
- *Daily postoperative chlorohexidine (CHG)
- *Daily postoperative linen and gown change
- *Covering incision site when at risk for contamination
- *Appropriate documentation of state of wound
- *Competency for all staff
- *Standardization of patient home care and education materials for monitoring the wound for infection
- Daily assessment of the need for all lines and catheters
- Normothermia maintained
- Tight glucose control maintained

*Bundles items used in pediatric surgery populations

Summary by Outcome

SSI Postoperative Bundle. Two studies (Agarwal et al., 2018; Caruso et al., 2019) measured SSI (*N* = 4951). For the outcome SSI rates, odds ratios were calculated and are included in the meta-analysis (see Figure 2 and Table 2). The OR indicated the intervention of postoperative bundles was favorable to the comparator of not using bundles, *OR* = 0.39, 95% CI [0.25, 0.60]. The use of postoperative bundles resulted in 13 to 25 fewer SSI per 1,000 surgeries.

Certainty of the evidence for SSI postoperative bundle. The certainty of the body of evidence was very low based on four factors[a]: *within-study risk of bias*, *consistency among studies, directness of evidence*, and *precision of effect estimates*. The evidence was of very low certainty, even with rating up for effect size. The body of evidence was assessed to have serious risk of bias, serious inconsistency, serious indirectness and serious imprecision. Risk of bias was serious due to study type; they were quality improvement initiatives. There was inconsistency due to differing bundle elements for each study. The evidence was indirect as one of the two studies measured SSIs in adults (Agarwal et al., 2018). The study was imprecise due to the low number of SSIs.

SSI Pre- and Intraoperative Bundles. Three studies (Fisher et al., 2016; Rubeli et al., 2019; Schweizer et al., 2015) measured SSI, (*N*= 43,971). For the outcome SSI rates, odds ratios were calculated and are included in the meta-analysis (see Figure 3 and Table 3). The OR indicated the intervention of preoperative and intraoperative bundles was favorable to the comparator of not using bundles, *OR* = 0.42, 95% CI [0.28, 0.68]. The use of preoperative and intraoperative bundles resulted in 2 to 3 fewer SSI per 1,000 surgeries.

Certainty of the evidence for SSI* pre- and intraoperative *bundles. The certainty of the body of evidence was very low based on four factors[a]: *within-study risk of bias*, *consistency among studies, directness of evidence*, and *precision of effect estimates*. The body of evidence was assessed to have serious risk of bias, serious inconsistency, and serious indirectness. Risk of bias was serious due to the studies were quality improvement. There was inconsistent due to differing bundle elements employed for each study. The evidence was indirect as two of the three studies included adults (Rubeli et al., 2019; Schweizer et al., 2015).

SSI Perioperative Bundles. Eleven studies (Agarwal et al., 2018; Caruso et al., 2019; Delgado-Corcoran et al., 2017; Elia-Guedea et al., 2017; Fisher et al., 2016; Frenette et al., 2016; Gould et al., 2016; Losh et al., 2017; Rubeli et al., 2019; Schweizer et al., 2015; Zywot et al., 2017)

measured SSI, (*N* = 55,683). The meta-analysis by Zywot et al. (2017) included another 22 studies (Anthony et al., 2011; Benlice & Gorgun, 2016; Bert et al., 2017; Bull et al., 2011; Cima et al., 2013; Connolly, Foppa, Kazi, Denoya, & Bergamaschi, 2016; Rogier MPH Crolla et al., 2012; DeHaas et al., 2016; Elia-Guedea et al., 2017; Ghuman et al., 2015; Hedrick, Heckman, et al., 2007; Hedrick, Turrentine, et al., 2007; Hewitt et al., 2017; Keenan et al., 2015; Keenan et al., 2014; Lutfiyya, Parsons, & Breen, 2012; Pérez-Blanco, García-Olmo, Maseda-Garrido, Nájera-Santos, & García-Caballero, 2015; Rumberger et al., 2016; Tanner et al., 2009; Matthew Tillman, Hania Wehbe-Janek, Bonnie Hodges, W Roy Smythe, & Harry T Papaconstantinou, 2013; Wick et al., 2012; Yamamoto et al., 2015). For the outcome SSI rates, odds ratios were calculated and are included in the meta-analysis (see Figure 4 and Table 4). The OR indicated the intervention was favorable to the comparator, *OR* = 0.49, 94% CI [0.38, 0.59]. The use of perioperative bundles resulted in 6 to 7 fewer SSI per 1000 surgeries.

Certainty of the evidence for SSI perioperative and intraoperative bundles. The certainty of the body of evidence was very low based on four factors[a]: *within-study risk of bias*, *consistency among studies, directness of evidence*, and *precision of effect estimates*. The body of evidence was assessed to have serious risk of bias, serious inconsistency, and serious indirectness. Risk of bias was serious due to the studies employed cohort or quality improvement methodologies. There was serious? inconsistency due to differing bundle elements for each study. The evidence was indirect as only three studies included pediatric patients (Caruso et al., 2019; Delgado-Corcoran et al., 2017; Gould et al., 2016).

SSI Pediatric Perioperative. A subgroup analysis was done on the three pediatric studies (Caruso et al., 2019; Delgado-Corcoran et al., 2017; Gould et al., 2016) measured SSI, (*N* = 3,340). For the outcome SSI rates, odds ratios were calculated and are included in the meta-analysis (see Figure 4 and Table 4). The OR indicated the intervention was favorable to the comparator, *OR* = 0.41, 94% CI [0.24, 0.69]. The use of perioperative bundles resulted in 12 to 29 fewer SSI per 1000 surgeries.

***Certainty of the evidence for* SSI pediatric perioperative.** The certainty of the body of evidence was very low based on four factors[a]: *within-study risk of bias*, *consistency among studies, directness of evidence*, and *precision of effect estimates*. The evidence was of very low certainty, even with rating up for effect size. The body of evidence was assessed to have serious risk of bias, serious inconsistency, and serious imprecision. Risk of bias was serious due to the studies were quality improvement. There was serious inconsistency due to differing bundle elements for each study. The findings were imprecise due to the low number of SSIs.

Identification of Studies

Search Strategy and Results (see Figure 1)

Search: (intraoperative OR intra-operative OR perioperative OR postoperative OR post-operative OR peri-operative OR (pre-, peri-, and postoperative bundle) OR PPPB[tiab]) AND ("Patient Care Bundles"[MeSH] OR bundle[tiab] OR bundles[tiab]) AND ("Surgical Wound Infection/prevention and control"[Mesh] OR "surgical site infection" OR SSI[tiab]) Filters: From 2005/01/01 to 2020/12/31

Search: (cardiac OR cardiothoracic OR sternal OR spinal OR spine OR neurosurgery) AND (intraoperative OR intra-operative OR perioperative OR postoperative OR post-operative OR peri-operative OR (pre-, peri-, and postoperative bundle) OR PPPB[tiab]) AND ("Patient Care Bundles"[MeSH] OR bundle OR bundles OR "quality improvement"[Majr]) AND ("Surgical Wound Infection/prevention and control"[Mesh] OR "surgical site infection" OR SSI[tiab]) Filters: From 2005/01/01 to 2020/12/31

Search: (cardiac OR cardiothoracic OR sternal OR spinal OR spine OR neurosurgery) AND (intraoperative OR intra-operative OR perioperative OR postoperative OR post-operative OR peri-operative OR (pre-, peri-, and postoperative bundle) OR PPPB[tiab]) AND ("Patient Care Bundles"[MeSH] OR bundle[tiab] OR bundles[tiab]) AND ("Surgical Wound Infection/prevention and control"[Mesh] OR "surgical site infection" OR SSI[tiab]) Filters: From 2005/01/01 to 2020/12/31

Records identified through database searching *n* = 142

Additional records identified through other sources *n* = 1

Studies Included in this Review

Citation	Study Type

Agarwal et al. (2018)	Cohort
Caruso et al. (2019)	Quality Improvement
Chiwera et al. (2018)	Quality Improvement
Delgado-Corcoran et al. (2017)	Quality Improvement
Elia-Guedea et al. (2017)	Cohort
Fisher et al. (2016)	Quality Improvement
Frenette et al. (2016)	Quality Improvement
Gould et al. (2016)	Quality Improvement
Harris et al. (2017)	Quality Improvement
Kles et al. (2015)	Quality Improvement
Lindblom et al. (2015)	Quality Improvement
Losh et al. (2017)	Quality Improvement
McGee et al. (2019)	Quality Improvement
Nordin et al. (2017)	Cohort
Rubeli et al. (2019)	Cohort
Russell et al. (2018)	Quality Improvement
Schaffzin et al. (2015)	Quality Improvement
Schweizer et al. (2015)	Cohort
Zywot et al. (2017)	MA/SR
*Anthony et al. (2011)	Cohort
*Benlice and Gorgun (2016)	Cohort
*Bert et al. (2017)	Cohort
*Bull et al. (2011)	Cohort
*Cima et al. (2013)	Cohort
*Connolly et al. (2016)	Cohort
*Crolla et al. (2012)	Cohort
*DeHaas et al. (2016)	Cohort
*Elia-Guedea et al. (2017)	Cohort
*Ghuman et al. (2015)	Cohort
*Hedrick, Heckman, et al. (2007)	Cohort
*Hedrick, Turrentine, et al. (2007)	Cohort
*Hewitt et al. (2017)	Cohort
*Keenan et al. (2014)	Cohort
*Keenan et al. (2015)	Cohort
*Lutfiyya et al. (2012)	Cohort
*Pérez-Blanco et al. (2015)	Cohort
*Rumberger et al. (2016)	Cohort
*Tanner et al. (2009)	Cohort
*Tillman, et al. (2013)	Cohort
*Wick et al. (2012)	Cohort
*Yamamoto et al. (2015)	Cohort

**References marked with an asterisk indicate studies included the meta-analysis*

Studies Not Included in this Review with Exclusion Rationale

Citation	Reason for exclusion
Anderson et al. (2017)	Narrative review

Cunningham et al. (2020)	Preoperative bundle only
Duff et al. (2018)	Study on bundle development tool
Duff et al. (2018)	Study on bundle development tool
Edmiston and Leaper (2016)	Narrative review
Edmiston et al. (2016)	Narrative review
Gómez-Romero et al. (2017)	Narrative review
Guzman-Pruneda et al. (2019)	Preoperative bundle only
Leaper et al. (2015)	Narrative review
Edmiston et al. (2018)	Study on surgical irrigation
Oetgen et al. (2019)	Survey of bundle types
Conway et al. (2019)	Thermal care
Lord et al. (2019)	Non-surgery adult neuro-icu patients
Chow et al. (2017)	Study on hospital transfers
Lo and Hunningher (2017)	Narrative review
Tartari et al. (2017)	Expert panel perspective
Scheithauer et al. (2016)	Non-English
Leaper et al. (2017)	Narrative review
Manivannan et al. (2018)	Study on surveillance of system
Santos-Jasso et al. (2020)	Bundle to increase feeds
Vandenberg et al. (2018)	No bundle
D. Leaper and Ousey (2015)	Narrative review
Miyahara et al. (2014)	Intervention: designated team for all surgeries
Loftus et al. (2012)	HubSrubs intervention
Hodge et al. (2019)	Preoperative bundle only

Methods Used for Appraisal and Synthesis

[a]The GRADEpro Guideline Development Tool (GDT) is the tool used to create the Summary of Findings table(s) for this analysis.

[b]Rayyan is a web-based software used for the initial screening of titles and / or abstracts for this analysis (Ouzzani, Hammady, Fedorowicz & Elmagarmid, 2017).

[c]Review Manager (Higgins & Green, 2011) is a Cochrane Collaborative computer program used to assess the study characteristics as well as the risk of bias and create the forest plots found in this analysis.

[d]The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram depicts the process in which literature is searched, screened, and eligibility criteria is applied (Moher, Liberati, Tetzlaff, & Altman, 2009).

[a]Ouzzani, M., Hammady, H., Fedorowicz, Z., & Elmagarmid, A. (2016). Rayyan-a web and mobile app for systematic reviews. *Systematic Reviews, 5*(1), 210. Doi:10.1186/s13643-016-0384-4

[b]Higgins, J. P. T., & Green, S. e. (2011). *Cochrane Handbook for Systematic Reviews of Interventions [updated March 2011]* (Version 5.1.0 ed.): The Cochrane Collaboration, 2011.

[c]GRADEpro GDT: GRADEpro Guideline Development Tool (2015). McMaster University, (developed by Evidence Prime, Inc.). [Software]. Available from gradepro.org.

