BMJ Open The use of triclosan-coated sutures to prevent surgical site infections: a systematic review and meta-analysis of the literature

Imran Ahmed, Adam Jonathan Boulton, Sana Rizvi, William Carlos, Edward Dickenson, NA Smith, Mike Reed

ABSTRACT

Introduction and objectives Surgical site infections (SSIs) represent a common and serious complication of all surgical interventions. Microorganisms are able to colonise sutures that are implanted in the skin, which is a causative factor of SSIs. Triclosan-coated sutures are antibacterial sutures aimed at reducing SSIs. Our objective is to update the existing literature by systematically reviewing available evidence to assess the effectiveness of triclosan-coated sutures in the prevention of SSIs.

Methods A systematic review of EMBASE, MEDLINE, AMED (Allied and complementary medicine database) and CENTRAL was performed to identify full text randomised controlled trials (RCTs) on 31 May 2019.

Intervention Triclosan-coated sutures versus non-triclosan-coated sutures.

Primary outcome Our primary outcome was the development of SSIs at 30 days postoperatively. A meta-analysis was performed using a fixed-effects model.

Results Twenty-five RCTs were included involving 11 957 participants. Triclosan-coated sutures were used in 6008 participants and non triclosan-coated sutures were used in 5949. Triclosan-coated sutures significantly reduced the risk of SSIs at 30 days (relative risk 0.73, 95% CI 0.65 to 0.82). Further sensitivity analysis demonstrated that triclosan-coated sutures significantly reduced the risk of SSIs in both clean and contaminated surgery.

Conclusion Triclosan-coated sutures have been shown to significantly reduced the risk of SSIs when compared with standard sutures. This is in agreement with previous work in this area. This study represented the largest review to date in this topic area. This moderate quality evidence recommends the use of triclosan-coated sutures in order to reduce the risk of SSIs particularly in clean and contaminated surgical procedures.

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INTRODUCTION

Surgical site infections (SSIs) represent a common complication throughout all surgical procedures.1 It is estimated that SSIs account for 5% of all surgical complications2 and 20% of all healthcare-associated infections.3 4 It is generally believed that the number of surgical procedures, particularly in elective orthopaedics,5 will increase over the next decade, therefore increasing the incidence of SSIs. SSIs are associated with prolonged hospital admission6 and increased morbidity and mortality.7 8 In addition to having a significant impact on patient care and experience, SSIs also add substantial costs to healthcare providers. It is estimated that SSIs cost UK healthcare services approximately £61 million in 20129 10 and figures from the US highlight the extensive cost of SSIs with an estimated additional US$2300 per case.11 Furthermore, Fleck et al12 found that the mean cost of treated a SSI following sternal wound incision was US$11 200.12 These are conservative estimates as active surveillance of SSIs not routinely performed.6

Due to the wide ranging deleterious effects of SSIs and their treatment, particularly in the context of increasing numbers of surgical procedures, there is a clinical need to reduce the incidence of SSIs. SSIs are multifactorial with patient factors such as age, comorbidities including diabetes, and immunosuppression13-15 contributing to their development, along with surgical factors. Many patient factors may not be optimised and hence research focus has been placed on surgical factors, including suture material.

SSIs may arise when bacteria colonise the suture material,16 creating a biofilm as it
passes through the skin.\(^{17}\) This biofilm establishes an immunity from both antimicrobial treatment and the host immune system.\(^{17}\) Once this biofilm develops there is an increased chance of a SSI developing. Research has shown bacteria may colonise monofilament and braided sutures.\(^{18-20}\) With this in mind, considerable work has been carried out since the 1950s with regards to coating suture material with an antimicrobial, including silver.\(^{21-22}\)

Triclosan (polychlorophenoxyphenol) has been used for its antiseptic properties for many years in toothpaste and soap and has an established safety profile.\(^{5}\) Triclosan has been used to successfully coat the following sutures and gained US food and drug administration approval in 2002: braided polyglactan 910 (Vicryl Plus), poliglecaprone 25 (Monocryl Plus) and polydioxanone (PDS Plus).

