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2016 WHO GLOBAL GUIDELINES FOR THE PREVENTION OF SURGICAL SITE INFECTION: A NEW STEP TO IMPROVE PATIENTS' SAFETY BEFORE, DURING AND AFTER SURGERY

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Abstract

Surgical site infections (SSIs) are among the most preventable health-care-associated infections and are a substantial burden to health-care systems and service payers worldwide in terms of patient morbidity, mortality, and additional costs. SSI prevention is complex and requires the integration of a range of measures before, during, and after surgery. No international guidelines are available and inconsistencies in the interpretation of evidence and recommendations of national guidelines have been identified. Given the burden of SSIs worldwide, the numerous gaps in evidence-based guidance, and the need for standardisation and a global approach, WHO decided to prioritise the development of evidence-based recommendations for the prevention of SSIs. The guidelines take into account the balance between benefits and harms, the evidence quality, cost and resource use implications, and patient values and preferences. On the basis of systematic literature reviews and expert consensus, we present 23 recommendations on preoperative, intraoperative and postoperative preventive measures. The WHO recommendations were developed with a global perspective and they take into account the balance between benefits and harms, the evidence quality level, cost and resource use implications, and patient values and preferences.

Key words: guidelines; patient safety; preventive measures; wound infections.

Introduction

Healthcare-associated infections (HAIs) are frequent on surgical wards (1,2) and represent a high burden on patients and hospitals (1,3) in terms of morbidity, mortality, prolonged length of hospital stay and additional costs (4). HAIs are avoidable infections that affect hundreds of millions of people each year worldwide. Following a systematic review of the literature and meta-analyses, WHO reported in 2010 that the prevalence of health-care-associated infections in low-income and middle-income countries (LMICs) was two to 20 times higher than in high-income countries, affecting up to a third of patients who had surgery (5-7). Surgical site infections (SSIs) are an important source (1) and may even be the most frequent HAI after excluding asymptomatic bacteriuria (8). Apart from endogenous risk factors, such as immune suppression (9-11), obesity (12) or advanced age (13), the role of external risk factors in SSI pathogenesis is now clearly established (1,3). The incidence of SSI is much lower in high-income countries, but it is still the second most common cause of HAI in Europe and the USA (5,14). Furthermore, data from the USA showed that up to 60% of the microorganisms isolated from infected surgical wounds have antibiotic resistance patterns (15). Multimodal (16), multicentre or supranational preventive intervention programs based on guidelines (1,17), "bundles" (18,19) or safety checklists (20) are gaining momentum on a global scale (21,22). In parallel, randomized studies provide insight into poorly explored risk factors and practical intervention measures. In 1999 SSI guidelines were published by CDC (23). The National Institute for Health and Clinical Excellence (NICE) in England, Wales and Northern Ireland issued guidance for the prevention and treatment of SSI in October 2008 (24).

Considering the epidemiological importance of SSIs, and the fact that these infections are largely preventable, WHO decided to prioritise the development of evidence-based recommendations for the prevention of SSIs. Many factors in the patient's journey through surgery contribute to the risk of SSI, and prevention is complex and requires the integration of a range of measures before, during, and after surgery. Further strong reasons to develop global guidelines on this topic include the absence of any international guidance document and inconsistencies in the interpretation of the evidence and strength of recommendations in national guidelines. In this review, the WHO recommendations for measures to be implemented or initiated during the preoperative period, will be presented. These were elaborated according to the best available scientific evidence and expert consensus with the aim to ensure high-quality care for every patient, irrespective of the resources available. In this review, the practical questions regarding the most effective measures to reduce SSI and the SSI rates achievable today are also addressed, as well as the theoretical possibility of achieving a zero SSI policy on a surgical ward, at least for clean orthopaedic surgery (3).