[d]Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). *P*referred *R*eporting *I*tems for *S*ystematic Reviews and *M*eta-*A*nalyses: The PRISMA Statement. PloS Med 6(7): e1000097. Doi:10.1371/journal.pmed1000097 **For more information, visit www.prisma-statement.org.**

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Acronyms Used in this Document

Acronym	Explanation
AGREE II	Appraisal of Guidelines Research and Evaluation II
BMI	Body mass index
CABG	Coronary artery bypass grafting
CAT	Critically appraised topic
CHG	Chlorhexidine
CPG	Clinical practice guideline
CRPT	Colorectal procedure targeted
CRS	Colorectal surgery
EBP	Evidence based practice
HER	Electronic health record
EMR	Electronic medical records
MRSA	Methicillin-resistant staphylococcus aureus
MSSA	Methicillin-sensitive Staphylococcus aureus
O:E	Observed to expected
OR	Operating room
PCP	Primary care physician
PC	Primary closure
PPE	Personal protective equipment
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
RAOR	Risk adjusted odds ratio
SAP	Surgical antimicrobial prophylaxis
SSI	Surgical site infection
SWI	Sternal wound infection
SWPB	Sternal wound prevention bundle
IV	Intravenous

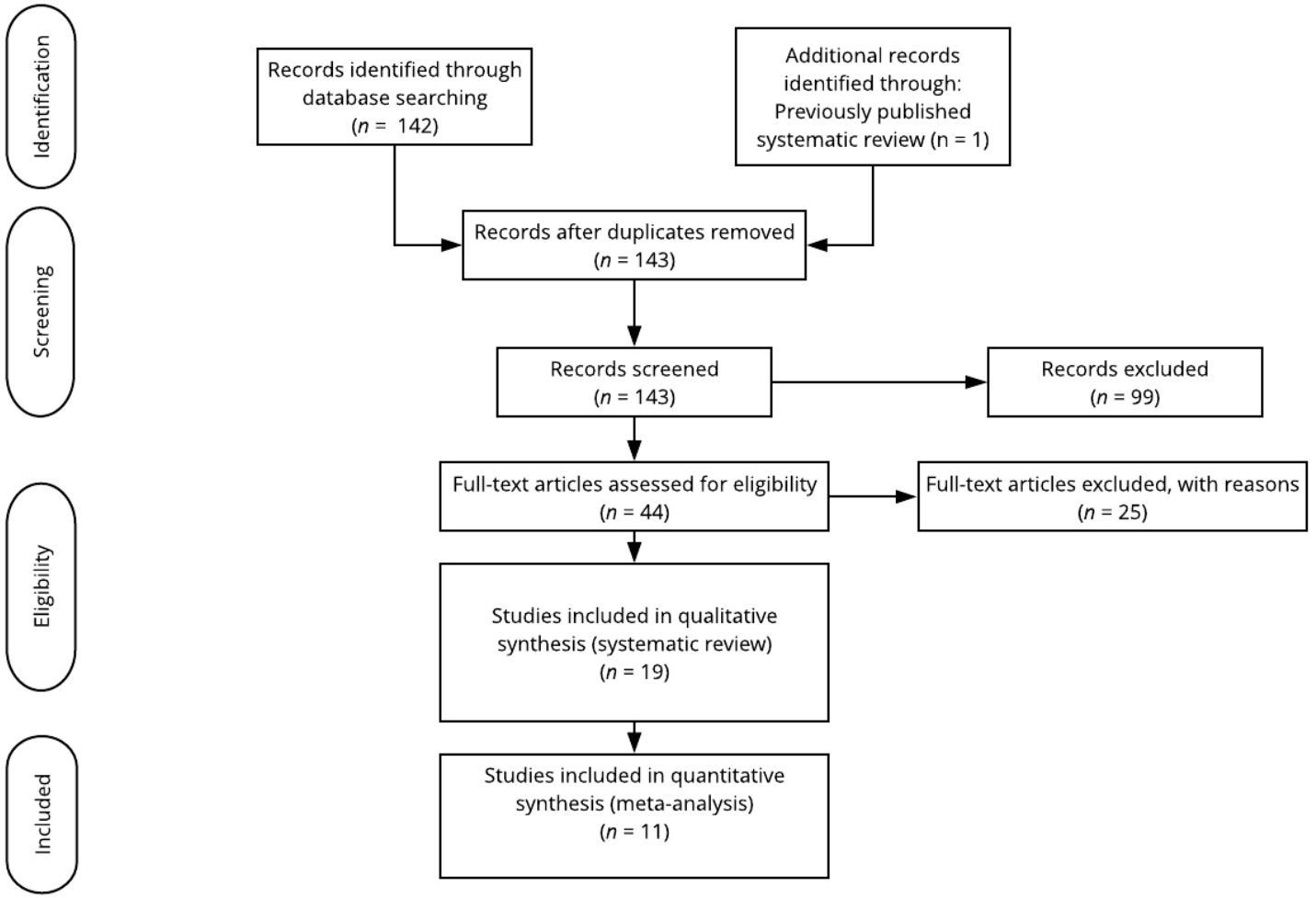

Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRIMSA)[d]

Table 1
Bundles by Study

Agarwal et al., 2018	• **Preoperative Bundle:**
	  ○ 4% CHG preoperative bathing for 5 days
	  ○ Nasal screening for *Staphylococcus aureus* preoperatively with administration of 2% mupirocin ointment for nasal decolonization for 5 days for positive tests
	  ○ CHG-alcohol as the standard preoperative preparation unless contraindicated.
	• **Postoperative Bundle:**
	  ○ Sterile technique for surgical dressing changes,
	  ○ Dressings to be changed daily for 7 days after spine surgery
	  ○ Standardization of dressing changes.
	• **Physician reporting:**
	  ○ All attending neurosurgeons and residents were informed of their individual infection rates for spinal fusion surgeries and their infection rate ranking when compared with their colleagues.

Caruso et al., 2019	• **Postoperative Bundle**
	  ○ Daily postoperative CHG
	  ○ Daily postoperative linen and gown change
	  ○ Dressing removed within 48 hours of procedure using aseptic technique
	  ○ Covering incision site when at risk for contamination
	  ○ Echocardiograms performed in sterile fashion
	  ○ Sterile environment standards, including appropriate attire, during procedures performed in the Cardiovascular Intensive Care Unit
	  ○ Minimize sternotomy exposure to home blankets
	  ○ Appropriate documentation of state of wound
	  ○ Appropriate swabbing of wounds for infections
	  ○ First postoperative antibiotic given at appropriate time and dose
	  ○ Postoperative antibiotic continued at appropriate time and dose for 24 hours, continued if chest open

Chiwera et al., 2018	• **Preoperative Bundle:**
	  ○ Skin decolonization with 4% CHG washes on the night before surgery and 2% CHG cloths on the day of surgery
	  ○ Patient education material on how to prepare the skin before surgery
	  ○ Use of electric hair clippers only where removal was needed
	• **Intraoperative Bundle:**
	  ○ Prior to incision, preparing skin with 2% CHG gluconate in 70% isopropyl alcohol (ChloraPrep™)
	  ○ Antibiotic prophylaxis within one hour prior to skin incision.
	  ○ All operating room staff wear face masks
	  ○ De-cluttering of theatres and design of cleanliness checklists to be signed off by surgeons before procedures started
	  ○ Segregation of scrub nurse trolleys for donor sites and sternal sites (only one used prior)
	  ○ Enhanced monitoring of theatre discipline
	• **Postoperative bundle:**
	  ○ Asepsis competency for all staff. Adherence to asepsis principles for all wound care
	  ○ "No peak" policy for all surgical wounds
	  ○ Patient education materials for monitoring the wound for infection

	○ Standardization of wound care protocols (dressing left in place)
Delgado-Corcoran et al., 2017	• **Preoperative Bundle:** ○ Nightly CHG baths and mupirocin nasal ointment twice daily for 2– 5 days prior to surgery ○ Outpatient mupirocin and CHG bath provided to patients during their preoperative outpatient visit with detailed instructions to begin application within 1–3 days of surgery • **Intraoperative Bundle:** ○ Intraoperative skin antisepsis with CHG solution and hair removal with clippers for all cardiac surgical patients undergoing sternotomy or thoracotomy ○ Standardized intravenous antibiotic doses by weight were administered at the following time points: within 5–60 minutes of the initial surgical incision, with initiation of cardiopulmonary bypass, and every 3 hours intraoperatively for the duration of the case • **Postoperative Bundle:** ○ Antibiotic duration was standardized to 48 hours after primary closure (PC) or 48 hours after delayed sternal closure ○ The occlusive sternal dressing applied at time of chest closure was removed 48 hours post-operatively. ○ A standardized checklist used to prompt team members to inspect the sternal wound 48 hours post-operatively and daily thereafter. ○ Standardized process for bedside care of an open sternum, including timing of dressing changes, sternal closure procedure, and chest tube removal were implemented.
Elia-Guedea et al., 2017	• **Preoperative Bundle:** ○ Proper Intravenous (IV) prophylaxis antibiotic administration- based on environmental microbial resistance. Selected 2 grams of amoxicillin-clavulanate along with 240 mG gentamicin • **Intraoperative Bundle:** ○ Second dose of 2 grams amoxicillin-clavulanate during surgery if operation took over 2 hours or when there was excessive blood loss (> 1 liter) ○ Location change- colorectal surgery room was changed to a new operating room. ○ Defined team of anesthesiologists, nurses, and assistants ○ Regulating movement in the operating theater ▪ Limit medical and nursing students, pharmaceutical suppliers ▪ Limit movement in and out of theater ▪ Encouraging clean hallways for entrance to the theater, and dirty hallways for exiting the theater ▪ Keeping theater doors closed during the operation ▪ Correct use of PPE ○ Aseptic handling of wounds after manipulation of the colon • **Postoperative Bundle:** ○ Proper wound care and handling of IV catheters
Fisher et al., 2016	• **Preoperative Bundle:** ○ Preoperative call – were CHG wipes received? ○ CHG wash (night before surgery) ○ CHG Wash (morning of operating room (OR)) ○ Preoperative MRSA screening nasal swab ○ Preoperative nasal decolonization • **Intraoperative Bundle:** ○ Intraoperative hair removal

	○ Intraoperative skin prep ○ Intraoperative antibiotic timing ○ Intraoperative antibiotic type ○ Intraoperative Antibiotic Dose and Redosing
Frenette et al., 2016	• **Preoperative Bundle:** ○ Shower with 4% CHG sponge the night before and the morning of surgery ○ Hair removal with clipper the night before or morning of surgery ○ Identify and treat active infections prior to surgery ○ 2% CHG- impregnated washcloths applied the night before and morning of surgery ○ Hair removal with clippers, if necessary, on call or in the OR. Size of hair removal the expected size of the dressing only. ○ Identification and treatment of active infections prior to surgery. If urinalysis was positive for leukocytes or nitrates, obtain a urine culture and treat as needed. ○ Screen, preoperatively for methicillin-resistant *Staphylococcus aureus (MRSA)* and treat with nasal mupirocin ointment. MRSA positive patients treated with vancomycin prophylaxis • **Intraoperative Bundle:** ○ Skin antisepsis with 0.5% CHG solution ○ Skin antisepsis with 2% CHG with 70% alcohol • **Postoperative Bundle:** ○ Initial dressing is non occlusive and changed 24 hours after the operation. Can be changed earlier if soaked and or soiled with blood. Change dressing no later than 48 hours post operatively. ○ Recommendation was made to pay attention to surgical technique at the vein donor site, including protect the sterile field. Control edema at the donor site with elastic stockings and compressive bandages, readjust daily in very obese patients. ○ Discontinue drains, chest tubes, Foley catheters and central lines. Daily assessment of the need for all lines and catheters
Gould et al., 2016	• **Preoperative Bundle:** ○ Soap & water bath and hair washing, followed by 2% CHG bath cloth application (neck to toes) the night before & morning of surgery ○ Dermatology assessment tool and consultation if necessary • **Intraoperative Bundle:** ○ Use of 2% CHG/70% isopropyl alcohol for skin antisepsis in OR ○ Antimicrobial silver wound contact dressing application after closure of incision in the OR Postoperative what? in hospital ○ Designated nursing unit post op ○ Postoperative nursing standard of care ○ "Back Home" teaching tool for nurses. Teach back is required • **Postoperative Bundle:** ○ Back Home kit ○ Written discharge instructions: ▪ Hand hygiene significance for patient and caregivers ▪ Surgical dressing changed if loose or soiled; maintained for 1 week ▪ Keeping the incision area clean includes the following: ▪ Personal hygiene: daily CHG bath ▪ Diaper changes every 2 hours; meticulous cleanliness of the lower back

	▪ Keep hair up and away from the incision ▪ Clean linens and clothing, keeping pets off areas where the patient rests ▪ Avoid swimming until cleared by physician during follow-up ▪ Signs and symptoms of infection, doctor's phone number ▪ Follow-up appointment 7 days after leaving the hospital
Harris et al., 2018	• **Preoperative Bundle:** ○ Weight-based dosing of preoperative antibiotics with redosing after four hours, ○ Iodophor nares swabs to decolonize the nose of all pathogens for 24 hours, • **Intraoperative Bundle:** ○ Silver-impregnated dressings to protect the surgical incision ○ Provide low volume-negative pressure to aid in healing, ○ Separate sterile instrument set for closing the incision (i.e., instruments used on the colon are removed, new closure instruments are provided, gowns and gloves are changed) ○ A new florescent imaging instrument to assess perfusion in the anastomosis and to check for microleaks.
Kles et al., 2015	• **Preoperative Bundle:** ○ Hair clipping always performed in pre-operative short stay area ○ Prevention strategies to prevent MRSA were standardized to a 5- day course of mupirocin nasal ointment ○ Patients with diabetes or a HbA1C greater than 6.5% were admitted the night before surgery and placed on an insulin drip ○ Any patient hospitalized ≥ 48 hours first-time vancomycin dose administered 2 hours prior to incision time • **Intraoperative Bundle:** ○ Any patient on epinephrine and or vasopressin was placed on an insulin infusion ○ Utilize antibiotic impregnated sutures ○ Change stitch of closing incision from a running suture to an interrupted suture on the distal fascia ○ Change to soft silicone silver impregnated dressing • **Postoperative Bundle:** ○ Dressing stayed in place for the first 7 days. The dressing was pulled back after 24 hours to assess the incision, then left in place unless soiled or insecure. ○ Dressing changes changed from aseptic technique to sterile technique
Lindblom et al., 2015	• **Preoperative Bundle:** ○ Two showers and scrubbing with 4% CHG detergent at the hospital ○ Antibiotic administration: cloxacillin 2 grams administered four to five times all in the day of surgery every four hours. First dose 30 to 60 minutes prior to incision • **Intraoperative Bundle:** ○ Increased discipline in the operating theater ▪ Decrease the number of door openings ▪ Restrict the number of people (maximum of 11) ○ Changed wound closure from sternal wires are figure-of-eights, to eight single sternal wires ○ All surgeons asked to double glove ○ Immediately post-op, skin and incision was scrubbed with 0.5% CHG in 70% ethanol prior to dressing placement ○ Room environment- ▪ Revised cleaning procedures for operation theater

	▪ Reusable materials ▪ Purchased disinfect-able keyboards ▪ Used more disposable materials • **Postoperative Bundle:** o Dressing were removed after 48 hours; the dressing was not replaced unless the wound was still open o Hand hygiene enforced o Disposable plastic aprons
Losh et al., 2017	• **Preoperative Bundle:** o Referral to smoking cessation program o Screening for diabetes, diabetes control o Standardized antibiotic bowel preparation o CHG wipes • **Intraoperative Bundle:** o Standardized antibiotic administration o Standardized hair clipping o Use of a wound protector o Wound irrigation o After anastomosis, all surgical gloves were changed by surgeons and scrub techs and all dirty instruments were removed from the surgical field o Repeat antibiotic dosing reviewed by surgeon and anesthesiologists. • **Postoperative Bundle:** o Normothermia maintained o Tight glucose control maintained
McGee et al., 2019	• **Preoperative Outpatient Bundle:** o Oral antibiotics o Mechanical bowel preparation, large volume polyethylene glycol o Preoperative skin cleansing the day before surgery o Preoperative skin cleansing the day of surgery o Timely initial administration of SSI antibiotic prophylaxis o Same day, preoperative day of surgery blood glucose < 200 mg/dL for ACS-NSQIP defined diabetics • **Intraoperative Bundle:** o Timely intraoperative re-administration of SSI antibiotic prophylaxis o First measure of temperature on arrival to PACU is ≥ 36.0◦C o Intraoperative skin preparation with CHG and alcohol-based solution o Impermeable wound protector for all incisions o Dedicated clean wound tray for all incisions o Gown and glove change for all scrubbed personnel prior to wound closure o Re-draping prior to wound closure o Sterile occlusive incision wound dressing placed in the OR o Intraoperative blood glucose at 2 ± 0.5 hours into surgery < 200 mg/dL for ACS-NSQIP defined diabetics • **Postoperative Bundle:** o Duration of antibiotic prophylaxis < 24 hours o Original dressing removed on post op day 2 o Daily incision cleansing with CHG after dressing removal until discharge, but no longer than 7 days.

