4-2023

Preoperative Skin Preparation Protocol for Patients Undergoing Abdominal and Spinal Surgery

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Date of Submission: 2 April 2023

Abstract

Surgical site infections are an avoidable complication in surgical patients and one of the most common hospital-acquired infections. Adverse effects of surgical site infections include increased hospital length of stay, increased costs to patient and healthcare system, disability, morbidity, and mortality. The purpose of this quality improvement project was to design a protocol with the objective of decreasing surgical site infections in abdominal and spinal surgery patients. The protocol developed used targeted depilation and antisepsis with a chlorhexidine wipe to mitigate infection risk. Results of the project showed a static hospital length of stay, no increase in preoperative time, and a 0.98% decrease in surgical site infections, though it did not achieve statistical significance related to the small sample size. Further exploration is warranted, though the results are promising for more widespread implementation.

Keywords: abdominal, spinal, surgical site infection, preoperative skin preparation, infection prevention

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Introduction

A surgical site infection (SSI) is defined as an infection at a site in which a surgery was previously performed, that occur within 30 to 90 days of the original procedure, or within one year of an implant procedure (Berríos-Torres et al., 2017; NHSN, 2022; Salahuddin et al., 2022). These infections present with varying symptoms dependent upon the depth of the infection, with either localized symptoms such as purulent drainage, or systemic effects in the case of organ space infections such as fever and sepsis (Liu et al., 2018).

Surgical Site Infections are among the most common nosocomial infections globally (Luwang et al., 2021; Nasser et al., 2020; Salahuddin et al., 2022) and are the second most common hospital acquired infection (HAI) in the United States (Salahuddin et al., 2022). Rates of SSI vary between 1% and 17.8% in the month following surgery (Liu et al., 2018; Salahuddin et al., 2022). Rates are highest among colorectal surgeries (CRS) at 15% to 30% related to the increased bacterial load found in the rectum and large intestine (Nasser et al., 2019; Zwyot et al. 2017). Adverse effects of SSI are numerous, including increased patient and hospital costs, increased length of stay, readmission, reoperation, permanent disability, detriments to patient mental health, morbidity, and mortality (Chen et al., 2020; Nasser et al., 2019; Salahuddin et al., 2022).

Description of Problem

A needs assessment performed at a central Michigan community hospital determined that there was a gap in care of the preoperative patient, specifically related to depilation and surgical

site antisepsis. During that time the facility reported multiple SSI occurring in spinal patients, and it was determined that a protocol to prevent SSI in both spinal and abdominal surgery patients needed to be developed and implemented.

Purpose of Study

The purpose of this evidence-based quality improvement (QI) project was to decrease the rate of surgical site infection by implementing a Preoperative Skin Preparation Protocol (PSPP) developed based on previous quality management data and available evidence aimed at reducing the likelihood of SSI.

Research Question

In abdominal and spinal surgery patients over 18 years of age, how does the utilization of a Preoperative Skin Preparation Protocol compared to current practice affect abdominal and spinal surgery preparation over a twelve-week period?

Statement of Objectives

The purpose of this DNP QI project was to reduce SSI in abdominal and spinal surgery patients in a central Michigan community hospital. The goal of the project was to increase adherence to the preoperative skin preparation protocol for the patient population by 85%. The overall project objectives were to:

1. Develop and implement a Preoperative Skin Preparation Protocol.
2. Decreased rates of SSI in abdominal and spinal surgery patients.

Review of Literature

A total of 24 studies were included in this review. The literature reviewed focused on surgical protocol and policy innovations and interventions to reduce SSI rates. Multiple studies

reviewed used multidisciplinary bundles, which are groups of interventions consisting of three or more elements designed to decrease SSI (Bert et al., 2017; Davidson et al. 2019; Higgins et al. 2018; Hoang et al., 2018; Reese et al., 2020; Rudder et al., 2019; Schouest et al., 2017; Vij et al., 2017; Weiser et al., 2018). These bundles were comprised of varying numbers of interventions, but commonalities were preoperative depilation, preoperative shower or hygiene, preoperative bowel prep, site preparation with CHG, perioperative antibiotic dosing/timing, intraoperative wound irrigation, intraoperative normothermia and normoglycemia, separate closing trays, and postoperative showers. An overall finding was that depilation and preoperative scrub are essential for best practice adherence and reduction in overall SSI (Parry, 2018; Schoest et al., 2017; Warren et al., 2018). See Appendix A for Evidence Table.

SSI Prevention

Preventing surgical infections is the aim of much research surrounding SSI and surgical risk reduction (Parry, 2018). Preventative practices standard to all surgeries regardless of surgical specialty include pre-hospital admission shower with antimicrobial soap, preoperative hair removal with clippers, and intraoperative antibiotic prophylaxis administration within 120 minutes of incision, appropriate surgical hand hygiene via hand scrub by surgery team, and maintenance of normothermia, and normoglycemia throughout the surgery and in the postoperative period. (AHRQ, 2017; Berríos-Torres et al., 2017; Parry, 2018; WHO, 2018). Preventative measures typically occur in conjunction with the pre-hospital, preoperative, intraoperative, and postoperative periods (Liu et al., 2018).

Standard preventative measures and preoperative optimization are also used for spinal surgery patients. Specifically in patients undergoing spinal surgeries, multiple protocols exist

regarding MRSA and MSSA screening with subsequent preoperative decolonization with specific antibiotics such as bacitracin or mupirocin (Higgins et al., 2018).

Preoperative Preparation

In the period immediately preceding a surgical procedure, there are multiple interventions that have become standard practice according to international guidelines. Davidson et al. (2019) as well as Schouest et al. (2017) advocated for the use of CHG wipes by the preoperative staff immediately prior to surgery in addition to the preoperative shower. The repeated use of the antimicrobial agent of choice reduces the bacterial load on the patient's skin by an amount significant enough to decrease the chances of SSI (Chen et al., 2020; Luwang et al., 2021). Skin preparation and depilation are essential to pre-operative best practice.

