International Journal of Surgery 54 (2018) 290–297

Contents lists available at ScienceDirect

International Journal of Surgery

journal homepage: www.elsevier.com/locate/ijsu

Review

A survey to identify the breach between evidence and practice in the prevention of surgical infection: Time to take action☆

Josep M. Badia[a,*], Anna L. Casey[b], Inés Rubio-Pérez[c], Cynthia Crosby[d], Nares Arroyo-García[e], José M. Balibrea[f]

[a] Department of Surgery, Hospital General de Granollers, Universitat Internacional de Catalunya, Spanish Association of Surgeons, Barcelona, Spain
[b] Clinical Research Scientist, Department of Clinical Microbiology, University Hospitals Birmingham NHS Foundation Trust, UK
[c] Department of Surgery, Hospital Universitario la Paz, Madrid, Spain
[d] Becton Dickinson & Co., Franklin Lakes, NJ, USA
[e] Department of Surgery, Hospital General de Granollers, Barcelona, Spain
[f] Department of Surgery, Hospital Universitari Vall d'Hebrón, Universitat Autònoma de Barcelona, Spanish Association of Surgeons, Barcelona, Spain

ARTICLE INFO

Keywords:
Surgical site infection
Surgical wound infection
Preventative measures
Prevention and control
Surveys and questionnaires

ABSTRACT

Background: The knowledge of the grade of implementation of preventative measures for surgical site infection (SSI) is crucial prior to planning dissemination strategies.
Methods: Online survey among the members of the Spanish Association of Surgeons (AEC) to know the actual application of measures, and to compare them with new recommendations issued by international organizations.
Results: Most of the 835 responding surgeons work in National Health Service Hospitals (91.3%). Surgeons of all super-specialties answered. 90.4% of responders recommend a preoperative shower, with normal soap or chlorhexidine. 60% recommend hair removal, preferably clipping, although 30% still recommend shaving. Povidone-iodine in aqueous solution or chlorhexidine in alcohol are used for skin preparation. Only 51.9% of surgeons allow solution to air drying before applying surgical drapes. In 83.2% of cases surgeons operate with a single pair of gloves. Perioperative normothermia and hyperoxia were used in 92% and 27.9% of cases, respectively. At the end of the procedure, peritoneal and wound lavage are used, in most cases with saline. Antimicrobial impregnated sutures are rarely used (85.7%) by surgeons, and 32% occasionally use negative pressure therapy on the closed wound.
Conclusions: There is great variability in the level of awareness and application of the main measures of SSI prevention among Spanish surgeons. Several areas for improvement have been detected, as core prevention measures are not in common use, and discontinued practices are continued to be used. These practices should be addressed by the AEC by drafting specific recommendations for the prevention of SSI in Spanish hospitals.

1. Introduction

Surgical site infection (SSI) is the most common health-care related infection in Spain (21.6%) [1] and Europe (19.6%) [2]. It is the most frequent postoperative complication, with rates up to 20% for colorectal surgery [3] and 45% following head and neck cancer surgery [4]. SSI represent a substantial financial burden [3], consumption of antibiotics and overall increase of sanitary costs [5–7]. In colorectal surgery, organ/space SSI is associated with a 3-fold higher length of stay, and an extra cost of 3052 Euros per patient. 23% of these patients are re-admitted, 60% require re-operation and 29% require intensive care. The additional direct medical costs related to SSI following head and neck surgery is 17,000 Euros [7]. This adds a significant additional cost per patient [6].

The numerous measures evaluated to prevent SSI have shown a varying grade of efficacy and have different levels of adoption among the surgical community. Recently, organizations such as WHO [8] and CDC [9] have published SSI prevention recommendations based on systematic reviews of the evidence. The Surgical Infection Section of the Spanish Association of Surgeons (AEC) determined that knowing the level of implementation of the main preventative measures was important prior to planning dissemination strategies and grouping them

☆ **Presented** as an oral communication at the: XI Catalan Congress of Surgery, Barcelona, Spain, 5–6 October 2017, and at the XXI Surgical Meeting of the Spanish Association of Surgeons, Malaga, Spain, 18–20 October 2017.

* Corresponding author. Universitat Internacional de Catalunya, Department of Surgery, Hospital General de Granollers, Av. Francesc Ribas 1, 08402 Granollers, Spain.
E-mail address: jmbadia@fhag.es (J.M. Badia).

https://doi.org/10.1016/j.ijsu.2018.04.038
Received 7 February 2018; Received in revised form 15 March 2018; Accepted 23 April 2018
Available online 25 April 2018
1743-9191/

Table 1
Summary of questions.

