Appendix Table C3-LQ-c. Intervention characteristics for SSI which do not control for secular trend or confounding

| **Study** | **Infection** | **Intervention Specifics** | **Positive or Negative Incentives** | **Feedback or consequences given to interveners/intervenees** |
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| Acklin, Switzerland - 2011 | SSI | When a spike in SSI following hip fracture surgery occurred, the hospital began a bundle intervention. Using evidence from international guidelines, an independent hospital epidemiology team developed internal guidelines, provided continuing education of staff, limited traffic in OR, standardized disinfection of surgical site, observed standard perioperative procedures and provided feedback to staff. An expert in quality improvement was hired to implement the interventions. Infection rate were regularly reported at internal grand rounds. |  | Infection rates were reported at internal grand rounds. A feedback session for all staff was organized. When one OR nurse had an increased association with SSIs, he/she was instructed separately about the intervention measures. |
| Awad, United States - 2009 | SSI | A MRSA bundle was initiated, which involved: 1) nasal screening of pts at admission, transfer, discharge, 2) contact isolation of positive pts, 3) standardized hand hygiene, 4) cultural transformation campaign with staff and leadership engagement thru positive deviance, and 5) ongoing monitoring of process and outcome measures. To implement this bundle, clinical staff were educated. Outcome measures were tracked on each unit, and data updated monthly. meetings with all staff were held to discuss unit data, including swab rates on admission, transfer, and discharge, # positive pts, and hand hygiene compliance. | The authors cite CMS’s consideration of adding MRSA to the list of conditions for nonpayment. | Monthly meetings in each unit were held to discuss swab rates, # positive pts, and hand hygiene compliance. |
| Berenguer, United States - 2010 | SSI | The hospital decided to enroll in the National Surgical Quality Improvement Program (NSQIP). The NSQIP receives the following data from trained nurses of enrolled hospitals: pre-operative risk factors, post-operative occurrences, mortality reports, SSI, and pt statistics. The NSQIP then generates a 12-mon biyearly report in which enrolled hospitals can compare their statistics with each other. When this hospital received their report, they were in the 4th quartile compared to other hospitals. They began using SCIP as a means to improve their outcomes. Nurses and physicians were trained on appropriate antibiotic choice, timing, and duration. Razors were removed from ORs and replaced with clippers. Anesthesiologists and surgeons were educated on post-operative normothermia and body warming devices were made available. Surgeons were alerted to the hospital’s high SSI rate and were encouraged to take the lead and become active participants in the quality safety team. | The hospital wanted to improve their statistics in the NSQIP reports, in comparison to the other hospitals. |  |
| Berry, United States - 2009 | SSI | ProvenCare’s goal is to deliver evidence-based recommended care to elective CABG pts. A steering committee was formed composed of senior leaders and a process improvement specialist. A cardiac surgeon was assigned within the clinical effectiveness division as the clinical improvement specialist whose role was to facilitate and coordinate the initiative. The initiative had 3 phases: review and validate best practice evidence, redesign processes, and implement new processes. CABG guidelines class I and IIa from American College of Cardiology/American Heart Association were reviewed in a series of consensus-building meetings of all Geisinger cardiac surgeons. This resulted in 19 clinically applicable recommendations and 40 measurable process elements. Those relating to SSI are preoperative antibiotics and tight perioperative glucose control. A multidisciplinary team was formed in each hospital, consisting of a physician, a cardiac physician asst, critical care nurse, OR nurse, cardiac rehabilitation tech, electronic health record programmer, and clinical process improvement specialist. The team assessed current process flows for CABG pts, determined which best practices were already in place, and redesigned the process to incorporate best practices not already in place. The Study-Act-Plan-Do process was used to standardize intra-operative glycemic control. Cardiac surgeons chose 110 mg/dl or greater as the trigger to start insulin infusion. Certified registered nurse anesthetists (CRNA) posted insulin protocol in OR and a daily feedback mechanism was put in place to alert CRNA of adherence. Director of anesthesia