Skin Preparation and Depilation

Hair holds microorganisms that cause infection, so different organizations have developed guidelines to guide safe hair removal (Parry, 2018; Tubre et al., 2018; WHO, 2018). Hair removal should never be executed with a razor, but with clippers, as razors can cause micro-abrasions which are then susceptible to opportunistic germs (Bert, et. al., 2017; Hoang et al., 2019; Parry, 2018).

Skin preparation is a critical intervention against SSI (AHRQ, 2017; Chen et al., 2020; Luwang et al., 2021). The skin is populated by any number of microorganisms that may enter the body at any break in the skin (Sufyan et al., 2018). The agent with which the skin is prepared immediately prior to surgery is a critical factor in preventing infection (Chen et al., 2020; Luwang et al., 2021). Multiple types of preparatory agents exist, but the two most common agents are CHG and some formulation of an iodophor, such as betadine soap or paint. Alcohol is

commonly used both alone and in combination with CHG. Five studies in this review indicated chlorhexidine-gluconate (CHG) and alcohol were superior preoperative skin cleansing agents s compared with iodophors (aBerríos-Torres et al., 2017; Chen et al., 2020; Davidson et al., 2019; Harnoss et al., 2018; Rudder et al., 2019; Sufyan et al., 2018).

Based on the available presenting evidence, CHG and depilation were integrated into the Preoperative Skin Preparation Protocol.

Methodology

Project Design

The project utilized a quasi-experimental study design based on the Donabedian Model for Quality Improvement as it directly relates to evidence-based practice changes. This model focuses on efficiency, cost-effectiveness, and use of quality-focused professionals and is expressed through the categories of process, balancing, and outcome measures (Butts & Rich, 2022). The sample included surgical patients over 18 years of age undergoing abdominal or spinal surgery at a central Michigan community hospital. Only elective cases were included in the project to prevent confounding variables from other influences on infection. Exclusion criteria included anyone under age 18, emergent cases, and any cases outside the included specialties.

Intervention

The Preoperative Skin Preparation Protocol included depilation as needed based on patient body hair and evidence-based skin antisepsis of the surgical site with a CHG wipe during the preoperative period. The wipes were purchased by the project unit manager with no outside funding provided. Protocol elements, body hair removal and anti-sepsis, were performed by the

nursing staff of a single preoperative unit. Chart audit reviewed preoperative documentation to ensure that the PSPP elements were performed appropriately. Approval was received from Institutional Review Boards (IRB) at both the project facility and the university prior to the start of implementation. There were no conflicts of interest for this project.

Measures

The primary outcome measures for this project included hospital length of stay (LOS) and SSI rates. Average pre-implementation hospital stay was compared to post-implementation stay, and pre-implementation SSI rates were compared to post-implementation rates. The operational definition of “length of stay” was defined as the days the patient was admitted to the hospital. The operational definition of “SSI rates” was defined as the number of patients who developed an SSI divided by the total number of patients in the population. The operational definition of "depilation" was defined as the removal of body hair on and around the procedural incision area.

Implementation

The implementation period ran from 21 November 2022 until 10 February 2023. Immediately preceding implementation, in-services were held to instruct staff on the appropriate method of depilation respective to specific procedures and appropriate use of the wipes. Preoperative nursing staff were asked to complete the pre-survey immediately after finishing the in-service, and the post-survey was disseminated in the week following the end of implementation. The protocol was performed on all elective abdominal and spinal surgery patients during the admission process in the preoperative period. The post-survey was disseminated in the week following the end of implementation using a QR code provided by

Qualtrics. Throughout the implementation period, I used Plan-Do-Study-Act (PDSA) cycles to remedy any failures noted and re-emphasize the use of the protocol within the project unit. Key stakeholders—including the head of general surgery, the project unit educator, and project unit manager—were updated throughout the implementation process, and feedback regarding methods with which the protocol was implemented was noted and incorporated as appropriate.

Data Collection and Analysis

Data was collected via retrospective chart audit with all patient information de-identified and stored in a password-protected document on a secure device only accessible to the primary investigator. Additional chart audits were performed with the assistance of the facility infection control specialist at the end of the project to ascertain the number of SSI in the project patient population. Analysis of the project variables included odds ratio of surgical site infections, and independent samples t-tests of preoperative time, depilation, and hospital length of stay.

Pre- and post-surveys were designed in Qualtrics to measure staff satisfaction. These were disseminated to staff using a QR code posted throughout the physical unit, though descriptive statistics were not able to be run due to poor responsiveness on the post-survey. This prevented nurse satisfaction from being evaluated as a balancing measure.

Results

The protocol included more diligent depilation of the surgical site, and the use of a CHG-impregnated wipe for skin decolonization prior to surgery. The protocol remained unchanged throughout implementation, though re-education was periodically performed to promote increased compliance over the course of the implementation period. All statistical analysis was performed with an alpha of 0.05 within SPSS version 29.

Compliance fluctuated throughout the implementation period but the initial goal of 85% compliance with protocol performance was achieved. This included PSPP completion on 331 of 387 total participants in the experimental group. There was a slight decrease in compliance related to an unexpected shortage of the wipes but was remedied through a PDSA cycle and reordering of supplies. An odds ratio was obtained to calculate the odds of an SSI occurring in the pre-implementation group versus the odds of it occurring in the post-implementation cohort. An odds ratio of 0.6512 was attained on SSI rates, with a rate of 2.78% in the pre-implementation cohort and 1.8% in the experimental group. While this showed a clinically significant 0.98% decrease in SSI rate, the impact was not statistically significant with a p-value of 0.4989. Data analysis revealed that a significantly larger sample size would likely yield statistical significance, so a lack of significance could have been due to this factor.