1. Demography	
	1.1. Type of hospital (National Health Service, teaching, private)
	1.2. Professional level of respondent surgeon (Resident, Consultant, Chief)
	1.3. Speciality within General Surgery (Colorectal, HPB, Emergency …)
2. General	
	2.1. Is there a hospital policy or protocol for prevention of Surgical Site Infection?
	2.2. Is there a safety policy in theatre?
	2.3. Is there a hospital policy on skin preparation?
3. Preoperative surgical prevention measures	
3.1. Preoperative bath or shower	3.1.1. Do you recommend a preoperative bath or shower for your patients?
	3.1.2. Bath or shower?
	3.1.3. Where? (at home, at hospital?)
	3.1.4. When? (same day, day before?)
	3.1.5. Which product? (bar soap, chlorhexidine soap?)
3.2. Hair removal	3.2.1. Yes or not?
	3.2.2. When? (day before, same day?)
	3.2.3. Where? (ward, theatre?)
	3.2.4. Method? (shaving, clipping, depilatory cream?)
3.3. First hand scrub for surgical team	3.3.1. Product? (antiseptic soap vs alcohol solutions?)
3.4. Second hand scrub for surgical team	3.4.1. Product? (antiseptic soap vs alcohol solutions?)
3.5. Second scrub of operative field in theatre?	3.5.1. Yes or not
	3.5.2. Product
3.6. Patient skin antisepsis	3.6.1. Who does it? (circulating nurse, scrubbed surgeon, non-scrubbed surgeon?)
	3.6.2. When? (before or after scrubbing?)
	3.6.3. Product: alcoholic solution or aqueous solution?
	3.6.4. Product: chlorhexidine or povidone iodine?
	3.6.5. Method: multiple-use bottles vs single-use bottles ?
	3.6.6. Method: application device (gauze and brushstroke?, single-use applicator?)
	3.6.7. Method: Paint or friction (back-and-forth)?
	3.6.8. Method: number of applications?
	3.6.9. Drying (allow spontaneous drying?, dry with towels?)
4. Intraoperative measures	
	4.1. How many pair of gloves?
	4.2. Do you change gloves during the operation?
	4.2.1. When? Why?
	4.3. Wound-edge protection devices in laparotomy
	4.3.1. Yes or not?
	4.3.2. Type of device (gauze, drape, plastic ring protector?)
	4.4. Normothermia
	4.4.1. Yes or not?
	4.5. Hyperoxia
	4.5.1. Yes or not?
	4.6. Peritoneal lavage at the end of laparotomy
	4.6.1. Yes or not?
	4.6.2. Product (saline, antiseptic solution, antibiotic solution?)
	4.7. Replacement of surgical instruments prior to closing incision
	4.7.1. Yes or not?
	4.8. Wound lavage before closing
	4.8.1. Yes or not?
	4.8.2. Product (saline, antiseptic solution, antibiotic solution?)
	4.9. Use of negative pressure wound therapy
	4.9.1. Yes or not?

into bundles that could increase their level of implementation. Therefore, it was decided to propose a survey with questions on the existence of safety protocols in the operating theatres, the preparation of the surgical patient, the products used for surgical washing, the patient skin preparation before surgery, the measures to protect the margins of the wound, the maintenance of normothermia, the use of perioperative hyperoxia and whether surgical instruments were replaced with sterile equivalents for closure of the incision.

2. Methods

An online survey (SurveyMonkey©; https://es.surveymonkey.com/r/FL7BJRC) was designed by a panel of surgical experts formulating 41 questions related to the core recommendations endorsed by international guidelines on SSI prevention. The survey questions addressed to which extent the AEC members have implemented SSI preventative measures, to determine the actual adherence to the preventative measures in their hospital and their personal preferences (Table 1).

Responses on the implementation of major SSI prevention measures were compared with the recommendations of the most recent clinical practice guidelines: the already mentioned WHO [8] and CDC [9] guidelines, plus The National Institute of Health and Clinical Excellence (NICE) Guideline (2008 [10] and 2013 update [11]); the Clinical Practice Guide for Surgical Patient Safety of the National Health System of Spain (2010) [12]; the Canadian Patient Safety Institute Guideline (2014) [13]; the 2014 update of the SHEA/IDSA Recommendation [14]

Table 2
Summary of recommendations from National and International clinical practice guidelines. Different systems of evidence quality gradation are used. These recommendations are also supported by different levels of evidence.

Preventative measure	NICE[a] [6,7] (2008, 2017)	Spanish [8] 2010	Canadian [9] 2014	Anderson [10] (SHEA/IDSA)[b] 2014	Scotland [11] 2015	Allegranzi [4] (WHO)[c] 2016	Berrios-Torres [5] (CDC)[d] 2017
Preoperative Bath/Shower	Shower or bath	Shower or bath	Shower or bath		Shower or bath	Shower or bath	Shower or bath
Hair removal	Do not (if YES: clipping)	Do not (if YES: clipping)	Do not (if YES: clipping)	Do not (if YES: clipping)	Do not (if YES: clipping)	Do not (if YES: clipping)	Do not (if YES: clipping)
Hand decontamination	First operation: antiseptic soap Subsequent: antiseptic soap or alcohol solution	First operation: antiseptic soap Subsequent: antiseptic soap or alcohol solution		"Appropriate" scrub		Scrub or rub	Scrub or rub
Antiseptic skin preparation	Aqueous or alcohol-based PI or CHG	PI or CHG	Alcohol CHG > PI	Alcohol PI or CHG	Alcohol CHG > PI	Alcohol CHG	Alcohol
Plastic incise drapes	Do not (if YES: iodophor-impregnated)	Do not		Do not		Do not	Do not
Double gloving	Yes	Yes				Unresolved	
Wound edge protection				Yes, plastic (dual > single)		Yes	
Normothermia	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Oxygenation	Yes (maintain O2 sat > 95%)	"Sufficient perfusion"		Yes Supplemental O2	Yes (maintain O2 sat > 95%)	Yes Supplemental O2	Unresolved
Wound irrigation	Do not	Do not				Unresolved	Yes (PI solution)
Antimicrobial suture			Do not	Do not		Yes	Yes
Negative pressure wound therapy						Yes (high risk)	

Blank: No recommendation issued.
[a] NICE: National Institute for Health and Clinical Excellence.
[b] SHEA/IDSA: Society for Healthcare Epidemiology of America/Infectious Diseases Society of America.
[c] WHO: World Health Organization.
[d] CDC: Centers for Disease Control and Prevention.

and the National Health Service Scotland Guideline (2015) [15]. A summary of these recommendations is shown in Table 2. A panel of experts from the Surgical Infection Section also conducted an extensive review of evidence and previous guidelines to be used in the discussion of the results.

A link to the web page containing the survey was disseminated to AEC members via email, newsletter and Twitter. The survey remained open for 40 days (7 March to 17 April 2017).

The results are expressed in percentages on the total answers obtained. Responses were entered into a computerized database that was analysed using the SPSS program (v.10.0, Chicago, IL, USA). The results are analysed using the chi-square test. Statistical significance was accepted at $p < 0.05$.

Responses on the implementation of major SSI prevention measures were compared with the recommendations of the most recent clinical practice guidelines: A summary of these recommendations is shown in Table 2.

3. Results

A total of 835 responses were received from a total of 4000 members. The professional level and subspecialties of respondent surgeons are shown in Figs. 1 and 2.

