WHO Surgical Site Infection Prevention Guidelines

Web Appendix 18

Summary of a systematic review on wound protector devices

1. Introduction

Although surgeons have progressively paid more attention to the control of operative wound contamination during surgical procedures, incisional surgical site infection (SSI) is still a frequent postoperative adverse event jeopardizing patient safety and increasing health care costs. A scrupulous aseptic surgical technique and the administration of adequate antibiotic prophylaxis prevent operative wound infection by decreasing contamination and eliminating the microorganisms that invade the surgical site, despite the efforts of the surgical team.

Conventional surgical drapes are commonly used by surgeons to limit the aseptic surgical area and to cover the freshly-made wound edges. Nevertheless, this non-fixed mechanical barrier may become dislodged or potentially contaminated. To better reinforce the aspects related to wound edge isolation, surgical wound protectors (WP) have been fabricated and marketed, unlike newly developed drugs that need different controlled studies before approval by regulatory bodies. These new surgical devices are comprised of a non-adhesive plastic sheath attached to a single or double rubber ring that firmly secures the plastic sheath to the wound edges, which can facilitate the retraction of the incision during surgery without the need for additional mechanical retractors and cloths. Theoretically, commercially-available WPs are intended to reduce wound edge contamination to a minimum during abdominal surgical procedures, including contamination from outside (clean surgery) and inside the peritoneal cavity (clean-contaminated, contaminated and dirty surgery). Although these surgical devices are already on the market, their real usefulness and cost-effectiveness warrants additional evidence-based analysis.

Few organizations have issued recommendations regarding the use of WP devices. The United Kingdom-based National Institute for Health and Care Excellence states that wound-edge protection devices may reduce SSI rates after open abdominal surgery, but no recommendation is given due to the lack of further high quality evidence *(1)*. The guidelines of the Society for Healthcare Epidemiology of America (SHEA)/Infectious Diseases Society of America (IDSA) recommend the use of impervious plastic WPs for gastrointestinal and biliary tract surgery *(2)*.

2. PICO question

Does the use of WP devices reduce the rate of SSI in open abdominal surgery?

- **P**opulation: inpatients and outpatients of any age undergoing either elective or urgent abdominal surgery through conventional open access
- **I**ntervention: use of single or double plastic ring WP devices
- **C**omparator: conventional wound protection, mainly through placing wet towels between the wound edge and steel type retractors
- **O**utcomes: SSI, SSI-attributable mortality

3. **Methods**

The following databases were searched: Medline (PubMed); EMBASE; Cumulative Index to Nursing and Allied Health Literature (CINAHL); Cochrane Central Register of Controlled Trials (CENTRAL); and WHO regional medical databases. The time limit for the review was between 1 January 1990 and 28 November 2014. Language was restricted to English, French and Spanish. A comprehensive list of search terms was used, including Medical Subject Headings (MeSH) (Appendix 1).

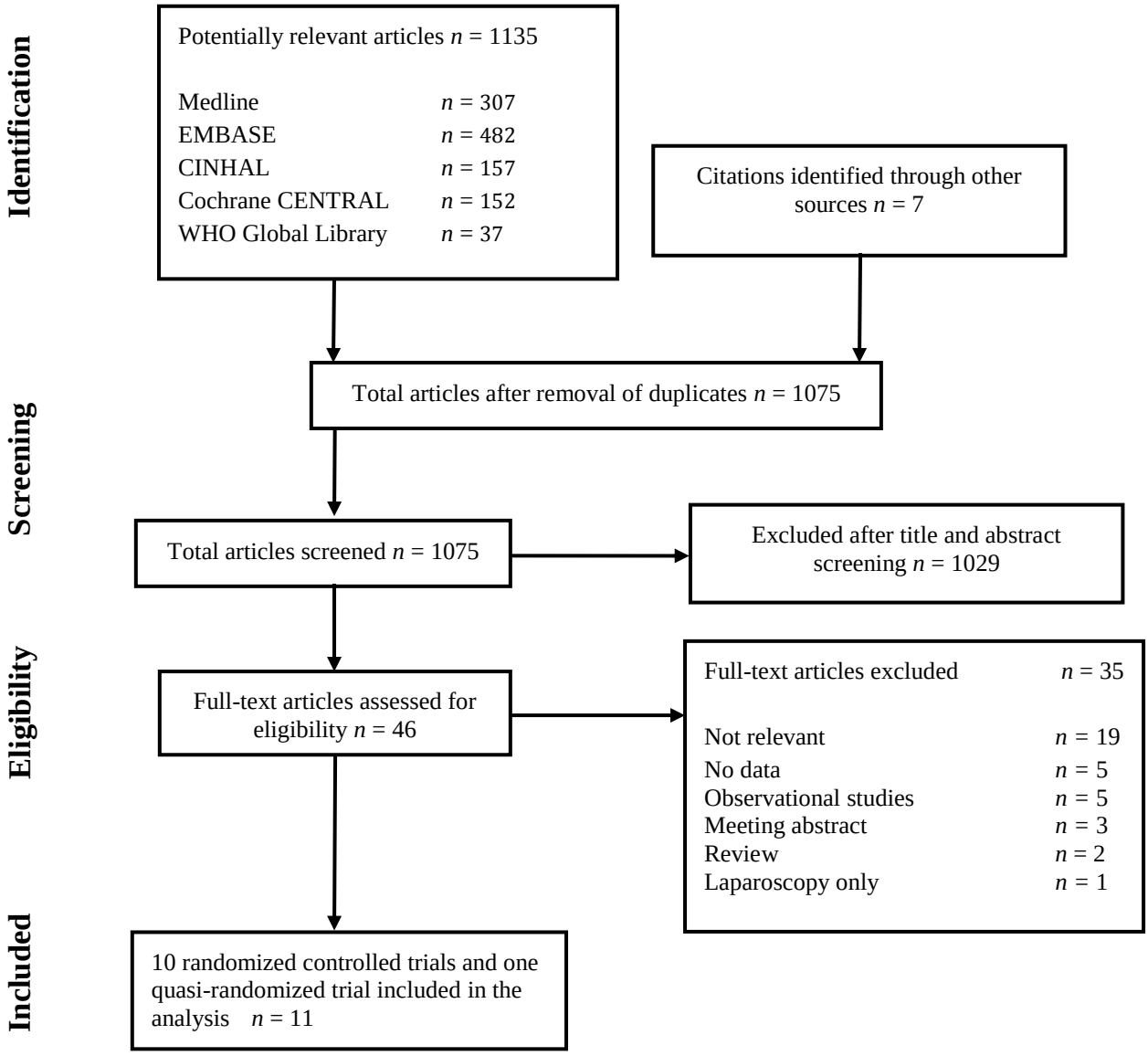
Two independent reviewers screened the titles and abstracts of retrieved references for potentially relevant studies. The full text of all potentially eligible articles was obtained and two authors then independently reviewed these for eligibility based on inclusion criteria. Duplicate studies were excluded.