reviewed protocol with all anesthesia personnel. Details on system for preoperative antibiotics were not provided. The electronic health record was adopted to include: clinical decision support, care flow maps, and history and physical templates. Performance data on all 40 process measures were continually monitored so that any process defect was quickly identified and immediately redesigned. Within 3 months, 100% reliability of process measures was achieved. | As a part of the existing hospital setting policy physician compensation was tied to physician performance and compliance. Also, all HCW’s were made aware that compliance with each of the process elements (as a team and as individuals)would be followed and that real-time feedback would be given so this would affect their performance; | When a lapse in adhering to new process measures occurred, the clinical improvement specialist worked with staff responsible for lapse and reinforced the new process measure.; Real-time feedback was able to be done due to the robust measurement strategy (A standardized abstraction tool that graphically depicts the sequential delivery of care and highlights defects) so any variation or ‘‘failure’’ was fed back to the responsible care provider and the improvement team on the day it occurred (as the clinical improvement specialist was notified for each new patient entering the process and the abstracted data tool was in use at a time in parallel to the care being provided); |
| Carles, France - 2006 | SSI | Weekly, the anesthesiologists created lists with pt name, type of surgery, and date of surgery and sent the list to the hospital pharmacy. Pharmacists prepared personalized surgical antibiotic prophylaxis kits (SAPK) with pt name, antibiotic to be given, and instruction sheet specifying dose, times of administration, and duration of antibiotic. SAPKs were delivered to the operating room on the morning of the planned surgery. |  |  |
| Forbes, Canada - 2008 | SSI | Three multidisciplinary working groups, one for each bundle, met to design new practice protocols. Members of the depts. of surgery, anesthesia, and perioperative nursing tested the new protocols prior to implementation. The new plans were introduced thru academic rounds and in-services. An OR nurse and a nurse from same-day surgery were study champions, acting as resources to other staff. The antibiotic bundle included: location of antibiotic administration was changed from the admissions unit to the OR. Preprinted, preoperative order forms were designed to standardize the choice of antibiotic. The plan was introduced to attending and house staff during rounds, and to nurses through a series of in-services. Before implementing the previously mentioned interventions, each working group conducted independent tests of change. |  | Monthly performance figures were posted in the OR. |
| Gomez, Argentina - 2006 | SSI | A multidisciplinary team of pharmacists and infection control personnel developed an automatic stop prophylaxis form which included pt info, surgery info, level of bacterial contamination of surgery, and surgeon name. The form had a checklist for antibiotic recommendations so the physician can check which antibiotic was to be administered. The forms were then sent to pharmacy and every morning, pharmacy checked the forms and stopped the antibiotic prophylaxis if the surgery had been completed. If physician wanted to extend antibiotics, he/she could call pharmacy for extension. Educational programs were presented to different surgical teams, nursing, and pharmacy staff on guidelines and how to use form. Each physician also received a 1 hr one-on-one instruction on antibiotic guidelines so that consensus was reached. |  |  |
| Graf, Germany - 2009 | SSI | When a rising incidence of deep sternal surgical site infections occurred, an infection control team was formed, including cardiac surgeons and nurses, anesthesiologists, technicians, ward physicians and nurses, and members of the infection control dept. The team developed a bundle of prevention strategies to be implemented. The bundle of prevention strategies included using hair clippers instead of shaving, administering antibiotic prophylaxis after 1st venous puncture during operation preparation, use of antiseptic body scrub, and bacterial decolonization measures. A pt-specific information sheet was created describing appropriate infection control measures before cardiac surgery, a standard operation protocol for infection control measures was implemented, and successful application of the infection control measures was documented using a rubber stamp in the pts’ files. Frequent education of physicians and residents from participating departments was conducted together, allowing for discussions on the practicality of prevention measures, optimizing the working process. Continuous feedback of SSI rates were provided to staff. |  |  |
