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Review Article

Intraoperative wound irrigation for surgical site infection prevention after laparotomy - A systematic review and network meta-analysis of randomised clinical trials[☆]

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A B S T R A C T

Introduction: There are conflicting recommendations surrounding the use of intraoperative wound irrigation (IOWI) to reduce surgical site infections (SSIs) for patients undergoing laparotomy. This study aimed to perform a systematic review and network meta-analysis of randomised clinical trials (RCTs) to elucidate the most appropriate IOWI solution to reduce SSIs following laparotomy.
Methods: A systematic review and network meta-analysis (NMA) was performed as per preferred reporting items for systematic reviews and meta-analysis (PRISMA)-NMA extension. Data analytics were performed using shiny and R.
Results: 11 RCTs were included involving 2943 patients. Overall, 1292 patients were randomised to normal saline (NS) (43.9%), 771 to povidone iodine (PI) (26.2%), 519 to polyhexidine (PH) (17.6%), 180 to electrolysed strongly acidic aqueous solution (ESAAS) (6.1%), 102 to none (control) (3.5%) and 79 to olanexidine (O) (2.7%). Non-significant differences in patient age, gender, body mass indices, or American Society of Anaesthesiologist grade were observed for each IOWI group (all $P > 0.050$). At NMA, IOWI using PH significantly reduced all cause SSIs in patients undergoing laparotomy (odds ratio (OR): 0.54, 95% confidence interval (CI): 0.36 – 0.80). Furthermore, IOWI using PH (OR: 0.54, 95% CI: 0.36 – 0.80) and ESAAS (OR: 0.36, 95% CI: 0.13 – 0.98) significantly reduced superficial SSI (SSSI) in patients undergoing laparotomy. For patients undergoing laparotomy in the elective setting, PH significantly reduced both SSI (OR: 0.41, 95% CI: 0.25 – 0.68) and SSSI (OR: 0.42, 95% CI: 0.22 – 0.82) rates.
Conclusion: IOWI with PH reduces SSIs in patients undergoing laparotomy and should therefore be considered in patients undergoing this procedure.

1. Introduction

Despite the technological advances in surgical practice in the 21st century, including the introduction of care bundles, standardisation of practice, and enhanced recovery after surgery (ERAS) protocols, surgical site infections (SSIs) remain a significant healthcare financial, resource and clinical burden. SSIs have been formally defined 'as incision or deep tissue infections at the operation site occurring up to 30 days after surgery',[1] and are typically characterised into superficial surgical site infection (SSSI), deep surgical site infection (DSSI) and organ surgical site infection (OSSI), based on their depth of infection within the cutaneous/subcutaneous tissues and within the abdominal cavity.[2] Moreover, SSIs remain problematic within the modern context as contemporary data has demonstrated an overall incidence of 8 - 30% in patients who undergo major abdominal surgery via laparotomy,[3,4] ranging from approximately 8.0% in elective patients to as high as 33.3% in the emergency setting.[5] Furthermore, SSIs have been robustly associated with delayed post-operative recovery, prolonged hospital stays, and in certain cases, the necessity for aggressive anti-microbial therapeutic regimens.[6] Importantly, the management of SSIs poses a burdensome workload of healthcare services, with negative sequalae on patients clinical outcomes (including patient morbidity and mortality), quality of life metrics and healthcare economics/cost [7–9]. Moreover, there is current evidence to suggest that there is increasing challenges surrounding antimicrobial resistance (AMR) in this clinical context, thus, surgical research efforts remains focused on developing pragmatic strategies to reduce the incidence of SSIs in the first instance.

It is imperative to note that patient-related risk factors for SSI (such as age, diabetes mellitus, and smoking status) are rarely modifiable in the short term preoperative setting especially in the emergency setting.[6] Therefore, emphasis has been placed on the optimisation of surgical-related factors which may prove beneficial in reducing SSI and

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their negative sequalae[10]; intraoperative wound irrigation (IOWI) involves the application of a dedicated solution over the wound site prior to wound closure after surgery.[11] IOWI is widely practiced across the world, despite some conflicting evidence based recommendations surrounding the use of this strategy to reduce SSIs: In the United States (US), the Centres Disease Control (CDC) guidelines (2017) support the use of povidone iodine (PI) use to reduce SSIs,[12] which is ratified by the and World Health Organisations' (WHO) recommendations (2017).[13] Contrary to these guidelines, the National Institution for Health and Care Excellence (NICE) from the United Kingdom (UK) recommend against the application of IOWI or cavity lavage (unless in the clinical trial setting) due to 'limited evidence' supporting its use in reducing SSIs (2019).[14] Taking these recommendations in tandem, there are conflicting guidelines surrounding the value of IOWI deployment as an effective strategy in reducing SSIs in patients undergoing major abdominal surgery through laparotomy.

