

SCIENTIFIC REVIEW

Chlorhexidine-Alcohol Versus Povidone-Iodine for Surgical Site Infection Prevention in Abdominal Surgery in Low- and Middle-Income Countries: A Systematic Review and Meta-Analysis

John Turyagumanawe^{1,2,3} | Enock Mukiibi¹ | Jackson Kakooza¹  | Michael Mugenyi¹ | Bienfait V. Mumbere¹ | Abass Alao Safiriyu⁴ | Ahmed Kiswezi Kazigo¹ | Umaru Kabuye¹ | Ibrahim Bwaga⁵ | Luis Nyende⁶ | Sedrick Bukyana¹ | Emmanuel Ibudi⁷ | Rashid Naziru⁸ | Denis Bitamazire⁷ | Catherine R. Lewis⁹  | Prosper Akankwasa¹⁰ | Theoneste Hakizimana¹⁰ 

¹Department of Surgery, Kampala International University, Western Campus, Ishaka Bushenyi, Uganda | ²Public Health Department, Hoima Regional Referral Hospital, Hoima, Uganda | ³Makerere University School of Public Health, Kampala, Uganda | ⁴Department of Physiology, Kampala International University, Western Campus, Ishaka Bushenyi, Uganda | ⁵Department of Obstetrics, Hoima Regional Referral Hospital, Hoima, Uganda | ⁶Department of Internal Medicine, Kampala International University, Western Campus, Ishaka Bushenyi, Uganda | ⁷Department of Surgery, Hoima Regional Referral Hospital, Hoima, Uganda | ⁸Department of Health Sciences, Islamic University in Uganda, Mbale, Uganda | ⁹Department of Surgery, St. Joseph's Hospital Kitovu, Masaka, Uganda | ¹⁰Department of Obstetrics and Gynecology, Kampala International University, Western Campus, Ishaka Bushenyi, Uganda

Correspondence: John Turyagumanawe (drjohnturya@gmail.com)

Received: 26 February 2026 | **Revised:** 8 April 2026 | **Accepted:** 25 April 2026

Keywords: chlorhexidine-alcohol | low- and middle-income countries | meta-analysis | povidone-iodine | surgical site infection

ABSTRACT

Background: Surgical site infections remain disproportionately common in low- and middle-income countries (LMICs). We systematically reviewed and meta-analyzed evidence comparing chlorhexidine-alcohol (CHG-ALC) and povidone-iodine (PI) for preoperative skin antisepsis in abdominal surgery in LMICs.

Methods: Following PRISMA guidelines, we searched PubMed, Scopus, Web of Science, and Lens.org from January 2015 to October 2025 for randomized trials and prospective cohort studies conducted in LMICs that compared CHG-ALC with PI and reported SSI outcomes after abdominal surgery. Because some eligible studies included mixed wound classifications, we performed a primary pooled analysis across eligible abdominal procedures and a pre-specified sensitivity analysis restricted to studies limited to clean-contaminated wounds. Study-level risk ratios (RRs) were pooled using a random effects model, and heterogeneity and publication bias were assessed using I^2 , τ^2 , Cochran's Q statistics, Egger's regression, and funnel plot-based methods.

Results: Fifteen studies including 7459 patients were analyzed. Overall, CHG-ALC was associated with a lower risk of SSI than PI (RR = 0.61, 95% CI 0.46–0.80; $p < 0.001$; and $I^2 = 0\%$). This effect remained significant when the largest trial was excluded (RR = 0.58, 95% CI 0.46–0.71) and when analysis was restricted to studies enrolling only clean-contaminated wounds (RR = 0.59, 95% CI 0.45–0.77; $I^2 = 0\%$). Regional subgroup analysis showed consistent benefit in South Asia (RR = 0.58, 95% CI 0.46–0.71; $I^2 = 0\%$), whereas evidence in sub-Saharan Africa was inconclusive (RR = 0.88, 95% CI 0.35–2.21; $I^2 = 90.8\%$).

Conclusion: CHG-ALC appears more effective than PI for reducing SSI after abdominal surgery in LMICs overall, with the most consistent evidence observed in South Asia. However, evidence from sub-Saharan Africa remains limited and heterogeneous. These findings support context-specific implementation and the need for additional African trials focused on abdominal procedures and clearly defined wound classes.

1 | Introduction

Patients in low- and middle-income countries (LMICs) face a disproportionately higher rate of surgical site infection (SSI) than those in high-income countries (HICs) [1]. For instance, a major multicenter trial conducted exclusively in LMICs reported a notably high overall SSI rate of 22.0% in patients undergoing abdominal surgery [1].

SSI remains the most common postoperative complication worldwide, constituting a major burden for patients and health systems [1]. SSI is considered a major infection control concern globally [2] and is the second [3] or third [4–6] most prevalent type of hospital-acquired infection, accounting for approximately 14%–16% of all nosocomial infections [3, 7].