Summary of results are shown in Table 3. Regarding hair removal, only in 5.4% of cases is routinely not removed. In 59.8% it is routinely removed, in 18.8% it is only removed at the surgeon's request, in 13.9% only in very hirsute people at the discretion of the person who prepares the patient. In the case of hair removal, it is completed with electric clippers with single-use heads or by shaving with razor (Fig. 3).

The most commonly used antiseptic solutions in healthy skin and

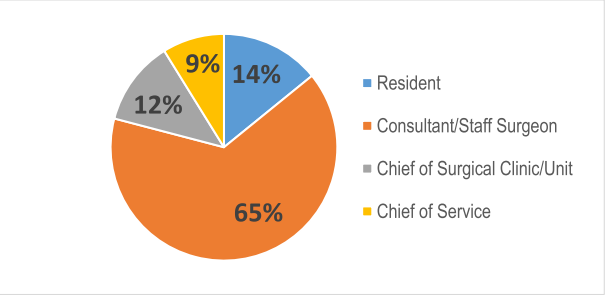

Fig. 1. Level of respondent surgeons.

without mucosal proximity are chlorhexidine in alcoholic solution (41.7%) and povidone iodine in aqueous solution (39.2%), followed by chlorhexidine in aqueous solution (9.8%) or povidone iodine in alcoholic solution (8.2%) (Fig. 4). There are no significant differences in the type of patient skin antiseptic agents used when comparisons are made by hospital size or by surgical subspecialty.

After application of the antiseptic, only 51.9% of respondents allow spontaneous drying of the solution before applying the surgical drapes. Colorectal surgeons allow spontaneous drying more frequently than the other specialties (57% vs. 48.3%, $p = 0.017$). Surgeons using alcohol-based solutions allow air drying more frequently than those using aqueous solutions (68.7% vs. 34.5%, $p < 0.001$). 23.5% of respondents had heard about a safety problem related to the use of alcoholic solutions in the operating theatre during the last few years.

Fig. 5 shows the results of wound edge protection. Colorectal specialists are using most frequently plastic protectors ($p < 0.05$), of one or two rings, whereas the rate of their use is significantly lower in the

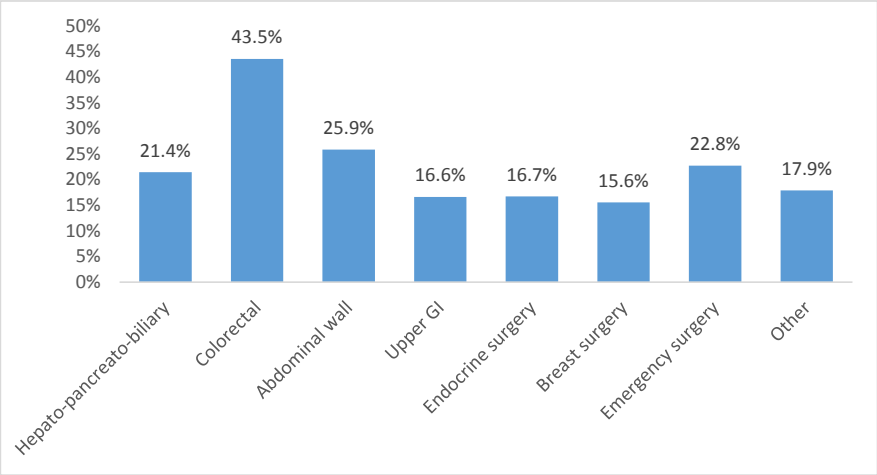

Fig. 2. Subspecialty of respondent surgeons.

case of hepato-biliopancreatic or emergency surgeons ($p < 0.05$).

4. Discussion

The level of awareness and application of accepted measures for the prevention of SSI seems to have great variability. The dissemination of standardized SSI prevention recommendations based on scientific evidence should improve infection rates consistently among hospitals. During the last decades, several measures to reduce the incidence of SSI have been analysed. Most have been evaluated in controlled studies, some with contrasting results, while others are the result of clinical observation or standard surgical practice and can hardly be subjected to structured scientific analysis. Moreover, many policies implemented in the operating room environment are not based on rigorous scientific studies, for example some of those related to surgical attire, surgical scrubs, masks and head gear [16]. Periodically, entities such as NICE [10,11], CDC [9], or WHO [8] issue clinical practice guidelines based on the analysis of available scientific evidence. Although based on the same original evidences, these guidelines sometimes do not show similar results, probably due to a miscellany of reasons: not all prophylactic measures have been sufficiently evaluated; there is variability in the inclusion of clinical studies in systematic reviews, and the different systems of evidence quality gradation which are used (Table 2). In addition, there may be a bias introduced by the evaluating groups regarding the need to analyse the evidence with a pragmatic approach. It is sometimes due to too weak level of evidence that requires distinguishing statistical significance from clinical significance. Some measures with weak evidence are, nonetheless, universally accepted by the surgical community and recommended from common sense and clinical practice. It would be desirable having a balanced and pragmatic approach in the drafting of recommendations that form a clinical practice guideline.

Ideally, a group of core measures with high level of evidence and which are highly recommended by most guidelines could be identified and should be recommended for all surgical procedures. These include the patient's preoperative shower, hand scrubbing of the surgical team, antibiotic prophylaxis when indicated, no hair removal, patient skin antisepsis with chlorhexidine in alcohol, and maintenance of normothermia and normoglycemia. On the other hand, there is another group of ancillary measures with lower level of evidence that can be suggested depending on the type of surgery, the local incidence of SSI and available resources.

The present study intends to determine the level of application of the main measures described for the prevention of SSI and to compare the results with the internationally accepted “core” recommendations. This should be used as a basis for the design and dissemination of bundles of preventative measures for postoperative infection. The survey did not include questions about the indication of systemic antibiotic prophylaxis, since it was considered a generic measure beyond the scope of the study.The results of the survey show a wide variability in the application of some of the core measures. Most of respondent surgeons suggest a preoperative shower, which can be with bar or antiseptic soap, in line with most of international recommendations [8–13,15] (Table 4).