While the incidence of SSIs following laparotomy remains persistently high, and the inherent difficulty in managing this complication remains problematic, it appears timely to conduct a comprehensive evaluation of all available and recent randomised clinical trial (RCT) data in ascertaining whether IOWI has a role in reducing SSI, while also establishing the most effective solution to use. In such an scenario, the deployment of network meta-analysis (NMA) methodology here demonstrates pragmatism as it facilitates the simultaneous comparison (both direct and indirect) of various IOWI strategies and their impact upon SSIs. Accordingly, the aim of the current study was to perform a systematic review and NMA of RCTs to decipher the most appropriate IOWI solution to reduce SSIs following laparotomy. The authors null hypothesis was that there would be a non-significant difference in SSIs for patients who underwent IOWI with PI compared to other solutions.

2. Methods

This systematic review was conducted in accordance to the 'Preferred Reporting Items for Systematic Reviews and Meta-Analyses' (PRISMA) extension statement, specifically for reporting systematic reviews that include NMAs of healthcare interventions.[15] This study was prospectively registered with the International Prospective Register of Systematic Reviews (PROSPERO – CRD42021037042). Local institutional ethical review and approval was not required for this study as it is a review of the currently available published evidence.

2.1. Population, intervention, comparison (PICO) outcome framework

Using the PICO framework,[16] the aspects the authors wished to address were as follows:

- Population: Adult patients aged 18 years or older who were indicated to undergo elective or emergency laparotomy for any indication.
- Intervention: Any patient randomised to have IOWI with povidone iodine (PI, or Bethdine©).
- Comparison: Any patient randomized to have IOWI with any of normal saline (NS), polyhexidine (PH), olanexidine (O), electrolysed strongly acidic aqueous solution (ESAAS), or none (control).
- Outcomes:
  - The primary outcomes of interest included surgical site infections (SSIs) at 30-days post-operatively, in accordance with the CDC definition for SSIs.
  - The secondary outcomes of interest included SSSI, DSSI and OSSI,[2] measured at 30-days post-operatively.
  - The tertiary outcomes of interest included length of hospital stay (LOS, measured in days), complications, relaparotomy, readmission and mortality rates 30-days post-operatively, and associated costs (measured in euros).

2.2. Search strategy

Two independent reviewers performed a systematic, electronic search of the PUBMED, EMBASE and Cochrane library databases for relevant studies. Included studies were limited to the English language and were restricted by year of publication such that studies performed within the last 20 years only (i.e.: 2005 – 2025), were included. All duplicates were manually removed, before title were screened, and studies considered appropriate had their abstracts and/or full text reviewed. Retrieved studies were reviewed to ensure inclusion criteria were met for the primary outcome measure. In cases of discrepancies in opinion among reviewers as to study eligibility, the senior author was asked to arbitrate. The initial search was performed on the July 10, 2025 and the final search was performed in August 2025.

2.3. Eligibility criteria

Studies were considered for inclusion if they were of prospective, randomized design comparing outcomes which evaluated the impact of IOWI with any of PI, PH, O, ESAAS, NS or none (control) following elective or emergency laparotomy (Supplementary Material 1). Patients undergoing relaparotomy were excluded, as were studies evaluating the efficacy of wound irrigation guns. Studies failing to fulfil this criteria were deemed ineligible and excluded from this study.

2.4. Data extraction

The following data were extracted and collected from retrieved studies meeting inclusion criteria: (1) first author name, (2) year of publication, (3) study design, (4) country of origin, (5) number of patients, (6) whether surgery was performed in the elective or emergency setting, (7) number of patients randomized to each IOWI strategy, (8) mean patient age of patients in each group, and (9) data pertaining to the primary, secondary and tertiary outcomes of interest, as described.

2.5. Statistical analysis

Descriptive statistics were used to determine associations between the different surgical approaches and the primary, secondary and tertiary outcomes of interest, using the Chi-squared test (χ^2), where appropriate.[17] All tests of significance were two tailed with $P < 0.050$ representing statistical significance. Descriptive statistics were performed using the Statistical Package for Social Sciences (SPSS) version 26 (International Business Machines Corporation, Armonk, New York).