| Hermsen, United States - 2008 | SSI | An order form for surgical antimicrobial prophylaxis was developed according to published guidelines, the hospital formulary and local prevalence of antimicrobial resistance. It was designed to assist in the choice, dose and duration of use of antibiotics. It also included guidelines for weight-based dosing and alternatives for patients with allergies. The form was made mandatory for all adult, elective, inpatient surgical procedures. Physicians, pharmacists and nurses were educated about the form and the Surgical Infection Prevention (SIP) program via written communication, posters, and presentations. Feedback was given to medical staff throughout the study. |  |  |
| Ichikawa, Japan - 2007 | SSI | Study staff created antibiotic protocols for the management of infections in children. The protocol includes the type of antibiotic, timing of antibiotics and dosing of Antibiotics for different disease/operations for different wound types. The infection control team (ICT) determined the choice of Antibiotics, its route of administration, and duration of use. The pre and intra-operative Antibiotics were administered exclusively by anesthesiologists at tracheal intubation or soon after intubation just before final positioning on the table. This was confirmed by the operating room nursing staff or attending surgeons. If an infection was detected, the ICT advised other staff about the protocols, adequate wound care management, and treatment. |  | If an infection was identified, a meeting was arranged for the ICT to advise other staff about protocols, wound care, and treatment. |
| Kable, Australia - 2008 | SSI | An interdisciplinary approach was taken to implementing antibiotic prophylaxis measures. Protocols for each surgery type were designed using guidelines, and approved by the Director of Microbiology and Infectious Diseases and the Director of Pharmacy. The protocols were inserted in the medical records of the corresponding pts by the pre-op staff. Staff were educated on the study and the protocols during training sessions. |  |  |
| Kramer, United States - 2008 | SSI | A continuous insulin infusion (CII) order set, was developed in 2004, but nurses found it cumbersome and difficult to use. The form was designed to avoid hypoglycemia. The cardiac team, led by a multidisciplinary quality improvement group, worked with graduate students to devise a new CII. The team focused on the clinical microsystem and nursing workflow. A color-coded nomogram for CII orders which fit on one page, was developed. The group also coordinated weekly intensive in-service sessions that stressed the dangers of hyperglycemia and the lesser dangers of hypoglycemia, and the nomogram was explained and feedback from the frontline users (nurses) was obtained. There was widespread acceptance of the new form by all nurses (OR, cardiothoracic ICU, general ICU), all of which would use the nomogram. |  |  |
| Liau, Singapore - 2010 | SSI | A project team was assembled consisting of surgeons, anesthesiologists, OR attendants, OR nurses, post-anesthesia care unit nurses (PACU), ward nurses, and ward physicians. The team identified factors causing SSI and voted for the following factors to work on: antibiotic prophylaxis, hypoglycemia, hair removal, and normothermia. Hair removal: shavers replaced clippers, reminder signs were posted, pts instructed not to shave preoperatively, OR attendants trained to use clippers, and the team worked with the purchasing dept to ensure a continuous supply of clippers. Antibiotic prophylaxis: The Department of Surgery Prophylactic Antibiotic Guideline was developed based on international guidelines, agreed upon by surgeons, pharmacists, and infection control, and distributed to all staff for reference and compliance. Signs and posters on the guideline were posted, and drugs were stocked accordingly. Glucose control: PACU and ward nursing officers were tasked to monitor and control blood glucose concentrations postoperatively. Normothermia: Warmed intravenous fluids, higher temp in OR, and use of warming blankets throughout entire operation were strategies employed. A pilot study was conducted and upon positive results, the full study was implemented. The operation workflow was modified to embed all of these changes. |  | Following the successful pilot study, hospital leadership spread the news to the rest of the surgical disciplines. Within 2 yrs, other subspecialties (breast, urology, vascular, endocrine, and orthopedics) adopted similar practices. |