The development of SSI imposes a severe clinical and financial burden [3, 8]. SSI is associated with serious morbidity, mortality, and excessive costs [2, 3, 9], particularly for patients who develop pain, disability, poor healing, and psychological challenges [1]. SSI is reported among the costliest hospital-acquired infections [9], and, on average, having an SSI generally lengthens a patient's hospital stay by seven to 10 days [4, 10]. Although complete elimination of surgical infections is likely impossible, reducing their incidence produces great benefits for patients and helps economize hospital resources [2].

Effective preoperative skin antisepsis is a widely recognized and critical intervention for preventing SSIs [3, 4]. The primary source of pathogens causing SSIs is commonly the patient's own microbial flora [5, 9] making decontamination of the surgical site essential [8]. An effective preoperative skin antiseptic must rapidly reduce the number of transient and resident microorganisms and suppress their growth for several hours after application [5]. The two most extensively researched skin disinfectants are povidone-iodine (PI) and chlorhexidine-alcohol (CHG-ALC) [3, 7]. PI is a traditional, broad-spectrum antiseptic, generally preferred universally and used since 1955 [6, 11]. PI functions by releasing elemental iodine, which is rapidly bactericidal, fungicidal, and viricidal [11]. However, the bactericidal activity of PI may be diminished in the presence of blood, necrotic tissue, or pus [4, 5].

CHG-ALC formulations, typically containing 2%–2.5% chlorhexidine gluconate in 70% isopropyl alcohol, are newer skin preparation agents [4, 6, 9]. This combination is highly effective due to the alcohol providing rapid antimicrobial action and the chlorhexidine component exhibiting a persistent residual antimicrobial activity on the skin surface, suppressing microbial growth for hours after application [3–5]. Unlike PI, CHG's activity is generally not inactivated by blood or serum protein [5]. CHG-ALC, although often more costly than PI, may be preferred for its potentially greater efficacy and ease of application [4, 12].

The efficacy comparison between CHG-ALC and PI remains a subject of considerable debate, and the optimal skin preparation agent is still uncertain [3, 4, 6, 10, 13]. Current literature presents conflicting and inconsistent reports on the comparative efficacy of the two agents [2, 4, 5]. Multiple systematic reviews and randomized controlled trials (RCTs) suggest the superiority of CHG-ALC [3]. A major knowledge gap exists because the applicability of international guidelines, which favor alcoholic chlorhexidine, remains a concern in resource-limited settings. Previous guidelines lacked sufficient data generated from LMICs [1]. Specific gaps in LMICs include reliance on smaller sample sizes [7], fewer multicenter studies, and variability in adherence to guidelines due to resource limitations. Because the mechanistic effects and clinical effects of interventions may differ significantly due to varying degrees of baseline SSI rates and resource availability [1], comparison of outcomes between LMICs and HICs as a subgroup is justified to understand these contextual differences.

Considering the conflicting evidence and the global variation in the SSI burden, particularly the data sparsity in LMICs, a comprehensive systematic review and meta-analysis is essential [1]. The primary objective of this systematic review and meta-analysis was to compare the effectiveness of CHG-ALC versus PI in preventing SSIs after abdominal surgery in LMICs. Because some eligible studies included mixed wound classifications, we conducted sensitivity analyses restricted to studies limited to clean-contaminated wounds in order to assess whether the main findings remained consistent within the target wound class. We aim to provide pooled evidence on the overall efficacy of CHG-ALC versus PI in preventing SSIs and evaluate subgroup differences between LMICs and HICs to assess the generalizability and applicability of interventions across diverse settings. The ultimate purpose is to inform future global clinical guidelines that are evidence-based, relevant, and economically appropriate for diverse healthcare settings, especially those constrained by resources.

2 | Materials and Methods

2.1 | Protocol and Registration

This review adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines and was registered with PROSPERO (CRD420251181054). Ethical approval was not required as only published data were analyzed.

2.2 | Search Strategy

The PICO framework was used to develop the study question: population (P): patients undergoing clean-contaminated abdominal surgery; intervention (I): CHG-ALC (any route/dose); comparison (C): PI; outcome (O): primary: SSI rates;

secondary: subgroup differences between LMICs and HICs. We searched Web of Science, Scopus, PubMed, and [Lens.org](https://www.lens.org) from January 1, 2015, to October 31, 2025, using terms for CHG-ALC (e.g., “chlorhexidine,” “CHG”), PI (e.g., “povidone-iodine,” “iodine”), SSI (e.g., “surgical site infection,” “wound infection”), and surgery (e.g., “abdominal,” “laparotomy”). Terms were linked using Boolean operators (AND and OR) to optimize precision and recall. Search strings are provided in Supporting Information S1. Only English language studies or translations were included.