An independent samples *t*-test of LOS data showed no significant difference in the mean LOS with a p value of 0.126. No statistically significant difference was found in independent samples *t*-test on depilation between the pre-implementation group and the implementation group, with a p-value of 0.067. This process measure, which is something as is currently occurs at the project site, was found to be lacking as the data did not account for when a patient did not have body hair necessitating depilation, which may have confounded the data. The project's balancing measure, preoperative time was not found to be significantly increased during implementation, with a p-value of 0.797 from the independent samples *t*-test.

Table 1. T-test results for Protocol Outcomes

	Mean Diff (SD)	df	*t*-statistic	*p, t*-test	d
LOS	0.58 (1.174)	189.569	1.536	0.126	1.366

	Mean Diff (SD)	df	*t*-statistic	*p, t*-test	d
Depilation	1.38 (0.485)	268.765	-1.842	0.067	0.478
Preop Time	-0.518 (19.833)	525	-0.257	0.797	20.571

Note, Mean Diff is the mean difference (pilot – baseline); SD is standard deviation of the mean difference; p, HOV is the p-value for the test of homogeneity of variance; df is the degrees of freedom for the test; t-statistic is the independent samples t-test test statistic; and p, t-test is the p-value for the independent samples t-test; and d is the Cohen's d mean difference effect size.

Discussion

The results of the project showed no significant difference in length of stay between the pre-implementation cohort and the implementation group. This could be attributed to the industry shift in patients being discharged home directly after surgery, rather than staying as part of an admission protocol that has been done historically. Many of the procedures required little to no time in the inpatient setting, such as hernia repairs and other minimally invasive abdominal procedures, which may have unintentionally robbed the protocol of a potentially significant difference in LOS.

While the protocol did yield a 0.98% decrease in SSI, it did not achieve statistical significance. However, this might be achieved with a larger sample size or longer implementation duration. There was not a statistically significant difference in depilation between the two cohorts. Though this data does not account for those on whom depilation was unnecessary, this suggests that the clinically significant decrease in SSI may be largely attributed to the CHG element of the protocol.

Multiple surgeons in other specialties at the project facility use a modified version of a CHG prescrub, and discussions are occurring on whether to permanently adopt the protocol as implemented during the study for preoperative patients of all specialties. A key factor that would

aid the continuity of the protocol is the lack of significant increase in preoperative time. Additionally, CHG wipes are relatively inexpensive, and would be absorbed into the existing preoperative cost incurred by any patient having surgery. This could subsequently save the hospital significant costs associated with care of postoperative infections, the amount of which might outweigh the small initial cost of the wipes.

Limitations

As this was a pilot project, there are few other published studies for the sake of comparison and guidance. This project was limited in its scope related to the length of implementation, limitation to two specialties, and high staff turnover at the time of implementation. The unanticipated barrier of staff turnover led to a percentage of noncompliance in spite of repeated re-education attempts. Furthermore, including an order set in the participants' admission orders could improve compliance. Additional research on a larger scale is warranted on a larger scale to determine the generalizability of the concept to other specialties, settings, and populations. This project was only performed on elective surgery patients, and larger scale studies would need to account for confounding variables such as existing infections and comorbidities if emergent/non-elective patients were included in the study. Furthermore, statistical analysis revealed that a larger sample size would have likely yielded more statistically significant results.

Conclusion

This QI initiative evaluated the effects of a preoperative protocol to decrease SSI and other associated factors. The PSPP was developed based on evidence based on published evidence surrounding SSI prevention (AHRQ, 2019; Berríos-Torres et al., 2017; Chen et al.,

2020; Forget et al., 2022; Harnoss et al., 2022; Liu et al., 2018; Luwang et al., 2021; Rudder et al., 2019; Schouest et al., 2017; Sufyan et al., 2018; Warren et al., 2020; WHO, 2018). Results showed that there is benefit to be gleaned from a formal preoperative preparation protocol in terms of SSI prevention, with the framework laid for additional studies. This has far-reaching benefits both for patients and the healthcare system, as the elimination of SSI results in an overall decrease in nosocomial infections and adverse events such as disability, morbidity, and mortality.

References

Ademuyiwa, A. O., Adisa, A. O., Bhangu, A., Brocklehurst, P., Chakrabortee, S., Ghosh, D., Glasbey, J., Haque, P. D., Hardy, P., Harrison, E., Ingabire, J. C. A., Ismail, L., Kadir, B., Lillywhite, R., Magill, L., de la Medina, A. R., Moore, R., Monahan, M., Morton, D., … Winkles, N. (2022). Study protocol for a cluster randomized trial of sterile glove and instrument change at the time of wound closure to reduce surgical site infection in low- and middle-income countries (CHEETAH). *Trials*, *23*(1). https://doi.org/10.1186/s13063-022-06102-5

Agency for Healthcare Research and Quality [AHRQ]. (2017). Implementing your surgical site infection prevention bundle: Slide presentation. HTTPS://www.ahrq.gov/hai/tools/surgery/modules/implementation/SSI-bundle-slides.html

Agency for Healthcare Research and Quality [AHRQ]. (2019, September). *Surgical site infections*. Patient Safety Network. https://psnet.ahrq.gov/primer/surgical-site-infections

Bath, M. F., Powell, J., Ismail, L., & Machesney, M. R. (2021). Use of pulsed lavage reduces the rate of surgical site infection after laparotomy. *Journal of Surgical Research*, 266, 300-305. https://doi.org/10.1016/j.Jess.2021.04.019

Berríos-Torres, S. I., Umscheid, C. A., Bratzler, D. W., Leas, B., Stone, E. C., Kelz, R. R., Reinke, C. E., Morgan, S., Solomkin, J. S., Mazuski, J. E., Dellinger, E. P., Itani, K. M., Berbari, E. F., Segreti, J., Parvizi, J., Blanchard, J., Allen, G., Kluytmans, J. A., Donlan, R., & Schecter, W. P. (2017). Centers for Disease control and prevention guideline for the prevention of Surgical Site Infection, 2017. *JAMA Surgery*, *152*(8), 784. https://doi.org/10.1001/jamasurg.2017.0904

Bert, F., Giacomelli, S., Amprino, V., Pieve, G., Ceresetti, D., Testa, M., & Zotti, C. M. (2017). The “bundle” approach to reduce the surgical site infection rate. *Journal of Evaluation in Clinical Practice*, 23(3), 642-647. https://doi.org/10.1111/jep.12694

Boudreaux, A. M., & Simmons, J. W. (2019). Prehabilitation and optimization of modifiable patient risk factors: The importance of effective preoperative evaluation to improve surgical outcomes. *AORN Journal*, *109*(4), 500–507. https://doi.org/10.1002/aorn.12646

Butts, J. B., & Rich, K. L. (2022). *Philosophies and theories for Advanced Nursing Practice* (3rd ed.). Jones & Bartlett Learning.

