Adapting surgical 'bundles' to prevent surgical site infections in obstetrics and gynecology (Review)

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Abstract. Surgical site infections (SSIs) are a complication in any surgical field and they are responsible for 38% of surgery-related patient deaths. Identifying appropriate prophylaxis and solutions to combat SSIs is of global interest. Several studies and reports on SSI raise awareness of this costly complication, both in terms of physical and mental suffering, and as a monetary burden. Knowing the risk factors and implementing strategies to reduce SSI risk represent an adequate approach to reduce SSI incidence. General risk factors of SSI are applicable in the obstetrics and gynecology field, alongside its specific characteristics, including immunological changes occurring during pregnancy, as well as disturbances of vaginal microbiota. The risk of SSI is determined by patient factors but also by preoperative, intraoperative and postoperative care. 'Bundle' prevention strategies have been smartly adopted and their efficiency has been demonstrated in colorectal surgery, cesarean deliveries and gynecological oncology surgeries. 'Bundle' measures may vary among studies, but they remain important prevention methods, which contribute to decreasing SSIs, which is a favorable outcome, and thus, are increasingly used as a routine practice. Therefore, healthcare personnel should aim for the early identification of risk factors to minimize the risk of SSI. All evidence-based methods for preventing and treating SSIs in all surgical fields should be considered to be integral components in order for the best care to be provided to patients.

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Contents

1. Introduction

Surgical site infections (SSIs) are a complication in all surgical fields and they are responsible for 38% of postoperative deaths (2001) (1). The additional cost per patient affected by SSI in low- and middle-income countries (LMICs) in Europe ranges between $174 and $29,610, whereas in high-income European countries it ranges between $21 and $34,000. These variations may be attributed to differences in clinical practice and relative prices of medical care across countries; the price difference in LMIC and high-income European countries is insignificant. Furthermore, the severity of SSI is associated with greater costs (1). Therefore, identifying appropriate prophylaxis and solutions to combat SSI is of global interest (1). The Centers of Disease Control and Prevention (CDC) reported that, in 2013, 1.9% of 16 million surgeries in the United States were complicated by an SSI (2). In obstetrics, 2-4% of cesarean sections (C-sections) and 2% of hysterectomies were complicated by SSI in the United States in 2020 (3). Patients with SSI are 60% more likely to spend time in the Intensive Care Unit, more than five times more likely to be readmitted and are twice as likely to die compared with patients without SSIs, according to statistics from 2016 (4).

A study on SSI has raised awareness of this costly complication, both in terms of physical and mental suffering, as well as economically (5). The aim of the present review was to evaluate possible strategies to prevent SSI. A study evaluating un-planned 30-day readmissions after hysterectomies revealed that the major reason was SSI (28.8%) (4). Lynch *et al* (6) underlined that the cost per patient of SSI post-surgery complications is 1.73 times higher than that of non-SSI complications ($3,678 vs. $2,116) (1). The data were gathered from a trial that analyzed the impact of preoperative whole body disinfection in postoperative wound infection prophylaxis, involving 3,733 patients from a Scottish hospital in the 1990s. Higher costs were reported from a study in the UK collecting data between June 2005 and April 2009, including infectious complications after femoral neck surgery (7). Wijeratna *et al* (7) reported 3.2% surgical site infections in 525 patients. Furthermore, the mean financial loss per infected patient was £7,726 ($11,809), whereas an uninfected patient produced £153 ($234) of profit to the hospital. The lowest additional cost due to SSI was evaluated in a 2019 Danish study, assessing the cost-effectiveness of incisional negative-pressure wound therapy in obese women after C-section (1). The reported costs per women were €5,793.60 ($6,488.25) in patients treated with vacuum-assisted closure (VAC; n=432) compared with €5,840.898 ($6,541.22) for standard dressing (n=444). A study conducted in Spain reported an additional cost of $15,733 due to SSI per patient, including only the healthcare (hospital care, ambulatory care, medical tests and examinations, health goods and prescription drugs), besides productivity loss and informal care costs (1).