Regarding hair removal, there is more discrepancy with current recommendations, as 60% of surgeons respond that it is routinely removed. It is known that the lowest rate of SSI is achieved by not removing hair, although it is accepted selectively to remove it [17]. As a method of elimination, it is even more worrisome that 30% use shaving with a razor, a method that increases the SSI rate compared to not removing or clipping [8,15] and that is not recommended in all guidelines [8–15].

The use of aqueous iodine solution for skin preparation (39%) appears high and should be reviewed in light of the copious evidence for the use of alcohol-based solutions [18,19]. Alcohol solutions have more immediate and residual activity and are currently suggested by most international guidelines [8,9,13–15]. In this sense, safety awareness in the operating room is important. The reintroduction of the alcohol in the surgical theatres may represent a safety problem due to the risk of ignition and flammability [20]. Almost 25% of respondents have knowledge of a safety concern related to alcohol in theatre.

It should be remembered that alcoholic solutions cannot be used in certain locations (mucous membranes, ear, eyes, mouth, neural tissue, open wounds, non-intact skin) and that their concentration should be limited to prevent burn injuries. Regardless of the antiseptic used, allowing time for the antiseptic solutions to air dry is imperative to maximize its efficacy and prevent a fire hazard [13]. In addition, the habit of drying the antiseptic with gauze or absorbent paper can lead to a break of antisepsis if areas not treated with antiseptic are inadvertently touched. Our survey shows an alarming drying rate of 41.6%. Almost 7% of surgeons apply the surgical drapes even if the solution is not dry, which represents an actual danger of ignition when alcoholic solutions are used. The present survey shows that the use of alcohol is associated with a significant increase in spontaneous drying. Probably alcohol, with its accelerated evaporation, facilitates compliance with drying-time protocols, avoid drying with gauzes and allow the minimum antimicrobial action time required. A single use applicator may also potentially encourage a standardized and more thorough approach to skin preparation.

The level of use of plastic adhesive incise drapes is relatively high, since 53.4% use them regularly or occasionally. These drapes, placed on the surgical field, are intended to reduce wound contamination with

Table 3
Summary of results.

Demography		
Type of hospital of respondents surgeons	National Health Service 759/831 (91.3%)	Private 72/831 (8.7%)
Size of the hospital	< 500 beds 487/825 (59.0%)	> 500 beds 338/825 (41.0%)
Years of experience	< 20 years 555/810 (68.5%)	> 20 years 255/810 (31.5%)
Hospital protocols		
Safety protocol in the operating theatre	Yes 731/816 (89.6%)	Not 85/816 (10.4%)
Protocol for prevention of SSI	Yes 722/816 (88.5%)	Not/don't know 94/816 (11.5%)
Preoperative surgical prevention measures		
Preoperative bath or shower	Yes 705/780 (90.4%)	Not/don't know 75/780 (9.6%)
Bath or shower	Bath 3/677 (0.4%)	Shower 674/677 (99.6%)
Place of bath or shower	Home 334/646 (51.7%)	Hospital 312/646 (48.3%)
Timing of bath or shower	Day before 141/725 (19.4%)	Same day 549/725 (80.6%)
Product for bath or shower	Bar soap 361/716 (50.4%)	Antiseptic soap 355/716 (49.6%)
Second skin cleansing at theatre before skin antisepsis	Yes 353/729 (48.4%)	Not 376/729 (51.6%)
Hair removal	Yes 732/772 (94.6%)	Not 42/772 (5.4%)
Product for first hand scrub	Antiseptic soap 718/770 (93.3%)	Alcoholic solution 36/770 (4.7%)
Product for successive hand scrubs	Antiseptic soap 571/761 (75.0%)	Alcoholic solution 190/761 (25.0%)
Product for patient skin antisepsis	Alcohol solution 383/767 (49.9%)	Aqueous solution 376/767 (49.1%)
Method for skin antisepsis	Brushstroke 722/762 (94.8%)	Single-use applicator 40/762 (5.2%)
Antiseptic bottle	Single-use (< 50 ml) 135/750 (18%)	Multiple-use (> 250 ml) 615/750 (82%)
Method of application	Concentric circles 521/763 (68.3%)	Back-and-forth 204/763 (26.7%)
Number of layers of antiseptic	One 491/765 (64.2%)	Two or more 274/765 (35.8%)
Antiseptic drying	Spontaneous drying 396/763 (51.9%)	Manual drying 367/763 (48.1%)
Surgical drapes	Plastic 694/766 (90.6%)	Cotton 72/766 (9.4%)
Plastic adhesive drapes	Always/sometimes 397/743 (53.4%)	Never 346/743 (46.6%)
Intraoperative surgical prevention measures		
Gloves	One pair 618/743 (83.2%)	Two pairs 125/743 (16.8%)
Gloves changing	At end of anastomosis/ operation 691/744 (92.9%)	Never 53/744 (7.1%)
Normothermia	Yes 679/738 (92%)	Not 59/7638 (8%)
Hyperoxia 0,80	Yes 206/738 (27.9%)	Not/unknown 532/738 (72.1%)
Peritoneal lavage at the end of laparotomy	Yes 663/741 (89.5%)	Never 78/741 (10.5%)
Product for peritoneal lavage	Saline 626/663 (94.4%)	Antiseptic/ antibiotic solution 37/663 (5.6%)
Antiseptic coated sutures	Sometimes 106/741 (14.3%)	Never 635/741 (85.7%)
Replacement of surgical instruments prior to closing incision (contaminated surgery)	Yes 654/743 (88.0%)	Never 89/743 (12.0%)
Wound lavage before closing	Yes 597/741 (80.6%)	Never 144/741 (19.4%)
Product for wound lavage	Saline 379/597 (63.5%)	Antiseptic/ antibiotic solution 218/597 (36.5%)
Negative pressure wound therapy (high risk surgery)	Sometimes 242/740 (32.7%)	Never 498/740 (67.3%)