Chen, S. Chen, J. W., Guo, B., & Xu, C. C. (2020). Preoperative antisepsis with chlorhexidine versus povidone-iodine for the prevention of surgical site infection: A systematic review and meta-analysis. *World Journal of Surgery*, 44(5), 1412-1424. https://doi.org/10.1007/s00268-020-05384-7

Crocker, A., Kornilo, A., Conly, J., Henderson, E., Rennert-May, E., & Leal, J. (2021). Using administrative data to determine rates of surgical site infections following spinal fusion and laminectomy procedures. *American Journal of Infection Control*, *49*(6), 759–763. https://doi.org/10.1016/j.ajic.2020.10.010

Davidson, C., Enns, J., Dempster, C., Lundeen, S., & Eppes, C. (2020). Impact of a surgical site infection bundle on cesarean delivery infection rates. *American Journal of Infection Control*, 48(5), 555-559. https://doi.org/10.1016/j.ajic.2019.09.005

Donabedian, A. (2005). Evaluating the Quality of Medical Care. Milbank Quarterly, 83(4), 691–729. https://doi.org/10.1111/j.1468-0009.2005.00397.x

Fatula, L. K., Nelson, A., Abbad, H., Ewing, J. A., Hancock, B. H., Cobb, W. S., Carbonell, A. M., & Warren, J. A. (2018). Antibiotic irrigation of the Surgical Site Decreases incidence of Surgical SITE infection after Open Ventral hernia repair. *The American Surgeon*, *84*(7), 1146–1151. https://doi.org/10.1177/000313481808400728

Forget, V., Azzam, O., Khouri, C., & Landelle, C. (2022). What is the benefit of preoperative washing with chlorhexidine gluconate-impregnated cloths on the incidence of surgical site infections? A systematic review and meta-analysis. Infectious Diseases Now, 52(4), 185–192. https://doi.org/10.1016/j.idnow.2022.01.007

Harnoss, J. C., Assadian, O., Kramer, A., Probst, P., Müller-Lantzsch, C., Scheerer, L., Bruckner, T., Diener, M. K., Büchler, M. W., & Ulrich, A. B. (2018). Comparison of chlorhexidine–isopropanol with isopropanol skin antisepsis for prevention of surgical-site infection after abdominal surgery. *British Journal of Surgery*, *105*(7), 893–899. https://doi.org/10.1002/bjs.10793

Higgins, M., Bommireddy, R., Shivji, F., Al-Shukri, J., & Billson, J. (2018). Impact of MSSA screening on rates of surgical site infection following lumbar spine surgery. European Spine Journal, 27(10), 2457–2462. https://doi.org/10.1007/s00586-018-5705-y

Hoang, S. C., Klipfel, A. A., Roth, L. A., Vrees, M., Schechter, S., & Shah, N. (2019). Colon and rectal surgery surgical site infection reduction bundle: To improve is to change. *The American Journal of Surgery*, *217*(1), 40–45. https://doi.org/10.1016/j.amjsurg.2018.07.008

Jones, L., Fraser, A., & Stewart, E. (2019). Exploring the neglected and hidden dimensions of large-scale healthcare change. *Sociology of Health & Illness*, *41*(7), 1221–1235. https://doi.org/10.1111/1467-9566.12923

Kay, D., Bhakta, A., Patel, J. A., Hourigan, J. S., Kumar, S., Davenport, D., & Beck, S. J. (2019). Novel Technique to Reduce the Incidence of SSI after Colorectal Surgery. *The American Surgeon*, *85*(7), 695–699.

Lockwood, C., Munn, Z., Jordan, Z., Pilla, B., Püschel, V. A., dos Santos, K. B., Albornos-Muñoz, L., Kent, B., Mu, P.-F., Khalil, H., McArthur, A., Porritt, K., Cooper, A., Sfetcu, R., & Lizarondo, L. (2022). JBI series paper 3: The importance of people, process, evidence, and technology in pragmatic, healthcare provider-led evidence implementation. *Journal of Clinical Epidemiology*. https://doi.org/10.1016/j.jclinepi.2022.04.007

Liu, Z., Dumville, J. C., Norman, G., Westby, M. J., Blazeby, J., McFarlane, E., Welton, N. J., O'Connor, L., Cawthorne, J., George, R. P., Crosbie, E. J., Rithalia, A. D., & Cheng, H.-Y. (2018). Intraoperative interventions for preventing surgical site infection: An overview of Cochrane reviews. *Cochrane Database of Systematic Reviews*, *2018*(2). https://doi.org/10.1002/14651858.cd012653.pub2

Luwang, A. L., Saha, P. K., Rohilla, M., Sikka, P., Saha, L., & Gautam, V. (2021). Chlorhexidine-alcohol versus povidone-iodine as preoperative skin antisepsis for prevention of surgical site infection in cesarean delivery—a pilot randomized control trial. *Trials*, 22(1). https://doi.org/10.1186/s13063-021005490-4

Moussa, L., Garcia-Cardenas, V., & Benrimoj, S. I. (2019). Change facilitation strategies used in the implementation of innovations in Healthcare Practice: A systematic review. *Journal*

of Change Management, *19*(4), 283–301. https://doi.org/10.1080/14697017.2019.1602552