Nordin et al., 2018	• **Preoperative Bundle:**
	  ○ Bowel prep required for all patients undergoing a procedure involving the rectum unless a proximal stoma is present and is not being concomitantly reversed
	  ○ Inpatient regimen
	  ○ GoLytely 25 mL/kg/h x 4 h
	  ○ Neomycin 15 mg/kg/dose (x 3 doses)
	  ○ Erythromycin 20 mg/kg/dose (x 3 doses)
	  • 10 mg/kg/dose for neonates <30 days old
	  ○ Patients >2 months: clean the abdomen with 2% CHG gluconate wipes
	  ○ Patients <2 months: clean the abdomen with antimicrobial wipes
	  ○ Measure patient temperature 1 h prior to operation
	  ○ Apply convection warming blanket for all patients with initial temperature <36.5 °C
	  • Recheck temperature every 30 min
	  ○ Preoperative Antibiotics
	  ○ Administer appropriate antibiotic to finish within 60 min of incision
	  ○ Cefazolin for foregut and HPB procedures. Redose as needed
	  ○ Cefoxitin for midgut/hindgut procedures. Redose as needed
	  ○ Gentamicin/clindamycin for patients with penicillin allergies
	  ○ Ampicillin/gentamicin acceptable for neonates within first week of life; add clindamycin after first week
	  ○ If patient is on adequate systemic antibiotics prior to the procedure, no additional antibiotics are needed. Redose as needed
	  ○ Skin Prep
	  ▪ CHG for all patients >2 months or >1 kg
	  ▪ 10% povidone-iodine for patients <2 months or <1 kg
	• **Intraoperative Bundle:**
	  ○ Closing Protocol (for procedures in which the bowel has been opened and fascial closure is needed)
	  ▪ Prior to fascial closure
	  ▪ All staff change gloves
	  ▪ Redrape the surgical field
	  ▪ Remove all dirty instruments; use clean instruments for fascia and wound closure

Rubeil et al., 2019	• **Preoperative Outpatient Bundle**
	  ○ Hair removed with clipper
	  ○ Antibiotic and antiseptic use
	  ▪ Surgical antimicrobial prophylaxis (SAP)
	  ▪ Cefuroxime 1.5 g IV (3 g for body weight > 80 kg) within 1 hour before incision
	  ▪ Dose repetition if duration of surgery exceeded 4 hours
	  ○ Skin disinfection
	  ▪ Alcohol-based solutions used for all surgeries except for transsphenoidal surgery) before three-point skull clamp placement
	  ▪ Disinfection of the incision border directly after incision and before wound closure
	• **Intraoperative Bundle:**
	  ○ Surgeons' hair on head and face completely covered
	  ○ Gloves exchanged every two hours

	○ Gloves exchanged before implantation of foreign material ○ Minimization of traffic and door openings in operating room ○ Surgeons' coaching: ▪ Gentle tissue handling and thorough mechanical hemostasis techniques such as irrigation, bipolar coagulation, and slight compression ▪ Limited use of hemostatic agents and foreign materials ▪ Specialized technical operation assistant team for neurosurgery
Russell et al., 2018	• **Preoperative Bundle:** ○ CHG bath three times prior to surgery. If unable to complete baths independently, baths were performed in the preop holding area.. ○ Hemoglobin A1c screened at their preoperative visit, Primary care physicians (PCPs) were notified of abnormal values ○ On day of surgery, a point of care serum glucose was drawn, if glucose was greater than 180 the patients were placed on the hyperglycemia protocol • **Intraoperative Bundle:** ○ All operative staff completed a sterile gown and glove change after the fascial closure ○ A separate sterile instrument was used for closing the wound • **Postoperative Bundle** ○ Daily CHG baths were performed by the nursing staff ○ Beginning on POD #2, the surgical team cleaned the incision with a CHG impregnated wand ○ The clinical practice guideline (CPGs) for antimicrobial prophylaxis in surgery were employed ○ Normothermia was maintained with Bair Paws™ ○ A SSI patient education packet was provided to the patient at their pre-operative visit and at discharge ○ The Alexis wound protector system was used for all open procedures
Schriefer et al., 2017	• **Preoperative Bundle:** ○ Prescribed weight based prophylactic antibiotics using the prophylactic antibiotic dosing table embedded within the electronic medical record (EMR) ○ Prealbumin and Vitamin D screening ○ Referrals to pediatric GI and nutritionist if nutrition labs off ▪ Treat prior to surgery ○ No nutrition lab values are drawn if body mass index (BMI) is normal using the CDC BMI calculator ○ 2% CHG wipes the night before and the day of surgery ○ Preoperative povidone-iodine nasal antiseptic swabs postinduction by the anesthesiologist regardless of MRSA cultures • **Intraoperative Bundle:** ○ Prewarming the operating room to a minimum of 75◦F prior to the patient's entry ○ All spine surgery patients prewarmed with air hugger ○ Other high-risk patients prewarmed using warming blankets, thermal gowns, and thermal hats • **Postoperative Bundle:** ○ Discontinue urinary catheter within 24-48 hours postoperative per hospital guideline, unless otherwise justified ○ Standardized intraoperative application of wound dressing ○ Discussion with attending physician prior to blood transfusion intra-/postoperatively

	○ Active MRSA surveillance where there is a history of MRSA, e.g. those residing in group home/ institution ○ Bone graft antibiotics for spine surgery using doses recommend by and infectious disease consult
Schweizer et al., 2015	• **Preoperative Bundle:** ○ Each hospital's lab used their standard tests ○ Patients with positive screening tests for either organism applied mupirocin intranasally twice a day and bathed with CHG once daily for up to five days prior to the procedure (patients that received fewer than 10 doses of mupirocin before their procedure received the remaining doses in the postoperative period. CHG bathing was not continued post-operatively) ○ Patients with negative screening tests bathed the night before and the morning of the procedure • **Intraoperative Bundle:** ○ The CPGs for antimicrobial prophylaxis in surgery were employed ▪ Antimicrobial agents used for perioperative prophylaxis varied by the patients' S aureus carrier status: ▪ Noncarriers and MSSA carriers received either cefazolin or cefuroxime for perioperative prophylaxis ▪ MRSA carriers received both cefazolin or cefuroxime and vancomycin ▪ If a patient had a confirmed β-lactam allergy, surgeons were encouraged to provide perioperative prophylaxis with vancomycin rather than cefazolin or cefuroxime and to add either gentamicin or aztreonam for gram-negative coverage ▪ Patients with negative screening tests but with documented histories of MRSA carriage or infection were treated as carriers.

Summary of Findings Table(s)

Table 2

Summary of Findings Table[a]: Postoperative Bundles

Certainty assessment							Summary of findings				
							Study event rates (%)			Anticipated absolute effects	
Participants (studies) Follow up	**Risk of bias**	**Inconsistency**	**Indirectness**	**Imprecision**	**Publication bias**	**Overall certainty of evidence**	**With Standard of Care**	**With Post Surgery bundle**	**Relative effect (95% CI)**	**Risk with Standard of Care**	**Risk difference with Post Surgery bundle**
SSI											
4951 (2 observational studies)	serious [a]	serious [b]	serious [c]	serious [d]	strong association	⨁◯◯◯ VERY LOW	96/2907 (3.3%)	27/2044 (1.3%)	**OR 0.39** (0.25 to 0.60)	33 per 1,000	**20 fewer per 1,000** (from 25 fewer to 13 fewer)

Notes

a. All the studies are quality improvement, which can reduce generalizability of the findings
b. Studies used different bundle elements
c. 1 of the 2 studies is on adults (Agarwal et al., 2018)
d. Low number of SSIs

Summary of Findings Table(s)

Table 3

Summary of Findings Table[a]: Intraoperative and Preoperative Bundles

Certainty assessment							Summary of findings				
							Study event rates (%)			Anticipated absolute effects	
Participants (studies) Follow up	**Risk of bias**	**Inconsistency**	**Indirectness**	**Imprecision**	**Publication bias**	**Overall certainty of evidence**	**With Standard of Care**	**With Pre and Intra Operative Bundle**	**Relative effect (95% CI)**	**Risk with Standard of Care**	**Risk difference with Pre and Intra Operative Bundle**
SSI											
43971 (3 observational studies)	serious [a]	serious [b]	serious [c]	not serious	strong association	⨁◯◯◯ VERY LOW	132/28897 (0.5%)	35/15074 (0.2%)	**OR 0.42** (0.28 to 0.61)	5 per 1,000	**3 fewer per 1,000** (from 3 fewer to 2 fewer)

Notes

a. Studies are Quality Improvement

b. Studies used different bundle elements

c. Two of three studies are on adult patients (Rubeli et al., 2019, Schweizer et al., 2015)

Summary of Findings Table(s)

Table 3

Summary of Findings Table[a]: Perioperative Bundles

Certainty assessment							Summary of findings				
							Study event rates (%)			Anticipated absolute effects	
Participants (studies) Follow up	**Risk of bias**	**Inconsistency**	**Indirectness**	**Imprecision**	**Publication bias**	**Overall certainty of evidence**	**With Standard of Care**	**With All Bundles**	**Relative effect (95% CI)**	**Risk with Standard of Care**	**Risk difference with All Bundles**
SSI											
67190 (30 studies)	serious [a]	serious [b]	not serious	not serious	strong association	⨁◯◯◯ VERY LOW	1529/42702 (3.6%)	718/24488 (2.9%)	**OR 0.51** (0.43 to 0.61)	36 per 1,000	**17 fewer per 1,000** (from 20 fewer to 14 fewer)
SSI - Pediatric Surgery											
3340 (3 studies)	serious [a]	serious [b]	not serious	serious [c]	strong association	⨁◯◯◯ VERY LOW	67/1744 (3.8%)	27/1596 (1.7%)	**OR 0.41** (0.24 to 0.69)	38 per 1,000	**22 fewer per 1,000** (from 29 fewer to 12 fewer)
SSI - Adult Surgery											
63850 (27 studies)	serious [a]	serious [b]	serious [d]	not serious	strong association	⨁◯◯◯ VERY LOW	1462/40958 (3.6%)	691/22892 (3.0%)	**OR 0.52** (0.44 to 0.63)	36 per 1,000	**17 fewer per 1,000** (from 20 fewer to 13 fewer)

Explanations

a. Studies are Quality Improvement

b. Bundle interventions are different. Surgery types are different.

c. Low number of SSIs

d. Adult Studies

Meta-analysis(es)

Figure 2. **Comparison: Postoperative Bundle versus Standard of Care, Outcome: SSI**

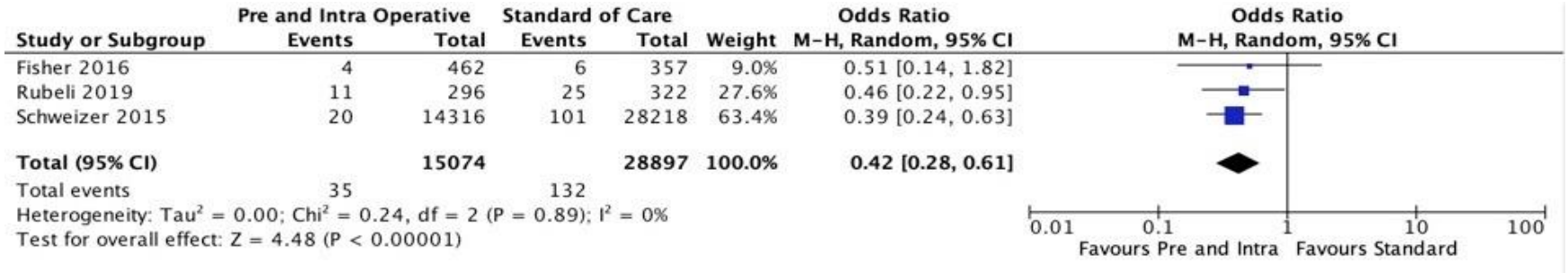

Figure 3. **Comparison: Preoperative and Intraoperative versus Standard Care, Outcome: SSI**