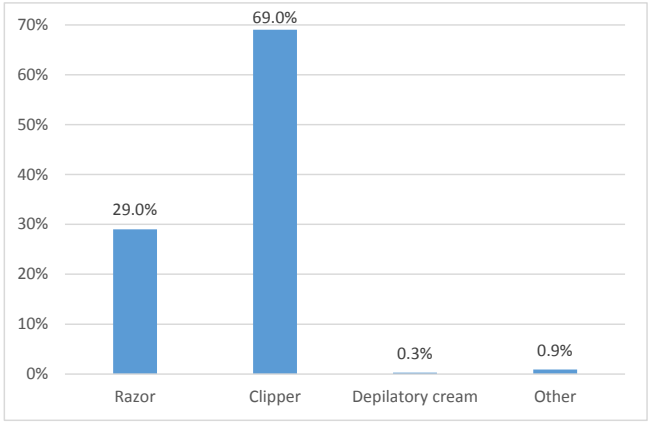

Fig. 3. Methods for hair removal.

microorganisms from the patient skin, but there is no evidence that they reduce SSI and there is even some evidence that they increase it [21], and are specifically not recommended by many guidelines in force [8–12,14].

Few surgeons use double gloving in this study (16.8%). There is a high rate of perforation of the gloves during surgery, and it has been shown that the addition of a second pair of gloves reduces perforations of the innermost gloves [22]. However, there is no evidence to correlate glove perforation rate and incidence of SSI. Despite this, some institutions have included double gloving in their recommendations, including the Royal College of Surgeons of England (2005) NICE (2008) and the Spanish Ministry of Health [10,12,23]. Although there is no solid evidence in this regard, there seems to be room for improvement in the glove changing policy, given that 41% of surgeons do not change them at the end of a digestive anastomosis and 35% do not do so before closing a laparotomy.

The efficacy of peritoneal lavages at the end of a laparotomy is an unresolved issue and the recommendations of the guidelines are disparate [8–12], but our study shows a widespread custom of performing lavage with saline, and the anecdotal use of antiseptic or antibiotic solutions. A meta-analysis based on experimental studies shows reductions of SSI and mortality up to 65% with irrigations of saline or antibiotic solutions [24]. On the contrary, in the same study wound lavage with antiseptic solutions obtains the same rate of SSI that when the irrigation is not performed. In the clinical setting, a meta-analysis concluded in 2015 that even though most of studies are old, wound irrigation in abdominal surgery is an effective, pragmatic and economical way to reduce SSI. They conclude that it might be worth re-evaluating their use for specific procedures [25]. Recently, a meta-analysis on the efficacy of antibiotic ointment after primary closure of surgical wounds found that topical antibiotics reduced the risk of SSI, compared to topical antiseptic or no topical treatment [26].

Some similar surveys have been published, but most have been done

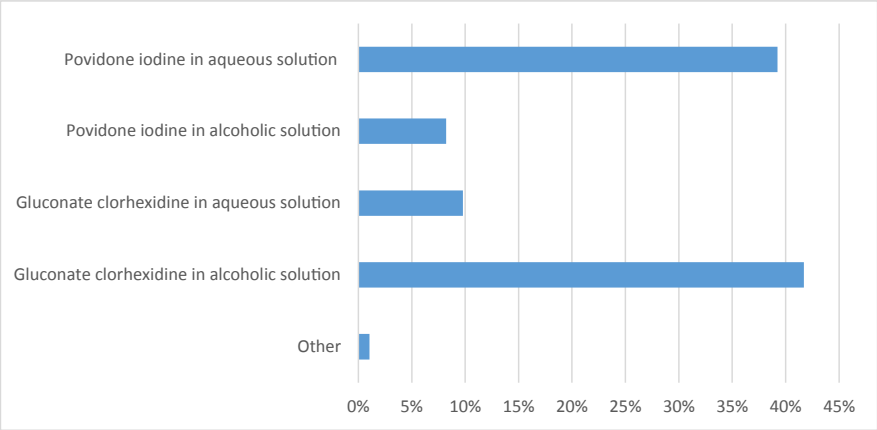

Fig. 4. Antiseptic solutions used for patient's skin preparation.

in specific geographical areas (hospitals from a single city [27] or a region [28,29] or specific surgeries (such as arthroplasty [30], coronary artery by-pass [31], or Caesarean sections [32]), the majority being addressed to hospitals or nurses and not to individual surgeons. The present survey is the only that collects feedback from surgeons at a country level, in various types of interventions within general surgery and the one that obtains the highest absolute number of responses.

Limitations of the study. It can be argued that the response rate to the survey is low. It is difficult to calculate accurately the response rate, given the uncertainty about the number of AEC members who actually received the survey information. Nevertheless, the number of responding surgeons is high and a response level of 835/4000 seems sufficiently representative. The study may be limited by self-report bias. Despite this, we believe that there is a balanced representation of different types of hospitals (size, teaching and ownership). Also, all surgical subspecialties are represented, which suggests that the results can be generalized to the reality of surgical practice in Spain. These results, although focused on surgeons from a single country, could represent the actual use of preventative measures in European countries.

In summary, it seems that preoperative shower, surgical hand scrub of the surgical staff, use of impermeable surgical drapes and perioperative normothermia are the measures with the highest level of adherence of AEC surgeons to the recommendations of current practice guidelines. Other measures, such as peritoneal lavage and wound irrigation with saline are frequently used, probably mainly by surgical tradition. On the other hand, other measures with high level of recommendation by main guidelines show a low level of utilization. In addition, some practices that are not recommended or that are even known to increase SSI rate are maintained. Among the detected areas of improvement are the high percentage of routine elimination of hair and razor shaving, the low use of alcoholic-based solutions for cutaneous antisepsis, the habit of drying the antiseptic and not allowing its action whilst air-drying, the policy of intraoperative glove changes, and the use of liquid and bacterial permeable wound edge protectors.