In vitro and in vivo studies have shown the effectiveness of triclosan-coated sutures\(^{23-25}\) in killing bacteria associated with SSIs and inhibiting colonisation of suture material, with one study demonstrating a 66% reduction in bacterial colonisation.\(^{26}\) Since then a large number of randomised controlled trials (RCTs) have been performed with contrasting results of the effectiveness of triclosan-coated sutures in the prevention of SSIs. Subsequent meta-analyses have also produced conflicting results and hence the true effect remains unclear.\(^{6,7,27-32}\) The most recent and largest systematic review to date was performed by de Jonge et al and found triclosan-coated sutures significantly reduced the incidence of SSIs.\(^{32}\) This review searched the literature up until November 2015 and included 6462 patients from RCTs published in peer-reviewed journals as well as conference abstracts. Performing robust methodological appraisal of conference abstracts is not possible, they do not permit thorough risk of bias assessments, and as they have not undergone the formal journal peer-review process, they represent a potentially biased and unreliable source of data. Since this review, a number of large, high-quality RCTs have been produced.\(^{33,34}\) Of note, a recent RCT of 2546 patients found that triclosan-coated sutures did not reduce the incidence of SSIs; a finding in contrast to the previous systematic review.\(^{32,34}\) This represents a substantial increase in the number of patients available for meta-analysis since the last review. As a result, we believe it is important to update the existing literature by performing a new, up to date, systematic review and meta-analysis to assimilate the current evidence and inform clinical practice. A new review should include a detailed risk of bias assessment and GRADE (Grading of Recommendations Assessment, Development and Evaluation) assessment of the quality of evidence.

This new systematic review and meta-analysis of the available literature aims to determine whether the use of triclosan-coated sutures reduces the incidence of SSIs in comparison to standard non-coated sutures.

**PICOS (Participants, Intervention, Comparator, Outcomes and Study design) statement**

The included population encompasses patients of any age and gender undergoing any surgical procedure utilising sutures to close the wound. The intervention studied is the use of triclosan-coated sutured and comparison is made with non-triclosan-coated sutures. The outcomes assessed are the rates of SSIs, including superficial and deep SSIs. This systematic review will only include RCTs.

**METHODS**

A systematic review of the available literature was conducted and is reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidance.\(^{35}\) A protocol for this review was prospectively registered with PROSPERO.

**Search methods**

Electronic searches were conducted using OVID SP on the following databases: MEDLINE (1946–May Week 4 2019); Excerpta Medica Database (EMBASE) (1974–2019 May 31); Allied and Complementary Medicine (AMED) (1985–May 2019); and Cochrane Central Register of Controlled Trials (CENTRAL). A multipurpose search was performed for all terms and the search terms were: ‘Triclosan’, ‘Anti-bacterial agents’, ‘Anti-infective agents, local’, ‘Coated materials, biocompatible’, ‘Biomimetic material’, ‘Sutures’, ‘Vicryl Plus’, ‘Monocryl Plus’, ‘PDS Plus’, ‘Surgical site infection’, ‘Surgical Wound infection’. The search was conducted on 31 May 2019. A copy of the search strategy can be seen in online supplementary file 1.

**Selection of studies**

Two authors (IA and AJB) independently selected studies for inclusion. Any discrepancies were resolved by discussion with a third author (ED). Titles and abstracts were screened and full texts obtained for any studies of interest. The eligibility criteria were formed from the PICOS statement and registered on PROSPERO prior to undertaking the search. Only RCTs published in peer-reviewed journals presenting new data were included.

**Data extraction**

Data were independently extracted from eligible included studies onto predetermined forms by two authors (IA and AJB). Any discrepancies were then resolved following discussion between two authors (IA and AJB) and a third author. Data extracted included baseline patient characteristics, surgical procedures performed, number of centres, suture material, SSI diagnostic criteria, length of follow-up, routine prophylactic antibiotic use and number of SSIs. Data regarding superficial of deep SSI was extracted when possible. Information regarding randomisation, blinding, funding and country of origin was extracted.
Assessment of risk of bias
Two authors (IA and AJB) independently appraised eligible studies according to the Cochrane Collaboration’s risk of bias tool, resolving any discrepancies with a third author (ED) as necessary. Review Manager V.5.3 was used to generate the summary figures. The parameters used for ‘other’ sources of bias included source of funding and antibiotic regime.

Two authors (IA and AJB) independently assessed the quality of evidence. We used the GRADE considerations (study limitations, consistence of effect, imprecision, indirectness and publication bias) to assess the quality of the body of evidence. Decisions to upgrade or downgrade body of evidence have been clearly stated in the discussion.