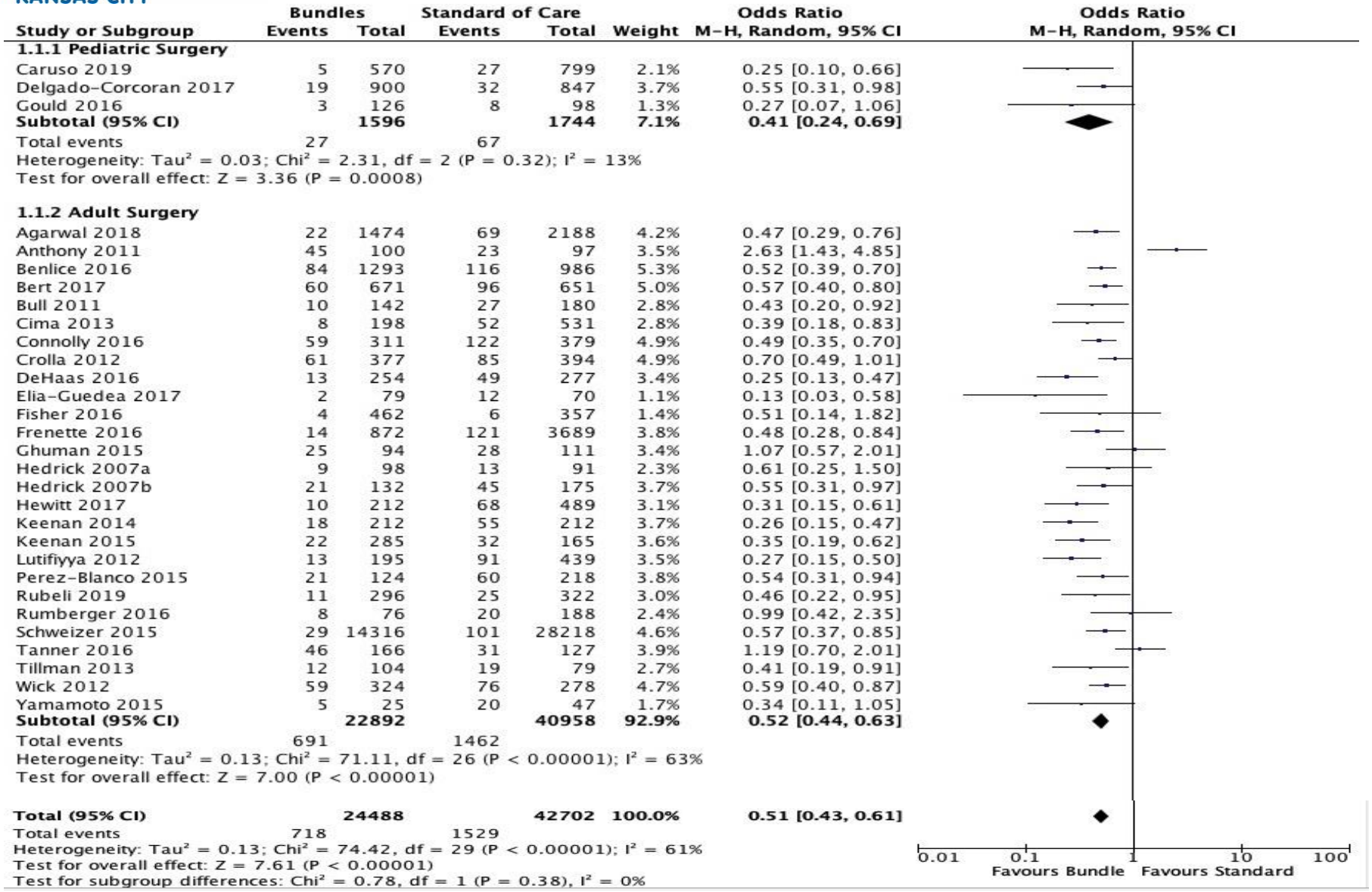

Figure 4. **Comparison: Perioperative Bundle versus Standard of Care, Outcome: SSI**

Characteristics of Intervention Studies

Agarwal et al., 2018

Characteristics of Study	
Methods	**Cohort**
Participants	**Participants:** Adult Surgical Spine Patients **Setting:** Single institution Surgical Care Center **Number enrolled into study:** Procedures • **Group 1, Procedures Preintervention 2007-2010**: *n* = 8751 • **Group 2, Preoperative Bundle 2011-2012:** *n* = 2108 • **Group 3, Postoperative Bundle 2013-2014:** *n* = 4675 • **Group 4, Physician reporting 2015-2016:** *n* = 1474 **Gender, males: (as defined by researchers)** • Not reported **Race / ethnicity or nationality (as defined by researchers):** • The study occurred in the United States. The authors did not identify race or ethnicity of the participants. **Age:** • Not reported **Inclusion criteria:** • All spinal surgery patients **Exclusion criteria:** • Not reported **Covariates identified:** • Not reported
Interventions	**Both:** • **Group 1, Preintervention:** ○ Prophylactic antibiotic, appropriate hair removal had been in place since 2004 • **Group 2, Preoperative Bundle:** ○ 4% CHG preoperative bathing for 5 days ○ Nasal screening for *Staphylococcus aureus* preoperatively with administration of 2% mupirocin ointment for nasal decolonization for 5 days for positive tests ○ CHG-alcohol as the standard preoperative preparation unless contraindicated. • **Group 3, Postoperative Bundle:** ○ Sterile technique for surgical dressing changes, ○ Dressings to be changed daily for 7 days after spine surgery ○ Standardization of dressing changes. • **Group 4, Physician Reporting:** ○ All attending neurosurgeons and residents were informed of their individual infection rates for spinal fusion surgeries and their infection rate ranking when compared with their colleagues.
Outcomes	**Primary outcome(s):** • *****All Surgical Site Infections **Secondary outcome(s)** • Cost

	Safety outcome(s): • Not reported *Outcomes of interest to the CMH CPG development team
Results	• **Group 1, Procedures Preintervention:** SSI was 2.9% in 2011. • **Group 2, Preoperative Bundle:** SSI increased to 3.3% (69 infections/2108 procedures) RR = 2.58, 95% CI [1.92,3.47], $p < .0001$). • **Group 3, Postoperative Bundle:** SSI rate declined to 2.3% (108 infections/4676 procedures) RR = 0.71, 95% CI [0.52, 0.95], $p = .03$). • **Group 4, Physician reporting:** SSI rate declined to 1.5% (22 infections/1474 procedures) RR = 0.65, 95% CI [0.41, 1.02]. $p = .07$) • Overall estimated annual cost savings of $291,000

Caruso et al., 2019

Characteristics of Study	
Methods	Quality Improvement
Participants	**Participants:** Pediatric patients undergoing cardiac surgeries **Setting:** 311-bed Quaternary, pediatric academic center with a 20-bed Cardiovascular Intensive Care Unit (CVICU), 2013-2017 California. **Number enrolled into study:** • **Group 1 Procedures Preintervention, 2013 - 2015:** *n = 799* • **Group 2 Procedures Post-surgical bundle 2015 – 2017:** *n = 570* **Gender, males: (as defined by researchers)** • **Group 1:** 56.2% • **Group 2:** 56.3% **Race / ethnicity or nationality (as defined by researchers):** • The study occurred in California. The authors did not identify race or ethnicity of the participants. **Age, mean in years, SD** • **Group 1:** 6.27 ± 10.9 • **Group 2:** 7.20 ± 11.3 **Inclusion criteria:** • Postoperative cardiac patients were included if they met National Healthcare Safety Network procedural mapping criteria **Exclusion criteria:** • Not reported **Covariates identified:** • Not reported
Interventions	A multidisciplinary SSI reduction oversight committee was formed to investigate SSIs. Previous efforts to reduce the incidence of SSIs relied on the preoperative and intraoperative care bundle, which included preoperative CHG gluconate (CHG) baths, not using a razor for hair removal, appropriate antibiotic timing prior to incision, appropriate skin antisepsis, and appropriate antibiotic redosing • **Group 1:** Historical control group, standard of care preintervention • **Group 2:** Postoperative Bundle ○ Daily postoperative CHG ○ Daily postoperative linen and gown change ○ Dressing removed within 48 hours of procedure using aseptic technique ○ Covering incision site when at risk for contamination ○ Echocardiograms performed in sterile fashion ○ Sterile environment standards, including appropriate attire, during procedures performed in the cardiovascular intensive care unit ○ Minimize sternotomy exposure to home blankets ○ Appropriate documentation of state of wound ○ Appropriate swabbing of wounds for infections ○ First postoperative antibiotic given at appropriate time and dose ○ Postoperative antibiotic continued at appropriate time and dose for 24 hours, continued if chest open

Outcomes	**Primary outcome(s):** • *Reduce SSI *Outcomes of interest to the CMH CPG development team

Results	• Prior to implementation, there were 27 SSIs in 799 pediatric cardiac surgeries, 3.4 SSIs per 100 surgeries
	• After the intervention, SSIs significantly decreased to 5 in 570 procedures, 0.9 SSIs per 100 surgeries; p = .0045
	• Limitations:
	  ○ Standardization alone has been associated with reductions in hospital-acquired infections. The design of the project did not allow for randomization of patients, which would have provided a method to definitely determine if the improvement was due to standardization or protocol measures. Some elements may have contributed more to the results than others.
	  ○ The pre- and intraoperative SSI reduction care bundle compliance was not measured during the postintervention/sustainment period
	  ○ There may have been unmeasured confounders, such as changes to surgical staff or products, that could have contributed to the results.

Chiwera et al., 2018-

Characteristics of Study	
Methods	**Cohort** , prospective cardiac SSI surveillance
Participants	**Participants:** Adults hospital, **Setting:** An acute health care organization in central London **Number enrolled into study:** *N* > 8,000 **Number completed:** *N* > 8,000 **Gender, males: (as defined by researchers)** • *n* = 71% **Race / ethnicity or nationality (as defined by researchers):** • The study occurred in London over 7 years. The authors did not identify race or ethnicity of the participants. **Age, mean/ years** • 2009 to 2011: 66.8 • 2012 to 2014: 65.3 • 2015 to 2016: 64.7 **Inclusion criteria:** • Underwent cardiac surgery **Exclusion criteria:** • Not reported **Covariates identified:** • Not reported
Interventions	**Both:** completing analyzing standardized SSI surveillance forms, electronic wound documentation, feedback to clinical teams Bundle use for all teams from 2012 • **Pre op bundle:** ○ Skin decolonization with 4% CHG washes on the night before surgery and 2% CHG cloths on the day of surgery ○ Patient education material on how to prepare the skin before surgery ○ Use of electric hair clippers only where removal was needed • **Intra-op bundle:** ○ Prior to incision, preparing skin with 2% CHG gluconate in 70% isopropyl alcohol (ChloraPrep™) ○ Antibiotic prophylaxis within one hour prior to skin incision. ○ All operating room staff wear face masks ○ De-cluttering of theatres and design of cleanliness checklists to be signed off by surgeons before procedures started ○ Segregation of scrub nurse trolleys for donor sites and sternal sites (only one used prior) ○ Enhanced monitoring of theatre discipline • **Post op bundle:** ○ Asepsis competency for all staff. Adherence to asepsis principles for all wound care ○ "No peak" policy for all surgical wounds ○ Patient education materials for monitoring the wound for infection

	○ Standardization of wound care protocols (dressing left in place of 4 days unless there was a clinical indication to change it sooner)
Outcomes	**Primary outcome(s):** • *Surgical site infections **Secondary outcome(s):** They reported costs, but not reported here **Safety outcome(s):** Not reported *Outcomes of interest to the CMH CPG development team
Results	Surgical site infections • Overall - Decreased from 5.4% in 2009 to 1.2 % in 2016, $p < .001$ • CABG – Decreased for 6.5% in 2009 to 1.2% in 2016, $p < .001$ • Deep organ infections – Decreased from 32 in 2009 to 7 in 2016, $p < .001$

Delgado-Corcoran et al., 2017

Characteristics of Study	
Methods	Quality Improvement
Participants	**Participants:** Pediatric patients undergoing cardiac surgeries **Setting:** 16-bed cardiac intensive care unit in a university-affiliated pediatric tertiary care children's hospital **Number enrolled into study:** *N* = 1747 (sternotomies) • **Group 1 Pre Intervention,2010-2012:** *n = 847* • **Group 2 Post Intervention 2012 – 2014:** *n = 900* **Gender, males: (as defined by researchers)** • Not reported **Race / ethnicity or nationality (as defined by researchers):** • The study occurred in the United States. The authors did not identify race or ethnicity of the participants. **Age, median in days, IQR** • **Group 1:** 234 (89-1587) • **Group 2:** 191 (25-1415) **Inclusion criteria:** • All sternotomies from the corresponding years were reviewed **Exclusion criteria:** • Not reported **Covariates identified:** • Not reported
Interventions	• **Group 1:** Historical control group, Sternal Wound Infections (SWI) were collected retrospectively from all patient with sternotomies • **Group 2:** ○ **Preoperative Sternal Wound Prevention Bundle (SWPB) intervention—** ▪ Nightly CHG baths and mupirocin nasal ointment twice daily for 2– 5 days prior to surgery ▪ Outpatient mupirocin and CHG bath provided to patients during their preoperative outpatient visit with detailed instructions to begin application within 1–3 days of surgery ○ **Intraoperative SWPB interventions—** ▪ Intraoperative skin antisepsis with CHG solution and hair removal with clippers for all cardiac surgical patients undergoing sternotomy or thoracotomy ▪ Standardized intravenous antibiotic doses by weight were administered at the following time points: within 5–60 minutes of the initial surgical incision, with initiation of cardiopulmonary bypass, and every 3 hours intra-operatively for the duration of the case ○ **Post-operative SWPB—** ▪ Antibiotic duration was standardized to 48 hours after PC or 48 hours after delayed sternal closure ▪ The occlusive sternal dressing applied at time of chest closure was removed 48 hours post-operatively. ▪ A standardized checklist used to prompt team members to inspect the sternal wound 48 hours post-operatively and daily thereafter.

	▪ Standardized process for bedside care of an open sternum, including timing of dressing changes, sternal closure procedure, and chest tube removal were implemented.
Outcomes	**Primary outcome(s):** • ***Reduce SWI *Outcomes of interest to the CMH CPG development team
Results	• During the pre-intervention period, 32 (3.8%) patients developed SWI while only 19 (2.1%) developed SWI during the post-intervention period, p = .04). • The rates of SWI following PC were not significantly different pre- and post-intervention 2.4% vs. 1.6%; p = .35. • However, patients with delayed sternal closure had significantly lower post-intervention infection rates, 10.6% vs. 3.9%; p = .02.