Nasser, H., Ivanics, T., Leonard-Murali, S., & Stefanou, A. (2020). Risk factors for surgical site infection after laparoscopic colectomy: An NSQIP database analysis. *Journal of Surgical Research*, *249*, 25–33. https://doi.org/10.1016/j.jss.2019.12.021

National Healthcare Safety Network [NHSN]. (2022, January). *2022 NHSN Patient Safety Component Manual*. National Healthcare Safety Network. Retrieved from https://www.cdc.gov/nhsn/pdfs/pscmanual/pcsmanual_current.pdf

Norman, G., Atkinson, R. A., Smith, T. A., Rowlands, C., Rithalia, A. D., Crosbie, E. J., & Dumville, J.C. (2017). Intracavity lavage and wound irrigation for prevention of surgical site infection. *Cochrane Database of Systematic Reviews* 2017(10). https://doi.org/10.1002/14651858.cd012234.pub2

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., … Moher, D. (2021). The Prisma 2020 statement: An updated guideline for reporting systematic reviews. *BMJ*. https://doi.org/10.1136/bmj.n71

Parry, A. (2018). Preventing infection in surgical patients. *British Journal of Nursing*, *27*(21), 1218–1220. https://doi.org/10.12968/bjon.2018.27.21.1218

Peng, X.-Q., Sun, C.-G., Fei, Z.-G., & Zhou, Q.-J. (2019). Risk factors for surgical site infection after spinal surgery: A systematic review and meta-analysis based on twenty-seven studies. *World Neurosurgery*, *123*. https://doi.org/10.1016/j.wneu.2018.11.158

Reese, S. M., Knepper, B., Amiot, M., Beard, J., Campion, E., & Young, H. (2020). Implementation of colon surgical site infection prevention bundle—the successes and challenges. *American Journal of Infection Control*, 48(11), 1287-1291. https://doi.org/10.1016/j.ajic.2020.05.010

Rudder, N. J., Borgert, A. J., Kallies, K. J., Smith, T. J., & Shapiro, S. B. (2019). Reduction of surgical site infections in colorectal surgery: A 10-year experience from an independent academic medical center. *The American Journal of Surgery*, 217(6), 1089-1093. https://doi.org/10.1016/j.amjsurg.2018.11.010

Salahuddin, M., Muddebihal, F., Thirunavukkarasu, A., Alanazi, A. A., Alrashdi, A. M., Alrashidi, A. M., Alanazi, W. O., Alruwaili, A. H., Alruwaili, A. F., & Alruwaili, K. N. (2022). Epidemiology and risk factors of post operative site infections in surgical patients: A systematic review. *Archives Of Pharmacy Practice*, *13*(1), 31–36. https://doi.org/10.51847/zoixqqgvc6

Schouest, J., Heinrich, L., Nicholas, B., & Drach, F. (2017). It's all about the bundle: Reducing surgical site infections in total joint and spine procedures using a bundled pre-operative prep protocol. *American Journal of Infection Control*, *45*(6). https://doi.org/10.1016/j.ajic.2017.04.170

Sufyan, A., Tariq, M., Bano, R., Aziz, O. B. A., & Zainab, A. (2018). Comparison between chlorhexidine-alcohol and povidone-iodine in preventing surgical site infection in clean-contaminated cases. *Pak Armed Forces Med*, 68(4), 802-806.

Toh, J. W., Phan, K., Hitos, K., Pathma-Nathan, N., El-Khoury, T., Richardson, A. J., Morgan, G., Engel, A., & Ctercteko, G. (2018). Association of mechanical bowel preparation and

oral antibiotics before elective colorectal surgery with surgical site infection. *JAMA Network Open*, *1*(6). https://doi.org/10.1001/jamanetworkopen.2018.3226

Tubre, D. J., Schroeder, A. D., Estes, J., ,Eisenga, J., & Fitzgibbons, R. J. (2018). Surgical site infection: The "Achilles Heel" of all types of abdominal wall hernia reconstruction. *Hernia*, 22(6), 1003-1013. https://doi.org/10.1007/s10029-018-1826-9

Vij, S. C., Kartha, G., Krishnamurthi, V., Pontianak, M., & Goldman, H. B. (2018). Simple operating room bundle reduces superficial surgical site infections after major urologic surgery. *Urology*, 112, 66-68. https://doi.org/10.1016/j.urology.2017.10.028

Warren, B. G., Nelson, A., Warren, D. K., Baker, M. A., Miller, C., Habrock, T., Bongu, J., Gowda, A., Johnson, J., & Anderson, D. J. (2020). Impact of preoperative chlorhexidine gluconate (CHG) application methods on preoperative CHG skin concentration. *Infection Control & Hospital Epidemiology*, 42(4), 464-466. https://doi.org/10.1017/ice.2020.448

Weiser, M. R., Gonen, M., Usiak, S., Pottinger, T., Samedy, P., Patel, D., Seo, S., Smith, J. J., Guillem, J. G., Temple, L., Nash, G. M., Paty, P. B., Baldwin-Medsker, A., Cheavers, C. E., Eagan, J., Garcia-Aguilar, J., Afonso, A., Aslam, A., Baldwin-Medsker, A., … Yeung, K. (2018). Effectiveness of a multidisciplinary patient care bundle for reducing surgical-site infections. *British Journal of Surgery*, *105*(12), 1680–1687. https://doi.org/10.1002/bjs.10896

World Health Organization [WHO]. (2018). *Preventing Surgical Site Infections: Implementation Approaches for Evidence-Based Recommendations*. World Health Organization. https://apps.who.int/iris/bitstream/handle/10665/273154/9789241514385-eng.pdf?sequence=1&isAllowed=y

Ying, H., Luo, Z.-W., Peng, A.-F., Yang, Q.-K., Wu, X., Chen, X.-Y., Huang, S.-H., Liu, J.-M., & Liu, Z.-L. (2021). Incidences and reasons of postoperative surgical site infection after lumbar spinal surgery: A large population study. *European Spine Journal*, *31*(2), 482–488. https://doi.org/10.1007/s00586-021-06967-1