In conclusion, we believe it is necessary for scientific societies and regulators to reiterate measures that contribute to SSI prevention, while discouraging the use of others that are unnecessary or even detrimental. A concerted effort by the surgical community will be needed to increase adherence to evidence-based SSI prevention practices.

Ethical approval

This article does not contain any studies with human participants or animals performed by any of the authors.

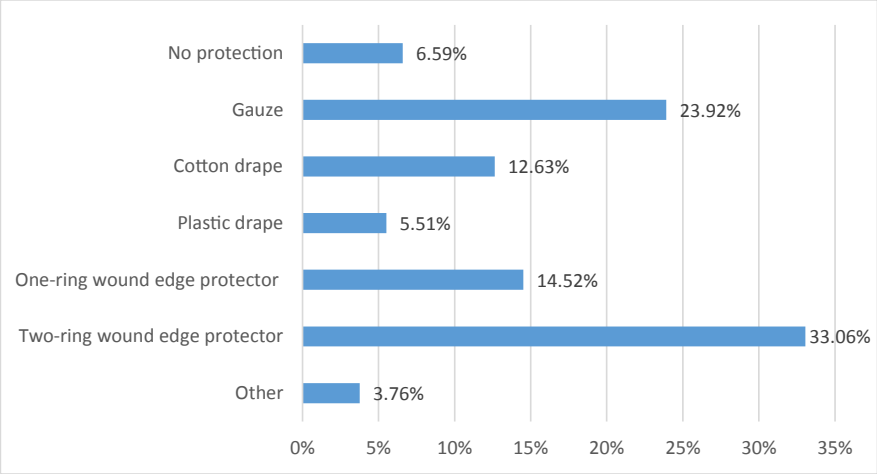

Fig. 5. Methods used for wound edge protection.

Table 4
Effect of preventative measures on SSI rate.

Preventative measure	Summary of results from meta-analysis or randomized trials from the WHO [8] recommendations unless otherwise stated.	Strength of recommendation (quality of evidence)		
		WHO [8]	CDC [9]	AEC (reference)
Preoperative bathing	No differences between plain soap and chlorhexidine gluconate soap (combined OR 0.92; 95% CI 0.80–1.04)	Conditional (moderate)	Strong (accepted practice)	Strong (moderate)
No removal of hair or clipping	Combined OR 1.78 (95% CI 0.96–3.29) for shaving,1.00 (0.06–16.34) for clipping, and 1.02 (0.42–2.49) for depilatory cream. Clipping better than shaving (OR 0.51; 0.29–0.91)	Strong (moderate)	Strong	Strong (moderate)
Surgical hand preparation by scrubbing or rubbing	Scrub or rub no difference (RR 1.02; 95% CI 0.70 to 1.48). Parienti [33], (cited in Cochrane review [34])	Strong (moderate)	Strong	Strong (moderate)
Alcohol-based antiseptic skin preparation	Alcohol-based antiseptic more effective than aqueous solutions in reducing the risk of SSI (combined OR 0.60; 95% CI 0.45–0.78) Alcohol-based chlorhexidine gluconate more effective than povidone-iodine in alcohol-based solutions (0.58; 0.42–0.80)	Strong (low-moderate)	Strong (high)	Strong (low-moderate)
Plastic incise drapes not necessary	Adhesive incise drapes not useful (OR 1.10; 0.68–1.78)	Conditional (low-very low)	Weak (high-moderate)	Weak (high-moderate)
Wound edge protectors in contaminated surgery	Reduction of SSI (OR 0.42; 95% CI 0.28–0.62)	Conditional (low-very low)	Not discussed	Strong (high)
Normothermia	Reduction of SSI (OR 0.33; 95% CI 0.17–0.62)	Conditional (moderate)	Strong (high-moderate)	Strong (high)
Increased fraction of oxygen (80%)	Reduction of SSI (OR 0.72; 95% CI 0.55–0.94)	*In favor* Strong (Moderate)	No recommendation (unresolved)	*Against* Weak (moderate)
Wound irrigation	Reduction of SSI with aqueous povidone-iodine solutions compared with irrigation with a saline solution (OR 0.31; 95% CI 0.13–0.73; p = 0·007).	Conditional (low)	Weak (moderate)	Strong (low)
Antimicrobial-coated sutures	Antimicrobial suture decreases SSI (OR 0.72; 95% CI 0.59–0.88)	Conditional (moderate)	Weak (moderate)	Not discussed
Negative pressure wound therapy in high risk surgery	Reduction of SSI (OR 0.56; 95% CI 0.32–0.96)	Conditional (low)	Not discussed	Conditional (low)

WHO: World Health Organization.
CDC: Centers for Disease Control and Prevention.
AEC: Surgical Infection Chapter of the Spanish Association of Surgeons.
OR: odds ratio.
RR: risk ratio.
CI: confidence interval.

Funding

None reported.

Author contribution

Study conception and design: JM Badia, A Casey, C Crosby, J Balibrea del Castillo.

Acquisition of data: JM Badia, N Arroyo.

Analysis and interpretation of data: JM Badia, I Rubio-Pérez, N Arroyo, J Balibrea del Castillo.

Drafting of manuscript: JM Badia, N Arroyo.

Critical revision of manuscript: JM Badia, A Casey, I Rubio-Pérez, C Crosby, N Arroyo, J Balibrea del CastilloGuarantor.

Conflicts of interest

1. Josep M Badia, report no conflicts of interest relevant to this article
2. Anna L Casey, report no conflicts of interest relevant to this article.
3. Inés Rubio-Pérez, report no conflicts of interest relevant to this article
4. Cynthia Crosby, works for Becton Dickinson & Co., Franklin Lakes, NJ, USA, and declares no conflicts of interest relevant to this article
5. Nares Arroyo-García, report no conflicts of interest relevant to this article
6. José Balibrea del Castillo, report no conflicts of interest relevant to this article

Research registration number

None.

Guarantor

Guarantor: JM Badia.