Thereafter, the relevant outcomes for patients randomized to each IOWI strategy were expressed as dichotomous variables, before being expressed as odds ratios (OR) with corresponding 95% confidence intervals (CIs). Continuous datapoints were derived from mean values and associated standard deviations (SD) and a pooled mean variance with differences expressed as mean differences (MD). Based on recommendations from the WHO and CDC, PI served as the principle comparator in all analyses performed. Subgroup analyses were performed for SSI data comparing data for patients undergoing surgery in the elective and emergency settings. NMA were performed using the netameta and shiny packages for R.[18]

2.6. Risk of bias assessment

As all included studies were of prospective, randomized design, methodology assessment was undertaken using the Risk of Bias 2.0 (ROB2) Assessment.[19]

3. Results

3.1. Literature search

The initial electronic literature search retrieved 788 studies and 15 were retrieved from other resources (e.g.: previous reviews of this topic). Overall, 135 duplicate studies were manually extracted. The remaining 668 titles were screened for relevance, before 40 studies had their abstracts reviewed. Thereafter, 22 manuscripts had their full texts reviewed and of these, 11 RCTs fulfilled our inclusion criteria [20–30]. The systematic search process is outlined in Fig. 1.

3.2. Study characteristics

As described, patient data from 11 RCTs were included [20–30]. Six of these studies compared outcomes following PI and NS (54.5%).[20,21,23,27,29,30] One study compared PH and NS (9.1%),[25] PI and O (9.1%),[26] ESAAS and NS (9.1%),[28] PH, PI and NS (9.1%),[22] and lastly, PH, NS and none (control) (9.1%)[24] respectively. Eight of these RCTs were conducted in Asian translational research facilities (72.7%) [21–23,26–30] and all 11 studies were performed between 2011 and 2025 (100.0%) [20–30]. Five of these studies recruited patients solely undergoing elective laparotomies (45.5%) [8,22,28–30], three RCTs recruited patients undergoing emergency laparotomies (27.3%),[20,21,23] two RCTs recruited patients undergoing both elective and emergency laparotomies (18.2%)[24,27] and one study did not specify (9.1%).[26] Basic trial data, eligibility criteria and risk of bias verdicts are outlined in Table 1. Trial specific data surrounding IOWI strategies are outlined in detail in Supplementary Material 1.

3.3. Patient characteristics

Overall, data from 2943 patients were included. In total, 1292 patients were randomised to NS (43.9%), 771 to PI (26.2%), 519 to PH (17.6%), 180 to ESAAS (6.1%), 102 to none (control) (3.5%) and 79 to O (2.7%). The mean patient age was 57.0 years (range: 18 – 95 years) and mean body mass indices (BMI) was 22.9 kg/m^2 (range: 13.1 kg/m^2 – 47.8 kg/m^2). The majority of patients were male (60.9%, 1310/2152). American Society of Anaesthesiologists (ASA) grades were III/IV represented 33.5% of included patients (478/1429) (Table 2). For each IOWI strategy, there was a non-significant difference in patient age, gender, BMI, or ASA grade (all $P > 0.050$).

3.4. Primary outcome measure

3.4.1. Surgical site infection

All 11 RCTs reported outcomes in relation to SSI [20–30]. Overall, 16.5% of patients sustained a SSI after IOWI for laparotomy (486/2943). When assessing raw data, ESAAS had the lowest SSI rate with 10.6% (19/180), followed by O (12.7%, 10/79), none (control) (12.8%, 13/102), PH (15.6%, 81/519), PI (17.4%, 134/771) and NS (17.7%,