The magnitude of the cost difference between SSI and non-SSI depends on the SSI definition, severity, patient population, choice of comparator, hospital setting and cost items (1). The CDC defines SSI as an infection that occurs at or near the surgical site incision within 30 days after the surgery (3). SSI is classified as superficial when it affects the skin or subcutaneous tissue, whereas it is classified as deep incisional if fascial and muscle layers are implicated or organ/space if any tissue deeper than muscle/fascial layer is manipulated/opened during surgery (3). Clinical and paraclinical diagnostic criteria of different types of SSI is presented in Table I. In the obstetrics and gynecology (OG) field, SSIs include the superficial type (two-thirds of SSIs) such as cellulitis, deep incisional abscesses or pelvic/vaginal cuff abscesses (2,3,8).

Microbial contamination at the surgical site is the first step in developing SSI and the infection can vary from trivial wounds to life-threatening conditions (9). The epidermis is inhabited by different pathogens, including bacteria, fungi and viruses, with a density of 3 million germs per square centimeter (9). Therefore, most surgical wounds are contaminated by bacteria. However, infection will only evolve in some cases (9). In most cases, innate host defenses will successfully eliminate the pathogens (10). Bacteria virulence and adjuvant microenvironment factors favor SSI complications (10).

Despite antisepsis treatment, bacteria may enter from fomites into the wound (10). Surgeries involving the female genital tract will encounter 10^6-10^7 bacteria/ml (10). The more severe the bacteria's virulence, the greater the probability of infection. For instance, coagulase-positive staphylococci require a smaller inoculum than coagulase-negative species (10,11). The bacteria's virulence cannot be easily controlled by preventive measures; it is an intrinsic variable influenced by the surgery site and the bacteria which colonize the patient's skin (10).

A few microorganisms are encountered more frequently in SSI following gynecological surgeries (3,12). In abdominal approaches, *Staphylococcus aureus* and *Staphylococcus epidermis* infection are the most prevalent (12), whereas in vulvar/perinea incisions anaerobic bacteria, gram-negative aerobes or polymicrobial pathogens (vaginal incision) are more frequent (3,12). For C-sections, ureaplasma species, coagulase-negative staphylococci, anaerobes, gram-negative species, *Staphylococcus aureus* and B group *Streptococcus* seem to prevail (3).

The microenvironment and the integrity of host defenses dictate a certain minimum amount of inoculum that results in an SSI, and consequently, its outcome (10,13).

In summary, the patients' skin is not sterile and the host defense mechanisms may be faulty. Therefore, known risk factors for the development of SSIs and mitigating strategies represent an important target in the pursuit of decreasing SSI prevalence.

2. Risk factors

The risk factors for SSI are divided into patient- and procedure-related risk factors, modifiable or non-modifiable. Details are presented in Table II. SSIs are often the result of multiple non-modifiable risk factors. Procedure-related risk factors should be considered to be modifiable (8).

SSI and diabetes have been linked in numerous studies (4,8,10). A recent literature review indicated perioperative hyperglycemia (in diabetic and non-diabetic patients) as a more significant risk factor for the development of SSI than hemoglobin A1c (14-17). Furthermore, perioperative hyperglycemia of 110-150 mg/dl increases the risk of SSI (14-17).

Diabetes has also been identified as a risk factor for SSI in gynecological surgery (18). In 2015, Al-Niaimi *et al* (19) recommended intensive glycemic control for the first 24 h for diabetics undergoing oncological gynecological surgeries. They retrospectively compared three groups: Patients with diabetes whose blood glucose was controlled via intermittent, subcutaneous insulin injections; patients with diabetes and postoperative hyperglycemia whose blood glucose was controlled through insulin infusion; and patients with neither diabetes nor postoperative hyperglycemia. The results of the study emphasized that patients in the second group had an SSI rate of 19%, which was similar to that of the third group (21%), whereas in the first group, the rate of SSI was higher (29%). The results of the study indicated that intensive glycemic control for patients with diabetes undergoing onco-gynecological surgeries reduces the rate of SSI by 35% (19).

Tobacco users develop vasoconstriction that leads to hypoxia and ischemia and ultimately translates into poor tissue perfusion (2). Smokers and former smokers have a risk

Table I. Diagnosis of different types of SSI (3,8).