References

[1] Study of Prevalence of Nosocomial Infections in Spain, (2016) EPINE website http://hws.vhebron.net/epine/Global/EPINE-EPPS%202016%20Informe%20Global%20de%20España%20Resumen.pdf , Accessed date: 13 August 2017.
[2] European Centre for Disease Prevention and Control, Point prevalence Survey of Healthcare-associated Infections and Antimicrobial Use in European Acute Care Hospitals 2011.2012, ECDC, Stockholm, 2013 ECDC website https://ecdc.europa.eu/sites/portal/files/media/en/publications/Publications/healthcare-associated-infections-antimicrobial-use-PPS.pdf , Accessed date: 13 August 2017.
[3] M. Pujol, E. Limón, J. López-Contreras, M. Sallés, F. Bella, F. GudiolVINCat Program, Surveillance of surgical site infections in elective colorectal surgery. Results of the VINCat Program (2007-2010), Enferm. Infec. Microbiol. Clin. 30 (Suppl 3) (Jun 2012) 20–25.
[4] N. Penel, C. Fournier, D. Lefebvre, J.L. Lefebvre, Multivariate analysis of risk factors for wound infection in head and neck squamous cell carcinoma surgery with opening of mucosa. Study of 260 surgical procedures, Oral Oncol. 41 (3) (Mar 2005) 294–303.
[5] J.M. Badia, A.L. Casey, N. Petrosillo, P. Hudson, S. Mitchell, C. Crosby, Impact of surgical site infection on healthcare costs and patient outcomes: a systematic review in six European countries, J. Hosp. Infect. 96 (2017) 1–15, http://dx.doi.org/10.1016/j.jhin.2017.03.004.
[6] E. Shaw, A. Gomila, M. Piriz, F. Obradors, R. Escofet, R. Vazquez, J.M. Badia, L. Martin, D. Fraccalvieri, M. Brugués, M.C. Nicolás, E. Espejo, A. Castro, A. Cruz, E. Limón, F. Gudiol, M. Pujol, Cost of organ/space infection in elective colorectal surgery. Is it just a problem of rates? Antimicrob. Resist. Infect. Contr. 4 (Suppl 1) (2015) 77.
[7] N. Penel, J.L. Lefebvre, J.L. Cazin, S. Clisant, J.C. Neu, B. Dervaux, Y. Yazdanpanah, Additional direct medical costs associated with nosocomial infections after head