Difficulties in Assessing Infections

An active surveillance program is the cornerstone for the detection of HAI and accurate calculation of SSI rates within an institution. Unfortunately, there is no consensus on a universally accepted surveillance strategy that would allow benchmarking of assessable infections (25). However, the National Nosocomial Infections Surveillance (NNIS) index for stratification could be useful, for example, and would represent at least an attempt to provide comparisons between hospitals (26). Surgical patients do not only acquire SSIs but they may be at higher risk to experience a HAI than nonsurgical patients, thus resulting in an additional burden on both the patient and the institution (27,28). If other institutional HAI rates remain unchanged or are increasing, a reduction of SSI may have only a minor impact on patient safety. To reduce infections in surgical wards, an infection control strategy must target all HAIs, including less severe HAIs, such as urinary tract infections (2).

Surveillance can be active, for example, by scheduled medical follow-up visits, or passive, but should be conducted within a minimum delay of 30 days following surgery (1 year in the case of implant surgery (1)). Of note, programs without active post-discharge surveillance readily miss between 48 (29,30) and 79% of all SSIs (31,32). An additional problem is wound depth. While most surveillance strategies easily detect post-surgical deep or organ space infections, they often fail to record superficial infections (1,33). This is an important issue as these infections may represent up to 65% of the overall SSI burden in absolute numbers (34). Haematogenous infections are witnessed in implant-related surgery (35). Although these are 'surgical site' in terms of localization, they originate from other sites and might be interpreted as primary SSIs if data are not validated by an expert. Finally, in surveillance programs based on microbiological evidence alone, the use of sonication of implants may enhance and alter the proportion of microbiologically documented SSIs (36). In summary, the surveillance strategy has a large influence on infection rates: the more sophisticated the strategy, the more likely the chance of detecting SSI and not to claim zero rates of HAI or SSI.

Current Benchmarks

The preventable proportion of HAI ranges from 10 to 70% in the literature (37). So far, a complete absence of nosocomial infection over several months has only been reported for catheter-related bloodstream infections (38,39). To the best of our knowledge, only one report has claimed almost zero SSI over an extended period of time (one of 176 neurosurgical shunt operations) (40) and it would appear that this is not easy to achieve outside minimally invasive, ambulatory surgery (39). In general, emergency surgery (41), dirty contaminated surgery (1,42) and surgery in resource-poor settings (43-45) yield higher SSI rates than general or clean elective surgery in high-income countries, presumably because clean elective surgery is performed in soft tissues or bone structures that are not routinely colonized by bacteria.

Among all clean elective surgery, cataract (46) and orthopaedic surgery (13) have the fewest SSIs, with an overall crude incidence of 0.05 to 1.1%, respectively. According to a large prevalence study in northern France, the relative SSI risk of genitourinary, cardiovascular, gynaecologic and gastrointestinal surgery compared with orthopaedic surgery was 2.1, 2.4, 2.6, 3.4 and 4.8, respectively

(13). Within the group of clean elective orthopaedic surgery, SSI risks may vary between different procedures. Arthroscopies harbour the absolute lowest SSI rates (0.1-0.4%) (3,42,47-49) and primary arthroplasties carry the lowest infection risk (0.5-0.9%) for implant-related procedures (28,50-53). Differences in arthroplasty infection rates may depend on the surveillance methods employed and the proportion of knee arthroplasties, which reveal a slightly higher infection risk than hip arthroplasties (35,53). The surveillance system used can also explain outliers, such as in the case of the United States Medicare system, with a documented lower incidence of primary arthroplasties (0.23%). However, only deep SSIs identified at 90 days post-implantation are reported in this system (54).

Preventing SSI

Pathogenesis

Most SSIs are believed to be acquired during surgery (55). This is supported by the success of SSI prevention measures directed towards activities in the operating theatre and a few reports demonstrating matching strains of pathogens from the surgeon's fingers and postoperative infection (56,57). However, despite much research on SSI, there are currently no data on the actual proportion acquired in the operating theatre versus post-operative care on wards. Similarly, within the subgroup of SSIs acquired during surgery, the proportion originating from the patient versus that transmitted by the surgical staff, operating theatre procedure or the environment remains unknown. Among the most frequently cited risk factors are diabetes mellitus (16), age (13), obesity (12) and incorrect or lack of antibiotic prophylaxis (58); other mentioned factors, such as low socioeconomic status (59) or postoperative pain (60), have not been thoroughly investigated (61). It is likely that with the construction of large databases for nationwide surveillance programs, new and as yet unidentified risk factors will emerge from research. Data on the clinical impact related to both endogenous and exogenous independent risk factors reveal risk indices oscillating between 1.3 (13) and 4.5 (14). Approximately half of all identified risk factors are endogenous and difficult to modify in the immediate preoperative and perioperative phase. For exogenous risk factors, past experience has identified those with the best and least costly chance to decrease SSIs.