Type of SSI	Diagnostic criteria
Superficial SSI	Purulent drainage from superficial incision ± culture testing; pain/tenderness; localized swelling; erythema; heat; superficial incision deliberately opened by surgeon; isolated pathogen from an aseptically obtained specimen
Deep incisional SSI	Purulent drainage from the incision (limited to fascia/muscle layers); fever >100.4˚F; localized pain; edema; isolated pathogen from an aseptically obtained specimen; abscess or other evidence of infection
Organ/space SSI	Purulent drainage from a drain placed into organ/space; abdominal/pelvic pain; fever; tender pelvic mass; pathogens identified from fluid/tissue; abscess or other evidence of infection

SSI, surgical site infection.

Table II. Risk factors for surgical site infection (14-19).

Patient-associated factors		
Modifiable	Non-modifiable	Procedure-related factors
Glycaemic control/diabetic status; active alcohol use and smoking; preoperative albumin <3.5 mg/dl; obesity (BMI >35 kg/m^2 or subcutaneous tissue >2 cm); immunosuppression	Age (>40 and <18 years); recent radiotherapy; history of skin and soft tissue infections; sex (males tend to have a higher risk)	Type of surgery; facility (inadequate ventilation, increased traffic in the operating room, inappropriate sterilization of equipment); longer duration of surgery

of SSI that is higher than that in nonsmokers (14). Furthermore, smoking is associated with a range of morbidities (16).

Abnormal serum albumin levels (normal range, 3.4-5.4 g/dl), which is an index for the nutritional status, can be found in the elderly, obese and diabetic population (2).

Obesity and diabetes are two major risk factors for SSI (17). Obesity and diabetes increase the risk of SSI in C-sections by 2 and 1.4 times, respectively (17). The coexistence of both is associated with a 9-fold increased risk compared with the risk of women with neither of these (20). Obesity-related pathophysiological factors that are associated with the increased risk of SSI are considered to be the poor tissue perfusion, the decreased antibiotic penetration, the altered innate host defenses and a suboptimal metabolic function (2,21,22). These altered factors are also found in diabetes (16,21,22).

Immunosuppression due to HIV infection or long-term steroid use poses a high risk for SSI due to downregulation of the immune system, which serves a critical role in infection susceptibility (2). Cell proliferation and normal inflammatory responses are impaired by both long-term steroid use and smoking (2).

Comorbidities, including chronic renal insufficiency, chronic obstructive pulmonary disease, an American Society of Anesthesiologists (ASA) score >3 (the ASA score evaluates the basal status of individuals, including comorbidities), advanced age and male sex, are likewise risk factors for SSI (12,17,23).

An increased duration of the surgical procedure (>180 min) has been demonstrated to be a risk factor for SSI in both abdominal and laparoscopic approaches (2,8,9,12). Furthermore, an incision length ≥20 cm has been demonstrated to serve a role in SSI development (5).

With respect to surgical approaches, in the gynaecological field, the rates of SSI appear to be low in vaginal and laparoscopic hysterectomy techniques (50% reduction in SSI incidence) compared with laparotomy (3.9% rate of SSI for open hysterectomies and 1.4% for minimally invasive procedures) (4,8). Some reviews suggest that robotic interventions are associated with a higher risk due to the increased duration of the surgical procedure (2,8). Despite developments in minimally invasive procedures, the approach for most hysterectomies is laparotomy (54.2%), followed by vaginal (16.7%) and laparoscopic (8.6%) approaches, while robotic intervention is employed less (8.2%) (4).

A randomized controlled trial of 595 laparoscopic procedures reviewing the risk of SSI has highlighted the difference among different types of entry (Veress needle, direct trocar insertion or open entry) (2,24). The results of the trial revealed fewer complications in direct trocar insertion and even fewer complications in open entries (2,24).

Another important element to be considered regarding SSI risk is the difference between scheduled and emergency surgeries. Emergency surgery does not allow for standard preoperative preparation; therefore, the incidence of SSI is higher in emergency surgical cases than in scheduled cases (8.4% vs. 2.5%) (23).