Elia-Guedea et al., 2017

Characteristics of Study	
Methods	Prospective Cohort Colorectal
Participants	**Participants:** • Adults, who had colorectal surgery from November 1. 2014 to May 31, 2015 **Setting:** Spain **Number enrolled into study:** *N* = 149 • **Group 1, Bundle Group:** surgeries performed February 14, 2015 to May 31, 2015*: n* = 79 • **Group 2, Historical Cohort Group,** surgeries performed November 1 2014 to February 13, 2015**:** *n* = 70 **Number completed:** *N* = 149 • **Group 1: Bundle Group** *n* = 70 • **Group 2: Historical Cohort Group** *n* = 79 **Gender, males: (as defined by researchers)** • **Group 1: Bundle Group** *n* = 52 (65.8%) • **Group 2: Historical Cohort Group** *n* = 46 (65.7%) **Race / ethnicity or nationality (as defined by researchers):** • The study occurred in Spain. The authors did not identify race or ethnicity of the participants. **Age, median in years, IQR** • **Group 1 Bundle Group:** 68.0 (61.0-76.0) • **Group 2: Historical Cohort Group:** 70.5 (59.5-79.0) **Inclusion criteria:** • Elective colorectal surgery • Followed Enhanced Recovery After Surgery protocol • All had mechanical bowel prep preoperatively, ○ Oral antibiotic, 1 gram of neomycin and erythromycin 13, 14 and 23 hours prior to the operation) when a primary anastomosis was going to be made in the left colon, sigmoid, or rectum. **Exclusion criteria:** • None reported **Covariates identified:** • Not reported
Interventions	• **Bundle** ○ **Pre** ▪ Proper IV prophylaxis antibiotic administration- based on environmental microbial resistance. Selected 2 grams of amoxicillin-clavulanate along with 240 mG gentamicin ○ **Intra** ▪ Second dose of 2 grams amoxicillin-clavulanate during surgery if operation took over 2 hours or when there was excessive blood loss (> 1 liter) ▪ Location change- colorectal surgery room was changed to a new operating room. ▪ Defined team of anesthesiologists, nurses, and assistants ▪ Regulating movement in the operating theater

	▪ Limit medical and nursing students, pharmaceutical suppliers ▪ Limit movement in and out of theater ▪ Encouraging clean hallways for entrance to the theater, and dirty hallways for exiting the theater ▪ Keeping theater doors closed during the operation ▪ Correct use of PPE ▪ Aseptic handling of wounds after manipulation of the colon ○ **Post** ▪ Proper wound care and handling of IV catheters
Outcomes	**Primary outcome(s):** • **SSI** ○ Superficial ○ Deep ○ Organ space *Outcomes of interest to the CMH CPG development team
Results	**See Figure 4**

Fisher et al., 2016

Characteristics of Study	
Methods	Quality Improvement
Participants	**Participants:** Pediatric patients undergoing surgery for cardiac, spine, ventricular cerebrospinal shunt. **Setting:** Pediatric Children's Hospital 2013-2015 **Number enrolled into study:** *N* = 968 • **Group 1 Pre EMR Bundle,2013 - 2014:** *n* = 545 • **Group 2 Post EMR Bundle 2014 – 2015:** *n = 423* **Number included SSI analysis:** • **Group 1:** *n* = 357 • **Group 2:** *n = 462* **Gender, males: (as defined by researchers)** • Not reported **Race / ethnicity or nationality (as defined by researchers):** • The study occurred in the United States. The authors did not identify race or ethnicity of the participants. **Age:** • Not reported **Inclusion criteria:** • All children aged 18 years or younger who underwent: o Open-chest cardiac surgery o Spine surgery with hardware implantation o Manipulation of a ventricular cerebrospinal fluid shunt **Exclusion criteria:** • Not reported **Covariates identified:** • Not reported
Interventions	**Group 1:** Pediatric SSI prevention bundle was adapted from elements provided by the Solutions for Patient Safety collaborative network • Preoperative Call – Were CHG wipes received? • CHG Wash (Night Before Surgery) • CHG Wash (Morning of OR) • Preoperative MRSA Screening Nasal Swab • Preoperative Nasal Decolonization • Intraoperative Hair Removal • Intraoperative Skin Prep • Intraoperative Antibiotic Timing • Intraoperative Antibiotic Type • Intraoperative Antibiotic Dose and Redosing **Group 2:** • Electronic health record (EHR) tool to increase bundle compliance

Outcomes	**Primary outcome(s):** • Bundle compliance • *SSI rate *Outcomes of interest to the CMH CPG development team
Results	• Nine months after implementation of the EHR tool, median SSI bundle compliance increased from 46% to 72% • SSI rates decreased from 1.68 to 0.87 per 100 operations, but was not significant • Limitations include the use of retrospective data.

Frenette et al., 2016

Characteristics of Study	
Methods	Retrospective quasi experimental Cohort Cardiac
Participants	**Participants:** Adults undergoing Coronary artery bypass grafting (CABG), combined CABG and valve, and valve procedures **Setting:** University hospital, Canada **Number enrolled into study:** *N* = 6,518 • **Group 1,** Pre intervention January 2007 - September 2009**:** *n* = 1,957 • **Group 2,** During intervention October 2009 - March 2014: *n* = 3,689 • **Group 3,** Post intervention April 2014 - 2009- March 2015: *n* = 872 **Number completed:** *N* = 6,518 • **Group 1,** Pre intervention January 2007- September 2009**:** *n* = 1,957 • **Group 2,** During intervention October 2009 - March 2014 *n* = 3,689 • **Group 3,** Post intervention April 2014 - March 2015: *n* = 872 **Gender, males: (as defined by researchers)** • Not reported **Race / ethnicity or nationality (as defined by researchers):** • The study occurred in Canada. The authors did not identify race or ethnicity of the participants. **Age:** • Not reported, only recruited those ≥ 18 years **Inclusion criteria:** • ≥ 18 years of age • Underwent CABG, combined CABG and valve procedure, or valve procedure alone • Assigned a value of one to each criterion (antibiotic selection, dosage, timing, and duration) ○ If three criteria or more criteria were met, the record was included **Exclusion criteria:** • If more than two of the above criteria (antibiotic selection, dosage, timing, and duration) were missing, the record was included in the secondary analysis, not the primary analysis **Covariates identified:** Not reported
Interventions	• **Practice 2007-2009** ○ Preoperative interventions ▪ Shower with 4% CHG sponge the night before and the morning of surgery ▪ Hair removal with clipper the night before or morning of surgery ▪ Identify and treat active infections prior to surgery ○ Intraoperative interventions ▪ Skin antisepsis with 0.5% CHG solution ○ Postoperative interventions ▪ Initial dressing removed 48 hours after surgery • **Practice after 2009** ○ Preoperative interventions ▪ 2% CHG- impregnated washcloths applied the night before and morning of surgery ▪ Hair removal with clippers, if necessary, on call or in the OR. Size of hair removal the expected size of the dressing only.

- Identification and treatment of active infections prior to surgery. If urinalysis was positive for leukocytes or nitrates, obtain a urine culture and treat as needed.
- Screen, preoperatively for methicillin-resistant *Staphylococcus aureus* (MRSA) and treat with nasal mupirocin ointment. MRSA positive patients treated with vancomycin prophylaxis

- Intraoperative interventions
  - Skin antisepsis with 2% CHG with 70% alcohol
- Postoperative interventions
  - Initial dressing is non occlusive and changed 24 hours after the operation. Can be changed earlier if soaked and or soiled with blood. Change dressing no later than 48 hours post operatively.
  - Recommendation was made to pay attention to surgical technique at the vein donor site, including protect the sterile field. Control edema at the donor site with elastic stockings and compressive bandages, readjust daily in very obese patients.
  - Discontinue drains, chest tubes, Foley catheters and central lines. Daily assessment of the need for all lines and catheters.

Antibiotic prophylaxis modifications		
Pre intervention	May 2009	July 2013
Standard dose of cefazolin for CABG	Standard dose of cefazolin as prophylaxis for all procedures Standard dose vancomycin administered only for confirmed MRSA carriers or in case of cefazolin allergy Cefazolin should be started within 60 minutes of incision, and vancomycin within 120 minutes. In each case they should be completed before incision. A repeat dose of cefazolin should be given 3 hours after the initial dose	For confirmed or high risk of MRSA and cefazolin allergic patients, for CABG with or without valve procedures: First choice Cefazolin 2 grams plus gentamicin 5 gm/kg (max 400 mg IV Second choice Vancomycin 15 mg/kg + gentamicin 5 mg/kg (max 400 mg)
Standard dose vancomycin for CABG and valve and valve procedures		
No post op recommendation		First choice Continue cefazolin 2 g every 8 hours X 3 doses (cefazolin 3 g if weight > 120 kg) Second choice: Vancomycin 15 mg/kg every 12 hours x 2 doses (cefazolin 3 g if weight > 120 kg) this seems like an error, please check
Timing of ATB discontinuation	Antibiotics should be continued 24 hours after surgery unless surgery is contaminated or dirty, that is infected.	Discontinue prophylaxis within 24 hours after operation for all clean and clean contaminated surgeries. If surgical wound is contaminated or dirty (infected) at the time of surgery, continue prophylaxis and adjust them according to results.

Outcomes	**Primary outcome(s):** • Overall SSI rates- **Secondary outcome(s)** • Superficial infection • Deep incisional infection • Organ space infection *Outcomes of interest to the CMH CPG development team
Results:	See Figure 4

Gould et al., 2016

Characteristics of Study	
Methods	Quality Improvement
Participants	**Participants:** Pediatric spinal fusion patients **Setting**: Children's Hospital Philadelphia **Number enrolled into study:** *N* = 224 surgeries • **Group 1 Pre bundle 2008-2011:** *n = 98* • **Group 2, Pre, Intra, Postoperative bundle 2011-2015:** *n = 126* **Gender, males: (as defined by researchers)** • Not reported **Race / ethnicity or nationality (as defined by researchers):** • The study occurred in the United States. The authors did not identify race or ethnicity of the participants. **Age:** • Not reported **Inclusion criteria:** • All spinal fusion patients **Exclusion criteria:** • Not reported **Covariates identified:** • Not reported
Interventions	**Bundle** • Preoperative ○ Soap & water bath and hair washing, followed by 2% CHG bath cloth application (neck to toes) the night before & morning of surgery ○ Dermatology assessment tool and consultation if necessary • Perioperative ○ Use of 2% CHG/70% isopropyl alcohol for skin antisepsis in OR ○ Antimicrobial silver wound contact dressing application after closure of incision in the OR Postoperative in hospital ○ Designated nursing unit for expertise and consistency of care ○ Postoperative nursing standard of care ○ "Back Home" teaching tool for nurses. Teach back is required • Postoperative at home (post discharge) ○ Back Home kit ○ Written discharge instructions: ▪ Hand hygiene significance for patient and caregivers ▪ Surgical dressing changed if loose or soiled; maintained for 1 week ▪ Keeping the incision area clean includes the following: ▪ Personal hygiene: daily CHG bath ▪ Diaper changes every 2 hours; meticulous cleanliness of the lower back ▪ Keep hair up and away from the incision

	▪ Clean linens and clothing, ▪ Keep pets off areas where the patient rests ▪ Avoid swimming until cleared by physician ▪ Signs and symptoms of infection, doctor's phone number ▪ Follow-up appointment 7 days after leaving the hospital
Outcomes	**Primary outcome(s):** • *SSI **Secondary outcome(s)** • Cost *Outcomes of interest to the CMH CPG development team
Results	• 224 surgeries were performed from 2008 to February 2015 • 3-year pre bundle SSI rate per 100 SF surgeries was 8.2% (8/98) • Mean SSI rate post bundle was 2.4 (3/126) (January 2011-February 2015) ○ 71% reduction in mean SSI rate (p = .0695) • No SSI occurred in neuromuscular patients (p = .008) post bundle • Compliance with bundle elements was 100% • Total cost savings of $3.0 million

Harris et al., 2018

Characteristics of Study	
Methods	Quality Improvement
Participants	**Participants:** Adult colorectal surgery patients **Setting:** Three Washington State Hospitals **Number enrolled into study:** *N* = • Not reported **Gender, males: (as defined by researchers)** • Not reported **Race / ethnicity or nationality (as defined by researchers):** • The study occurred in the United States. The authors did not identify race or ethnicity of the participants. **Age:** • Not reported **Inclusion criteria:** • Adults undergoing colorectal surgery **Exclusion criteria:** • Not reported **Covariates identified:** • Not reported

Interventions	**Bundle:**
	• Preoperative:
	  ○ Weight-based dosing of preoperative antibiotics with redosing after four hours
	  ○ Iodophor nares swabs to decolonize the nose of all pathogens for 24 hours
	• Intraoperative:
	  ○ Silver-impregnated dressings to protect the surgical incision and provide low volume-negative pressure to aid in healing
	  ○ Separate sterile instrument set for closing the incision (i.e., instruments used on the colon are removed, new closure instruments are provided, gowns and gloves are changed)
	  ○ A new florescent imaging instrument to assess perfusion in the anastomosis and to check for microleaks.