Zhang, X., Liu, P., & You, J. (2022). Risk factors for surgical site infection following spinal surgery. *Medicine*, *101*(8). https://doi.org/10.1097/md.0000000000028836

Appendix A

Evidence Table

Authors	Year	Country Where Research Conducted	Theory Guiding Study and Identification of Variables	Independent or Treatment Variable	Dependent or Outcome Variable	Design Type	Sample (n=) methods	Data Collection Tools	Brief Summary of Results	Strength of Evidence
Ademuyiwa, Adisa, Bhangu, Brocklehurst, Chakrabortee, Ghosh, Glasbey, Haque, Hardy, Harrison, Ingabire, Ismail, Kadir, Lillywhite, Magill, de la Medina, Moore, Monahan, Morton, & Winkles	2022	Multiple (16 countries)	Theory not specified	Glove and instrument change at closing of fascial layer	SSI	RCT	64 hospitals, 12,800 pts	Data collected intraoperatively, at trial entry, at D/C from hospital, and 30d p/ surgery; entered into secure online server through University of Birmingham; data anonymized on secure server.	Ongoing	II
Bath, Powell, Ismail, & Machesney	2021	UK	Theory not specified	Pulse lavage of surgical site in laparotomy pts.	SSI	Non-randomized control trial	179 pts	All patients undergoing laparotomy in 2018 or 2019 identified using two databases; all pts ≥18 who underwent clean-contaminated, contaminated, or dirty procedure were included; data collected from admission to 30d f/u.	Statistically significant reduction in SSI in pulse lavage group; recommend further RCTs to confirm results and optimize for translation.	III

Authors	Year	Country Where Research Conducted	Theory Guiding Study and Identification of Variables	Independent or Treatment Variable	Dependent or Outcome Variable	Design Type	Sample (n=) methods	Data Collection Tools	Brief Summary of Results	Strength of Evidence
Berríos-Torres, Umscheid, Bratzler, Leas, Solomkin, Mazuski, Dellinger, Itani, Berbari, Segreti, Parvizi, Blanchard, Allen, Kluytmans, Donlan, & Schecter	2017	USA	Theory not specified	N/A	N/A	CPG; systematic review	N/A	Systematic review; search of MEDLINE, EMBASE, CINAHL, and Cochrane Library.	Dependent on intervention.	I
Bert, Giacomelli, Amprino, Pieve, Ceresetti, Testa, & Zotti	2017	Italy	Theory not specified	Bundle: specifically created infection risk calculation, preoperative shower, depillation, antibiotic prophylaxis, body temperature control.	SSI	Retrospective Cohort Study	3314 patients	Regional surveillance system on hip prosthetic sx and colon sx.	Statistically Significant in one population	IV
Chen, Chen, Guo, & Xu	2020	China	Theory not specified	CHG vs. Iodine as skin preparation agent	SSI	Systematic Review w/ Meta-Analysis	30 studies	Systematic review; search of PUBMED, Web of Science, EMBASE, and CNKI.	Statistically Significant	I
Davidson, Enns, Dempster, Lundeen, & Eppes	2019	USA	Theory not specified	Bundle: CHG shower, CHG wipes, prophylactic abx, vaginal prep, team double gloved entire time, new instruments for closing.	SSI	Single-Site cohort study	4014 patients	Surgical checklist attached to charting.	Statistically Significant	IV

Authors	Year	Country Where Research Conducted	Theory Guiding Study and Identification of Variables	Independent or Treatment Variable	Dependent or Outcome Variable	Design Type	Sample (n=) methods	Data Collection Tools	Brief Summary of Results	Strength of Evidence
Fatula, Nelson, Abbas, Ewing, Hancock, Cobb, Carbonell, & Warren	2018	USA	Retrospective Study	Abx Irrigation of surgical site	SSI	Retrospective Cohort Study	852 patients	Retrospective chart audit using Greenville Health System Hernia Center database.	Dependent on Variable	IV
Harnoss, Assadian, Kramer, Probst, Muller-Lantzsch, Scheerer, Bruckner, Diener , Buchler, & Ulrich	2018	Germany	Theory not specified	Skin preparation agents	SSI	Prospective Sequential Study	500 patients	Study conducted in Department of surgery with informed consent on pts receiving elective midline laparotomy.	Statistically Significant	
Higgins	2018	UK	Theory not specified	MSSA Screening	SSI	Single-Site Cohort study	1307 pts	Of patients who had lumbar sx during a 1yr period, they were filtered through EHR for signs or documentation of SSI.	Statistically significant reduction in SSI after implementation of MSSA screening & preoperative decolonization program.	
Hoang, Klipfel, Roth, Vrees, Schecter, & Shah	2018	USA	Theory not specified	Bundle: oral abx bowel prep, preoperative hair removal with clippers, blood glucose <200, preoperative IV abx w/i 1hr of incision, redosing abx q3h, intraop FiO2 >60%, pt temp kept at >36.5, at closure, all new instruments and PPE, 100% FiO2 by NRB in postop.	SSI	Single-Site cohort study	1351 patients	Pt sample drawn from institutional database to assess 30day outcomes of pts having colon or rectal surgery.	Statistically Significant	IV