Obstetric surgeries have a lower SSI incidence compared with gynecological surgeries (1.2% vs. 10.3%) (15). A study performed in India evaluated risk factors for SSI in an OG department with the following results (18): i) Women >40 years old have a higher risk for SSI and young maternal age represents a risk factor for SSI following C-section; ii) grand-multipara women (>5 deliveries) have a 3 times higher risk than primiparous women; iii) a number of vaginal examinations >10 up to 48 h prior to surgery increases the risk of SSI and each vaginal examination increased the risk by 31%; iv) presence of abnormal vaginal discharge (OG possesses a unique challenge as pathogens can ascend from vagina/endocervix to the surgical site) is associated with an increased risk of SSI; v) chorioamnionitis represents a major risk for SSI post C-section; vi) comorbidities, such as diabetes, anemia, arterial hypertension (gestational hypertension implies a 2.9 times higher risk for developing SSI) and systemic diseases, increased the risk nearly 6-fold; and vii) general risk factors: ASA score >3 imposes a 1.52-2.7 times higher SSI risk, each additional intraoperative hour doubled the risk after the first hour of surgery, antibiotic prophylaxis not within 1 h of surgery increased the risk by nearly five times and each hospitalization day after surgery increased the risk by 5%.

The complete and correct diagnosis of SSI is based on medical history, physical examination, wound cultures and blood tests (3). Imaging techniques are not mandatory; they are required when physical examination fails to localize the SSI (3). Patients can harbor indolent infections (dental, urinary, skin and soft tissues) at the time of surgery (9). Thus, pre-existing infections can be the source for hematogenous spread or a contiguous site for bacterial transfer (9). These remote infections increase the risk of SSI 3 to 5-fold (9). For instance, bacterial vaginosis as well as other pathogen colonization should be treated before hysterectomy (9).

3. Prevention

Preoperative and intraoperative interventions.

Bathing and showering techniques: Decolonization protocol. A protocol of two to three sequential showers with 4% chlorhexidine gluconate with a 1-min pause before rinsing obtains maximal skin surface concentrations (chlorhexidine needs to dry on the skin for maximal effect) (8,14,25,26).

Skin preparation. There is evidence that alcohol-based preparations are effective in reducing SSI due to their rapid, though not persistent, bactericidal effect (14). The addition of iodine-based and chlorhexidine-based solutions in alcohol-based preparations might be optimal to prolong the bactericidal effect (14). Due to the lack of convincing studies, the recommendation remains for alcohol-based solution, and when not available, for chlorhexidine, which might be superior to iodine (8,14,25-27).

Methicillin-resistant *Staphylococcus aureus* (MRSA) is widely considered as the primary cause of SSI (8,9,11). Patients can often be colonized from former hospitalizations (12). MRSA decontamination in gynecologic patients is often incomplete and does not seem to reduce SSI (9). Therefore, it is not universally recommended (9).

Smoking. Patients are recommended to cease smoking at least 4-6 weeks before surgery (14).

Hair removal. Hair removal is not recommended (except when it intervenes with surgery) due to microscopic cuts and abrasions that disrupt the protective barrier of the skin against germs (14,25). Furthermore, it is recommended to use clippers instead of razors (3,14,25).

Supplemental intraoperative oxygen. It has been suggested that supplemental intraoperative oxygen could reduce the incidence of SSI (8). The increased oxygen exposure leads to increased collagen deposition and improved immune defense, while antibiotic activity may be amplified at higher levels of oxygen (8). Hyperoxygenation does not have an impact on SSI for abdominal, and OG surgery (2).

Antibiotic prophylaxis. A single weight-adjusted dose of antibiotic is recommended within 1 h before incision (28). Postoperative antibiotic prophylaxis has not been observed to decrease SSI in standard operations; a second dose is recommended if the blood loss is >1,500 ml or in case of prolonged surgery time (>180 min) (2).

The key is to use appropriate antibiotics, according to local germ prevalence and antimicrobial resistance, specific to each surgical field (12,29). The American College of Obstetricians and Gynecologists recommends no antibiotic prophylaxis in patients with low risk of SSI who undergo clean procedures (hysteroscopy, laparoscopy and laparotomy) and recommends antibiotic prophylaxis for hysterectomy, induced abortion, hysterosalpingogram and uro-gynecology procedures (30). An alarming aspect is represented by the 87.1% of patients who receive appropriate antibiotic prophylaxis and the 40.2% of patients who receive antibiotics when they are not indicated (2).