The Global Guidelines for the Prevention of Surgical Site Infection

The Global Guidelines for the Prevention of Surgical Site Infection were developed by a panel of experts who reviewed the latest evidence on preventing SSIs. They include concrete recommendations to be applied in the pre-, intra-, and postoperative periods. Until now, no international evidence-based guidelines had been published, and there are inconsistencies in the interpretation of evidence and recommendations regarding existing national guidelines.

The guidelines are valid for any country and are suitable for local adaptation. They take into account the strength of available scientific evidence, cost and resource implications, and patient values and preferences, the WHO says. The guidelines complement the WHO Surgical Safety Checklist by providing more detailed recommendations on SSI prevention, the agency says. The new guidelines, if implemented, will save lives, reduce harm, cut costs, and limit the spread of antibiotic resistance, the WHO predicts.

Pre-operative measures

1. Immunosuppressive agents commonly used for preventing the rejection of transplanted organs or for the treatment of inflammatory diseases could lead to impaired wound healing and an increased risk of infection in patients administered these agents (62). By contrast, the discontinuation of immunosuppressive treatment could induce flares of disease activity, and long-term interruptions of therapy might induce the formation of anti-drug antibodies and subsequently decrease their effect (63).
2. The nutritional status of patients can lead to alterations in host immunity that can make them more susceptible to postoperative infections. Early nutritional support can improve the outcome of major surgery and decrease the incidence of infectious complications in selected malnourished or severely injured patients (64,65).
3. Preoperative whole-body bathing or showering is considered to be good clinical practice to ensure that the skin is as clean as possible before surgery and reduce the bacterial load, particularly at the site of incision. In general, an antiseptic soap is used in settings in which it is available and affordable.
4. S aureus is one of, if not the most common health-care-associated pathogen worldwide, and can have severe consequences, including po-

stoperative wound infection, nosocomial pneumonia, catheter-related bacteraemia, and increased mortality when it has meticillin resistance patterns (66-68). S aureus nasal carriage is a well defined risk factor for subsequent infection in various patient groups. Mupirocin nasal ointment (usually applied twice daily for 5 days) is an effective, safe, and fairly cheap treatment for the eradication of S aureus carriage and is generally used in combination with a whole body wash.