Outcomes	**Primary outcome(s):** • *SSI **Secondary outcome(s)** • Cost *Outcomes of interest to the CMH CPG development team
Results	• 74.6% reduction in readmissions • 22.73% reduction in length of stay • 84.5% reduction in colon surgical site infections measured by incidence and 54.55% standard infection ratio • 95% compliance with the use of both order sets during an 18-month period • $670,000 in savings over 18 months

Kles et al., 2015

Characteristics of Study	
Methods	Cohort Cardiac Procedures
Participants	**Participants:** Patients undergoing CABG **Setting:** Adult Regional Medical Center, USA **Number enrolled into study:** *N* = 262 after the interventions put into place. Number not available for pre-interventions **Number completed:** *N* = NA **Gender, males: (as defined by researchers)** • Not reported **Race / ethnicity or nationality (as defined by researchers):** • The study occurred in Athens, Georgia, USA. The authors did not identify race or ethnicity of the participants. **Age:** • Not reported **Inclusion criteria:** • Adult who had undergone CABG surgery **Exclusion criteria:** • Not reported **Covariates identified:** • Not reported • DWI deep sternal wound infection
Interventions	**Preoperative, Intraoperative, Postoperative Bundles** • Hair clipping always performed in pre-operative short stay area • Prevention strategies to prevent MRSA were standardized to a 5- day course of mupirocin nasal ointment • Patients with diabetes or a HbA1C greater than 6.5% were admitted the night before surgery and placed on an insulin drip • Any patient hospitalized ≥ 48 hours a first-time vancomycin dose administered 2 hours prior to incision time • Any patient on epinephrine and or vasopressin placed on an insulin infusion • Antibiotic impregnated suture • Change stitch of closing incision from a running suture to an interrupted suture on the distal fascia • Change to soft silicone silver impregnated dressing • Dressing stayed in place for the first 7 days. Previous practice was to change at 48 hours. The dressing was pulled back after 24 hours to assess the incision, then left in place unless soiled or insecure. • Dressing changes changed from aseptic technique to sterile technique
Outcomes	**Primary outcome(s):** • Deep sternal wound infections **Secondary outcome(s)** • Not reported **Safety outcome(s):** • Not reported *Outcomes of interest to the CMH CAT development team

Results	Two patients developed deep sternal wound infections after the above changes were made. The incidence rate decreased from 3.71/100 procedures to 0.7/100 procedures

Lindblom et al., 2015

Characteristics of Study

Methods	**Cohort Quality study** CABG sternal wounds only, Did not report data per person or procedure
Participants	**Participants:** Adults, who underwent isolated CABG. An isolated CABG is a procedure that is performed on the patient for the first time, and no other procedure is done at the same time. Records from procedures performed from the start of 2006 to the end of 2012 were included. **Setting:** Sweden **Number eligible:** *N* = 1642 • **Completed post discharge survey:** *n* = 1515 • **Selected surveys:** *n* = 503 **Number completed:** *N* =503 **Gender, males: (as defined by researchers)** • **Group 1:** *n* = 410 (81.5%) • **Race / ethnicity or nationality (as defined by researchers):** • The study occurred in Sweden. The authors did not identify race or ethnicity of the participants. **Age, mean in years, (SD)** • **Group 1: 67 ± 9** **Inclusion criteria:** • Isolated CABG • Completed the questionnaire **Exclusion criteria:** • Not reported **Covariates identified:** • Type of sternal wound infection, superficial or deep. Data includes both types. ○ Period one ▪ There were more patients with elevated insulin-like growth factor 1 (IGF-1), $p < .05$. ○ Period two ▪ More patients on corticosteroid treatment, $p < .05$ ▪ Fewer blood transfusions, $p < .05$ ▪ Higher perioperative blood glucose $p < .001$
Interventions	**Pre intervention** • Home shower, followed by shower at the hospital • Hair removal, leg and chest performed with a disposable clipper the night before surgery • Skin was scrubbed with 0.5% CHG in 70% ethanol, allowed to air dry • Ultra clean air • All surgical scrubs were tightly woven with cuffs. Helmets were tucked under the shirt neckline • Cloxacillin 2 grams administered 3 times per day of 2 days, starting the morning of surgery • Blood glucose management

	2006-2007	2008-2011
Not Diabetic	5-7 mMol/L	4-6 mMol/L
Diabetic	Not reported	5-7 mMol/L

	• Dressing stayed in place if dry for 4 days
	Post intervention
	• Two showers and scrubbing with 4% CHG detergent at the hospital
	• Antibiotic administration: cloxacillin 2 grams administered four to five times all in the day of surgery every four hours. First dose 30 to 60 minutes prior to incision
	• Increased discipline in the operating theater
	  ○ Decrease the number of door openings
	  ○ Restrict the number of people (maximum of 11)
	• Changed wound closure from sternal wires are figure-of-eights, to eight single sternal wires
	• All surgeons asked to double glove
	• Immediately post-op, skin and incision was scrubbed with 0.5% CHG in 70$ ethanol prior to dressing placement
	• Room environment-
	  ○ Revised cleaning procedures for operation theater
	  ○ Reusable materials
	  ○ Purchased disinfect-able keyboards
	  ○ Used more disposable materials
	• Dressing were removed after 48 hours; the 4dressing was not replaced unless the wound was still open
	• Hand hygiene enforced
	• Disposable plastic aprons

Outcomes	**Primary outcome(s):** • Predictors for sternal wound infection *Outcomes of interest to the CMH CAT development team
Results	Predictors were • Elevated IGF-1 • More blood transfusions • Peri-operative blood glucose level No statistics were reported for bundle elements Biases- • Results are from a self-reported questionnaire. Subjects with infection complications may have been too sick to complete the questionnaire. • From the completed questionnaires, every third questionnaire completed based on chronological order of operation date were selected. • Chose chronological sampling of records over random to take seasonal fluctuations into account but did not report on seasonality at any time.

Losh et al., 2017

Characteristics of Study	
Methods	Cohort Quality study Colorectal surgery
Participants	**Participants:** Adult patients undergoing colorectal surgery **Setting:** California **Number enrolled into study:** *N* = 1,468 cases **Number completed:** *N* = 1,238 complete with 30 day record **Gender, males: (as defined by researchers)** **Race / ethnicity or nationality (as defined by researchers):** • The study occurred in California, USA. The authors did not identify race or ethnicity of the participants. **Age, mean** • Not reported **Inclusion criteria:** • Colorectal surgery, with 30-day follow up surveys completed **Exclusion criteria:** • Subjects who may have not returned for care of a SSI **Covariates identified:** Not reported
Interventions	• **Bundle elements** ○ Preoperative ▪ Referral to smoking cessation program ▪ Screening for diabetes, diabetes control ▪ Standardized antibiotic bowel preparation ▪ CHG wipes ○ intraoperative ▪ Standardized antibiotic administration ▪ Standardized hair clipping ▪ Use of a wound protector ▪ Wound irrigation ▪ After anastomosis, all surgical gloves were changed by surgeons and scrub techs and all dirty instruments were removed from the surgical field ▪ Repeat antibiotic dosing reviewed by surgeon and anesthesiologists. ○ Postoperative ▪ Normothermia maintained ▪ Tight glucose control maintained ○ Staff interventions ▪ Limit operating room traffic ▪ Time staff breaks and coordinate OR assignments ▪ Dedicated environmental service teams ▪ Sterilization procedure refined ▪ Optimized EMR for data capture ▪ Completed root cause analysis for each SSI after implementation of bundle. • **Compliance**

	○ Compliance to the preoperative bundle was completed by office staff ○ Compliance to peri and post-operative bundles were completed quarterly by chart review.
Outcomes	**Primary outcome(s):** • Rate of SSIs **Secondary outcome(s)** • Compliance **Safety outcome(s):** • Not reported *Outcomes of interest to the CMH CAT development team
Results	**Compliance** • As compliance improved, SSI rates decreased ○ Develop patient education materials to improve use of CHG wipes ○ Study liaisons in the OR, floor, clinic and PACU shared outcomes and encouraged compliance as improvement were seen. ○ Gave an example of when interest in the project decreased, infection rates increased ○ Gaves a reference on correlation between bundle compliance and outcomes **Rate of SSI- all surgeries** • Rate of SSI decreased from 6.9% to 2.0% from 2012 to 2015 • Odds ratio at this center ○ Acquiring an SSI, fell from *OR* =6.9 to *OR* = 2.0 • Odds ratio ○ Acquiring an SSI, fell from *OR* = 3.56 to *OR* = 1.37 ○ Morbidity fell from *OR* = 2.4 to *OR* = 1.04 ○ Mortality fell from *OR* = 1.61 to *OR* = 0.94 **Rate of SSI- colorectal surgeries** • Rate of SSI decreased from 2.39% to 1.1% from 2012 to 2014 • Rate had slight increase in 2015 to 1.38%

McGee et al., 2019

Characteristics of Study	
Methods	Cohort - Colorectal per patient
Participants	**Participants:** Patients undergoing non-emergent colectomy or proctectomy surgeries from July 1, 2015 to December 31, 2017. **Setting:** Illinois- state-wide quality improvement initiative 32 hospitals **Number enrolled into study:** *N* = Total, 5137 *n* = *2615*, Baseline period *n* = *1122,* Implementation period *n* = 1400, Post-implementation period **Number completed:** *N* = 5137 **Gender, males: (as defined by researchers)** • 2475 (48.2%) **Race / ethnicity or nationality (as defined by researchers):** • The study occurred in Illinois, USA. The authors did not identify race or ethnicity of the participants. **Age, Years, mean (SD)** • 60.4 (14.9) **Inclusion criteria:** • Not reported **Exclusion criteria:** • Not reported **Covariates identified:** • Not reported
Interventions	**Both:** Recommended hospital policy changes recommended, but not followed up with data • Minimization of OR traffic • Hair clipping at surgical site • Universal wound classification • Hand hygiene surveillance of all OR providers Statewide bundles with abstraction guidelines and definitions released to 53 adult hospitals. Hospitals had four months to develop local bundle elements, and monitoring strategies. Target date was September 19, 2016 • **Bundle elements** ○ Preoperative Outpatient ▪ Oral antibiotics ▪ Mechanical bowel preparation, large volume polyethylene glycol ▪ Pre-operative skin cleansing the day before surgery ▪ Pre-operative skin cleansing the day of surgery ○ Preoperative Inpatient ▪ Timely initial administration of SSI antibiotic prophylaxis ▪ Same day, preoperative day of surgery blood glucose < 200 mg/dL for ACS-NSQIP defined diabetics ○ Intraoperative

	▪ Timely intraoperative re-administration of SSI antibiotic prophylaxis ▪ First measure of temperature is ≥ 36.0◦C ▪ Intraoperative skin preparation with CHG and alcohol-based solution ▪ Impermeable wound protector for all incisions ▪ Dedicated clean wound tray for all incisions ▪ Gown and glove change for all scrubbed personnel prior to wound closure ▪ Re-draping prior to wound closure ▪ Sterile occlusive incision wound dressing placed in the OR ▪ Intraoperative blood glucose at 2 ± 0.5 hours into surgery < 200 mg/dL for ACS-NSQIP defined diabetics ○ Postoperatively ▪ Duration of antibiotic prophylaxis < 24 hours ▪ Original dressing removed on post op day 2 ▪ Daily incision cleansing with CHG after dressing removal until discharge, but no longer than 7 days.
Outcomes	**Primary outcome(s):** • 30-day post-operative complication ○ Any SSI ▪ Superficial ▪ Deep ▪ Organ space **Secondary outcome(s)** • Not reported **Safety outcome(s):** • Not reported *Outcomes of interest to the CMH CPG development team
Results	**Compliance:** • Compliance to the bundle was negatively correlated with occurrence of SSI. In a linear manner, Increased compliance resulted in lower SSI rate, overall morbidity, and extended length of stay. Trends were not significant but noticed. **SSI:** ○ Pre bundle vs. Post bundle ○ Pre bundle vs. Intra bundle

Nordin et al., 2018

Characteristics of Study	
Methods	Cohort Pre-/post-intervention along with case control
Participants	**Participants:** All patients who had a GI surgery **Setting:** Tertiary free-standing pediatric hospital **Number enrolled into study:** *N* = unable to report as an approximate number was provided by the authors for the pre-intervention group • **Group 1, pre-intervention:** *n* ≈ 605 • **Group 2, post-intervention:** *n* = 1474 unique patients, 1595 total surgeries • **Group 3, SSI cases:** *n* = 53 • **Group 4, SSI controls:** *n* = 106 **Number completed:** *N* = unable to report as an approximate number was provided by the authors for the pre-intervention group • **Group 1, pre-intervention:** *n* ≈ 605 • **Group 2, post-intervention:** *n* = 1474 unique patients, 1595 total surgeries • **Group 3, SSI cases:** *n* = 53 • **Group 4, SSI controls:** *n* = 106 **Gender, males: (as defined by researchers)*** • **Group 1:** *n* = Not reported • **Group 2:** *n* = 416 • **Group 3:** *n* = Not reported • **Group 4:** *n* = Not reported **Race / ethnicity or nationality (as defined by researchers):** • The study occurred in Columbus, OH. The authors did not identify race or ethnicity of the participants. **Age, years:** • **Group 1:** *n* = Not reported • **Group 2a (without SSI):** 7.26 • **Group 2b (with SSI):** 8.33 • **Group 3:** *n* = Not reported • **Group 4:** *n* = Not reported **Inclusion criteria:** • All patients undergoing GI surgery **Exclusion criteria:** • Appendectomies and trauma operations **Covariates identified:** • Not reported
Interventions	**Group 1:** • Standard of Care **Group 2:** • Perioperative bundle implemented in Nov. 2014. Modified in January 2016 to include closing protocol for all stoma closures. Bundle compliance monitoring began in August 2014. **Preop Bowel Prep**

	• Bowel prep required for all patients undergoing a procedure involving the rectum unless a proximal stoma is present and is not being concomitantly reversed
	• Inpatient regimen
	  ○ GoLytely 25 mL/kg/h x 4 h
	  ○ Neomycin 15 mg/kg/dose (x 3 doses)
	  ○ Erythromycin 20 mg/kg/dose (x 3 doses)
	  ▪ 10 mg/kg/dose for neonates <30 days old
	Preop Cleansing
	• Patients >2 months: clean the abdomen with 2% CHG gluconate wipes
	• Patients <2 months: clean the abdomen with antimicrobial wipes
	Preop Warming
	• Measure patient temperature 1 hour prior to operation
	• Warming blanket for all patients with initial temperature <36.5 °C
	  ○ Recheck temperature every 30 min
	Preop Antibiotics
	• Administer appropriate antibiotic to finish within 60 min of incision
	  ○ Cefazolin for foregut and procedures. Redose as needed
	  ○ Cefoxitin for midgut/hindgut procedures. Redose as needed
	  ▪ Gentamicin/clindamycin for patients with penicillin allergies
	  ▪ Ampicillin/gentamicin acceptable for neonates within first week of life; add clindamycin after first week
	  ○ If patient is on adequate systemic antibiotics prior to the procedure, no additional antibiotics are needed. Redose as needed
	Skin Prep
	• CHG for all patients >2 months or >1 kg
	• 10% povidone-iodine for patients <2 months or <1 kg
	Closing Protocol (for procedures in which the bowel has been opened and fascial closure is needed)
	• Prior to fascial closure
	  ○ All staff change gloves
	  ○ Redrape the surgical field
	  ○ Remove all dirty instruments; use clean instruments for fascia and wound closure