The recommended antibiotic prophylaxis for all hysterectomies is cefazolin 1-2 g (3 g in patients with obesity) via intravenous (IV) injection (8). For patients with penicillin allergies, clindamycin 600 mg IV plus gentamicin 1.5 mg/kg IV or metronidazole 500 mg IV plus gentamicin 1.5 mg/kg IV are recommended (8). Patients treated with β-lactam alternatives (clindamycin/gentamicin or metronidazole/gentamicin) or non-standardized antibiotics (clindamycin or gentamicin alone) have a higher risk of SSI compared with patients treated with traditional β-lactam antibiotics (8).

Intraoperative normothermia. Maintaining a core temperature higher than 36˚C may decrease the risk of SSI among other complications (2). On the other hand, a temperature 1.5˚C below the normal core temperature may lead to an increased risk of SSI, decreased oxygen tension in tissues, peripheric vasoconstriction, cardiac dysfunction and coagulopathy (4,9).

Blood loss. Increased blood loss is associated with increased fluid administration and fluid resuscitation, and thus, the subsequent excessive fluid gain could result in poor tissue oxygenation and insufficient wound healing (2).

Surgical techniques. Previous studies have demonstrated a decrease in the SSI rate for triclosan antibiotic suture material compared with standard suture material (14) and a lower rate of wound dehiscence with interrupted vs. continuous suturing (2,31). Interrupted suture was most commonly used by surgeons in the context of impaired fascial tissue quality (31). Regarding the skin closure, continuous absorbable suture claims to have a lower rate of wound dehiscence as the material does not need to be removed, persisting in place to support the integrity of the incision, contrarily to the nonabsorbable sutures that are removed from 7 to 10 days after surgery (2). The 2019 National Institute for Health and Care Excellence guideline on SSIs could not precisely state the number of individuals who experience SSI or wound dehiscence after abdominal surgery by comparing the use of continuous and interrupted sutures, due to the low quality of the evidence (32). These conclusions emerged from a randomized controlled trial from 2014 conducted by Diener *et al* (33), including 1,224 individuals, after analyzing the outcomes by surgery type 30 days to 1 year after surgery.

There was no difference in wound infections or complications in gynaecologic obese (>3 cm subcutaneous fat) patients with vertical midline incision when comparing different skin closure techniques, with or without closed suction drainage (8).

In obstetrical patients with >2 cm subcutaneous tissue, closure of the dead space reduces seroma formation and SSI (8). By contrast, in gynaecological patients, the rates of wound complications were not improved by the closure of subcutaneous tissue (8).

High-tension, repeated incisions, extensive undermining, traumatized soft tissue and degree of contamination are general incision-related risk factors for SSI (17).

Topical antibiotics. Topical antibiotics applied to surgical sites with the primary intention of healing may be superior to no topical antibiotics. The 2019 National Institute for Health and Care Excellence guideline on SSIs could not precisely state the number of individuals who experience SSI or wound dehiscence after abdominal surgery by comparing the use of continuous and interrupted sutures, due to the lack of evidence (32). A systematic review analyzing results of eight trials involving 5,427 subjects suggested that administrating topical antibiotics may reduce the risk of SSI compared with no antibiotics (34). In this scrutiny, patients treated with topical antibiotics developed fewer SSIs; 20 SSIs cases fewer per 1,000 subjects in the group treated with topical antibiotics compared with no topical antibiotics (34).

Standard surgical dressing. The surgical dressing should be left in place for at least 24 h and less than 48 h (2).

VAC. Developed in the 1990s in animal models by Morykwas *et al* (35), the VAC methodology is based on the effect of topical negative pressure therapy on local blood flow, granulation tissue formation, decreased bacterial load and flap survival. When applied to humans, the standardized VAC method involves the following steps: i) Surgical debridement of the wound; ii) shaping the open-cell foam (polyurethane ether foam) to accurately fit the wound surface; iii) sealing with adhesive drape up to the skin around the wound, with an opening for the suction tube; and iv) attaching the tube to the cannister that is connected to a vacuum pump (36).