Authors	Year	Country Where Research Conducted	Theory Guiding Study and Identification of Variables	Independent or Treatment Variable	Dependent or Outcome Variable	Design Type	Sample (n=) methods	Data Collection Tools	Brief Summary of Results	Strength of Evidence
Kay, Bhakta, Patel, Hourigan, Kumar, Davenport, & Beck	2019	USA	Theory not specified	Closure technique	SSI	Retrospective Chart Review	1083 patients	Query using ACS-NSQIP database for those undergoing elective and emergent colorectal operations using appropriate codes.	Statistically Significant	VI
Liu, Dumville, Norman, Westby, Blazeby, McFarlane, Walton, O'Connor, Cawthorne, George, Crosbie, Rithalia, & Cheng	2018	N/A	Theory not specified	skin prep, prophylactic abx, skin sealants, use of drapes, use of PPE, glove protocols, use of electrocautery, maintaining oxygenation, temp control, blood glucose control, irrigation/lavage, closure methods, theatre traffic	SSI	Systematic Review	30 studies	search of Cochrane Library	Variable Dependent	I
Luwang, Saha, Rohilla, Sikka, Saha, & Gautam	2021		Theory not specified	CHG vs. Iodine for skin antisepsis in C/S pts	SSI	RCT	311 pts	Pts were randomized using computer-generated table; pts followed for 30d p/ surgery.	Rate of SSI was lower in CHG-alcohol group than in iodine group, though did not reach statistical significance.	II

Authors	Year	Country Where Research Conducted	Theory Guiding Study and Identification of Variables	Independent or Treatment Variable	Dependent or Outcome Variable	Design Type	Sample (n=) methods	Data Collection Tools	Brief Summary of Results	Strength of Evidence
Norman, Atkinson, Smith, Rowlands, Rithalia, Crosbie, & Dumville	2017	N/A	N/A	Intracavity lavage and wound irrigation	SSI	Systematic Review	59 RCTS, 14,738 pts	Literature search of Cochrane Wounds Specialized Register, CENTRAL, Ovid MEDLINE, Ovid Embase, and EBSCO CINAHL plus; also searched 3 clinical trial registries.	No clear difference in SSI between irrigation and non irrigation groups; some difference between abx irrigation and non abx irrigation, low certainty; some difference in pulse lavage and standard methods, low certainty.	I
Reese, Knepper, Amiot, Beard, Campion, & Young	2020	USA	Theory not specified	Bundle: neomycin oral abx, CHG bathing, CHG/ ETOH skin antisepsis, use of wound protector, perioperative abx w/ i 1hr of incision, optimal abx administration, glove change for fascial closure, dressing placed on separate table, date written on dressing, maintain euglycemia, remove dressing w/i 48hr of sx, daily wound cleansing, CHG bath before D/C	SSI	Single-site cohort study	280 elective cases, 143 urgent/ emergent cases	Randomization using RITA, established SSI per CDC criteria	Decrease in SSI, not statistically significant; Univariate analysis revealed most important components of bundle were appropriate skin prep, use of wound protector, and OR glove change before closure of fascia.	IV

Authors	Year	Country Where Research Conducted	Theory Guiding Study and Identification of Variables	Independent or Treatment Variable	Dependent or Outcome Variable	Design Type	Sample (n=) methods	Data Collection Tools	Brief Summary of Results	Strength of Evidence
Rudder, Borgert, Kallies, & Smith	2019	USA	Theory not specified	Preoptimization clinic, at home skin prep with CHG, nutrition drink, bowel prep, pre-warming, dry time of skin prep, skin prep w/ CHG, time out and surgical checklist, rocephin or flagyl as abx, normothermia, glycemic control, minimally invasive if possible, use of wound protectors, closing trays, restrictive transfusion protocol, pt education videos, nutrition drink postop, ERAS	SSI	Single-Site Retrospective Study/ PDSA	1508	Multidisciplinary study for all Patients undergoing abdominal surgeries in study period.	Statistically Significant	VI
Salahuddin, Muddebihal, Thirunavukkarasu, Alanazi, Alrashdi, Alrashidi, Alanazi, Alruwaili, Alruwaili, & Alruwaili	2022	N/A	N/A	Risk factors for SSI	SSI	Systematic Review	18 articles	Extensive literature search of Medline, Cochrane, Embase, Dare; English language only, during last ten years, must have been published in PR journal with ISSN.	Prevalence and Incidence of SSI variant to WHO regions, causative organisms; risk factors include: wound class, longer sx duration and LOS, more drain time, reoperation, preoperative stay at hospital, HTN, dental disease, DMII, higher ASA score.	I