and neck cancer surgery: a hospital-perspective analysis, Int. J. Oral Maxillofac. Surg. 37 (2) (Feb 2008) 135–139 Epub 2007 Nov 19.
[8] B. Allegranzi, P. Bischoff, S. de Jonge, N.Z. Kubilay, B. Zayed, S.M. Gomes, M. Abbas, J.J. Atema, S. Gans, M. van Rijen, M.A. Boermeester, M. Egger, J. Kluytmans, D. Pittet, J.S. Solomkin, WHO Guidelines Development Group. New WHO recommendations on preoperative measures for surgical site infection prevention: an evidence-based global perspective, Lancet Infect. Dis. 16 (12) (Dec 2016) e276–e287, http://dx.doi.org/10.1016/S1473-3099(16)30398-X.
[9] S.I. Berríos-Torres, C.A. Umscheid, D.W. Bratzler, B. Leas, E.C. Stone, R.R. Kelz, C.E. Reinke, S. Morgan, J.S. Solomkin, J.E. Mazuski, E.P. Dellinger, K.M.F. Itani, E.F. Berbari, J. Segreti, J. Parvizi, J. Blanchard, G. Allen, J.A.J.W. Kluytmans, R. Donlan, W.P. SchecterHealthcare Infection Control Practices Advisory Committee, Centers for disease control and prevention guideline for the prevention of surgical site infection, 2017, JAMA Surg. 152 (2017) 784–791, http://dx.doi.org/10.1001/jamasurg.2017.0904.
[10] National Institute for Clinical Excellence, Surgical Site Infection. Prevention and Treatment of Surgical Site Infection, National Institute for Clinical Excellence, London, 2008 NICE website http://www.nice.org.uk/guidance/cg74/resources/surgical-site-infectionsprevention-and treatment-975628422853 , Accessed date: 13 August 2017.
[11] National Institute for Clinical Excellence, Surgical Site Infection. A Summary of Selected New Evidence Relevant to NICE Clinical Guideline 74 'Prevention and Treatment of Surgical Site Infection' 2008, National Institute for Health and Care Excellence, London, 2013 NICE website https://www.nice.org.uk/guidance/qs49/resources/surgical-site-infection-2098675107781 , Accessed date: 13 August 2017.
[12] Ministry of Health, Social Services and Equality. Clinical Practice Guideline for Surgical Patient Safety, Ministry of Health, Social Services and Equality website, Madrid, 2010http://www.guiasalud.es/GPC/GPC_478_Seguridad_Paciente_AIAQS_compl.pdf , Accessed date: 13 August 2017.
[13] The Canadian Patient Safety Institute, Prevent Surgical Site Infections. Getting Started Kit. Safer Healthcare Now, The Canadian Patient Safety Institute, Canada, 2014 CPSI website http://www.patientsafetyinstitute.ca/en/toolsResources/Pages/SSI-resources-Getting-Started-Kit.aspx , Accessed date: 13 August 2017.
[14] D.J. Anderson, K. Podgorny, S.I. Berríos-Torres, D.W. Bratzler, E.P. Dellinger, L. Greene, A.C. Nyquist, L. Saiman, D.S. Yokoe, L.L. Maragakis, K.S. Kaye, Strategies to prevent surgical site infections in acute care hospitals: 2014 update, Infect. Contr. Hosp. Epidemiol. 35 (2014) 605–627, http://dx.doi.org/10.1086/676022.
[15] Health Protection Scotland, What are the Key Infection Prevention and Control Recommendations to Inform a Surgical Site Infection (ISQ) Prevention Quality Improvement Tool? National Health Services Scotland, Scotland, 2015 Health Protection Scotland website http://www.hps.scot.nhs.uk/resourcedocument.aspx?id=2805 , Accessed date: 13 August 2017.
[16] T.A. Markel, T. Gormley, D. Greeley, J. Ostojic, A. Wise, J. Rajala, R. Bharadwaj, J. Wagner, Hats off: a study of different operating room headgear assessed by environmental quality indicators, J. Am. Coll. Surg. 225 (5) (Nov 2017) 573–581.
[17] J. Tanner, P. Norrie, K. Melen, Preoperative hair removal to reduce surgical site infection, Cochrane Database Syst. Rev. (11) (2011) CD004122, , http://dx.doi.org/10.1002/14651858.CD004122.pub4.
[18] M. Maiwald, E.S. Chan, The forgotten role of alcohol: a systematic review and meta-analysis of the clinical efficacy and perceived role of chlorhexidine in skin antisepsis, PLoS One 7 (9) (2012) e44277, , http://dx.doi.org/10.1371/journal.pone.0044277.
[19] G.P. Privitera, A.L. Costa, S. Brusaferro, P. Chirletti, P. Crosasso, G. Massimetti, et al., Skin antisepsis with chlorhexidine versus iodine for the prevention of surgical site infection: a systematic review and meta-analysis, Am. J. Infect. Contr. 45 (2) (2017) 180–189, http://dx.doi.org/10.1016/j.ajic.2016.09.017.
[20] A. Bonnet, M. Devienne, V. De Broucker, V. Duquennoy-Martinot, P. Guerreschi, Operating room fire: should we mistrust alcoholic antiseptics? Ann. Chir. Plast. Esthet. 60 (4) (2015 Aug) 255–261, http://dx.doi.org/10.1016/j.anplas.2015.05.004.
[21] J. Webster, A. Alghamdi, Use of plastic adhesive drapes during surgery for preventing surgical site infection, Cochrane Database Syst. Rev. (1) (2013) CD006353.
[22] J. Tanner, H. Parkinson, Double gloving to reduce surgical cross-infection, Cochrane Database Syst. Rev. (3) (2006) CD003087, , http://dx.doi.org/10.1002/14651858.CD003087.pub2.
[23] J.M. Badia, J. Ruiz-Tovar, Specific measures for the prevention of surgical site infection, in: J.M. Badia, X. Guirao (Eds.), Surgical Infections. Guidelines of the Spanish Association of Surgeons, second ed., Arán Ediciones, Madrid, 2016ISBN: 978-84-16585-10-6.
[24] M. Qadan, D. Dajani, A. Dickinson, H.C. Polk Jr., Meta-analysis of the effect of peritoneal lavage on survival in experimental peritonitis, Br. J. Surg. 97 (2010) 151–159, http://dx.doi.org/10.1002/bjs.6906.
[25] T.C. Mueller, M. Loos, B. Haller, A.L. Mihaljevic, U. Nitsche, D. Wilhelm, H. Friess, J. Kleeff, F.G. Bader, Intra-operative wound irrigation to reduce surgical site infections after abdominal surgery: a systematic review and meta-analysis, Langenbeck's Arch. Surg. 400 (2015) 167–181, http://dx.doi.org/10.1007/s00423-015-1279-x.
[26] C.F. Heal, J.L. Banks, P. Lepper, E. Kontopantelis, M.L. van Driel, Meta-analysis of randomized and quasi-randomized clinical trials of topical antibiotics after primary closure for the prevention of surgical-site infection, Br. J. Surg. 104 (9) (Aug 2017) 1123–1130.
[27] F. Demir, A survey on prevention of surgical infections in operating theaters, Worldviews Evidence-Based Nurs. 6 (2009) 102–113, http://dx.doi.org/10.1111/j.1741-6787.2009.00152.x.
[28] L.J. Conway, M. Pogorzelska, E.L. Lasrson, P.W. Stone, Surgical site infection prevention policies and adherence in California Hospitals, 2010, Infect. Contr. Hosp. Epidemiol. 33 (2012) 640–641, http://dx.doi.org/10.1086/665716.
[29] C. Eskicioglu, A.R. Gagliardi, D.S. Fenech, S.S. Forbes, M. McKenzie, R.S. McLeod, A.B. Nathens, Surgical site infection prevention: a survey to identify the gap between evidence and practice in University of Toronto teaching hospitals, Can. J. Surg. 55 (4) (2012) 233–238, http://dx.doi.org/10.1503/cjs.036810.
[30] B.F. Ricciardi, M.P. Bostrom, L. Lidgren, J. Ranstam, K.M. Merollini, A. W-Dahl, Prevention of surgical site infection in total joint arthroplasty: an international tertiary care center survey, HSS J. 10 (1) (2014 Feb) 45–51, http://dx.doi.org/10.1007/s11420-013-9369-1.
[31] P. Injean, J.A. McKinnell, P.P. Hsiue, S. Vangala, L.G. Miller, P. Benharash, R.G. Brindis, A.L. Gregson, Survey of preoperative infection prevention for coronary artery bypass graft procedures, Infect. Contr. Hosp. Epidemiol. 35 (6) (Jun 2014) 736–737, http://dx.doi.org/10.1086/676435.
[32] C. Argani, E. Notis, R. Moseley, K. Huber, S. Lifchez, L.A. Price, J. Zenilman, A. Satin, T.M. Perl, G. Sood, Survey of Cesarean delivery infection prevention practices across US academic centers, Infect. Contr. Hosp. Epidemiol. 36 (10) (Oct 2015) 1245–1247, http://dx.doi.org/10.1017/ice.2015.161.
[33] J.J. Parienti, P. Thibon, R. Heller, Y. Le Roux, P. Theobald, H. Bensadoun, et al., Hand-rubbing with an aqueous alcoholic solution vs traditional surgical hand-scrubbing and 30-day surgical site infection rates, J. Am. Med. Assoc. 288 (6) (2002) 722–727.
[34] J. Tanner, J.C. Dumville, G. Norman, M. Fortnam, Surgical hand antisepsis to reduce surgical site infection, Cochrane Database Syst. Rev. (1) (Jan 22 2016) CD004288, , http://dx.doi.org/10.1002/14651858.CD004288.pub3.