The VAC method has been used as complementary or alternative to surgery for a wide range of wounds aiming to decrease morbidity, mortality, costs and hospitalization duration, and increase patient quality of life (17). The 2016 Surgical Site Infection Guidelines of the American College of Surgeons and Surgical Infection Society state that silver-nylon dressings are associated with decreased SSI and shorter periods of hospitalization (14). Negative pressure reduces the fluid accumulation and the frequency of dressing changes to every 3-5 days (37). Although there are reports that VAC does not reduce the bacterial bioburden, most cases treated this way healed without incidents potentially because the foam reacts similar to a foreign body and generates an inflammatory reaction in the surgical site, and fails to reduce the extent of bacterial colonization (38-40).

A previous study has suggested that VAC therapy speeds up the wound healing process and decreases the risk of wound complications (41). Previous studies reported a reduction of SSI incidence in several surgical fields when using VAC therapy compared with standard dressings when used on a closed surgical incision (5,40). In 2016, the World Health Organization (WHO) recommended negative pressure wound therapy on clean closed incisions as an innovative measure in high-risk patients for SSI with marked clinical results (42). A study evaluated the cost burden of SSI in patients undergoing laparotomy as $165,105 for standard SSI care and $96,767 for VAC wound therapy (17).

A systematic review analyzed prophylactic (or closed incision) negative pressure wound therapy and conventional wound dressing, and demonstrated that VAC was beneficial in preventing SSI (43). This type of prophylactic approach limits SSI by reducing the wound dead space, avoiding the accumulation of fluids, stimulating the growth of the tissue and by preventing microorganisms from entering through the incision (43). Overall, VAC may be the most cost-effective wound healing therapy for patients at high risk of SSI (43).

The instrumentation used for VAC therapy may be too expensive for low-income countries, and thus, a simple, low-cost do-it-yourself (DIY) vacuum dressing has been developed (41). The DIY approach to VAC reaches approximately half of the level of negative pressure produced by commercially available pump-activated vacuum dressings (41). Nonetheless, this pressure is considered to have a positive effect in preventing SSI (41). The protocol used in the DIY approach to VAC includes the following steps (40): i) Dry the skin around the surgical site; ii) fold a gauze so that it fits the size of the wound; iii) size and trim the drape to cover the gauze with an additional 2-3-cm border; iv) apply the drape over the gauze, including the 2-3-cm border; v) pass a needle subcutaneously from outside the dressing into the gauze and evacuate the air around the gauze with a syringe to create negative pressure; and vi) the exudate from the surgical site is collected in the gauze.

Posthospital. A number of SSIs occur after discharge, and they can be easily underestimated without surveillance. A prior study conducted by our research team in Bucharest, Romania in 2018 sustained this theory (12). Posthospital surveillance was strongly recommended in our study, especially in patients with high risk for SSI (12). To the best of our knowledge, no reliable methods have been described to identify SSI in such a setting. Surveillance methods using questionnaires for surgeons or patients have low sensitivity and specificity (10).

4. Surgical 'bundles'

In 2016, the WHO issued guidelines with evidence-based recommendations to reduce SSI (42). Several hospitals have designed preoperative 'bundles' (based on prevention techniques described in previous studies) to prevent bacterial colonization, adapted to each surgical field, type of surgery and risk factor status (1,6,14,25,26). The American College of Surgeons and Surgical Infection Society has also offered recommendations for preventing SSI, which are particularly required in the era of drug-resistant bacterial pathogens (12,44).

The 'bundle' contributes to decreasing SSI incidence, and thus, is becoming a routine practice (14). In a previous study, SSI was reduced from 4.9 to 1.6% after using a colorectal 'bundle' (14).

Several physicians have investigated the potential aid of creating and incorporating a SSI bundle in daily practice (25,26). For instance, in a previous study, surgeons set up six perioperative measures that were linked to independent risk factors of SSI and evaluated >4000 surgery cases (colostomies) (8). A strong inverse association was found between the rates of SSI and the number of measures followed. The measures implemented in the study were: Appropriate prophylactic antibiotics, mechanical bowel preparation with oral antibiotics, postoperative normothermia, minimally invasive approach, surgery time <100 min and glucose ≤140 mg/dl in postoperative day 1.