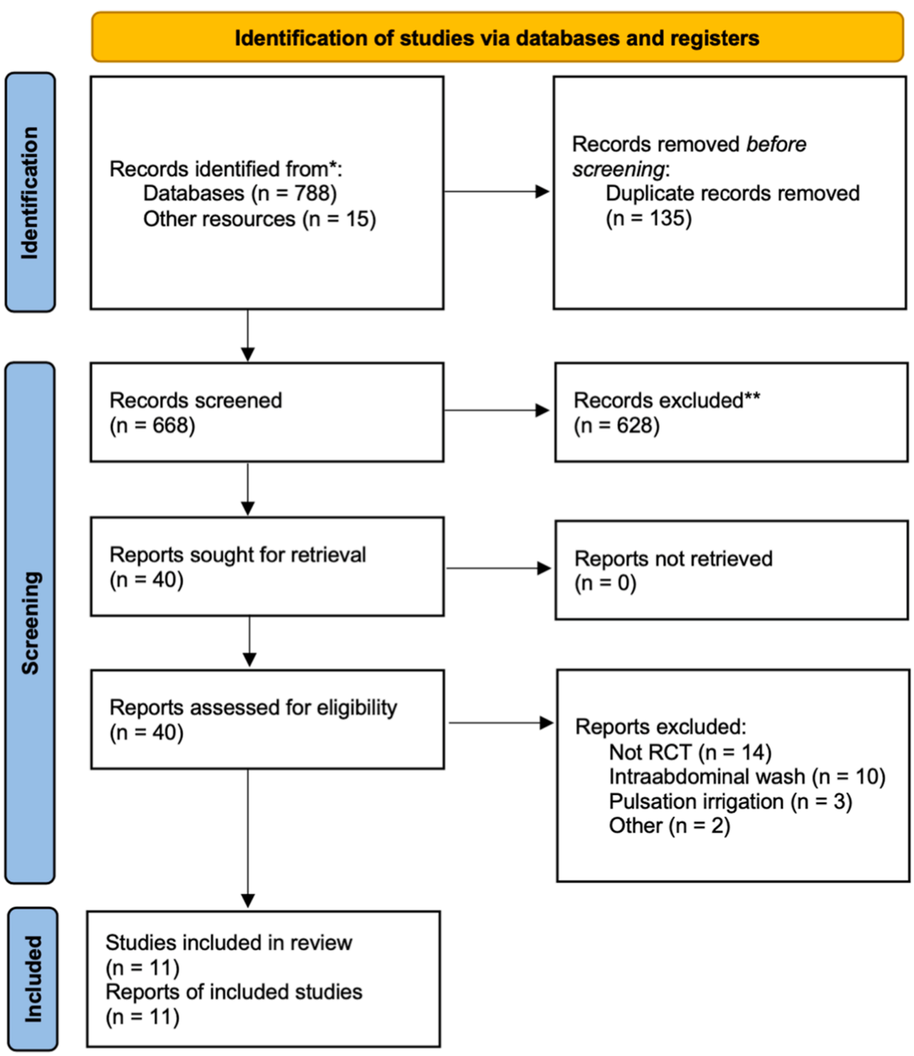

Fig. 1. PRISMA flowchart demonstrating the systematic search process.

Table 1
Basic trial characteristics.

Study	Year	Country	Design	Type Surgery	Setting	Number	Trial arm 1	Trial arm 2	Control	RoB
Adeleke	2024	Nigeria	RCT	Midline Laparotomy	Emergency	53	PI	-	NS	Some
Ali	2023	Pakistan	RCT	Laparotomy	Emergency	180	PI	-	NS	Low
Avinash	2025	India	RCT	Laparotomy	Elective	354	PH	PI	NS	Low
Maetomo	2023	Japan	RCT	Midline Laparotomy	Emergency	284	PI	-	NS	Low
Mueller	2024	Germany	RCT	Midline/Transverse Laparotomy	Emergency/Elective	689	PH	NS	Nothing	Low
Obara	2020	Japan	RCT	Laparotomy	-	153	O	-	PI	Low
Strobel	2019	Germany	RCT	Laparotomy	Elective	220	PH	-	NS	Low
Takeda	2024	Japan	RCT	Laparotomy	Emergency/Elective	134	PI	-	NS	Some
Takesue	2011	Japan	RCT	Laparotomy	Elective	363	ESAAS	-	NS	Some
Vinay	2019	India	RCT	Laparotomy	Elective	180	PI	-	NS	Some
Zhou	2023	China	RCT	Laparotomy	Elective	333	PI	-	NS	High

ROB; risk of bias assessment, RCT; randomised clinical trial, PI; providone iodine, NS; normal saline, PH; Polyhexidine, O; olanexidine, ESAAS; electrolysed strong acidic aqueous solution.

Table 2
Patient characteristics.

Study	Year	N	Mean age (range)	Male: Female	BMI (range)	ASA (class I:II: III:IV)
Adeleke	2024	53	40.8 years (18-85)	30:23	-	11/19/ 22/1
Ali	2023	180	36.8 years (12-65)	103:77	23.1 kg/m^2	-
Avinash	2025	354	50.1 years	207:147	21.7 kg/m^2	113/ 207/34
Maetomo	2023	284	68.5 years	-	23 kg/m^2	-
Mueller	2024	689	65.9 years (18.5- 94.9)	402:287	-	41/292/ 356
Obara	2020	153	69.5 years (21-93)	-	22.1 kg/m^2 (13.1 - 46.4)	-
Strobel	2019	220	57.9 years	-	25.1 kg/m^2	-
Takeda	2024	134	69 years (20-92)	-	22.5 kg/m^2 (13.6 - 47.8)	-
Takesue	2011	363	51.9 years	220:143	-	-
Vinay	2019	180	-	128:52	-	-
Zhou	2023	333	59.2 years	220:113	-	38/230/ 65

N; number, BMI; body mass indices, ASA; American Society of Anaesthesiologist grade.