Outcomes	**Primary outcomes:**
	• SSI rates (based on number of infections divided by the total number of GI procedures per month)
	  ○ SSI rates were further calculated for:
	  ▪ Each procedure category (foregut, hepatopancreaticobilary, or midgut/hindgut)
	  ▪ Timing of surgery (elective, urgent or emergent)
	• Bundle compliance
	• LOS
	• 30-day inpatient charges
	Secondary outcomes:
	• Patients with an SSI were matched to two similar patients without an SSI to validate the effect of SSI development on primary outcomes
	Safety outcomes:
	• Not Reported
	*Outcomes of interest to the CMH CPG development team

Results	* **Pre/post intervention data findings:** *SSI rate:* • pre-bundle implementation was 3.4% which significantly increased to 7.1% (p = .05) during the pre-bundle timeframe • post-bundle implementation the rate decreased to 4.7% of these SSIs the included the following: ○ midgut/hindgut rate: 8.0% ○ foregut: 2.3% ○ HPB: 1.1% • Baseline stoma closure DDI rate was 21.4% an significantly decreased to 7.9% post-implementation (p = .03) *30-day mortality rate:* • pre-bundle implementation: not reported • post-bundle implementation rate 1.15% (n = 17) *Bundle compliance:* • pre-bundle compliance: 43% • post-bundle compliance: 80% (p < .001) **Case-control data findings:** *LOS:* • Patient did not experience an SSI: 8.3 days (p = .002) • Patient experiencing SSI: 13.9 days • By procedure category: ○ Midgut/hindgut cases significantly decreased from 20.3 to 13.6 days (p = .02) ○ Stoma closures significantly decreased from 12.6 to 7.9 days (p = .04) *Hospital charges:* • Patient did not experience an SSI: $80,997 ($p$ = .002) • Patient experiencing SSI: $131,897 • Average 30-day inpatient charges did not significantly change post-bundle implementation • Average stoma closure charges decreased from $94,262 to $50,088 ($p$ = .01) *30-day mortality rate:* • pre-bundle implementation: not reported • post-bundle implementation rate 1.15% (n = 17) *Bundle compliance:* • pre-bundle compliance: 43% • post-bundle compliance: 80%

Rubeil et al., 2019

Characteristics of Study	
Methods	**Cohort**
Participants	**Participants:** Patients that had a cranial neurosurgical intervention between January and July 2012 (pre-intervention) and January and July 2014 (post-intervention) **Setting:** Tertiary care hospital, Kantonsspital Aarau, Switzerland **Number enrolled into study:** *N* = 618 (the enrollment represents 520 unique patients) • **Group 1, preintervention:** *n* = 322 (52.1%) • **Group 2, postintervention:** *n* = 296 (47.9%) **Number completed:** *N* = 618 • **Group 1:** *n* = 322 (52.1%) • **Group 2:** *n* = 296 (47.9%) **Gender, males: (as defined by researchers)** • **Group 1:** *n* = 169 (52%) • **Group 2:** *n* = 152 (51%) **Race / ethnicity or nationality (as defined by researchers):** • The study occurred in Switzerland. The authors did not identify race or ethnicity of the participants. **Age, median in years, IQR:** • **Group 1:** 59 (47-73) • **Group 2:** 61 (48-71) **Inclusion criteria:** • All patients who had a cranial neurosurgical intervention **Exclusion criteria:** • Not reported **Covariates identified:** • Pt. covariates: Age, sex, BMI, surgery indication, cranial trauma within four weeks of surgery, ASA physical classification, perioperative corticosteroid use, non-CNS malignancy, diabetes, NNIS risk index • Procedural covariates: Mode and duration of surgery, elective and clean surgery, wound and CSF drains, ICP monitoring devices hemostatic agents, implanted foreign material, surgical antimicrobial prophylaxis (SAP) employed, postoperative bleeding, surgeon's experience

Interventions	**Group 1:** Standard of Care
	Group 2: Perioperative bundle and standardized surveillance implemented in January 2013 addressing six known SSI concerns:
	Patient prep:
	• Hair removed with clippers
	• Preparing the patient
	• Antibiotic and antiseptic use:
	Antibiotic and antiseptic usage:
	• Surgical antimicrobial prophylaxis (SAP)
	  ○ Cefuroxime 1.5 g IV (3 g for body weight > 80 kg) within 1 hour before incision
	  ○ Dose repetition if duration of surgery exceeded 4 hours
	• Skin disinfection

	○ Alcohol-based solutions used for all surgeries except for transsphenoidal surgery) before three-point skull clamp placement ○ Disinfection of the incision border directly after incision and before wound closure **Barrier precautions:** • Surgeons' hair on head and face completely covered • Gloves exchanged every two hours • Gloves exchanged before implantation of foreign material • Minimization of traffic and door openings in operating room **Surgeons' coaching:** • Gentle tissue handling and thorough mechanical hemostasis techniques such as irrigation, bipolar coagulation, and slight compression • Limited use of hemostatic agents and foreign materials • Specialized technical operation assistant team for neurosurgery **Surveillance standard work:** • Routine monitoring of bundle compliance in the operating room with personal feedback by members of the infection prevention team • Routine discussion of perioperative complications, in particular infections and postoperative bleeding and their prevention measures, by the head of the department
Outcomes	**Primary outcomes:** • SSIs • Mortality at 3 months and a year **Secondary outcomes:** • Risk factors for SSI **Safety outcomes:** • Not reported *Outcomes of interest to the CMH CPG development team
Results	**Pre/post intervention data findings:** SSI rate*:* • pre-bundle SSI rate was 7.8% which significantly decreased to 3.7% (p = .03) after the bundle was implemented • Surgeon classification SSI rates: ○ Junior faculty rates decreased from 14.6% to 4.3%, the authors did not report if this was a significant decrease* ○ Senior faculty rates remained low for the two timeframes, 4.5% versus 3.3% • SSI type, n = 36 ○ Superficial (p > .05) ▪ Pre-implementation, n = 3 (12%) ▪ Post-implementation, n =1 (9.1%) ○ Deep (p = .21) ▪ Pre-implementation, n = 4 (16%) ▪ Post-implementation, n = 4 (36.4%) ○ Organ/space (p = .45) ▪ Pre-implementation, n = 18 (72%) ▪ Post-implementation, n = 6 (54.5%) *Mortality rate* 3 months ○ pre-bundle implementation: n = 24 (8.7%)

	○ post-bundle implementation rate: *n* = 23 (9.7%) • 1 year ○ pre-bundle implementation: *n* = 29 (14.7%) ○ post-bundle implementation rate *n* = 19 (13.8%)

Russell et al., 2018

Characteristics of Study	
Methods	Cohort
Participants	**Participants:** Patients undergoing colorectal or general surgery **Setting:** University of California Los Angeles Health System **Number enrolled into study:** *N* = 3525 • **Group 1, colorectal division:** *n* = 720 • **Group 2, general surgery department:** *n* = 2805 **Number completed:** *N* = 3525 • **Group 1, colorectal division:** *n* = 720 • **Group 2, general surgery department:** *n* = 2805 **Gender, males: (as defined by researchers),** Not reported **Race / ethnicity or nationality (as defined by researchers):** • The study occurred within the Los Angeles Health System. The authors did not identify race or ethnicity of the participants. **Age:** Not reported **Inclusion criteria:** • Not reported **Exclusion criteria:** • Not reported **Covariates identified:** Not reported
Interventions	**Group 1:** Standard of Care **Group 2:** Bundle implementation: The bundle was developed and implemented within the Colorectal Surgery Division from June 2014 to May 2015, and then spread to the entire General Surgery Division in September 2015. The bundle consisted of: **Patient prep:** • Patients were instructed to bathe with CHG three times before their surgery. Patients who were unable to complete baths were bathed in the preoperative holding area with CHG. **Post-operative CHG treatment:** • Daily CHG baths were performed by the nursing staff For how long? • Beginning on POD #2, the surgical team cleaned the incision with a CHG impregnated wand **Antibiotic selection, timing and dosage:** • The CPGs for antimicrobial prophylaxis in surgery were employed **Normothermia:** • Normothermia was maintained with Bair Paws™ **Patient education:** • An SSI patient education packet was provided to the patient at their pre-operative visit and at discharge **Sterile wound closure technique:** • All operative staff completed a sterile gown and glove change after the fascial closure • A separate sterile instrument was used for closing the wound **Wound protectors:** • The Alexis wound protector system was used for all open procedures **Euglycemia:** • Patients were screened for Hemoglobin A1c at their pre-operative visit, PCPs were notified of abnormal values

	• On day of surgery, a point of care serum glucose was drawn, if glucose was greater than 180 the patients were placed on the hyperglycemia protocol
Outcomes	**Primary outcome(s):** • SSI risk adjusted odds ratio (*raOR*) for colorectal procedure targeted (CR-PT) and all general surgery procedures • Observed to expected (O:E) ratios for SSI (superficial, deep, and organ space SSIs • Bundle compliance **Secondary outcome(s)** • Not identified **Safety outcome(s):** • Not reported *Outcomes of interest to the CMH CPG development team

Results	**Pre-/post-intervention data findings:**
	raORs:
	• CR-PT ($p < .05$)
	  ○ Pre-bundle implementation mean raOR = 1.22
	  ○ Post-bundle implementation mean raOR = .95
	• General Surgery ($p < .05$)
	  ○ Pre-bundle implementation mean raOR = 1.32
	  ○ Post-bundle implementation mean raOR = 1.04
	O:E ratios:
	• CRS ($p < .01$)
	  ○ Pre-bundle implementation mean O:E = 1.74
	  ○ Post-bundle implementation mean O:E = 1.31
	• General Surgery ($p < .01$)
	  ○ Pre-bundle implementation mean O:E = 1.67
	  ○ Post-bundle implementation mean O:E = 1.25
	Bundle compliance:
	• CRS
	  ○ Post-operative CHG and normothermia reached 70% compliance by the end of the first year
	  ○ Pre-operative CHG reached 70% compliance by the end of the second year
	  ○ Euglycemia reached 70% compliance by the end of the third year
	• General Surgery
	  ○ Normothermia, pre- and post-operative reached 70% compliance the third quarter of 2016 and sustained it for nine months (the study ended)
	The authors provided a figure that illustrates that as compliance with the process measures increased there was a decline in the SSI O:E ratios however

Schriefer et al., 2017

Characteristics of Study	
Methods	Quality Improvement Orthopedic surgery
Participants	**Participants:** Children undergoing orthopedic surgeries, categorized into High Risk by type of surgery (e.g. neuromuscular or complex surgeries) or patient co-morbidities (e.g. malnutrition). **Setting:** Children's Hospital, Rochester NY, USA **Number enrolled into study:** *N* = 541 **Number completed:** *N* = 541 **Gender, males: (as defined by researchers)** • Not reported **Race / ethnicity or nationality (as defined by researchers):** • The study occurred in Rochester NY, USA. The authors did not identify race or ethnicity of the participants. **Age, mean** • Not reported **Inclusion criteria:** • Not reported **Exclusion criteria:** • Not reported **Covariates identified:** • Not reported
Interventions	**Both: Bundles were implemented in the spring of 2014.** • Bundles below • Also give recommendations and dosing charts for prophylactic antibiotic for neonatal/pediatric surgery
Outcomes	**Primary outcome(s):** • **SSI-** do not delineate deep, superficial, or organ space **Secondary outcome(s)** • Compliance defined as all elements complied with 95%. **Safety outcome(s):** • Not reported *Outcomes of interest to the CMH CAT development team

Results	**SSI results**
	• Pre- 4% (6/154)
	• Post 0 (0/198)
	Compliance:
	• Areas with 100% compliance
	  ○ Preoperative antibiotic selection and timing
	  ○ MRSA positive patients, nasal swabs in the OR
	  ○ Standard wound dressing application
	• Areas of non-compliance
	  ○ Documentation of CHG wipes the night before surgery and the day of surgery
	  ○ Temperature of the patient in the OR

Bundles for Schriefer 2014

	High Risk Surgeries	Low Risk Surgeries
Antimicrobial Prophylaxis	Prescribed weight based prophylactic antibiotics using the prophylactic antibiotic dosing table embedded withing the EMR	
Nutrition evaluation and treatment	Prealbumin and Vitamin D screening Referrals to pediatric GI and nutritionist if nutrition labs off Treat prior to surgery	No nutrition lab values are drawn if BMI is normal using the CDC BMI calculator
Antiseptic skin	2% CHG wipes the night before and the day of surgery	2% CHG wipes the day of surgery
Staphylococcus aureus screening and or decolonization	Preoperative povidone-iodine nasal antiseptic swabs postinduction by the anesthesiologist regardless of MRSA cultures	
Warming	Prewarming the operating room to a minimum of 75◦F prior to the patient's entry All spine surgery patients prewarmed with AIR huggers Other high-risk patients prewarmed using warming blankets, thermal gowns, and thermal hats	Prewarm using warming blankets, thermal gowns, and thermal hats
Urinary catheter	Discontinue urinary catheter within 24-48 hours postoperative per hospital guideline, unless otherwise justified	
Wound dressing	Standardized intraoperative application of wound dressing	
Blood transfusion	Discussion with attending physician prior to blood transfusion intra-/postoperatively	
MRSA surveillance	Active MRSA surveillance where there is a history of MRSA, e.g. those residing in group home/ institution	
Antibiotics	Bone graft antibiotics for spine surgery using doses recommend by and infectious disease consult	