Publication bias was assessed following construction of a funnel plot in order to identify the presence or absence of bias of this kind.

Statistical analysis
A fixed-effects model was used to calculate the predominant relative risk (RR) and the 95% CIs of the studies included. Statistically heterogeneity was first assessed using a funnel plot and more formally using the $I^2$ statistic. Forest plots were then generated summarising the results of the meta-analysis using Review Manager V.5.3.

Patient and public involvement
Given the design of this study and the retrospective nature, patient and public members were not involved in the development and conduct of this review. With the aid of patient and public members we will produce lay summaries of the results available for patients.

RESULTS
The search revealed 357 records of possible relevance. No other sources of records were identified. Removal of duplicates left 249 records to be examined. Two hundred and nineteen records were excluded based on title and abstract screening. Thirty full texts were assessed for eligibility and 25 studies were included in the meta-analysis (see figure 1).

![PRISMA flow diagram of search results](http://bmjopen.bmj.com/)

**Figure 1** PRISMA flow diagram of search results. PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses.
**Study characteristics**

Study characteristics are summarised in table 1. Twenty-five RCTs were included in this review involving 11957 patients.2,7 11 33 34 38-57 There were 6008 patients randomised to triclosan-coated sutures and 5949 patients to standard sutures. In studies which reported mean age, the mean age reported in 23 out of 25 studies was comparable between the two groups (54.8 vs 54.8). For the studies which reported gender 57% of the included patients were male. Eight studies were multicentre, with the remainder single-centre studies (n=17). Vicryl was compared with Vicryl Plus in 12 studies,2,7 11 33 34 41-44 48-50-57 3 studies compared PDS versus PDS Plus,7,38 55 1 study compared PDS II with PDS II Plus,44 2 study compared Monocryl against Monocryl Plus,45 57 1 compared Chinese silk with Vicryl Plus,53 4 studies compared Vicryl and Monocryl versus Vicryl Plus and Monocryl Plus33 56-52 and 2 studies compared Vicryl and PDS versus Vicryl Plus and PDS Plus.2,42

To define SSI, the centre for disease control (CDC) criteria were used by 18 studies,2,7 11 33 34 41-44 48-50-57 clinical diagnosis or wound cultures was used by 3 studies,38 45 49 and 4 did not provide explicit definitions.39 40 46 47 Seventeen studies used a follow-up duration of 30 days or 1 month or 4 weeks,2,7 11 33 34 38 41-45 46-49 51-53-57 3 for 6 weeks,48 50 52 2 for 2 weeks,44 45 1 for 80 days,40 1 until discharge47 and 1 study did not specify a follow-up regime.39 Routine prophylactic antibiotics were used in 19 studies,7,11 33 34 38 41-45 46-49 51-53-57 no prophylactic antibiotics were used in 1 study,40 1 used prophylactic antibiotics in high-risk patients only,52 1 study used prophylactic antibiotics in 30% of participants33 and 3 did specify prophylactic antibiotic use.41 43 55

**Surgical site infection**

The risk of developing SSI was significantly reduced in the triclosan group compared with the standard suture group (RR 0.73, 95% CI 0.65 to 0.82). Heterogeneity was low to moderate ($\chi^2=24.66, p=0.21, I^2=17\%$). There were 420 instances of SSI among 6008 patients in the triclosan-coated suture group and 581 SSIs in 5949 patients in the standard suture group (see figure 2).

**Subgroup analysis**

Eight studies reported superficial and deep infections separately.7,11 33 34 42 46-51 57 There were 152/3507 cases of superficial SSI in the triclosan group and 164/3626 cases in the standard suture group, producing a meta-analysis risk ratio of 0.95 (95% CI 0.72 to 1.25). The risk of developing a deep infection was lower in the triclosan group when compared with the standard suture group; however, this was not significant (RR 0.77, 95% CI 0.55 to 1.07). There were 61/3507 cases of deep infections in the triclosan group and 85/3626 cases in the standard suture group (see figure 3).

Ten studies reported the incidence of SSI for clean surgery.33 34 39 43 49-53 56 Triclosan-coated sutures were associated with a significantly lower incidence of SSI (149/3029) when compared with standard sutures (250/1117) (RR 0.71, 95% CI 0.58 to 0.88).