5. Mechanical bowel preparation (MBP) involves the preoperative administration of substances (polyethylene glycol and sodium phosphate are the most widely used) to induce voiding of the intestinal and colonic contents. It is commonly believed to reduce the risk of postoperative infectious complications by decreasing the intraluminal faecal mass, thus theoretically decreasing the bacterial load in the intestinal lumen. preoperative oral antibiotics should be used in combination with MBP in adult patients undergoing elective colorectal surgery to reduce the risk of SSI. MBP should not be done alone without oral antibiotics. An activity against both facultative Gram-negative and anaerobic bacteria should be guaranteed, and non-absorbable antibiotics should be used preferably.
6. Removal of hair from the intended site of surgical incision has traditionally been part of the routine preoperative preparation of patients. Hair is perceived to be associated with poor cleanliness and SSIs. Although hair removal might be necessary to facilitate adequate exposure and preoperative skin marking, the method used can cause microscopic trauma of the skin and increase the risk of SSIs. Hair should either not be removed or, if absolutely necessary, it should be removed only with a clipper. Shaving is strongly discouraged at all times, whether preoperatively or in the operating room.
7. Surgical antibiotic prophylaxis (SAP) refers to the prevention of infectious complications by administering an antimicrobial agent before exposure to contamination during surgery (69). Successful SAP requires delivery of the antimicrobial agent in effective concentrations to the operative site through intravenous administration at the appropriate time. The half-life of the agent used, the underlying condition(s) of the individual patient (eg, bodymass index, or renal or liver function), the time needed to complete the procedure, and the protein binding of the antibiotic should be taken into account to achieve adequate serum and tissue concentrations at the surgical site at the time of incision and up to wound closure – in particular to prevent incisional SSI.
8. Surgical hand preparation is vitally important to maintain the least possible contamination of the surgical field, especially in the case of sterile glove puncture during the procedure. Surgical hand preparation should be done either by scrubbing with a suitable antimicrobial soap and water or using a suitable alcohol-based hand rub before donning sterile gloves. However, the rapid antimicrobial action, wider spectrum of activity, lower side effects and the absence of the risk of hand contamination by rinsing water in resource-poor areas might favour alcohol-based solutions (21,70,71). Brushes are not recommended for surgical hand preparation (21,70,72).
9. The aim of surgical site skin preparation is to reduce the microbial load on the patient's skin as much as possible before incision of the skin barrier. The most common agents include chlorhexidine gluconate and povidone-iodine in alcohol-based solutions. Operating room staff should be trained and informed about the potential harms associated with the solutions used for surgical site preparation. Alcohol-based solutions should not be used on neonates or come into contact with mucosa or eyes, and caution should be exercised because of their flammable nature. Chlorhexidine gluconate solutions can cause skin irritation and must not be allowed to come into contact with the brain, meninges, eye, or middle ear.
10. Antimicrobial skin sealants are sterile, film-forming cyanoacrylate-based sealants commonly applied as an additional antiseptic measure after using standard skin preparation on the surgical site and before skin incision. They are intended to remain in place and block the migration of flora from the surrounding skin into the surgical site by dissolving over several days postoperatively. Antimicrobial sealants should not be used after surgical site skin preparation for the purpose of reducing SSIs.

Peri-and post-operative measures

1. Adequate surgical site tissue oxygenation is thought to have a role in preventing SSIs. A high partial pressure of oxygen in the blood achieved through the administration of hi-

gh-concentration oxygen (hyperoxia, defined as oxygen at 80% FiO_2) provides more adequate oxygenation at the surgical incision – particularly at infected tissue (73), which has a lower oxygen tension than non-infected tissues (74) – and might enhance oxidative killing by neutrophils. Patients undergoing general anaesthesia with endotracheal intubation for surgical procedures should receive 80% FiO_2 intraoperatively and, if feasible, for 2-6 h in the immediate postoperative period.