| Martin, United States - 2010 | SSI | The following changes in surgical wear were implemented: 1) during stages and reconstruction, staff wore surgical caps to contain hair and no jewelry except smooth wedding rings were allowed, 2) during removal, staff scrubbed with CHG and alcohol and wore sterile gloves and pts draped with sterile towels and sterile dressing applied, and 3) during reconstruction, staff scrubbed with CHG and alcohol and wore sterile gloves and gowns. |  |  |
| Nemeth, United States - 2010 | SSI | One month of education of the anesthesia, nursing and surgical staffs, and the inclusion of the question “Has the antibiotic been administered within the correct time frame?” added to the verification of patient identity, operative procedure, and surgical site during the pre-operative ‘time out’. |  |  |
| Ozgun, Turkey - 2010 | SSI | Pre-intervention data was collected on antibiotic prophylaxis use. This data was analyzed and shared with physicians and residents. General and branch meetings were held to educate the surgeons, residents, and nurses on antibiotic prophylaxis. Topics discussed included choice of antibiotic, timing of administration, and duration. Specific problems and misuses that were detected in the pre-intervention data were discussed separately within each branch. If surgeons could not attend meetings, they were caught up to the study individually. Guideline documents were distributed to staff and posters were hung around the hospital. |  | Misuses of antibiotics detected in the pre-intervention data were discussed separately within each surgery branch. |
| Parker, United States - 2007 | SSI | The Six Sigma approach is a data-driven, quality improvement methodology developed by Motorola and improved by GE. It is used to improve outcomes by reducing process variability. A 10-member multidisciplinary team consisting of physician process champions, nurses, a hospital epidemiologist, and an outcome administrator were assigned a 3M “black belt” mentor responsible for team building and overall project management. All team members participated in a two month Six Sigma “green belt” training to learn the tools and concepts necessary to begin this quality improvement project. A process map was made to help outline the critical steps involved in increasing compliance with antibiotic prophylaxis. The intervention aimed to reinforce use of standardized preoperative order forms, eliminate administration of antibiotic prophylaxis in the surgical admissions preoperative area, and send antibiotics and IV tubing to the OR. A 1 week education program preceded the beginning of the project. The education program targeted all clinicians that might interact with the patient. In 2005, an electronic anesthesia record keeping system (ARKS) was instituted in the main ORs. ARKS acts as a decision support tool to remind the anesthesia provider to administer the antibiotics at an optimal time. ARKS also displays a reminder to give a second dose if the first dose was given >60 min prior to incision. |  |  |
| Pastor, United States - 2010 | SSI | A multidisciplinary task force was convened to implement changes and monitor compliance with SCIP process measures. The task force consisted of surgeons, anesthesiologists, infection control personnel, and intra-operative nurses. The committee identified and assisted in overcoming the following obstacles: obtaining certain antibiotics inside operating room, availability of warming blankets in preoperative area, tracking of temp and glucose readings in nursing and recovery room flow sheets. The task force also provided in-service education for all staff on the SCIP process measures. |  |  |
| Paull, United States - 2010 | SSI | The NCPS initiated a Medical Team Training (MTT) Program in VHA hospitals. In each facility, a nurse educator from NCPS worked with a hospital leader (chief of surgery, nurse manager) to develop a plan for preoperative briefing and postoperative debriefing. Instructors from NCPS then held learning sessions for physicians, nurses, residents, and allied health care personnel working in the OR, post-anesthesia care unit, ICU, and surgery clinics. In addition to providing instruction on pre-operative briefings and post-operative debriefings, the sessions also gave examples of checklists. Over 12.000 providers underwent training. Each facility developed their own checklist, using either paper, slider board, poster, whiteboard, electronic, or other. One item on the checklist was a reminder to administer antibiotic prophylaxis within 60 min of incision. Prophylactic antibiotic use was then reviewed retrospectively in 45 +/- 7 charts/facility pre checklist and in 33 +/- 6 charts/facility post checklist. |  |  |