The two authors extracted data in a predefined evidence table (Appendix 2) and critically appraised the retrieved studies. Quality was assessed using the Cochrane Collaboration tool to assess the risk of bias of randomized controlled studies (RCTs) *(3)* (Appendix 3). Any disagreements were resolved through discussion or after consultation with the senior author, when necessary.

Meta-analyses of available comparisons were performed using Review Manager version 5.3 as appropriate *(4)* (Appendix 4). Adjusted odds ratios (OR) with 95% confidence intervals (CI) were extracted and pooled for each comparison with a random effects model. The Grading of Recommendations Assessment, Development and Evaluation (GRADE) methodology *(5)* (GRADE Pro software) *(6)* was used to assess the quality of the body of retrieved evidence (Appendix 5).

4. **Study selection**

Flow chart of the study selection process



5. Summary of the findings and quality of the evidence

Eleven studies *(7-17)* including 10 RCTs *(7-16)* and one prospective controlled trial *(17)* comparing the use of a WP device vs. conventional wound protection were identified with an SSI outcome. Patients were adults undergoing abdominal surgical procedures with laparotomy.

Six studies *(7, 11-13, 15, 17)* used a single-ring WP device as the intervention. Among these, 4 trials *(11, 13, 15, 17)* demonstrated that the use of a single-ring WP led to a significant reduction of the SSI rate when compared with standard wound protection. However, 2 trials showed no difference of risk *(7, 12)*. A meta-analysis of this subgroup (Appendix 4, comparison 1) showed the benefit of a single-ring WP in reducing the SSI rate when compared with standard wound protection (OR: 0.51; 95% CI; 0.34–0.76).

Five *(8-10, 14, 16)* of the 11 studies used a double-ring WP device as the intervention. In 2 trials *(10, 14)*, there was a significant reduction of the SSI rate when using a double-ring WP. Three trials *(8, 9, 16)* showed no difference in risk. A meta-analysis of this subgroup (Appendix 4, comparison 1) showed the benefit of a double-ring WP in reducing the rate of SSI (OR: 0.25; 95% CI: 0.13–0.50).

The overall meta-analysis (Appendix 4, comparison 1) including all 11 studies showed the benefit of using a WP device when compared with standard wound protection in reducing the rate of SSI (OR: 0.42; 95% CI: 0.28–0.62). In meta-regression analysis, there was no strong evidence for a difference in the effect between a single- and double-ring WP (P=0.107). A sensitivity analysis comparing the RCTs and the prospective controlled trial *(17)* indicated that there was no difference in the results, irrespective of whether the quasi-randomized trial was included or not.

The quality of the evidence for this comparison was very low due to risk of bias, inconsistency and publication bias (Appendix 5). Most studies had an unclear to high risk in random sequence generation and unclear allocation concealment. There was considerable asymmetry observed in the funnel plot, compatible with the preferential publication of small studies demonstrating a benefit (Appendix 4, funnel plot 1).

A subgroup analysis discriminating between different degrees of wound contamination in abdominal surgery (clean-contaminated, contaminated and dirty) showed that the use of a WP device is beneficial in reducing the SSI rate when compared to standard wound protection in clean-contaminated (OR: 0.63; 95% CI: 0.4–0.99) and contaminated (OR: 0.31; 95% CI: 0.15–0.64) procedures, but not in dirty (OR: 0.22; 95% CI: 0.04–1.21) surgery (Appendix 4, comparisons 2a-c). However, in meta-regression analysis, there was no evidence that the effect differed between clean-contaminated (P=0.244) or contaminated (P=0.305) or dirty (P=0.675) surgery and other surgery.

The body of retrieved evidence focused on adult patients and no study was available in the paediatric population. The literature search did not identify any studies that reported SSI-attributable mortality.

In conclusion, the available evidence can be summarized as follows.

- **WP device vs. standard wound protection** (comparison 1)
  Overall, a very low quality of evidence shows that a single- or double-ring WP device has a benefit in reducing the rate of SSI compared with regular wound protection and retraction.

Of note, the included studies have some limitations. Blinding of care providers was not feasible due to the nature of the intervention and therefore it is likely to be a source of bias. The authors reported an appropriate random sequence generation process in only 4 of the 11 studies *(10-12, 14)*. In addition, only 4 studies described allocation concealment *(8, 11, 12, 14)*. The combined baseline SSI rate of the control group in the studies investigating the single-ring WP device was twice as high as in those investigating the double-ring device. This was believed to be due to differences in participating centres, surgeons, etc. There was considerable asymmetry observed in the funnel plot, compatible with the preferential publication of small studies demonstrating a benefit. SSI definitions and follow-up varied across studies. Although the outcomes of interest are incisional (superficial plus deep) SSIs with the use of a WP device, the type of SSI was reported differently across studies.

6. Other factors considered in the review of studies

The systematic review team identified the following other factors to be considered.

Potential harms

In patients with abdominal adhesions, the insertion of a WP device might be difficult and lead to the need to enlarge the incision, to injuries to the small bowel and to the prolongation of the procedure. There may be also limited space to access the surgical field after insertion of the device. Therefore, the operating surgeon needs to be familiar with handling a WP device during placement, in the operative phase and upon removal.

Values and preferences

No study was found on patient values and preferences with regards to this intervention. Patients will certainly prefer to be treated by surgeons who are familiar with the use of WP devices in order to reduce the risk of complications.

Resource use

Few studies addressed the cost-effectiveness of the intervention. Two small studies found the use of WPs to be cost-effective *(10, 15)*, while one larger trial did not *(18)*. Sookhai and colleagues *(15)* calculated that the use of wound edge protectors would have led to a potential saving of US$ 319 913 at a total cost of US$ 1620 per patient per procedure. Lee and colleagues *(10)* calculated a potential saving of US$ 430 per patient per procedure. Cheng and colleagues *(8)* concluded that UK£ 350 are required to prevent one probable superficial incisional SSI that costs UK£ 117 to treat. However, the authors found the additional costs too difficult to quantify, for example, regular outpatient consultations with medication, repeated travel to the hospital for dressings and absenteeism from work. A cost-effective analysis of a RCT comparing a single-ring WP with standard wound protection showed that the ratio of incremental cost per quality-adjusted life year (QALY) gained was not worthwhile *(18)*. The use of a WP device was more costly and equally effective compared to standard care, but there was significant uncertainty around incremental costs and QALYs.