2. Hypothermia is defined as a core temperature less than 36°C. It commonly occurs during and after surgical procedures lasting more than 2 h because of impairment of thermoregulation by anaesthesia, combined with exposure to a cold environment (the operating room) (75,76). Unintended hypothermia is considered to be an adverse event of general and regional anaesthesia and might be associated with increased cardiac complications, blood loss due to impaired coagulation, impaired wound healing, decreased drug metabolism, decreased immune function, and an increased risk of SSI (75,77-80).
3. A rise in blood glucose concentration is commonly observed in the operative and postoperative periods because of a surgical stress response, resulting in increased secretion of catabolic hormones (eg, catecholamines or cortisol), inhibition of insulin secretion, and insulin resistance (81). Observational studies have shown that hyperglycaemia is associated with an increased risk of SSIs in both diabetic and non-diabetic patients (82-84). Using a protocol with strict blood glucose target concentrations is associated with a substantial benefit for the reduction of SSI prevalence. Hypoglycaemia is a possible serious side-effect associated with these intensive protocols and close reliable monitoring of blood glucose concentrations is crucial for this intervention.
4. Adequate intravascular volume is an essential component of tissue perfusion and an important aspect of tissue oxygenation (85). In unbalanced fluid states – ie, hypovolaemia and hypervolaemia – tissue oxygenation is compromised and might increase the risk of SSI (86). The use of goal-directed fluid therapy intraoperatively reduces the risk of SSI.
5. Drapes and gowns are available for single-use or multiple-use, with varying compositions. Adhesive plastic incise drapes are used on a patient's skin after surgical site preparation, with or without antimicrobial impregnation, and the surgeon performs the incision of the drape and the skin simultaneously. Either sterile disposable non-woven or sterile reusable woven drapes and gowns can be used. Adhesive incise drapes (with or without antimicrobial properties) should not be used for the purpose of preventing SSI.
6. Wound-protector devices (or wound-edge protectors) are comprised of a non-adhesive plastic sheath attached to a single or double rubber ring that firmly secures the sheath to the wound edges. They facilitate the retraction of the incision during surgery and are aimed at reducing wound-edge contamination to a minimum during abdominal surgical procedures. Wound-protector devices are recommended in clean-contaminated, contaminated, and dirty abdominal surgical procedures for the prevention of SSI.
7. Intraoperative wound irrigation refers to the flow of a solution across the surface of an open wound. It is a widely practised procedure and considered to help prevent SSIs (87-89). Among other benefits, wound irrigation is intended to physically remove cellular debris, surface bacteria, and body fluids, to dilute possible contamination, and to function as a local antibacterial agent when an antiseptic or antibiotic agent is used. Incisional wound irrigation with an aqueous povidone-iodine solution might have a benefit, particularly in clean and clean-contaminated wounds. Antibiotic incisional wound irrigation before closure should not be used for the purpose of preventing SSI. This practice is associated with an unnecessary risk of antimicrobial resistance. Allergic reactions and metabolic adverse events should be considered as potential harms of iodine uptake. Current evidences are insufficient to recommend for or against saline irrigation of incisional wounds for the purpose of preventing SSIs.
8. Prophylactic negative-pressure wound therapy (pNPWT) consists of a closed sealed system connected to a vacuum pump, which maintains negative pressure on the wound surface. The use of pNPWT on primarily closed surgical incisions in high-risk conditions (eg, poor tissue perfusion due to surrounding soft tissue or skin damage, decreased blood flow, bleeding or haematoma, dead space, or intraoperative contamination) is recommended for the purpose of the prevention of SSIs, taking available resour-

ces into account.

9. Sutures with antimicrobial properties were developed with the aim to prevent microbial colonisation of the suture material in operative incisions. Early studies showed a reduction of the number of bacteria in vitro and wound infections in animals (90-92) using triclosan-coated sutures and this effect was subsequently confirmed in clinical studies. Several novel antimicrobial coatings are now available, but still no clinical studies have been done that compare the efficacy with non-coated sutures (93,94). The use of antimicrobial-coated sutures for the purpose of reducing the risk of SSI is recommended. Because the effect appears to be independent of the type of procedure or wound contamination classification, this recommendation applies to any type of surgery.
10. Conventional ventilation systems pass air with a mixed or turbulent flow into the operating room. These systems aim to homogenise the fresh air, the air, and aerosols and particles within the room. Laminar airflow systems pass the fresh air unidirectionally with a steady velocity and approximately parallel streamlines to create a zone in which the air, aerosols, and particles within the room are driven out. Systems with laminar airflow are frequently used in an environment where contamination with particles is a serious adverse event – eg, orthopaedic implant surgery. However, laminar airflow systems are complex and expensive and require careful maintenance. Laminar airflow ventilation systems should not be used as a preventive measure to reduce the risk of SSI in patients undergoing total arthroplasty surgery.
11. Drainage tubes are widely used in surgery to remove any fluid or blood that collects in the wounds and cavities created by the surgical procedure and thus might cause complications. However, drains might adversely affect surgical outcomes – eg, affecting anastomotic healing by causing infection in the anastomotic area and the abdominal wound. Many systematic reviews investigating the effect of drains on the related infection risk compared with no wound drainage have been published with conflicting results. The optimal time for drain removal after surgery might influence this risk, but it remains unknown. Furthermore, in most cases, antibiotic prophylaxis is continued postoperatively when a drain is used, but this practice is not evidence-based and raises serious concerns in terms of contributing to the emergence of antimicrobial resistance. antibiotic prophylaxis should not be continued in the presence of a wound drain for the purpose of preventing SSI. Wound drains should be removed when clinically indicated.
12. A wide variety of wound dressings are available. Advanced dressings are mainly hydrocolloid, hydrogels, fibrous hydrocolloid, or polyurethane matrix hydrocolloid dressings and vapour-permeable films. Advanced dressings should not be used for the prevention of SSIs.
13. The preventive effect of the routine use of SAP has long been recognised; however, the necessary duration of SAP to achieve the desired effect has been a matter of debate. Most guidelines recommend a maximum postoperative SAP duration of 24 h, but increasing evidence shows that using only a single preoperative dose (and possible additional intraoperative doses according to the duration of the operation) might be non-inferior. Despite this, surgeons still often routinely continue SAP up to several days after surgery, which leads to serious concerns for the risk of antimicrobial resistance. SAP prolongation should be avoided, also because of the widespread risk of antimicrobial resistance. Continuing antibiotic administration in cardiac and orthognathic surgery has potential benefit, but further well designed RCTs on this topic are needed.