| Potenza, United States - 2009 | SSI | In response to SCIP guidelines, a team consisting of members from each specialty, as well as nursing and pharmacy, convened. A lead performance improvement nurse and a data analyst were designated for technical and logistical organization, data abstraction, and analysis. The team core met monthly to review data and the whole team met quarterly. Charts were reviewed for compliance with 9 SCIP guidelines. The team identified barriers to compliance with antibiotic prophylaxis, normothermia, appropriate hair removal, and glucose control. First, they educated all staff on the project and the goals and emphasized the need to standardize their approaches to basic surgical issues. Next, methods to address the 9 SCIP guidelines were developed. The methods covered 3 main areas: people, process, and systems. To improve antibiotic prophylaxis compliance, there was a gradual agreement among key surgical personnel on antibiotic selection and a standard policy for timing of administration was set. The pharmacy created a system to deliver approved antibiotics and anesthesia stocked them on carts. Surgical house staff and faculty were given laminated cards with SCIP guidelines including antibiotic choices. ORs also have antibiotic listings for quick reference. Anesthesiologists, responsible for administering antibiotics, were empowered to question antibiotic choice, and the anesthetic worksheet was revised to include SCIP guidelines, which improved documentation. |  |  |
| Rauk, United States - 2010 | SSI | A team consisting of administrators, staff, physicians, and infection control personnel met to identify potential causes of SSI after cesarean deliveries. Next the team developed a preoperative skin preparation protocol. The new protocol included using 2% CHG clothes preoperatively on all pts undergoing c-section as well as all pts with prolonged labor or other risk for c-section. The clothes were no-rinse. Staff were instructed on use of the clothes, proper attire, room setup, skin coverage, and sterile technique. A video was made to demonstrate these techniques and a knowledge assessment tool was developed. The team also developed a quick reference sheet on the clothes. Flash sterilization of instruments was eliminated. All sterilization was done at central surgical supply and availability of enough surgical instruments was provided so that flash sterilization was no longer necessary. |  | Following educational instruction, a knowledge base assessment tool ensured the staff understood the instructions. |
| Shimoni, Israel - 2009 | SSI | The epidemiology nurse and hospital’s infections disease consultant persuaded heads of obstetrics and anesthesia departments to empower 6 operating room nurses to ensure that the 13 anesthesiologists give 1g or 2g of cefazolin (1 g if under 80 kg weight and 2 g if 80 kg or more) after cord clamping of caesarean births. |  |  |
| Suchitra, India - 2009 | CAUTI;SSI | An education program was conducted at the respective hospitals by a trained microbiologist. Small groups comprising of 10-15 staff were allowed to attend the education program, which extended for 2.5 to 3 h and was conducted as two sessions for the sake of convenience. It was conducted during the duty hours of the staff. The topics covered were hand washing, waste disposal, skin disinfection, universal precautions, hospital-acquired infections and prevention of infections. The sessions were interactive and the HCW were encouraged to ask questions. |  |  |
| Takahashi, Japan - 2010 | SSI | An antimicrobial stewardship team from the department of Infection Control and Prevention consisting of an infection control doctor and certified pharmacist prepared manuals with a physician from each department and chief surgeons in each department on the appropriate use of antimicrobial prophylaxis. The appropriateness of AMP was determined by the “Guideline for prevention of SSI, 1999” established by HICPAC and “Guidelines for implementation of clinical studies on surgical antimicrobial prophylaxis (2007)”. A manual was created for each of the 15 surgical departments outlining the correct use of antimicrobial prophylaxis (AMP). Nurses administered AMP in the pre-intervention period under the direction of a surgeon while an anesthesiologist administered AMP in the operating suite during the post intervention period. After the post-intervention period, each department received feedback of its AMP data discussed with surgeons, anesthetists, pharmacists, microbiologists and nurses. Educational meetings were organized for medical staff. Persons implementing feedback and educational meeting were not specified. |  | Study staff provided feedback of AMP data to departments surgeons, anesthetists, pharmacists, microbiologists, and nurses |