229/1292) respectively (P = 0.124, χ^2). At NMA, IOWI using PH significantly reduced SSI in patients undergoing laparotomy (OR: 0.54, 95% CI: 0.36 – 0.80) (Fig. 2A). For patients undergoing laparotomy in the elective setting, PH significantly reduced SSI rates (OR: 0.41, 95% CI: 0.25 – 0.68) (Fig. 2B) while a non-significant difference was observed for those undergoing NS and PI in the emergency setting (Fig. 2C). Individual trial data and network plots for SSI rates are outlined in Supplementary Material 2A and 2B.

3.5. Secondary outcome measures

3.5.1. Superficial surgical site infection

Four RCTs reported outcomes in relation to SSSI.[20,22,24,28] Overall, 11.7% of included patients sustained a SSSI after IOWI for laparotomy (169/1450). When assessing available data, ESAAS had the lowest SSSI rate with 6.1% (11/180), followed by PH (7.6%, 31/410), none (control) (8.8%, 9/102), NS (12.4%, 77/623) and PI (28.5%, 41/144) respectively ($P < 0.001$, χ^2). At NMA, IOWI using PH (OR: 0.54, 95% CI: 0.36 – 0.80) and ESAAS (OR: 0.36, 95% CI: 0.13 – 0.98) significantly reduced SSSI in patients undergoing laparotomy (Fig. 3A). For patients undergoing laparotomy in the elective setting, PH significantly reduced SSSI rates (OR: 0.42, 95% CI: 0.22 – 0.82) (Fig. 3B). Unfortunately, there was no data available to evaluate SSSI rates for those undergoing emergency laparotomies. Individual trial data and network plots for SSSI rates are outlined in Supplementary Material 3A and 3B.

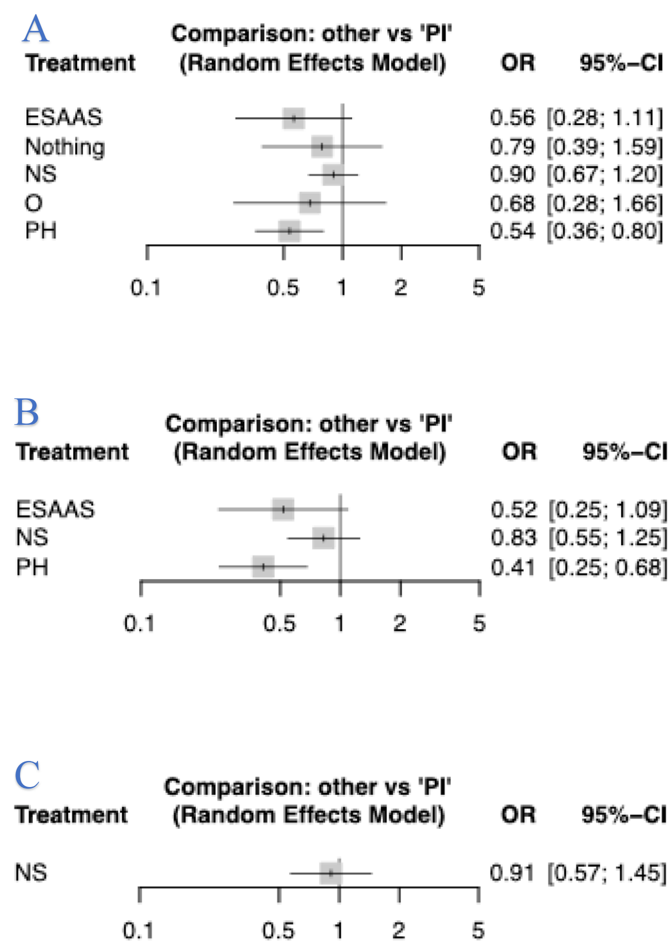

Fig. 2. Forest plots outlining differences in overall surgical site infections for (A) all laparotomies, (B) elective laparotomies and (C) emergency laparotomies based on intraoperative wound irrigation strategies.