Other Measures with High Efficacy

Expertise of the Surgeon

The surgeon's expertise and surgical technique is probably very important, although subjective and difficult to analyse (17). Furthermore, it is almost impossible to perform a randomized trial on this subject. An excellent surgical technique is believed to reduce SSI by: maintaining effective haemostasis while preserving adequate blood supply; gentle handling of tissue; removal of devitalized tissue; eradication of dead space; and appropriate management of the postoperative incision (1). These techniques can be learned and it has been suggested since the mid-1980s that surgical simulation has a beneficial impact on surgeons' experience and performance (95).

Active Surveillance with Feedback

Decreases in SSI rates have been observed in national surveillance networks in European countries, such as France (13,29,96,97), Germany (42,98) and The Netherlands (31,32,99). An active surveillance programme may decrease SSI rates by merely reporting data without any other formal interventions (29). Some experts question whether studies using data from national surveillance networks can be used to support the effectiveness of surveillance with feedback as there is no information about other interventions implemented in the many hospitals that have contributed to the data. However, the reports do not mention these theoretical aspects. In 1985, the Study on the Efficacy of Nosocomial Infection Control (SENIC) showed that the presence of a dedicated infection control team, together with surveillance and feedback of observed data, resulted in a 38% decrease of SSIs among participating hospitals (100). However, the structural mechanism of implementing such a strategy is complex and requires engineering changes in behavioural (98) as well as system aspects. In addition, it differs according to the setting and takes several years to develop gradually to its full effectiveness (42,97), although the impact can be very powerful, with reports ranging from a 25 (42) to 50% decrease in SSI rates (97) within 4-6 years following implementation.

Multimodal Intervention

Instead of targeting single risk factors, it is advised to target several at the same time, although they are usually based on pre-/post intervention studies and not randomized trials or meta-analyses. Multimodal interventions, sometimes in the form of so-called "bundles", have become very popular in recent years (101). A variant are safety check-lists (20) that have been inspired from the airline industry. The multimodal approach does not need to cover all potential risk factors. Local (10,16), nationwide ("100k lives campaign" (18) and Surgical Care Improvement Project (9,19)) and global (World Health Organization Global Patient Safety Challenges "Clean Care is Safer Care" and "Safe Surgery Saves Lives" (20,22)) intervention programs rely on only three to six key targets and have achieved substantial results. For example, Trussell et al. implemented a quality care initiative including peri-incisional antibiotic prophylaxis, close glucose control and hair clipping and reported 1.5% SSIs in the intervention group compared with 3.5% in the comparator arm (16). The USA's 100k lives program recommended correct antibiotic prophylaxis, glucose control and intraoperative normothermia, and achieved a 27% reduction in SSI rates (18). Globally, the WHO strategies are effective through education programs, use of alcohol-based hand rub and access to safe surgical care. Multimodal interventions based on bundles or checklists are the strategy with the highest impact in terms of SSI prevention.