Six studies reported clean-contaminated surgery and there was no difference between the two groups (160/1540 vs 156/1504) (RR 1.02, 95% CI 0.83 to 1.25).2,7 40 42 46-54

Four studies reported the incidence of SSIs in contaminated surgery.47 48 55 57 Triclosan-coated sutures were associated with a significantly lower risk of SSI (22/438) when compared with standard sutures (55/443) (RR 0.43, 95% CI 0.27 to 0.7).

Two further studies reported the incidence of SSI for dirty surgery.45 48 There was not a significant difference in the incidence of SSIs between the two groups of sutures (25/102 vs 35/105) (RR 0.74, 95% CI 0.46 to 1.18) (see figure 4).

**Risk of bias**

The results of the risk of bias screening can be seen on figure 2. The majority of studies had a clear randomisation sequence generation and allocation concealment using sealed envelopes. Five out of 25 (20%) had high risk of selection bias, either because the randomisation method was not stated or a quasi-randomisation method was used. Two further studies had a risk of selection bias due to unclear allocation concealment methods. Ten out of 25 studies (40%) had high risk of performance and detection bias due to either absence of blinding of the participants and outcome assessors or the methods of blinding were not stated. Four out of 25 (16%) were at high risk of other bias due to source of funding. One study had differences in antibiotic regime between the two groups, with one group not receiving any antibiotic prophylaxis.

The distribution of studies in the funnel plot was symmetrical. No evidence was found for publication bias in this analysis (figure 5).

Statistical heterogeneity was assessed using the $t^2$ (0.02) test and the $I^2$ (17%) test, indicating there is low heterogeneity between the studies included in this review based on the recommendations in the Cochrane handbook.