Schweizer et al., 2015

Characteristics of Study	
Methods	**Cohort (Pre-/post-intervention) Cardiac and orthopedic surgery**
Participants	**Participants:** Patients undergoing a primary hip or knee arthroplasty (i.e., replacement or resurfacing) or primary cardiac operation through a median sternotomy incision **Setting:** 20 US urban hospitals within the Hospital Corporation of America system **Number enrolled into study:** *N* = 42,534 (the enrollment represents 38,049 unique patients with 10,833 being cardiac and 31,701 being hip or knee arthroplasties) • **Group 1, pre-intervention:** *n* = 28,218 (66%) ○ **Cardiac:** *n* = 7,576 (27%) ○ **Hip or Knee Arthroplasties:** *n* = 20,642 (73%) • **Group 2, post-intervention:** *n* = 14,316 (34%) ○ **Cardiac:** *n* = 7,576 (27%) ○ **Hip or Knee Arthroplasties:** *n* = 20,642 (73%) **Number completed:** *N* = = 42,534 • **Group 1, pre-intervention:** *n* = 28,218 (66%) ○ **Cardiac:** *n* = 7,576 (27%) ○ **Hip or Knee Arthroplasties:** *n* = 20,642 (73%) • **Group 2, post-intervention:** *n* = 14,316 (34%) ○ **Cardiac:** *n* = 7,576 (27%) ○ **Hip or Knee Arthroplasties:** *n* = 20,642 (73%) **Gender, males: (as defined by researchers)** • **Group 1:** *n* = 13,149 (47%) ○ **Cardiac:** *n* = 5,168 (68%) ○ **Hip or Knee Arthroplasties:** *n* = 4,325 (39%) • **Group 2:** *n* = 6,582 (46%) ○ **Cardiac:** *n* = 2257 (70%) ○ **Hip or Knee Arthroplasties:** *n* = 4325 (39%) **Race / ethnicity or nationality (as defined by researchers):** • The study occurred in US. The authors did not identify race or ethnicity of the participants. **Age, median years, (range)** • **Cardiac:** 67 (18-95) • **Hip or Knee Arthroplasties:** 68 (18-107) **Inclusion criteria:** • Hospitals using some but not all of the bundle elements during the pre-intervention period could participate • Patients ≥ 18 years • Surgeries could be scheduled, urgent, or emergent primary hip or knee arthroplasty or primary cardiac operation which used a median sternotomy approach **Exclusion criteria:** • Arthroplasty revisions • Cardiac transplants • Transapical valve implantation • Operations performed using percutaneous or thoracotomy • Patients with preexisting infections at the surgical site

	Covariates identified: • MRSA or MSSA • Operation group

Interventions	**Group 1:**
	• Standard of Care
	Group 2:
	• Patients nares swabbed pre-operatively 10-14 days before surgery but no more than 30 days before to determine MRSA and MSSA carrier status
	  ○ Each hospital's lab used their standard tests
	  ○ Patients with positive screening tests for either organism applied mupirocin intranasally twice a day and bathed with CHG once daily for up to five days prior to the procedure (patients that received fewer than 10 doses of mupirocin before their procedure received the remaining doses in the postoperative period. CHG bathing was not continued post-operatively)
	  ○ Patients with negative screening tests bathed the night before and the morning of the procedure
	  ○ The CPGs for antimicrobial prophylaxis in surgery were employed (Bratzler, 2013)
	  ▪ Antimicrobial agents used for perioperative prophylaxis varied by the patients' *S aureus* carrier status:
	  • Noncarriers and MSSA carriers received either cefazolin or cefuroxime for perioperative prophylaxis
	  • MRSA carriers received both cefazolin or cefuroxime and vancomycin
	  • If a patient had a confirmed β-lactam allergy, surgeons were encouraged to provide perioperative prophylaxis with vancomycin rather than cefazolin or cefuroxime and to add either gentamicin or aztreonam for gram-negative coverage
	  • Patients with negative screening tests but with documented histories of MRSA carriage or infection were treated as carriers.
	• Patients who were either not screened because they had emergent operations or whose screening results were not known at the time of their operations received vancomycin and cefazolin or cefuroxime for perioperative prophylaxis. In these situations, nasal swabs were obtained for MSSA and MRSA screening and patients began the decolonization regimen immediately before their operations. Mupirocin was continued until screening test results were known; mupirocin was discontinued if test results were negative

Outcomes	**Primary outcomes:** • Rate of complex MSSA or MRSA SSIs • Rates of all SSI (superficial or complex SSI^, caused by any pathogen • LOS during index admission • Readmission rates for SSI treatment **Secondary outcomes:** • Not reported **Safety outcomes:** • Adverse events

	*Outcomes of interest to the CMH CPG development team ^Complex SSI defined as an SSI within the deep incisional area or organ space
Results	**Pre-/post-intervention data findings:** One hospital stopped the intervention on March 31, 19 hospitals continued the intervention through March 14, 2014. Median pre-bundle period was 39 months (range 39-43), and the median intervention period was 21 months (range 14-22). *SSI rates:* • Complex *S aureus* SSIs ○ Pre-bundle implementation *n* = 101 ○ Post-bundle implementation *n* = 29 ○ Regression analysis identified a significant reduction in complex *S aureus* SSIs with bundle implementation *OR = 0.60,* 95% CI [0.37, 0.98] ○ the number of months without a complex SSI increased from 2 of 39 months (5.1%) to 8 of 22 months (36.4%, *p* = .006) ○ Monthly rates of complex SSIs decreased from 36 to 21 per 10,000 operations (MD = -15, 95% CI [-35, -2]) ○ Rate ratio = 0.58, 95% CI [0.37, 0.92] • MRSA and MSSA rates did not change significantly • Subgroup analyses ○ Complex *S aureus* SSIs decreased significantly for scheduled operations, Rate ratio = 0.55, 95% CI [0.35, 0.86] this same decrease was not noted for urgent or emergent operations ○ Complex *S aureus* SSIs decreased significantly for hip and knee arthroplasties (difference per 10,000 operations) Rate ratio = 0.48, 95% CI [0.29, 0.80] ○ The rates of all *S aureus* SSIs, all gram-negative SSIs and complex SSIs caused by any pathogen did not decrease significantly. Adherence to bundle*: • Patient adherence ○ Complex *S aureus* SSIs rates decreased significantly in the fully adherent group compared to the pre-intervention period; Rate ratio = 0.26, 95% CI [0.10, 0.69] ○ Rates did not decrease in the partially adherent or nonadherent group • Surgeon adherence ○ Complex *S aureus* SSIs decreased significantly when surgeons implemented at least some bundle elements, *Rate ratio* = 0.54, 95% CI [0.34, 0.88] compared to surgeons who did not implement any bundle elements, *Rate ratio* = 0.80, 95% CI [0.33, 1.98] *Adherence definitions: ♦ Fully adherent for urgent/emergent operations defined as patient received both mupirocin (>/= 1 day) and prophylaxis with vancomycin and cefazolin or cefuroxime ♦ Fully adherent for scheduled operations among MRSA carriers defined as patient received CHG bathing, mupirocin for three days or more, and prophylaxis with vancomycin and cefazolin or cefuroxime ♦ Fully adherent for scheduled operations among MSSA unknown and MRSA negative defined as patient received CHG bathing, mupirocin for three days or more, and cefazolin or cefuroxime prophylaxis ♦ Fully adherent for scheduled operations among *S aureus* negative defined as patient received CHG bathing, and cefazolin or cefuroxime prophylaxis Adverse events: • Four patients experienced a mild skin irritation with the pre-operative CHG bathing, symptoms abated after the product was discontinued • No events were noted with mupirocin

Zywot et al., 2017

Characteristics of Study	
Design	Quantitative Synthesis (meta-analysis)
Objective	Evaluate colorectal surgery (CRS) surgical site infection (SSI) bundles on SSI rates, bundle components, along with identifying key features for implementation strategies and achieving high compliance. PICO: In patients with colorectal surgery what SSI care bundles: • Decrease SSI rates • Decrease levels of SSI classifications • Improve individuals' compliance rate practice

Methods	**Protocol and registration.**
	The protocol for this study was registered with PROSPERO international prospective register of systematic reviews (C RD42017057644).
	Eligibility Criteria.
	• For inclusion in the systematic review:
	  ○ Studies evaluating the use of an SSI care bundle (defined as having at least three elements) in patients undergoing an elective or emergent CRS
	  ○ Full text
	• For inclusion in MA:
	  ○ Studies reporting pre- and post-intervention SSI data for CRS
	Information sources.
	• PubMed, Scopus, Crossref, and Cochrane Central Registry of Controlled Trials (1966–2017) databases were searched from study inception to March 2017.
	• Search strategy employed: subject headings, keywords, and free text terms for "bundle", "SSI", and "colorectal surgery" or their variations. Search was not restricted by language.
	• Ancestry search was employed to identify additional studies.
	• If studies had the potential to meet inclusion criteria but were lacking data, the study authors were contacted requesting the additional data.
	Study Selection.
	• Initially two study authors independently screened the titles and abstracts of the articles to determine if they met the inclusion criteria.
	• For disagreements related to screening, consensus was obtained through the review by a third and fourth researcher.
	• Upon obtaining consensus for included studies, all full text articles were reviewed by the two initial researchers for data extraction
	Data collection process.
	• Data extraction included the following:
	  ○ Study design
	  ○ country
	  ○ Study starting and ending dates
	  ○ Cohort sizes
	  ○ SSI rates pre- and post-intervention
	  ○ SSI classifications
	  ○ Surgeries included in the study

	○ Bundle elements ○ Bundle adherence rates ○ SSI adverse effects ○ Outcomes of interest: ▪ Primary: SSI rates after care bundles implemented ▪ Secondary: SSI classification (superficial, deep, or organ/space) **Risk of bias (RoB) across studies.** • Checklist assesses the quality of randomized and non-randomized studies. The National Collaborating Center for Methods and Tolls has evaluated this checklist and identified it to be a valid, reliable and methodologically strong instrument. The checklist is comprised of five sections: study quality, external validity, study bias, confounding and selection bias and power. • Scoring of studies: ○ High quality ≥ 19 ○ Medium quality 10 to 18 ○ Low quality < 10 [Reviewer's note, in reviewing the psychometric properties of the Downs and Black quality checklist the maximum score possible is 27. Scores between 24-28 are considered excellent, between 19-23 are considered good, between 14-18 are considered fair or < 14 scores are considered poor (Gaggioli, Villani, Serino, Banos, & Botella, 2019).] • Sensitivity analysis occurred by omitting each study in succession • Publication bias was assessed by: ○ Funnel plot visualization ○ Egger's and Begg's tests with a *p* value of < .05 considered to be statistically significant **Summary measures.** • 95% confidence interval (CI) and relative risk (*RR*) were calculated. **Synthesis of results.** • Meta-analysis was performed using Comprehensive Meta-Analysis software Version 3 (Biostat, Englewood, NJ, USA). • For studies reporting zero event in any group, a continuity correction factor of 0.5 was adopted to calculate the *RR* and variance. • Heterogeneity between studies, was measured using the Cochrane's Q statistic and I^2 statistic. Heterogeneity was considered statistically significant when $p < .05$ or $I^2 > 50$. • If heterogeneity was observed, data was analyzed using a random-effects model. Conversely, in the absence of heterogeneity, a fixed-effects model was utilized.
Results	**Study Selection.** **Number of articles identified:** *N* = 1775 **Full-text articles assessed for eligibility:** *n* = 168 ○ **Studies included in qualitative synthesis:** *n* = 35* ○ **Studies included in quantitative synthesis:** *n* = 23* [Reviewer's note: the PRISMA diagram and the results section do not report the same values for the studies included in the qualitative and quantitative analysis. Therefore, the reviewer choose to count the citations throughout the article and report those numbers.] **Synthesis of results.** • Eighteen of the 30 studies reported a statistically significant change in SSI rates, reduction rates ranged from 27 to 69%. • From MA (*N* = 17,619):

	○ Primary outcomes ▪ Overall SSI rates decreased after bundle implementation: 1318/8823 (14.9%) vs 821/8796 (9.3%)* *Heterogeneity was significant (p = .001, I_2 = 70.690) between studies, Random-effects modeling was used. ▪ There was a 40.2% significant reduction in the risk of SSIs RR = .598, 95% CI [0.496, 0.722], p < .001 ○ Secondary outcomes ▪ SSI classification rates: • Superficial SSI rates were reported in 15 studies (n = 13,922): 6929 pre-implementation and 6993 post-implementation. The relative risk of reduction of 43.7% was significant: RR = 0.563, 95% CI [0.417, 0.761], p < .001 • Deep SSI rates were reported in 10 studies (n = 7107): 3877 pre-implementation and 3230 post-implementation. These findings were not considered significant RR = .767, 95% CI [0.460, 1.280], p = .310. • Organ/Space SSI rates were reported in 11 studies (n = 7304): 3974 pre-implementation and 3330 post-implementation. The reduction of 34.1% was reported as significant RR = .659; 95% CI [0.436, 0.996], p = .048 ▪ Subgroup analysis: • Elective vs. elective or emergent surgeries found no different in SSIs (p = .794) • Bundles (no difference between SCIP in risk reduction by bundles (p = .232) ◊ Twelve studies implemented SCIP or SCIP-like bundles ◊ Nineteen bundles included SCIP elements with additional interventions ◊ Four studies were compliant with SCIP measures prior to implementation of a CRS SSI bundle • Studies (n = 9) that incorporated mechanical bowel prep and oral antibiotics into the bundle had a significantly greater SSI risk reduction (55.4 vs 31.8%, p = .015). • Including a sterile instrument closure tray in the bundle significantly reduced SSI risk (58.6 vs. 33.1%, p = .019) • Significant benefit was measured when gloves were changed prior to closure (56.9 vs 28.5%, p = .002) • SSI rates did not significantly change with the inclusion of a pre-operative CHG showers or cleansing wipes (p = .098). **Risk of bias across studies.** Based on Gaggioli et al. (2019) the quality assessment scores for the included studies ranged from excellent (n = 1), good (n = 29), and fair (n = 1). There was no evidence of publication bias for the primary outcome, Egger's test (p = .291) or Begg's test (p = .398).
Discussion	**Summary of evidence.** The implementation of a care bundle appears to decrease the risk for acquiring a SSI **Limitations.** • Heterogeneity and variation amongst the included studies. • Of the included studies two were randomized control trials, one study's design was not reported and the remainder were cohort studies. Including cohort studies can increase bias due to the possibility of participant selection • Not all the included studies were peer reviewed. • The included studies were published between 2007 and 2017, this is the time period in which SSI prevention was evolving.

	• Some studies did not disclose the standard practice that existed prior to the bundle implementation.
Funding	The author's did not report a funding source for this SR/MA.

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