7. **Key uncertainties and future research priorities**

The systematic review team identified the following key uncertainties and future research priorities.

The prevalence of mostly low quality small studies highlights the need for properly designed multicentre RCTs. The SSI outcome should be defined according to the United States Centers for Disease Prevention and Control criteria and subspecified as superficial, deep and organ/space occupying. Specific and relevant surgical procedures should be included regarding the level of wound contamination and the rate of incisional SSI, for example, colorectal surgery and laparotomy for peritonitis. Investigators should consider comparing single- with double-ring WP devices. Trials should report adverse events related to the intervention. Cost-effectiveness studies are also needed.

APPENDICES

Appendix 1: Search terms

Medline (through PubMed)

1 "surgical wound infection"[Mesh] OR surgical site infection* [TIAB] OR "SSI" OR "SSIs" OR surgical wound infection* [TIAB] OR surgical infection*[TIAB] OR post-operative wound infection* [TIAB] OR postoperative wound infection* [TIAB] OR wound infection*[TIAB]
2 (wound protect*) OR wound retractor) OR Alexis retractor) OR Alexis wound protector) OR wound protector) OR wound protector device) OR "protective devices"[MeSH Terms]
3 Step 1 AND Step 2
4 "colony count, microbial"[Mesh] or colonization [TIAB] OR transmission [TIAB] OR contamination [TIAB]
5* ((((wound retractor) OR Alexis retractor) OR Alexis wound protector) OR wound protector) OR wound protector device
6 Step 4 AND Step 5
7 Step 3 OR Step 6
8 AND ("1990/01/01"[PDat] : "2014/12/31"[PDat]))

*Excluded protective devices (mesh) due to the large amount of extra not relevant hits (1600)

EMBASE

1. surgical infection/ or (surgical site infection* or SSI or SSIs or surgical wound infection* or surgical infection* or post-operative wound infection* or postoperative wound infection*).ti,ab, kw.
2. wound retractor.mp. or exp retractor/ OR wound protector.mp. OR protective device.mp. or exp protective equipment/ OR Alexis retractor.mp.
3. Step 1 AND Step 2
4. surgery.ti,ab,kw.
5. colony count, microbial.ti,ab,kw. OR colonization.ti,ab,kw. OR contamination.ti,ab,kw. OR transmission.ti,ab, kw.
6. Step 2 AND Step 4 AND Step 5
7. Step 3 OR Step 6
8. limit 7 to yr="1990 - current"

CINAHL

S1. MH "wound infection+") OR "wound infection" OR (MH "surgical wound infection")
S2. (MH "surgical instruments") OR (MH "surgical mesh") OR "wound protector" OR "wound retractor"
S3. S2 AND S1

Cochrane CENTRAL

1. wound infection:ti,ab,kw
2. surgical wound infection:ti,ab,kw

3. wound protector OR wound retractor OR (protective device AND surgery) OR wound protection
4. 1 or 2
5. 4 AND 3

WHO Global Regional Medical Databases

((SSI) OR (surgical site infection) OR (surgical site infections) OR (wound infection) OR (wound infections)) AND ((wound protector) OR (wound retractor) OR (protective device) OR (wound protection)

ti: title; ab: abstract; kw: keyword

Appendix 2: Evidence tables

Appendix 2a: Studies related to single-ring wound protectors

Author, year, references	Study design/setting	Population, type of surgery, approach, timing	Type of wound included	Intervention	Comparison	Outcome - SSI definitions	Results	Limitations
Baier, 2012 *(7)*	RCT single centre university hospital. Germany	199 patients Colorectal for malign and benign colorectal diseases. No appendectomy or ostomy reduction. Laparotomy and laparoscopy-assisted surgery. Elective antibiotic prophylaxis, skin preparation and sterile draping were standardized.	Groups: 1. clean-contaminated 2. contaminated 3. dirty	n=98 3M Steri-Drape™ (3M, St Paul, MN; USA) with ring (3 sizes according to the length of the incision).	Standard measures and wet cloth towel (n=101)	Incisional CDC criteria Follow-up 30 days (early discharge patients contacted by telephone at day 30)	I: 20/98 (20%) (superficial SSI: 17/98; deep SSI: 3/98) C: 30/101 (29.7%) (superficial SSI: 22/101; deep SSI: 8/101) *P* > 0.05 for all SSIs. OR not provided Lost to follow-up: 33 In a subgroup of patients with contaminated or dirty surgery (n=116): I: 10/116 C: 23/116 *P* <0.05 In a multivariate analysis, wound classification was not a a risk factor.	Underpowered study: the authors calculated the sample size from a study with 3 times more patients and an expected high effect of 75% SSI decrease. 33 previously included patients were also excluded from the analysis because of reoperation/ complications different from SSI. The authors simply removed them from the analysis. No intention-to-treat analysis, no reporting of adverse events.

Brunet, 1994 *(17)*	Quasi-RCT single centre November 1991-November 1992 France	149 patients Abdominal - laparotomy - elective/urgent.	Groups: 1. clean 2. contaminated 3. dirty	n=73 Adhesive plastic with ring (3 sizes to adequately encompass the incision).	n=76 Not specified	Incisional SSI: non-CDC criteria; pus oozing from the wound. Follow-up: up to 1 month after surgery.	I: 6/73 (8.2%) C: 18/76 (23.7%) *P*=0.01 No OR or RR reported SSI rate per group: 1: 0/17 (0%) vs. 3/15 (20%) *P*=0.09 2: 5/50; 10% vs. 10/53 (18.9%) *P*=0.2 3: 1/6; 17% vs. 5/8 (62.5%) *P*=0.12	Published in a non-indexed journal. Although there are significant differences, the quality of the study is poor and adverse events and standard measures are not specifically described. Two patients excluded because of technical difficulties in placing the wound ring protector, but unclear if patients were removed from the analysis. Antibiotic prophylaxis was given in elective cases only for colorectal procedures. No significant differences between groups, probably because the