**Discussion**

This large systematic review of 25 randomised clinical trials included 11957 patients and there were 1001 instances of SSI. The subsequent meta-analysis supports the use of triclosan-coated sutures in reducing the risk of SSIs. We report a significantly lower risk of SSI when triclosan-coated sutures were used, compared with standard sutures in RCTs. Triclosan-coated sutures were used in a wide range of surgeries, including both adult and paediatric patients. The use of triclosan-coated sutures significantly reduced the risk of SSI in meta-analyses of clean surgery and also contaminated surgery. Further subgroup analysis revealed a non-statistically significant reduction in the risk of developing deep SSIs with triclosan-coated sutures. Triclosan-coated sutures appear to have no effect on the incidence of superficial SSIs.
<table>
<thead>
<tr>
<th>Study</th>
<th>No of participants</th>
<th>No of centres</th>
<th>Surgery type</th>
<th>Sutures used</th>
<th>SSI criteria</th>
<th>Duration of follow-up</th>
<th>Routine prophylactic antibiotics?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arslan et al</td>
<td>177</td>
<td>1</td>
<td>Surgery for pilonidal disease</td>
<td>Vicryl versus Vicryl plus</td>
<td>CDC criteria</td>
<td>30 days</td>
<td>Yes</td>
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<tr>
<td>Baracs et al</td>
<td>385</td>
<td>7</td>
<td>Elective colorectal surgery</td>
<td>PDS versus PDS Plus</td>
<td>Not stated</td>
<td>30 days</td>
<td>Yes</td>
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<tr>
<td>Chen et al</td>
<td>241</td>
<td>1</td>
<td>Head and neck surgery</td>
<td>Vicryl versus Vicryl Plus</td>
<td>Local erythema with purulent discharge, wound dehiscence, or skin necrosis</td>
<td>Not stated</td>
<td>Yes</td>
</tr>
<tr>
<td>Diener et al</td>
<td>1185</td>
<td>24</td>
<td>Laparotomy</td>
<td>PDS versus PDS Plus</td>
<td>CDC criteria</td>
<td>30 days</td>
<td>Yes</td>
</tr>
<tr>
<td>Ford et al</td>
<td>147</td>
<td>1</td>
<td>Paediatric general surgery</td>
<td>Vicryl versus Vicryl Plus</td>
<td>Not stated</td>
<td>80 days</td>
<td>No</td>
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<td>Galal and El-Hindawy</td>
<td>450</td>
<td>1</td>
<td>All surgery</td>
<td>Vicryl versus Vicryl Plus</td>
<td>CDC criteria</td>
<td>30 days</td>
<td>Not stated</td>
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<tr>
<td>Ichida et al</td>
<td>1023</td>
<td>1</td>
<td>Gastroenterological surgery</td>
<td>Vicryl and PDS II versus Vicryl Plus and PDS Plus</td>
<td>CDC criteria</td>
<td>30 days</td>
<td>Yes</td>
</tr>
<tr>
<td>Isik et al</td>
<td>510</td>
<td>1</td>
<td>Cardiac surgery</td>
<td>Vicryl versus Vicryl Plus</td>
<td>CDC criteria</td>
<td>1 month</td>
<td>Not stated</td>
</tr>
<tr>
<td>Justinger et al</td>
<td>856</td>
<td>1</td>
<td>Laparotomy</td>
<td>PDS II versus PDS II Plus</td>
<td>CDC criteria</td>
<td>2 weeks</td>
<td>Yes</td>
</tr>
<tr>
<td>Karip et al</td>
<td>106</td>
<td>1</td>
<td>Pilonidal sinus excision followed by Karydakis flap repair</td>
<td>Monocryl Plus versus Monocryl Plus</td>
<td>Rash, fever or purulent discharge</td>
<td>2 weeks</td>
<td>Yes</td>
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<tr>
<td>Lin et al</td>
<td>102</td>
<td>1</td>
<td>Total knee replacement surgery</td>
<td>Vicryl versus Vicryl plus</td>
<td>CDC criteria</td>
<td>30 days</td>
<td>Yes</td>
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<tr>
<td>Mattavelli et al</td>
<td>300</td>
<td>4</td>
<td>Elective colorectal surgery</td>
<td>Vicryl and PDS versus Vicryl Plus and PDS Plus</td>
<td>CDC criteria</td>
<td>30 days</td>
<td>Yes</td>
</tr>
<tr>
<td>Mingmalairak et al</td>
<td>100</td>
<td>1</td>
<td>Appendectomy</td>
<td>Vicryl versus Vicryl Plus</td>
<td>Not stated</td>
<td>30 days, 6 months and 1 year</td>
<td>Yes</td>
</tr>
<tr>
<td>Nakamura et al</td>
<td>410</td>
<td>1</td>
<td>Elective colorectal surgery</td>
<td>Vicryl versus Vicryl Plus</td>
<td>CDC criteria</td>
<td>30 days</td>
<td>Yes</td>
</tr>
<tr>
<td>Rasic et al</td>
<td>184</td>
<td>1</td>
<td>Elective colorectal cancer surgery</td>
<td>Vicryl versus Vicryl Plus</td>
<td>Not stated</td>
<td>To discharge</td>
<td>Yes</td>
</tr>
<tr>
<td>Renko et al</td>
<td>1633</td>
<td>1</td>
<td>Paediatric surgery</td>
<td>Vicryl and Monocryl and PDS versus Vicryl Plus and Monocryl Plus and PDS Plus</td>
<td>CDC criteria</td>
<td>30 days</td>
<td>In 30%</td>
</tr>
<tr>
<td>Roy et al</td>
<td>110</td>
<td>1</td>
<td>Gastrointestinal surgery</td>
<td>PDS versus PDS plus</td>
<td>CDC criteria</td>
<td>30 days</td>
<td>Yes</td>
</tr>
<tr>
<td>Ruiz-Tovar et al</td>
<td>110</td>
<td>3</td>
<td>Open colorectal surgery with faecal peritonitis</td>
<td>Vicryl versus Vicryl Plus</td>
<td>CDC criteria</td>
<td>60 days</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Continued
<table>
<thead>
<tr>
<th>Study</th>
<th>No of participants</th>
<th>No of centres</th>
<th>Surgery type</th>
<th>Sutures used</th>
<th>SSI criteria</th>
<th>Duration of follow-up</th>
<th>Routine prophylactic antibiotics?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seim et al&lt;sup&gt;69&lt;/sup&gt;</td>
<td>328</td>
<td>1</td>
<td>CABG (Coronary artery bypass graft) leg wound</td>
<td>Vicryl versus Vicryl Plus</td>
<td>Positive bacterial culture and clinical judgement</td>
<td>4 weeks</td>
<td>Yes</td>
</tr>
<tr>
<td>Sprowson et al</td>
<td>2546</td>
<td>3</td>
<td>Primary THR (total hip replacement) or TKR (total knee replacement)</td>
<td>Vicryl versus Vicryl Plus</td>
<td>CDC criteria</td>
<td>30 days</td>
<td>Yes</td>
</tr>
<tr>
<td>Tabrizi et al&lt;sup&gt;64&lt;/sup&gt;</td>
<td>320</td>
<td>2</td>
<td>Dental implant surgery</td>
<td>Vicryl versus Vicryl plus</td>
<td>CDC criteria</td>
<td>30 days</td>
<td>Yes</td>
</tr>
<tr>
<td>Thimour-Bergstrom et al&lt;sup&gt;60&lt;/sup&gt;</td>
<td>392</td>
<td>1</td>
<td>CABG (+/- AVR (aortic valve replacement), MVR (Mitral valve replacement)) with saphenous vein graft</td>
<td>Vicryl and Monocryl versus Vicryl Plus and Monocryl Plus</td>
<td>CDC criteria</td>
<td>60 days</td>
<td>Yes</td>
</tr>
<tr>
<td>Turtiainen et al&lt;sup&gt;51&lt;/sup&gt;</td>
<td>276</td>
<td>3</td>
<td>Non-emergency lower-limb arterial surgery</td>
<td>Vicryl and Monocryl versus Vicryl Plus and Monocryl Plus</td>
<td>CDC criteria</td>
<td>30 days</td>
<td>Yes</td>
</tr>
<tr>
<td>Williams et al&lt;sup&gt;52&lt;/sup&gt;</td>
<td>150</td>
<td>1</td>
<td>Mastectomy</td>
<td>Vicryl and Monocryl versus Vicryl Plus and Monocryl Plus</td>
<td>CDC criteria</td>
<td>6 weeks</td>
<td>If considered at risk</td>
</tr>
<tr>
<td>Zhang et al&lt;sup&gt;53&lt;/sup&gt;</td>
<td>101</td>
<td>6</td>
<td>Mastectomy</td>
<td>Chinese silk versus Vicryl Plus</td>
<td>CDC criteria</td>
<td>30 days</td>
<td>Not stated</td>
</tr>
</tbody>
</table>