3.5.2. Deep surgical site infection

Four RCTs reported outcomes in relation to DSSI.[20,22,24,28] Overall, 3.2% of included patients sustained a DSSI after IOWI for laparotomy (43/1359). When assessing available data, using none (control) had the lowest DSSI rate with 1.0% (1/102), followed by PH (2.2%, 9/410), ESAAS (2.8%, 5/180), NS (3.8%, 21/623) and PI (4.9%, 7/144) respectively (P = 0.349, χ^2). At NMA, there was no significant difference in DSSI rates irrespective of IOWI method used in patients undergoing laparotomy (Fig. 4A). For patients undergoing laparotomy in the elective setting, a non-significant difference was observed for wound irrigation strategies (Fig. 4B). Unfortunately, there was no data available to

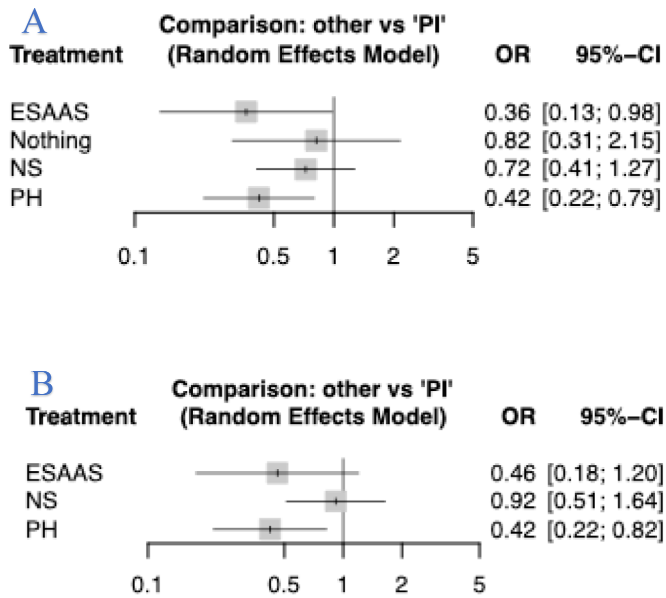

Fig. 3. Forest plots outlining differences in superficial surgical site infections for (A) all laparotomies and (B) elective laparotomies based on intraoperative wound irrigation strategies.

evaluate SSSI rates for those undergoing emergency laparotomies. Individual trial data and network plots for DSSI rates are outlined in Supplementary Material 4A and 4B.

3.5.3. *Organ surgical site infection*

Three RCTs reported outcomes in relation to OSSI.[20,24,28] Overall, 3.9% of included patients sustained a OSSI after IOWI for laparotomy (43/1005). When assessing available data, using none (control) had the lowest OSSI rate with 2.9% (3/102), followed by PH (3.1%, 9/292), NS (3.8%, 19/505), ESAAS (4.4%, 8/180), and PI (15.4%, 4/26) respectively (P = 0.034, χ^2). At NMA, there was no significant difference in OSSI rates irrespective of IOWI method used in patients undergoing laparotomy (Fig. 5). Unfortunately, there was no data available to evaluate OSSI rates for those undergoing elective and emergency laparotomies. Individual trial data and network plots for OSSI rates are outlined in Supplementary Material 5A and 5B.

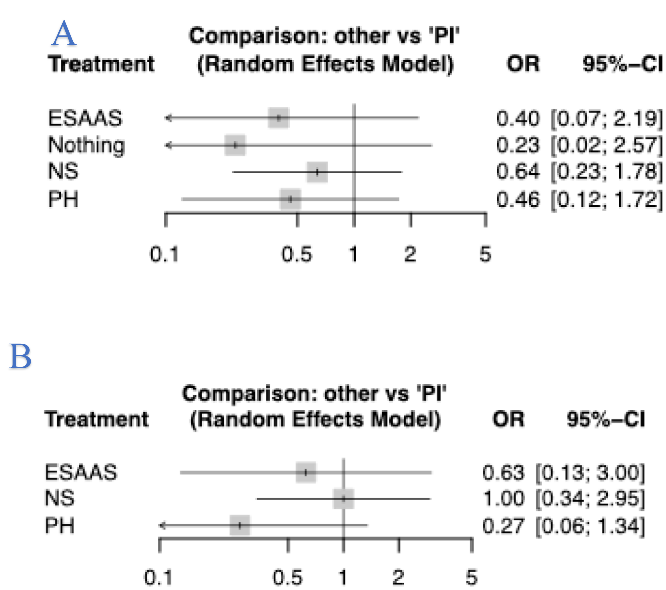

Fig. 4. Forest plots outlining differences in deep surgical site infections for (A) all laparotomies and (B) elective laparotomies based on intraoperative wound irrigation strategies.