								study was underpowered.
Mihaljevic, 2014 *(11)*	RCT multicentre 16 hospitals September 2010-November 2012 Germany	546 patients Mean age, 68 years Abdominal – laparotomy - elective.	Groups: *A priori* 1. clean 2.clean-contaminated (clean, clean-contaminated, contaminated and dirty at the final analysis)	n=274 3M Steri-Drape™ with ring.	n=272 Surgical towels	SSI: CDC criteria Follow-up: external monitoring. Up to 45 days fixed (2,4,6 and 8) and in between periods (10 to 14 and 30 to 45). Lost to follow-up: 46 (all included in the intention-to-treat analysis). Overall mortality (deaths): I: 7 C: 4 Not attributable to study.	Overall SSI **Intention-to-treat analysis** I: 53/300 (17.7%) C: 74/294 (25.5%) OR: 0.64 (95% CI : 0.43-0.95) *P*=0.026 **Complete case analysis** I: 27/274 (9.9%) C: 52/272 (19.1%) OR: 0.46 (95% CI: 0.28-0.76) *P*=0.002 **Per protocol analysis** I: 25/240 (10.4%) C: 52/267 (19.5%) OR: 0.48 (95% CI: 0.29-0.8) *P*=0.005 **Subgroup analysis:** for clean contaminated/	No information about how surgeons and the surgical team (nurses, assistants) handle surgical field protectors /towels when contaminated at some point during the surgical procedure.

							contaminated I: 26/225 (11.6%) C: 47/221 (21.3%) OR: 0.48 (95% CI: 0.29-0.81) *P*=0.006	
Pinkney, 2013 *(12)*	RCT multicentre 21 hospitals February 2010-January 2012 UK	735 patients Median age: I: 66.4 years C: 64.2 years Abdominal Laparotomy - elective/urgent	Groups: 1. clean 2. clean-contaminated 3. contaminated 4. dirty	n=369 (382 randomized; 376 received laparotomy; 7 lost to follow-up.) 3M Steri-Drape™ with ring (3 sizes available).	n=378 (378 randomized; 373, received laparotomy, 7 lost to follow-up.) Surgical towels (surgeon decision)	Incisional SSI (superficial): CDC criteria. Follow-up: on days 5 to 7 or at discharge, then on days 30 to 33. For those patients unable to come to the hospital, home visits were planned. Among the total patients initially assessed for eligibility, 118 were excluded (reasons well defined) prior to randomization. Lost to follow-up: 14 (7 in each group).	I: 91/369 (24.7%) C: 93/366 (25.4%) OR: 0.97 (95% CI: 0.69-1.36) *P*=0.85 Assuming the maximum benefit from the intervention in *post hoc* sensitivity analysis: OR: 0.77 (95% CI: 0.54-1.09) *P*=0.14 SSI rate (degree of wound contamination) 1: 8/24 (33.3%) C: 7/29 (24.1%) **2**: I: 61/269 (22.7%) C: 63/263 (24%) **3**: I: 10/48; (20.8%)	SSI not classified other than superficial. Authors reported the rate of superficial incisional infection; no data provided on the overall SSI rate. No information about how surgeons and surgical team (nurses, assistants) handle visibly contaminated surgical field protectors in either group.

							C: 15/48 (31.3%) **4**: I: 12/28 (42.9%) C: 7/25 (28%) Length of stay (median of days): I: 9 (IQR: 6-15) C: 9 (IQR: 6-14) *P*=0.83 Overall mortality: no difference I: 8 (2.13%) C: 12 (3.21%)	
Redmond, 1994 *(13)*	RCT single centre university hospital Ireland	213 patients Mean age: 60 years Gastrointestinall aparotomy - elective/urgent. Antibiotic prophylaxis and skin preparation standardized.	Groups: 1. clean-contaminated 2. contaminated 3. dirty	n=102 WP not specified, poor description.	n=111 “received no protection”.	Incisional SSI: non-CDC criteria; purulent discharge or bacterial growth in wound samples. Follow-up at postoperative days 5-10 and 30.	I: 11/102 (10.8%) C: 27/111 (24.3%) *P*<0.05 OR not provided SSI rate per group: **1**: I: 6/75 (8%) C: 9/85 (10.58%) **2**: I: 3/21 (14.28%) C: 10/18 (55.5%) **3**: I: 2/6 (33.3%) C: 8/8 (100%)	Study published as an abstract A great amount of information on the methodology is lacking.

Sookhai, 1999 *(15)*	RCT, single centre, university hospital Ireland	352 patients Abdominal laparotomy- not specified Antibiotic prophylaxis and skin preparation standardized.	Groups: 1. clean-contaminated 2. contaminated 3. dirty	n=170 Single-ring WP "wound protector with a plastic ring placed inside the peritoneal cavity" – "impermeable plastic drape with four adhesive patches".	n=182 No WP	Incisional SSI: non-CDC criteria Presence of a purulent discharge, a culture positive at discharge, pain/tenderness, localized swelling, erythema or cellulitis occurring within 30 days of surgery. 30-day follow-up.	I: 23/170 (13.5%) C: 54/182 (29.6%) OR adjusted for degree of wound contamination: 0.31 (95% CI: 0.16-0.60) *P* <0.001 OR for each group: **1**: 0.52 (95% CI: 0.22-1.20) I: 9/129; C: 17/134 **2**: 0.16 (95% CI: 0.05-0.48) I: 8/33 C: 20/30 **3**: 0.18 (95% CI: 0.01-2.31) I: 6/8 C: 17/18	Not indicated how patients lost to follow-up were handled-RCT published as a letter in *The Lancet*. Randomization sequence generation not defined. Intention-to-treat analysis not performed.

RCT: randomized controlled trial; WP: wound protector; CDC: Centers for Disease Prevention and Control; I: intervention; C: control; SSI: surgical site infection; OR: odds ratio; CI: confidence interval; RR: risk reduction; IQR: interquartile range.

Appendix 2b: Studies related to double-ring wound protectors

Author, year, reference	Study design/setting	Population, type of surgery, approach, timing	Type of wound included	Intervention	Comparison	Outcome - SSI definitions	Results Incisional – SSI rate	Limitations
Cheng, 2012 *(8)*	RCT single centre university hospital November 2008-November 2010 Malaysia	64 patients Colorectal laparotomy - elective Bowel preparation only for ultra-low anterior resection with protective ileostomy.	Group: clean-contaminated	n=34 Alexis-O double-ring WP (single size up to 17 cm in length)	n=30 Wound packing and standard retractor	Incisional SSI: CDC criteria 30-day follow-up.	I: 0/34 (0%) C: 6/30 (20%) *P*=0.006 OR not provided Lost to follow-up: 8	3 cases per month in a a university hospital department: restricted/low rate of recruitment. The number of procedures per surgeon is not provided: potential bias might be derived from such a possible imbalance if poor performers are in the standard group. A maximum incision length of 17 cm allowed for in the WP. No specific limitation for the standard procedure. No statement about adverse events.