Another survey evaluated 16 studies on the efficiency of 'surgical bundles' with clinically important impact (45). The SSI rate in the bundle group was 7.0%, whereas that in the standard care group was 15.1%, so the rate of SSI was reduced by more than half. In 2013, a 51% SSI reduction was observed in the vascular surgery field by applying a four-component 'bundle': Hair removal, prophylactic antibiotics, normothermia and operating room discipline (26).

'Bundle' prevention has been applied and showed efficiency in colorectal surgery, C-section delivery and oncological gynecological surgeries (8).

Oncological gynecological surgery has been demonstrated to be a field suitable for SSI reduction by 'bundle' programs (26). Rates of SSI reduction among surgeries for ovarian cancer, with or without bowel resection (by 77.6 and 79.3% respectively) and uterine cancer (by 100%) validated this program's efficiency (26). Recently, a multidisciplinary team convened by the Council on Patient Safety in Women's Health Care published a thorough SSI prevention 'bundle' in benign gynecology (9).

Regarding C-sections, an SSI reduction 'bundle' was implemented in a previous study (25). This included hair removal by electric clipper, skin preparation with chlorhexidine, antibiotic prophylaxis before incision (cefazolin 1 g IV bolus and azithromycin 500 mg bolus IV), placenta removal by traction of the umbilical cord, closure of deep subcutaneous layer >2 cm and subcuticular suture for skin closure. Other measures included jewelry wearing restriction, prohibition of long sleeves for neonatal attire in the operation room and hand hygiene compliance. Their conclusion stated that C-section 'bundles' reduced the rate of SSI (98.4% positive outcome) (25).

'Bundle' measures may vary among studies, but they all include important prevention methods such as antibiotic administration, appropriate hair removal, normothermia, glycemic control (9), and hand and forearm scrub (46). A Consensus Statement for SSI prevention in major gynecologic surgery recommends 'bundle' programs and provides a mnemonic (WASHING) of risk factors (4): i) Weight; ii) antibiotic resistant skin flora (MRSA); iii) smoking cessation; iv) hygiene (skin preparation); v) immune deficiency status; vi) nutritional status; and vii) glycaemic control.

In addition, Gillispie-Bell (46) considers the operating room environment to be a crucial factor in the development of SSI. Hypothermic (34.5˚C) patients display a decreased blood perfusion that reduces antibiotic penetration into the subcutaneous and adipose tissue (46). Hypothermia also enhances intraoperative blood loss, deteriorates wound healing and augments cardiac morbidity (46). Gillispie-Bell (46) defines normothermia as a core temperature of at least 36˚C measured immediately on the post-anesthesia care unit. A gynaecology-specific 'bundle' has been assessed in other studies that found a reduction in the SSI rate from 1.3 to 0.5% in patients undergoing hysterectomies (43,46-48). Implementing surgical 'bundles' is a multidisciplinary effort involving physicians (both gynaecologists and anaesthesiologists), nurses and patients (43). The gynaecology-specific 'bundle' is extrapolated from general surgery 'bundles' on the basis of existing evidence and best practice guidelines and includes: Wipes with chlorhexidine gluconate; hair removal; preoperative warming (forced-air warming devices); skin preparation (abdominal and, specifically, vaginal preparation); change gloves before closing fascia; sterile dressing; intraoperative normothermia; antimicrobial prophylaxis; and monthly meetings to assess feedback (43,47,48). Moving forward in the SSI prevention with evidence-based 'surgical bundles' that are rapidly covering all surgical fields (4), OG departments should take into consideration the main prevention methods to build 'bundles' in reducing SSI. Given the success of these strategies in other surgical fields and also recently in the OG field (16), it is recommended that these are adapted in each hospital. Reducing SSI and contributing to lowering multi-drug resistant pathogens is a collective struggle. A way to obtain good health outcomes in an efficient manner is to cover an entire cycle of care for a surgical procedure as a 'bundle'.

5. Conclusion

The risk of SSI is determined by patient factors and preoperative, intraoperative and postoperative care. Consequently, it is difficult to predict when or which wound will become infected. On this account, healthcare personnel should focus on the early identification of risk factors, especially the modifiable ones, including obesity, alcohol use and smoking, and glycemic control, to minimize the risk of SSI. All evidence-based methods of preventing and treating SSI should be considered as integral components of the best care.

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Competing interests

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