CDC, centre for disease control; RCTs, randomised controlled trials.
There have been 11 previous reviews in this topic area, the results of these reviews have been summarised in Table 2.27 28 30–32 58–63 Our results support the findings of Konstantelias et al who concluded that triclosan-coated sutures were associated with a significantly lower risk of SSI when compared with standard sutures.32–61 In addition, the authors concluded that triclosan-coated sutures significantly reduced the risk of SSI in clean, clean-contaminated and contaminated surgery; in agreement with our findings.61 de Jonge et al reported a meta-analysis of 21 RCTs including 6462 patients, also concluding that triclosan-coated sutures significantly reduced the risk of SSI compared with standard sutures.32 Five out of 11 reviews included a risk of bias assessment27 31 32 59 63 and only one review assessed the quality of evidence using the GRADE criteria.59

### Figure 2

A meta-analysis of all studies included in this review. The forest plot is comparing triclosan coated sutures vs standard sutures on risk of developing surgical site infection. On the right of the figure a summary of our risk of bias assessment can be seen.

### Figure 3

Subgroup analysis comparing triclosan coated sutures versus standard sutures on the risk of developing superficial and deep infections.
Figure 4  
Subgroup analysis comparing triclosan coated sutures versus standard sutures on the risk of developing surgical site infections in clean, clean contaminated, contaminated and dirty surgery.