								No statement about handling of patients lost to follow-up/intention-to-treat.
Horiuchi, 2007 *(9)*	RCT single centre university hospital September 2003-August 2004 Japan	221 patients Gastrointestinal surgery laparotomy - not specified They stated "open non-traumatic colorectal and gastric surgery". Excluded: gastrointestinal perforations. Groups: gastric colorectal, hepato-pancreato-biliary other. Antibiotic prophylaxis standardized according to type of surgery. Bowel	Group: clean-contaminated	n=111 Alexis®-O double-ring WP (Applied Medical, Rancho Santa Margarita, CA, USA) Gastric (n=37) colorectal (n=40) hepato-pancreato-biliary (n=23) other (n=11)	n=110 Wound margin left untreated Gastric (n=36) colorectal (n=52) hepato-pancreato-biliary (n=18) other (n=4)	Incisional SSI: CDC criteria Follow-up unclear	SSI - incisional I: 0/111 (0%) C: 9/110 (8.1%) *P*= 0.002 SSI total I: 8/111 (7.2%) C: 16/110 (14.5%) SSI total: I: 8/111 (7.2%) C: 7/110 (6.3%) Analysis for colorectal surgery: difference for incisional SSI found. I: 0/40 (0%) C: 7/52 (13.4%) *P*= <0.05 Length of stay: I: 34.4 days C: 33.8 days Deaths following anastomotic	No method of concealment described or follow-up period. Within the colorectal surgery: no description of the degree of wound contamination.

		preparation for colorectal surgery.					leakage: I: 2 vs. C: 1	
Lee, 2009 *(10)*	RCT single centre community teaching hospital May 2006- May 2008 USA	109 patients Appendiceal surgery McBurney laparotomy - urgent Groups were comparable for "degree of appendicitis at time of operation". Antibiotic regimen was standardized (preoperative, simple application, complicated application, ruptured).	Group: dirty	n=61 Alexis®-O double-ring WP (small size, 2.5-6 cm) "..degree of appendicitis at time of operation": acute (n=28) suppurative (n=11) gangrenous (n=7) perforated (n=15)	n=48 Regular wound retractors "..degree of appendicitis at time of operation": acute (n=23) suppurative (n=7) gangrenous (n=4) perforated (n=14)	Incisional SSI: not CDC criteria "significant subcutaneous SSI" necessitating wound opening or treatment with antibiotics. Included patients prescribed a separate course of antibiotics after discharge from the hospital. Follow-up: 21 days	I: 1/61(1.6%) C: 7/48 (14.6%) *P*=0.02 I: Perforated (n=1) C: Acute (n=2) Suppurative (n=1) Perforated (n=4) OR not provided Lost to follow-up: 1 Patients withdrawn: 3	Study SSI definition: it is quite common that patients operated for a complicated appendicitis receive an additional antibiotic treatment, regardless of the postoperative outcome. However, there is a risk that a patient with an uneventful postoperative course could be classified in the SSI incisional infection group because of the postoperative antibiotic treatment. No description of the size of the

								incision. No data on adverse events. No statement about handling of patients lost to follow-up/intention-to-treat.
Reid, 2010 *(14)*	RCT multicentre 4 hospitals January 2007-June 2008 Australia	130 patients (mean age, 63 years) Colorectal (benign and malign) surgery. Laparotomy - elective	Group: clean-contaminated	n=64 Alexis®-O double-ring WP	n=66 Regular wound retractors Of note, it is not clear if some additional protection was used and placed in between the regular retractors and the wound incision	Incisional SSI: CDC criteria Follow-up: 30 days	I: 3/64 (4.69%) C: 16/66 (22.7%) *P*=0.004 OR not provided Number needed to treat to prevent 1 SSI: 6 (95% CI: 3.4-15) Absolute risk reduction of 18.04% by employing a WP Mean length of stay: I: 13.7 days C: 12.3 days Lost to follow-up: 5 (3 protocol violations, 2	8 different surgeons were involved; the proportion of operations was unequally distributed among all surgeons. Bowel preparation plus surgical technique depending on surgeon. 5 patients excluded from the analysis; 2 deaths and 3 protocol violations. No clear statement regarding death as an adverse event. No statement about handling of patients lost to

							deaths)	follow-up/intention-to-treat. The authors report one organ/space infection in each group and 2 anastomotic leaks in the intervention group (unclear whether the patients had also incisional SSI or not).
Theodoridis, 2011 *(16)*	RCT single centre university hospital January 2008-July 2008 Greece	231 patients C-section Pfanestiel laparotomy - elective or urgent-emergent Both arms have the same antibiotic prophylaxis after cord clamping - 2 doses up to a maximum of 24 hours	Group: clean-contaminated	n=115 Alexis®-O double-ring WP	n=116 Regular wound retractors (no additional potection provided)	Incisional SSI: not CDC criteria Wound dehiscence, pain or tenderness at the lower abdomen, localized swelling, redness and heat or purulent discharge from the wound. Follow-up unclear.	I: 0/115 (0%) C: 3/116 (2.6%) *P*: 0,006 No OR provided	Unclear process of randomization and blinding. No data are provided on follow-up, adverse events, intention-to-treat analysis and blind assessment.

SSI: surgical site infection; RCT: randomized controlled trial; WP: wound protector; CDC: Centers for Disease Prevention and Control; I: intervention; C: control; SSI: surgical site infection; OR: odds ratio; CI: confidence interval.