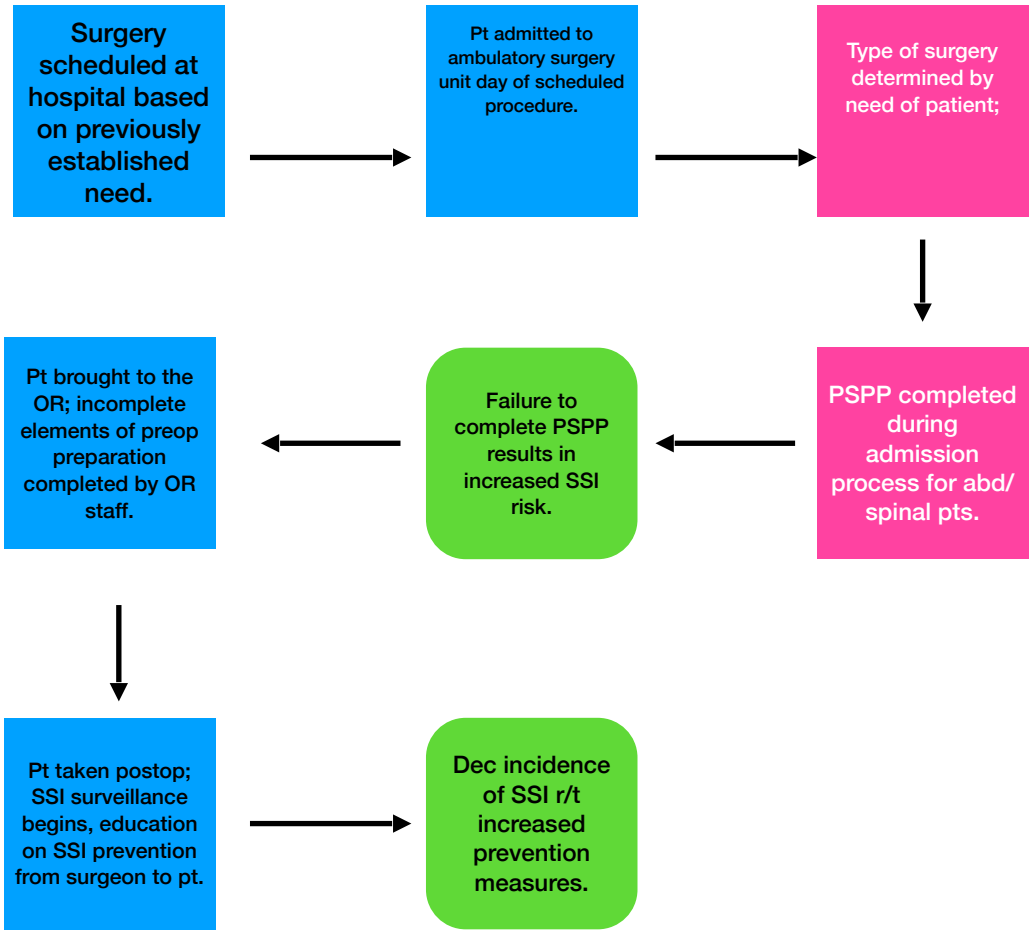
Authors	Year	Country Where Research Conducted	Theory Guiding Study and Identification of Variables	Independent or Treatment Variable	Dependent or Outcome Variable	Design Type	Sample (n=) methods	Data Collection Tools	Brief Summary of Results	Strength of Evidence
Schouest, Heinrich, Nicholas, Drach	2017		Theory not specified	On-siteCHG cloth application preoperatively, Iodine swab for nares, CHG oral rinse.	SSI	Quasi-Experimental cohort study	Not stated	Not specified	Post-intervention found 46% reduction in SSI of surgical pts, though not statistically significant; $719,128 cost savings annually as result.	IV
Sufyan, Tariq, Bano, Aziz, & Zainab	2018	Pakistan	Theory not specified	CHG-ETOH vs.Iodine as antiseptic agent	SSI	RCT	840 pts, 420 in CHG group, 420 in iodine group	Consent was obtained from every patient; sorted into groups by lottery; all pts received same preop and postop care, w/ f/u wily x4wk postop; data processed in SPSS	CHG-ETOH had significantly lower rate of SSI over iodine, with a p value of 0.016.	II

Authors	Year	Country Where Research Conducted	Theory Guiding Study and Identification of Variables	Independent or Treatment Variable	Dependent or Outcome Variable	Design Type	Sample (n=) methods	Data Collection Tools	Brief Summary of Results	Strength of Evidence
Tubre, Schroeder, Estes, Eisenga, & Fitzgibbons	2018	USA	Theory not specified	N/A	SSI	Review of Literature	N/A	Not specified	Risk factors: comorbidities, immunocompromised, OR environmental factors, bowel resection, emergent procedure, nasal carriage of staph aureus, smoking; Interventions proven to decrease SSI include postponing sx in case of infection, perioperative normoglycemia, hair removal, screening for MRSA, abx prophylaxis, abx coated sutures, glove change at closing, antiseptic prophylaxis, appropriate skin prep, surgeon hand prep	N/A

Authors	Year	Country Where Research Conducted	Theory Guiding Study and Identification of Variables	Independent or Treatment Variable	Dependent or Outcome Variable	Design Type	Sample (n=) methods	Data Collection Tools	Brief Summary of Results	Strength of Evidence
Vij, Kartha, Krishnamurthi, Ponziano, & Goldman	2017	USA	Theory not specified	Appropriate dry time for skin antisepsis, glove change at closing, irrigating wound before closure, separate instrument set before closure.	SSI	Single-Site Cohort study	1125 patients	Included all major urologic patients in study period, followed data with ACS-NSQIP database	Statistically Significant	IV
Weiser, Gonen, Usiak, Pottinger, Samedy, Patel, Seo, Smith, Guillem, Temple, Nash, Paty, Baldwin-Medsker, Cheavers, Eagan, & Garcia-Aguilar	2018	USA	Theory not specified	Appropriate abx selection, consultation for raised A1c level, CHG shower (night before and morning of sx), mechanical bowel prep, oral abx, SSI risk assessment provided to surgeon, abx admin before incision, appropriate method of hair removal, normothermia, intraoperative abx reposing, closing tray for open procedures, d/c abx at 24h postop, shower on postop day 2.	SSI	Single Site Cohort Study	1828	Used the National Nosocomial Infections Surveillance risk index to select patients.	Statistically Significant	IV
Ying, Luo, Peng, Yang, Wu, Chen, Huang, Liu & Liu	2021	China	Theory not specified	Risk factors	SSI	Retrospective Chart Review	7240 pts	Medical records of pts with SSI collected via EHR, including demographic data, staff data, ASA, and infection type data.	Gram negative bacteria most common pathogen implicated in SSI p/ lumbar surgery; pts with lumbar stenosis had highest incidence of SSI	VI

Authors	Year	Country Where Research Conducted	Theory Guiding Study and Identification of Variables	Independent or Treatment Variable	Dependent or Outcome Variable	Design Type	Sample (n=) methods	Data Collection Tools	Brief Summary of Results	Strength of Evidence
Zwyot, Lau, Fletcher, & Paul	2017	N/A	N/A	Bundles inclusive of preop smoking cessation, MBP w/ oral abx, SCIP elements, glycemic control, skin prep with alcohol and one other agent, wound protectors, double gloves, glove change at closing, abx coated sutures, postop supplemental O2, mupirocin topical application.	SSI	Meta-Analysis and Systematic Review	23 Studies; 17,557 pts	Literature search conducted of PubMed, Scopus, Crossref, and Cochrane Central Registry of Controlled Trials through 2017. Studies not excluded based on language. Studies included if bundle had at least 3 elements.	Significance dependent upon variable	I

Process Flowchart



Theoretical Framework

Donabedian A, Wheeler JR, Wvszewianski L. Quality, cost, and health: an integrative model. Med Care. 1982 Oct:20(10):975-92.