Postponing Elective Surgery in the Case of Symptomatic Remote Infection

This issue is regarded as high evidence in the CDC guidelines (1), although there are no randomized trials on the topic of postponing to the best of our knowledge. However, a number of case series and retrospective studies exist reporting a haematogenous origin for total joint arthroplasty infections and secondary infections of other orthopaedic implants. Although the incidence of true haematogenous arthroplasty infections in the case of active remote infection is probably lower than formerly believed (35,102), most experts agree that elective surgery should be postponed until the remote infection is cured. The necessity to postpone in the case of asymptomatic bacteriuria (103) or even urinary tract infection (104) in elective orthopaedic surgery or nonimplant-related surgery is less certain. Common sources of haematogenous implant infections are often the skin, the GI tract or the lungs (35).

Other Measures yet to be Confirmed in Future Trials

Several new approaches show promising results in randomized trials, but have been reported only once or on very few occasions. As an example, Dutch investigators reported that naso- and oropharynx decontamination with chlorhexidine before cardiac surgery significantly lowered deep SSIs, bacteraemia and lower respiratory tract infections (105). This needs confirmation in further trials as a similar approach failed to show any benefit for ventilator-associated pneumonia (106). Further concerns about the potential for chlorhexidine resistance, in particular among staphylococci, require further study and explanation (107). The future will show if continuous, positive airway pressure during anaesthesia significantly lowers the risk for several HAIs by avoidance of postoperative hypoxemia (108). Another debate concerns whether minimal invasive surgery or the use of laparoscopy versus laparotomy may lower SSI risk (42,101,109).

Conclusion

Zero HAI (or zero SSI) is theoretically possible in clean elective surgery, but there is no published report so far of zero infection in a surgical unit over a prolonged period. All HAIs have to be targeted, thus requiring different prevention programs conducted at the same time. This goal requires multidisciplinary, multifaceted commitment, dedicated infection control teams and efforts, and institutional and behavioural elements to ensure sustainability. National surveillance networks may help benchmarking. Current benchmarks for SSI are 0.1% risk in arthroscopy and cataract surgery. A multimodal approach is recommended, including optimized antibiotic prophylaxis, active post-discharge surveillance and continuous performance feedback. The future of SSI prevention will certainly be marked by multimodal, multicenter or national intervention programs, bundles (1,18) and checklists (20) targeting not only SSIs, but also various nosocomial infections among patients exposed to surgical procedures. SSIs will become an integral issue of patient safety (22) not only in the operating theatre, but also up to hospital discharge and beyond. With the rise of same-day surgery, ambulatory patients will be included in these programs more frequently. Active post-discharge surveillance, the standardization of surveillance protocols and enhanced funding are prerequisites to set up and conduct these programs that will prove cost effective in the long-term. Raising awareness at different levels, including local/ national authorities and the public, may trigger efforts for reporting SSIs and international benchmarking, and thus possibly contribute towards a further decrease of current infection rates. These interventions do not require new sophisticated technology. An improved adherence to established basic principles such as surgical hand preparation, skin antisepsis, adequate antibiotic prophylaxis, less traumatic, less invasive and shorter surgery duration, improved haemostasis and avoidance of hypothermia or hyperglycaemia will remain cornerstones, while decolonization of various patient body sites may soon find its place in the armentarium (101). The relatively highest achievements will be obtained in resource-poor countries thanks to individual initiatives, national programs and WHO-directed interventions (21,22). Surgeons' technical skills and non-invasive techniques will continuously improve as a result of ever-increasing professional training, including mandatory monitored performance skills or simulation models resulting in increased overall patient safety (95). From an academic standpoint, we still lack a complete understanding of exactly when the surgical site starts to develop infection, what the premises that drive microbial colonization to infection are and why some patients get infected and others do not. There is certainly enough room to improve work up of the pathogenesis, search for hidden risk factors lurking inside large databases and to implement well-conducted randomized studies. Although the guidelines are intended for surgical patients of all ages, some recommendations do not apply to the paediatric population, owing to lack of evidence or inapplicability. This is clearly stated in the guidelines. No one should get sick while seeking or receiving care. Preventing surgical infections has never been more important, but it is complex and requires a range of preventive measures. These guidelines are an invaluable tool for protecting patients. The WHO's next step will be to work with countries and experts to prepare an implementation guide and assessment toolkit.

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