Appendix 3. Risk of bias assessment of the included studies

Type of study	Author, year, reference	Random sequence generation	Allocation concealment	Blinding of participants	Blinding for care providers	Blinding of outcome assessment	Incomplete outcome data	Selective outcome reporting	Other sources of bias
Single-ring WP	Baier, 2012 *(7)*	HIGH	UNCLEAR	HIGH	HIGH	UNCLEAR	HIGH	LOW	-
	Brunet, 1994 *(17)*	HIGH[1]	UNCLEAR	LOW	HIGH	HIGH	HIGH	LOW	HIGH[2]
	Mihaljevic, 2014 *(11)*	LOW	LOW	LOW	HIGH	LOW	LOW	LOW	-
	Pinkney, 2013 *(12)*	LOW	LOW	LOW	HIGH	LOW	LOW	LOW	-
	Redmond, 1994 *(13)*	UNCLEAR	UNCLEAR	UNCLEAR	HIGH	LOW	UNCLEAR	LOW	
	Sookhai, 1999 *(15)*	UNCLEAR	UNCLEAR	UNCLEAR	HIGH	LOW	UNCLEAR	UNCLEAR	-
Double-ring WP	Cheng, 2012 *(8)*	UNCLEAR	LOW	LOW	HIGH	UNCLEAR	LOW	HIGH	HIGH[3]
	Horiuchi, 2007 *(9)*	UNCLEAR	UNCLEAR	UNCLEAR	HIGH	LOW	UNCLEAR	UNCLEAR	-
	Lee, 2009 *(10)*	LOW	UNCLEAR	LOW	HIGH	LOW	LOW	LOW	-
	Reid, 2010 *(14)*	LOW	LOW	LOW	HIGH	LOW	LOW	LOW	HIGH[4]
	Theodoridis, 2011 *(16)*	UNCLEAR	UNCLEAR	UNCLEAR	HIGH	UNCLEAR	UNCLEAR	LOW	-

1: Quasi-randomized controlled trial.

2: Antibiotic prophylaxis was given in elective cases only for colorectal operations.

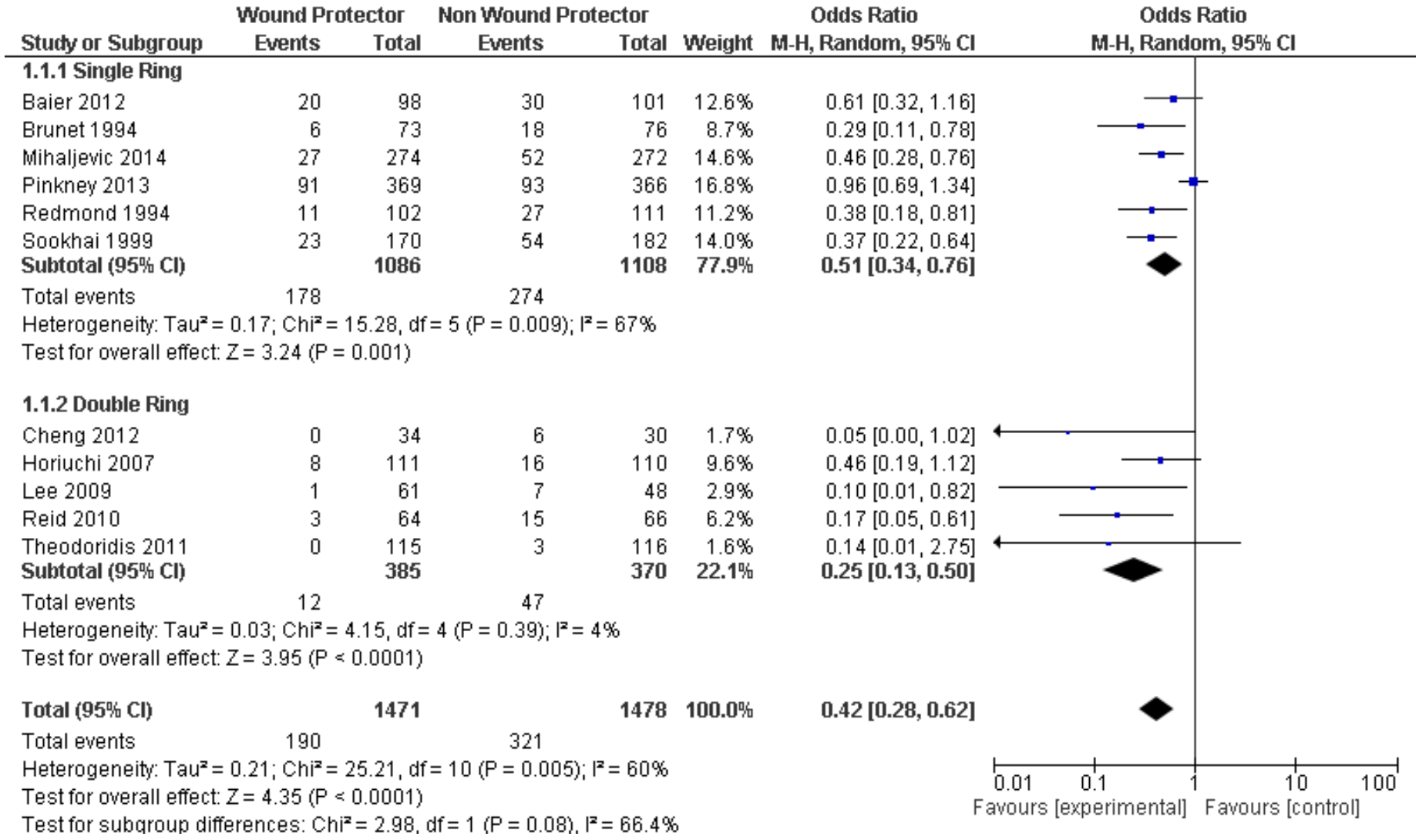
3: 3 cases per month in a university hospital department: restricted/low rate of recruitment. The number of procedures per surgeon is not provided, thus a potential bias might be derived from such a possible imbalance if poor performers are in the standard group.

4: The proportion of operations was unequally distributed among all surgeons who participated in the study. The surgeon may contribute to different SSI rates.

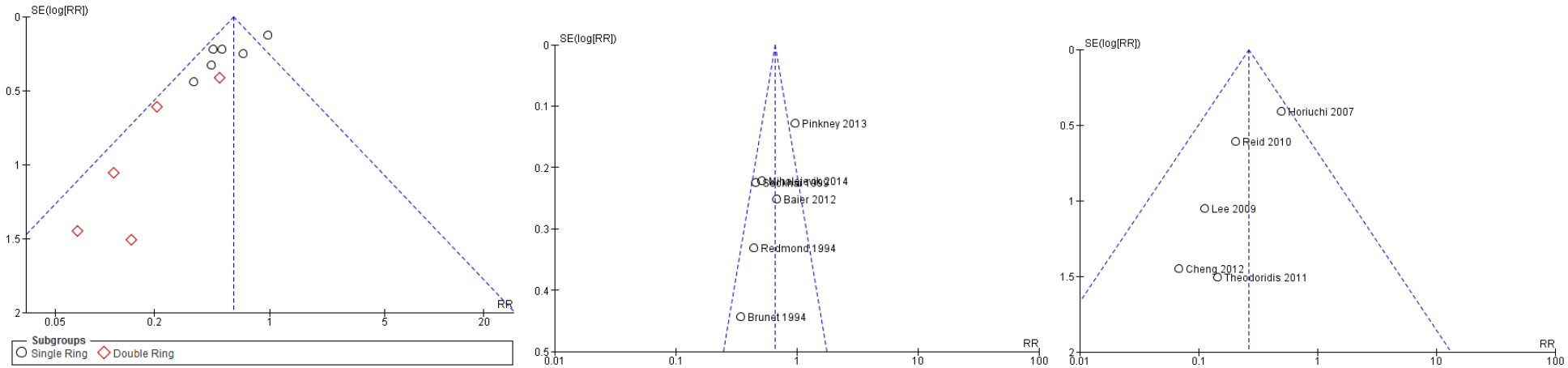
WP: wound protector

Appendix 4: Comparisons

Comparison 1: Wound protector device (single- and double-ring) vs. conventional wound protection in abdominal surgery - SSI outcome