| Wax, United States - 2007 | SSI | an interactive visual reminder for prophylactic antibiotic administration was activated in the anesthesia information management system (AIMS) in nearly all anesthetizing locations. An event icon with the wording “Prophylactic Antibiotics Given” would appear between the “Position/Prep Start” and “Procedure/Surgery Start” icons. The event icon could then be acknowledged or ignored. | The surgical Care Improvement project mandate to publicly report surgical antibiotic selection/timeliness and pay-for-performance initiatives by payers as well as accrediting organizations and competitive forces in the market place were noted as motivating factors to increase compliance. | Practitioners with low compliance rates were interviewed. It was found that some had custom AIMS configurations that suppressed the antibiotic reminder and some felt that it was redundant to have to document seeing the reminder as well as document the actual administration of the antibiotic. |
| Whitman, United States - 2008 | SSI | The hospital-wide Performance Improvement Committee reviewed hospital-specific data and challenged the university surgical faculty to improve compliance with antibiotic prophylaxis guidelines. In spring 2005, surgical chairs began developing a protocol for antibiotic selection for operations performed in their respective departments. In January 1, 2006 they then implemented a surgical scheduling order form in which specialty-specific antibiotic prophylaxis was listed on the physician form to aid in the appropriate selection of antibiotics. In July 2006, the Temple University Hospital (TUH) adopted a policy mandating physician admission orders be available to the preadmission testing area (PAT) a the time of preadmission appointment to ensure orders for antibiotics were on the chart the day of admission. From Sept. 2006 through November 2006 TUH required administration of prophylactic antibiotics before the patient could leave the preparation and hold area. From December 2006 to June 2007, the Department of Anesthesia assumed responsibility for administering ordered antibiotic prophylaxis in the operating suite at the time of “universal timeout”. In order to promote timely cessation of antibiotic prophylaxis, the hospital’s associate director for perioperative services (first author) educated residents and faculty at each of the department’s routinely scheduled monthly resident educational meetings. In September 2006, a separate pathway for ordering “prophylactic antibiotics” was added to the electronic medical record, although the pathway could be bypassed. Hospital reports were reviewed monthly by the TUH SCIP committee and also presented at the operating room executive committee meeting. | Surgical Care Improvement Project requiring all Medicare participating hospitals to report specific data about antibiotic prophylaxis | Data acquisition was overseen by the medical record abstractors’ director (coauthor) and reports reviewed by the TUH SCIP committee |
| Willemsen, Netherlands - 2007 | SSI | This hospital was founded after a merger of 3 hospitals, and different antibiotic guidelines from before the merger were used by different staff. A multidisciplinary team of microbiologists and pharmacists created a standardized guideline which was approved by all surgeons and anesthetists. The guideline included information on antibiotic choice, dosage, and timing. The project coordinator educated all staff involved in perioperative antibiotic prophylaxis, which included nurses, pharmacy assistants, and anesthesia technicians. All antimicrobials in supply closets were switched in the ORs and on the wards, to only those recommended in the guideline. |  |  |
| Zvonar, Canada - 2008 | SSI | Following the baseline audit a multidisciplinary team was formed. The team recommended that antibiotics be given at time of anesthesia administration. To facilitate delivery, in June 2003, pre-mixed pre-op doses of antibiotics were sent to the OR with the patient’s chart and were also made available in the OR suites. Also patients with BMI>30 or weight>90kg, received a larger dose of antibiotics. The surgeon was to confirm that antibiotic prophylaxis was administered prior to incision. Antibiotics were also to be given intra-operatively for surgeries >3-4 hours. The second audit in 2004 showed some barriers so changes to the protocol were made. Nurses and pharmacists were allowed to automatically substitute larger doses for patients with BMI>30 or weight>90kg. Antibiotic prophylaxis was also added to the pre-op checklist. A list of surgeries requiring prophylaxis and recommended agents was created. Allergy and cross-allergy education also took place. In March 2005, a pre-op time out was implemented. This was used to verify that the patient, procedure, and surgical site were all correct as well as to ensure antibiotic prophylaxis was administered. |  | The data from the audit was used to make changes to the protocol. |