Figure 5  
A funnel plot to assess for the presence of publication bias.
<table>
<thead>
<tr>
<th>Author</th>
<th>Date</th>
<th>Journal</th>
<th>No of studies</th>
<th>No of participants</th>
<th>Findings</th>
<th>Risk of bias</th>
<th>Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wang et al</td>
<td>2013</td>
<td>British Journal of Surgery</td>
<td>17</td>
<td>3720</td>
<td>Triclosan-coated sutures significantly reduced SSI rate compared with standard sutures. RR 0.7 (95% CI 0.57 to 0.85). Triclosan-coated sutures significantly reduced SSI rate in ‘clean’ and ‘clean-contaminated’ surgery.</td>
<td>Included</td>
<td>Not included</td>
</tr>
<tr>
<td>Edmiston et al</td>
<td>2013</td>
<td>Surgery</td>
<td>13</td>
<td>3568</td>
<td>Triclosan-coated sutures significantly reduced SSI rate compared with standard suture. RR 0.734 (95% CI 0.59 to 0.91). No subgroup analysis was performed.</td>
<td>Not included</td>
<td>Not included</td>
</tr>
<tr>
<td>Daoud et al</td>
<td>2014</td>
<td>Surgical infections</td>
<td>15</td>
<td>4800</td>
<td>Triclosan-coated sutures significantly reduced SSI rate compared with standard sutures. RR 0.67 (95% CI 0.54 to 0.84). No subgroup analysis was performed.</td>
<td>Not included</td>
<td>Not included</td>
</tr>
<tr>
<td>Apisarnthanarak et al</td>
<td>2015</td>
<td>Infection Control and Hospital Epidemiology</td>
<td>29 (22 RCT and 7 non-RCT)</td>
<td>11 942</td>
<td>Triclosan-coated sutures significantly reduced SSI rate compared with standard suture. RR 0.65 (95% CI 0.549 to 0.769). RR for RCT alone 0.74 (95% CI 0.61 to 0.89). Triclosan-coated sutures significantly reduced SSI rate for all CDC wound classifications.</td>
<td>Not included</td>
<td>Not included</td>
</tr>
<tr>
<td>Guo et al</td>
<td>2015</td>
<td>Journal of Surgical Research</td>
<td>13</td>
<td>5256</td>
<td>Triclosan-coated sutures significantly reduced risk of SSI compared with standard suture. RR 0.76 (95% CI 0.65 to 0.88). Triclosan-coated sutures significantly reduced risk of SSI in abdominal surgery. RR 0.70 (95% CI 0.63 to 0.99). There was no significant difference in cardiac and breast surgery.</td>
<td>Included</td>
<td>Not included</td>
</tr>
<tr>
<td>Sandini et al</td>
<td>2016</td>
<td>Medicine</td>
<td>6 (only included elective colorectal surgery)</td>
<td>2168</td>
<td>Triclosan-coated sutures did not significantly reduce the risk of SSI compared with standard sutures in elective colorectal surgery. OR 0.81 (95% CI 0.58 to 1.13)</td>
<td>Included</td>
<td>Not included</td>
</tr>
<tr>
<td>Wu et al</td>
<td>2017</td>
<td>European Journal of Microbiology and Infectious Disorders</td>
<td>18 (13 RCTs and 5 non RCTs)</td>
<td>7458</td>
<td>Triclosan-coated sutures significantly reduced risk of SSI compared with standard suture in both the RCTs (OR 0.72; 95% CI 0.59 to 0.88) and the non-RCTs (OR 0.58; 95% CI 0.40 to 0.83). Triclosan-coated sutures significantly reduced the risk of SSIs in clean surgery.</td>
<td>Included</td>
<td>Included</td>
</tr>
<tr>
<td>de Jonge et al</td>
<td>2017</td>
<td>British Journal of Surgery</td>
<td>21</td>
<td>6462</td>
<td>Triclosan-coated sutures significantly reduced risk of SSI compared with standard suture. RR 0.72 (95% CI 0.60 to 0.86).</td>
<td>Included</td>
<td>Not included</td>
</tr>
<tr>
<td>Leaper et al</td>
<td>2017</td>
<td>British Journal of Surgery</td>
<td>34 (20 RCTs and 14 non-RCTs)</td>
<td>16 762</td>
<td>Triclosan-coated sutures significantly reduced risk of SSI compared with standard sutures. OR 0.61 (95% CI 0.52 to 0.73). No significant difference in SSI rate for ‘contaminated’ or ‘dirty’ wounds</td>
<td>Not included</td>
<td>Not included</td>
</tr>
</tbody>
</table>
Quality of evidence

Using the GRADE criteria, the evidence was graded as ‘moderate’ quality. The reason for downgrading was due to study limitations. Studies had high risk of selection bias due to unclear randomisation and allocation methods. In addition, studies had a high risk of performance and detection bias due to issues with blinding of participants and outcome assessors. The body of evidence was not downgraded for inconsistency as there was narrow point estimates and low study heterogeneity (I²=17%). There were no issues with indirectness or imprecision as the outcome measures used are directly aligned to the outcome measures of interest in this review. There were also a large number of participants included in this review with satisfactory event rate numbers. Our symmetrical funnel plot indicated no risk of publication bias. Given the quality of the evidence we are moderately confident in the effect estimate, the true effect is likely to be close to the estimate of the effect.