Funnel plot 1: Overall included studies (left) and studies on single- (middle) and double- (right) ring wound protectors



SSI: surgical site infection; M-H: Mantel-Haenszel; CI: confidence interval.

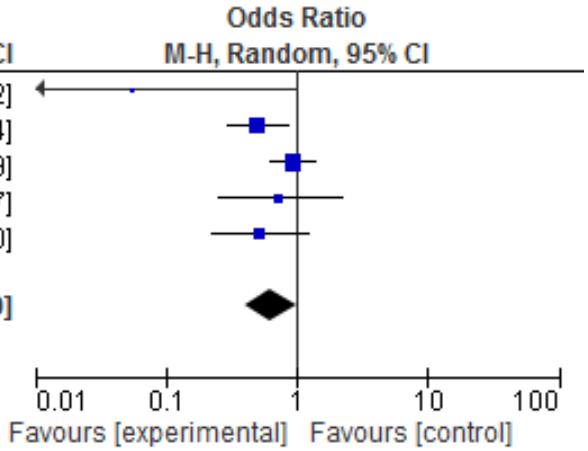
Comparison 2: Wound protector vs. no wound protector. Subgroup analysis of degree of wound contamination (clean-contaminated, contaminated and dirty) - SSI outcome

Comparison 2a: Clean-contaminated surgery

Study or Subgroup	Experimental Events	Experimental Total	Control Events	Control Total	Weight	Odds Ratio M-H, Random, 95% CI
Cheng 2012	0	34	6	30	2.3%	0.05 [0.00, 1.02]
Mihaljevic 2014	26	220	46	217	30.3%	0.50 [0.30, 0.84]
Pinkney 2013	61	269	63	263	36.4%	0.93 [0.62, 1.39]
Redmond 1994	6	75	9	85	12.9%	0.73 [0.25, 2.17]
Sookhai 1999	9	129	17	134	18.2%	0.52 [0.22, 1.20]
Total (95% CI)		**727**		**729**	**100.0%**	**0.63 [0.40, 0.99]**
Total events	102		141			

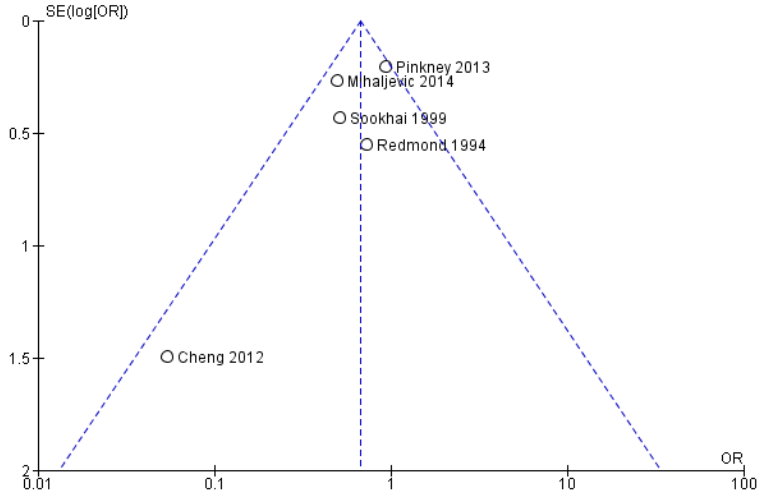
Heterogeneity: $Tau^2 = 0.10$; $Chi^2 = 7.03$, df = 4 (P = 0.13); $I^2 = 43\%$

Test for overall effect: Z = 2.02 (P = 0.04)



SSI: surgical site infection; M-H: Mantel-Haenszel (test); CI: confidence interval.

Funnel plot 2a: Clean-contaminated surgery

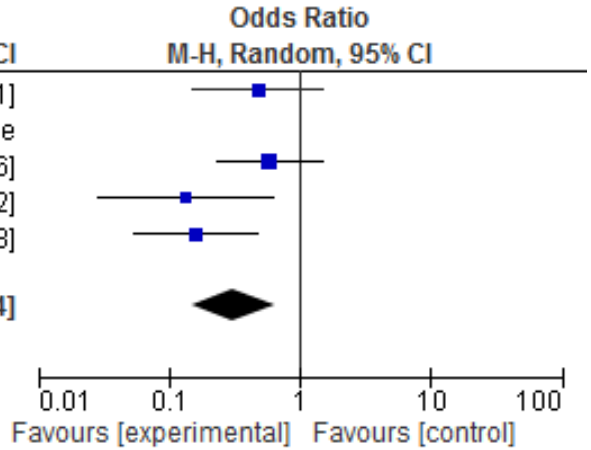


Comparison 2b: Contaminated surgery

Study or Subgroup	Experimental Events	Experimental Total	Control Events	Control Total	Weight	Odds Ratio M-H, Random, 95% CI
Brunet 1994	5	50	10	53	24.9%	0.48 [0.15, 1.51]
Mihaljevic 2014	0	5	0	3		Not estimable
Pinkney 2013	10	48	15	48	32.0%	0.58 [0.23, 1.46]
Redmond 1994	3	21	10	18	16.7%	0.13 [0.03, 0.62]
Sookhai 1999	8	33	20	30	26.4%	0.16 [0.05, 0.48]
Total (95% CI)		**157**		**152**	**100.0%**	**0.31 [0.15, 0.64]**
Total events	26		55			