3.6. *Tertiary outcome measures*

3.6.1. *Complications*

Four RCTs reported outcomes in relation to post-operative complications.[22,24,29,30] Overall, 14.3% of included patients sustained a non-SSI related complication (222/1556). When assessing available data, PI had the lowest complication rate with 11.0% (41/374), followed by PH (13.4%, 55/410), NS (15.7%, 105/670), and using none (control) (20.6%, 21/102) respectively (P = 0.046, χ^2). At NMA, there was a non-significant difference in post-operative complications across the included IOWI strategies (Supplementary Material 6A). Individual trial data and network plots for complications are outlined in Supplementary Material 6B and 6C.

3.6.2. *Length of stay*

Four RCTs reported outcomes in relation to LOS involving IOWI for PI, NS, PH and none (control).[20,22,24,30] At NMA, there was a non-significant difference in LOS across the four included IOWI strategies (Supplementary Material 7A). Individual trial data and network plots for LOS are outlined in Supplementary Material 7B and 7C.

3.6.3. *Readmissions and relaparotomy*

Just one RCT reported outcomes in relation to readmission rates.[22] Overall, 3.4% of included patients required readmission (12/354). When assessing available data, PH had the lowest readmission rate with 1.7% (22/118), followed by both PI and NS (both 4.2%, 5/118) respectively (P = 0.460, χ^2).

Just one RCT also reported outcomes in relation to relaparotomy rates.[24] Overall, 12.1% of included patients required readmission (83/689). When assessing available data, PH had the lowest relaparotomy rate with 9.3% (27/292), followed by NS (10.5%, 31/295) and none (control) (14.7%, 15/102) respectively (P = 0.304, χ^2). As just one study provided data for readmission and relaparotomy, NMA was unascertainable for these outcome measures.

3.6.4. *Mortality*

Two RCTs reported outcomes in relation to mortality.[22,24] Overall, 2.0% of included patients died during the course of these studies (21/1043). When assessing available data, PH had the lowest mortality rate with 1.2% (5/410), followed by none (control) (2.0%, 2/102), NS (2.2%, 9/413), and using PI (20.6%, 5/118) respectively (P = 0.228, χ^2). At NMA, there was a non-significant difference in mortality rates across the included IOWI strategies (Supplementary Material 8A). Individual trial data and network plots for complications are outlined in Supplementary Material 8B and 8C.

3.6.5. *Cost*

Just one RCT reported outcomes in relation to cost of IOWI strategies.[20] Overall, the estimated cost per patient for PI was 1.07 euro per

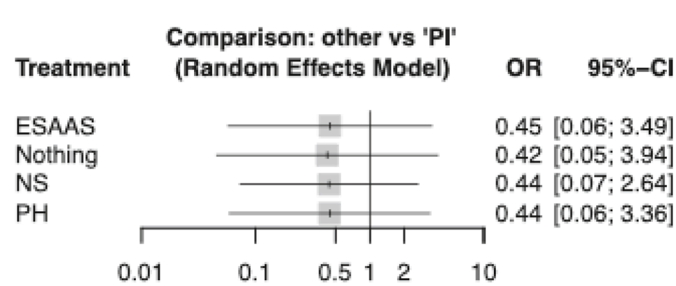

Fig. 5. Forest plots outlining differences in organ surgical site infections based on intraoperative wound irrigation strategies.

wound, compared to 0.52 euro for NS. As just one study provided data for cost, NMA was unascertainable for this outcome measure.

3.6.6. Risk of bias assessment

Risk of bias was assessed in each of the 11 RCTs included in this review. Six of the 11 studies were deemed to be of 'low' risk [21–26] while four were considered to demonstrate 'some' risk of bias [20,25,27–29]. One included RCT was considered to have a 'high' risk of bias.[30] Summaries of the risk of bias assessment are outlined in brief in Table 1.

4. Discussion

The data integrated for analysis in this systematic review and NMA robustly supports the use of IOWI with PH to facilitate a significant reduction in SSIs following laparotomy, thus successfully challenging the authors' null hypothesis. In this study, PH both significantly reduced both overall and superficial SSIs when compared directly with PI, which yielded a relatively concerning 17.4% overall SSI rate. Interestingly, this data also seemingly opposes recommendations from both the WHO and CDC, who indicate that PI should be considered for IOWI as a means of reducing SSI following major surgery. Therefore, this NMA of contemporary RCT data suggests that PI should not be used for IOWI as routine, with IOWI with PH being suggested as the most appropriate strategy in counteracting any potentially salvageable SSI post-laparotomy.