The strengths of this current review include the thorough and systematic nature of data collection. This review represents the most up to date review of the literature and is the largest review of RCTs to date, including 11,957 patients from 25 RCTs. A recent RCT in elective hip and knee surgery included 2,546 participants, the largest RCT to date in this subject. This review is the only review to include this important and well-conducted study. In addition, this systematic review only included peer-reviewed studies with published full texts. Previous meta-analyses have included conference abstracts which do not go through the same rigorous peer-review process as full journal publications and thus represent a potential danger to review quality. Furthermore, robust quality and risk of bias assessment is not possible with these abstract publications.

A further strength of this review is the detailed and systematic quality assessments, along with robust Cochrane risk of bias assessments, of all included studies. As demonstrated in table 2 5 out of 11 reviews assessed risk of bias and 1 out of 11 reviews assessed the quality of evidence. A strength of this review is the inclusion of a thorough risk of bias and GRADE assessment. In addition, this new review included further detailed sub group analysis based on superficial versus deep surgical infections and based on type of surgery, for example, clean, clean-contaminated, contaminated and dirty surgery.

The main weakness of this review is the study population. The review includes procedures which were classed as clean, clean-contaminated, contaminated and dirty. These types of surgery would all have differing rates of SSI. The authors therefore performed a subanalyses of the different categories of surgery. Routine antibiotic prophylaxis was used in 15 studies with a variation in the antibiotic agent used and the timing. This is a potential confounder for the frequency of SSI. A proportion of the included studies assessed patients with an underlying malignancy who may have been immunosuppressed. This influences the rate of SSI and is not accounted for in many of the included studies.

Another weakness is the heterogeneity in the use of triclosan-coated sutures. In some studies, triclosan was used for closure of all surgical layers, whereas in other studies triclosan-coated sutures were only used on the superficial layers. This study heterogeneity should be noted when interpreting the meta-analysis result. This review reports trials using CDC criteria for superficial site infections. It is important to note that a stitch abscess does not meet the criteria for a superficial site infections. Patients may present with a stitch abscess to healthcare professionals and undergo treatment. This study does not report the impact of triclosan-coated sutures on stitch abscesses.

Our review is the largest review of RCTs to date in terms of patient numbers and demonstrates clinical effectiveness of triclosan-coated sutures when compared with standard sutures when assessing SSI rate. SSIs have been shown to have a significant impact on patient
quality of life, as well as an increased burden on healthcare providers in terms of resource allocation. The cost of triclosan sutures is variable; however, the cost of SSI to patients and healthcare providers is sizeable.\textsuperscript{10-12} A robust cost-analysis has not been performed, nevertheless, organisations should consider carefully whether they routinely use triclosan-coated sutures in light of these positive meta-analysis findings. This review also identified that triclosan-coated sutures significantly reduced the risk of SSIs in clean and contaminated surgery, therefore thoughtful consideration should be paid to whether they are routinely used in this patient population. The results demonstrate that triclosan-coated sutures may not be as effective in reducing SSI rate in ‘clean-contaminated’ and ‘dirty’ surgery. However, a potential explanation for dirty surgery is the low patient numbers included in this subgroup. This is a potential area of future research given the effectiveness of triclosan-coated sutures in ‘clean’ and ‘contaminated’ surgery.

CONCLUSION

This systematic review identified 25 RCTs examining the effect of triclosan in reducing incidence of SSI, compared with non-coated sutures. The subsequent meta-analysis included 11,957 patient and revealed an overall risk ratio of RR 0.73 (95% CI 0.65 to 0.82) of developing SSI in favour of triclosan-coated sutures, thereby demonstrating a statistically significant lower risk of SSI following closure of a surgical wound with triclosan-coated sutures. Further analysis has demonstrated that triclosan-coated sutures significantly reduced the risk of SSIs in clean and contaminated surgery. This study is in agreement with previous smaller and less robust reviews which have produced comparable results. This is the largest review of RCTs in terms of number of included studies and number of participants from RCTs to demonstrate the clinical effectiveness of triclosan-coated sutures. Further detailed cost-effectiveness is required to assess the economic benefit of implementing the use of these sutures. The evidence considered in this review suggests that triclosan-coated sutures are effective in reducing SSIs, the use should in particular be considered in clean and contaminated surgery.

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