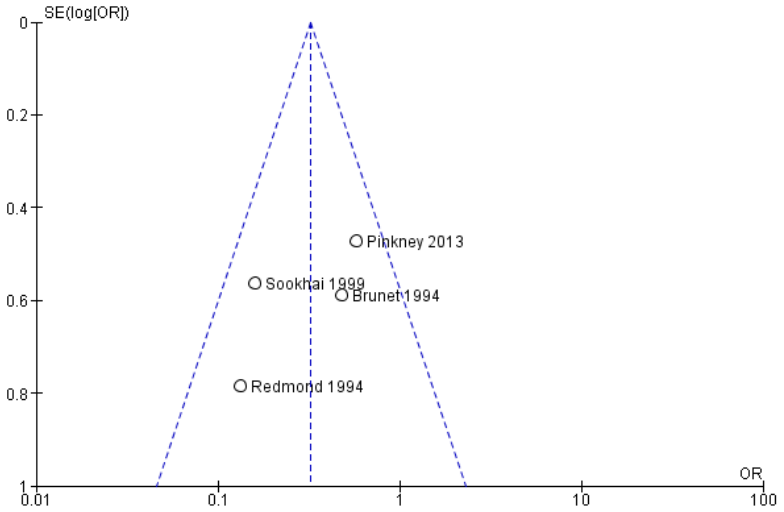
Heterogeneity: Tau² = 0.21; Chi² = 4.81, df = 3 (P = 0.19); I² = 38%

Test for overall effect: Z = 3.18 (P = 0.001)



M-H: Mantel-Haenszel (test); CI: confidence interval

Funnel plot 2b: Contaminated surgery

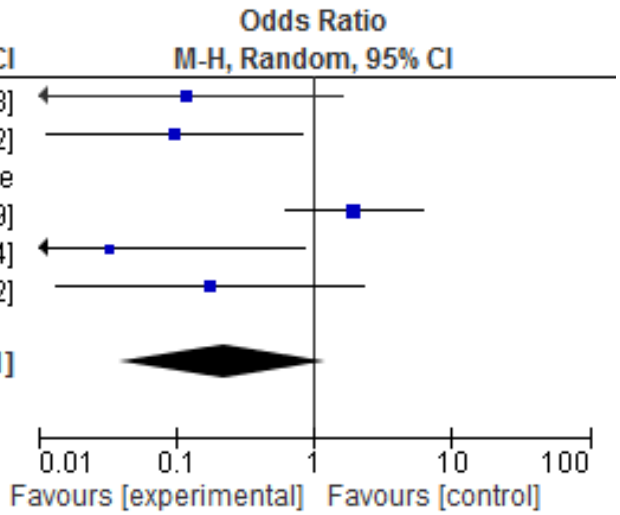


Comparison 2c: Dirty surgery

Study or Subgroup	Experimental Events	Experimental Total	Control Events	Control Total	Weight	Odds Ratio M-H, Random, 95% CI
Brunet 1994	1	6	5	8	18.3%	0.12 [0.01, 1.58]
Lee 2009	1	61	7	48	21.1%	0.10 [0.01, 0.82]
Mihaljevic 2014	0	0	1	1		Not estimable
Pinkney 2013	12	28	7	25	27.5%	1.93 [0.61, 6.09]
Redmond 1994	2	6	8	8	14.7%	0.03 [0.00, 0.84]
Sookhai 1999	6	8	17	18	18.3%	0.18 [0.01, 2.32]
Total (95% CI)		**109**		**108**	**100.0%**	**0.22 [0.04, 1.21]**
Total events	22		45			

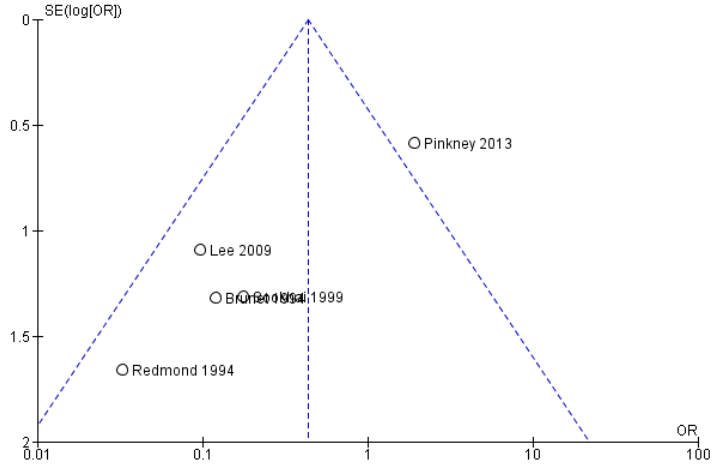
Heterogeneity: Tau² = 2.43; Chi² = 12.20, df = 4 (P = 0.02); I² = 67%

Test for overall effect: Z = 1.74 (P = 0.08)



M-H: Mantel-Haenszel (test); CI: confidence interval

Funnel plot 2c: Dirty surgery



Appendix 5: Grade tables

Comparison 1: Wound protector device vs. conventional wound protection

Quality assessment							№ of patients		Effect		Quality
№ of studies	**Study design**	**Risk of bias**	**Inconsistency**	**Indirectness**	**Imprecision**	**Other considerations**	**Wound protector device**	**No wound protector**	**Relative (95% CI)**	**Absolute (95% CI)**	
Surgical site infections: all studies											
11	RCTs	Serious [1]	Serious [2]	Not serious	Not serious	Publication bias strongly suspected [5]	190/1471 (12.9%)	321/1478 (21.7%)	**OR: 0.42** (0.28-0.62)	**113 fewer per 1000** (from 70 fewer to 145 fewer)	⊕◯◯◯ VERY LOW
Surgical site infections: single-ring wound protector only											
6	RCTs	Serious [1]	Serious [3]	Not serious	Not serious	None	178/1086 (16.4%)	274/1108 (24.7%)	**OR: 0.51** (0.34-0.76)	**104 fewer per 1000** (from 47 fewer to 147 fewer)	⊕⊕◯◯ LOW
Surgical site infection: double-ring wound protector only											
5	RCTs	Serious [1]	Not serious	Not serious	Serious [4]	None	12/385 (3.1%)	47/370 (12.7%)	**OR: 0.25** (0.13-0.50)	**92 fewer per 1000** (from 59 fewer to 108 fewer)	⊕⊕◯◯ LOW

1. Risk of selection bias.
2. High heterogeneity, I^2 =60%.
3. High heterogeneity, I^2 =70%.
4. Optimal information size not met.
5. Although not a large number of studies, there is a considerable asymmetry in the funnel plot.

SSI: surgical site infection; RCT: randomized controlled trial; OR: odds ratio; CI: confidence interval.

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