When evaluating the crude data surrounding SSI reduction rates from the current study, PH provided an almost 50% relative reduction in SSIs compared to PI. This data is of particular interest in the context of the modern surgical era, where an increasing financial and inpatient and outpatient resource burden associated with the management of SSIs potentially overburdening healthcare economies,[8] many already limited and poorly resourced. For example, contemporary estimations across several well-resourced European healthcare services indicate that each SSI costs local services approximately 6000 - 9000 euro per SSI, with subsequent hospitalisations costing anything from 7000 to 20,000 euro, depending on the severity of the patients' clinical conditions.[31] Therefore, IOWI with PH may serve as an important antimicrobial adjunct to reduce a proportion of preventable SSIs, with the caveat of potentially counteracting unnecessary healthcare costs at local, national and international levels.[32]

This study pragmatically included all recent RCT data (published in the previous 20 years, 2005 – 2025) to ensure that contemporary data, representative of current surgical practices and translational research standards, were integrated to provide data which would be robust enough to potentially direct clinical care, while also mitigating potential rebuttals that included RCT results may be antiquated. This has been successfully achieved by the authors and is increasingly important, given the current clinical challenges faced by AMR in the 21st century: Longitudinal projections of AMR patterns indicate that a 65.9% increase in deaths attributed to AMR is forecasted by 2050, with 1.9 million people potentially dying annually from such infections (which were previously sensitive to current antimicrobial regimens).[33] Therefore, the use of current data was appropriate for this study, with PH being highlighted as the most beneficial IOWI solution to prevent SSIs. Importantly, PH's role in serving to reduce SSIs, while not propagating further AMR is multifactorial; PH is known to provide broad-spectrum antimicrobial cover against a spectrum of fungi, parasites, bacteria and certain viruses,[33,34] while also having capacity to kill drug resistant species such as *Methicillin-resistant Staphylococcus Aureus* (MRSA) and *Vancomycin-resistant Enterococcus* (VRE).[35,36] Furthermore, PH use has been detailed to carry low adverse-reaction rates rendering it a potentially suitable perioperative adjunct to current antimicrobial prophylaxis which may have a role to play in reducing SSIs and their negative sequalae.[35]

While this study has several strengths, including representing a synthesis of level I evidence from 11 RCTs and almost 3000 patients, thus mitigating any selection or confounding biases, the authors acknowledge that this study is subject to several unavoidable limitations. Firstly, as we know to be true (and unavoidable) for the majority of surgical RCTs performed, none of the included RCTs in this analysis could be 'blinded' by design. The inherent inability to blind surgeons to interventions such as IOWI renders these RCTs to be classed as 'open label', making them subject to the 'glass ceiling effect' of potential biases (i.e.: the challenge in 'truly' being able to blind surgeons to interventions in the context of operations).[37] Secondly, it is plausible that certain potential confounders (for example, patient age, patient comorbidities, smoking status, etc.) may have influenced the results of these independent studies, thereby impacting the results of this NMA. However, it is important to note that the allocation of patients to groups via randomisation in RCTs should mitigate such potential issues. Thirdly, study heterogeneity may limit the robustness of results yielded, in particular, when 4 and 1 of the included studies had 'some' and 'high' risk of bias respectively. Finally, subgroup analyses for data representing the various CDC wound categories (i.e.: clean, clean-contaminated, contaminated, and infected) were unascertainable for this study. This is likely to main limitation of the current study, as this inevitably limits the robustness of results and their translatability into contemporary clinical practice. Despite these limitations, this NMA of RCTs provides comprehensive, high-quality analyses which shed further light upon the value of IOWI in the setting of patients undergoing laparotomy.

5. Conclusion

In conclusion, this study demonstrates the pragmatism of using IOWI with PH to reduce SSIs in patients undergoing laparotomy. Furthermore, this data supports the clinical use of PH in the elective setting as an adjunct to reduce SSIs in a proportion of patients. Therefore, IOWI should be considered in patients undergoing laparotomy, in both the elective and emergency setting.

CRediT authorship contribution statement

Matthew G. Davey: Writing – review & editing, Writing – original draft, Software, Methodology, Formal analysis, Data curation, Conceptualization. **Czara A. Kennedy:** Writing – review & editing, Supervision, Methodology, Conceptualization. **Mohammed Alazzawi:** Resources, Project administration, Formal analysis, Data curation, Conceptualization. **Conor Toale:** Visualization, Methodology, Investigation, Formal analysis, Conceptualization. **Carolyn Cullinane:** Writing – review & editing, Visualization, Software, Methodology, Conceptualization. **Noel E. Donlon:** Writing – review & editing, Writing – original draft, Visualization, Supervision, Formal analysis, Conceptualization.

Funding

No funding was obtained for this study.

Data availability

Data will be made available upon reasonable request from the corresponding author.

Conflict of interest

None of the authors have any interests to declare.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.amjsurg.2026.116930.

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