Eligible studies were RCTs or prospective cohort studies conducted in hospital settings in low-income, lower middle-income, or upper middle-income countries, defined according to World Bank income classification at the time of study conduct or publication. Studies were required to compare preoperative CHG-ALC with PI and report SSI outcomes after abdominal surgery. Because some otherwise eligible abdominal surgery trials included mixed wound classifications, these studies were retained in the primary analysis to preserve completeness of LMIC evidence, but their influence was examined in a pre-specified sensitivity analysis restricted to studies enrolling only clean-contaminated wounds. Studies limited to high-income settings were excluded. We also excluded case reports, reviews, editorials, noncomparative studies, nonabdominal procedures, and studies without extractable SSI outcome data relevant to the review question. Studies in other languages with a reliable English translation available for full-text assessment were considered eligible. This criterion was pre-specified to maintain methodological consistency in study selection, data extraction, and risk-of-bias evaluation across included articles. Nonetheless, we acknowledge that this approach may have excluded relevant evidence from some LMIC settings and may have introduced language bias. Studies that did not compare CHG-ALC and PI were excluded. Two reviewers independently screened titles and abstracts, followed by full-text assessments. Disputes were resolved via a third reviewer.

2.3 | Data Extraction and Quality Assessment

Data were extracted in duplicates using a standardized form, capturing study characteristics, participant demographics, anti-septic formulations, application protocols, and SSI outcomes. Risk of bias was independently assessed by two reviewers using the Joanna Briggs Institute (JBI) critical appraisal checklist for randomized controlled trials (Supporting Information S1: Table S1).

2.4 | Statistical Analysis

For each study included, raw event counts and total sample sizes were extracted for the CHG-ALC and PI groups and used to compute study-level risk ratios (RRs) for SSI. When adjusted estimates were unavailable, unadjusted event data were synthesized. Studies without sufficient numerical outcome data to reconstruct a study-level effect estimate were excluded from quantitative pooling. Missing outcome data were not imputed. RR for SSI were pooled using a random effects model (restricted maximum likelihood for τ^2) in jamovi v2.6.44 (MAJOR module). Heterogeneity was assessed with I^2 , τ^2 , and Cochran's Q statistics. Publication bias was evaluated using fail-

safe N, Kendall's tau, Egger's regression, and funnel plots. Subgroup analyses explored regions and LMIC versus HIC differences.

2.5 | Sensitivity and Subgroup Analyses

To assess the robustness of our findings and explore sources of heterogeneity, we conducted pre-specified sensitivity and subgroup analyses. Sensitivity analyses included (1) sequential exclusion of each study (leave-one-out analysis) to identify influential studies, (2) exclusion of the FALCON trial [14] given its large sample size (68% of total participants) and inclusion of contaminated and dirty wounds beyond our clean-contaminated focus, (3) exclusion of studies that included mixed wound classifications, (4) stratification by study design (single-center vs. multicenter trials), (5) exclusion of studies with quality scores below the median, and (6) comparison of random effects versus fixed effects models.

Subgroup analyses examined (1) geographic region (South Asia, sub-Saharan Africa, and North Africa/Middle East), (2) surgical procedure type (cesarean section, laparotomy, cholecystectomy, and hernia repair), (3) study quality score (high vs. moderate), and (4) sample size (≥ 200 vs. < 200 participants). Between-subgroup heterogeneity was assessed using Cochran's Q test with statistical significance set at $p < 0.10$.

All sensitivity analyses were conducted using random effects models (REML estimator) in jamovi v2.6.44 (MAJOR module). Results were considered robust if the direction and statistical significance of the pooled effect remained consistent across sensitivity analyses.

3 | Results

3.1 | Study Selection

From 508 records retrieved (Web of Science: 296, Scopus: 78, Lens.org: 81, and PubMed: 53), 85 duplicates were removed. A total of 423 titles and abstracts were screened, and 392 were excluded. A total of 31 reports were sought for retrieval, 12 were not retrieved, and 19 were assessed for eligibility. Four reports were excluded with reasons, and 15 studies were included in the final review and meta-analysis (Figure 1). A total of 7459 patients were included from Benin, Ghana, Nigeria, Rwanda, South Africa, Pakistan, India, and Egypt (Table 1).

3.2 | Meta-Analysis Results

The random effects meta-analysis of 15 studies demonstrated a significant reduction in SSI risk with CHG-ALC (RR = 0.6071, 95% CI: 0.4630–0.7952, and $p < 0.001$), corresponding to a mean reduction of approximately 39% (Table 2). Low heterogeneity was observed ($I^2 = 0\%$, $Q(14) = 10.048$, $p = 0.759$, and $\tau^2 = 0.000$; Table 3).

3.3 | Sensitivity Analyses

3.3.1 | Leave-One-Out Analysis

Sequential exclusion of individual studies demonstrated the robustness of the overall effect estimate (Table 4). The pooled

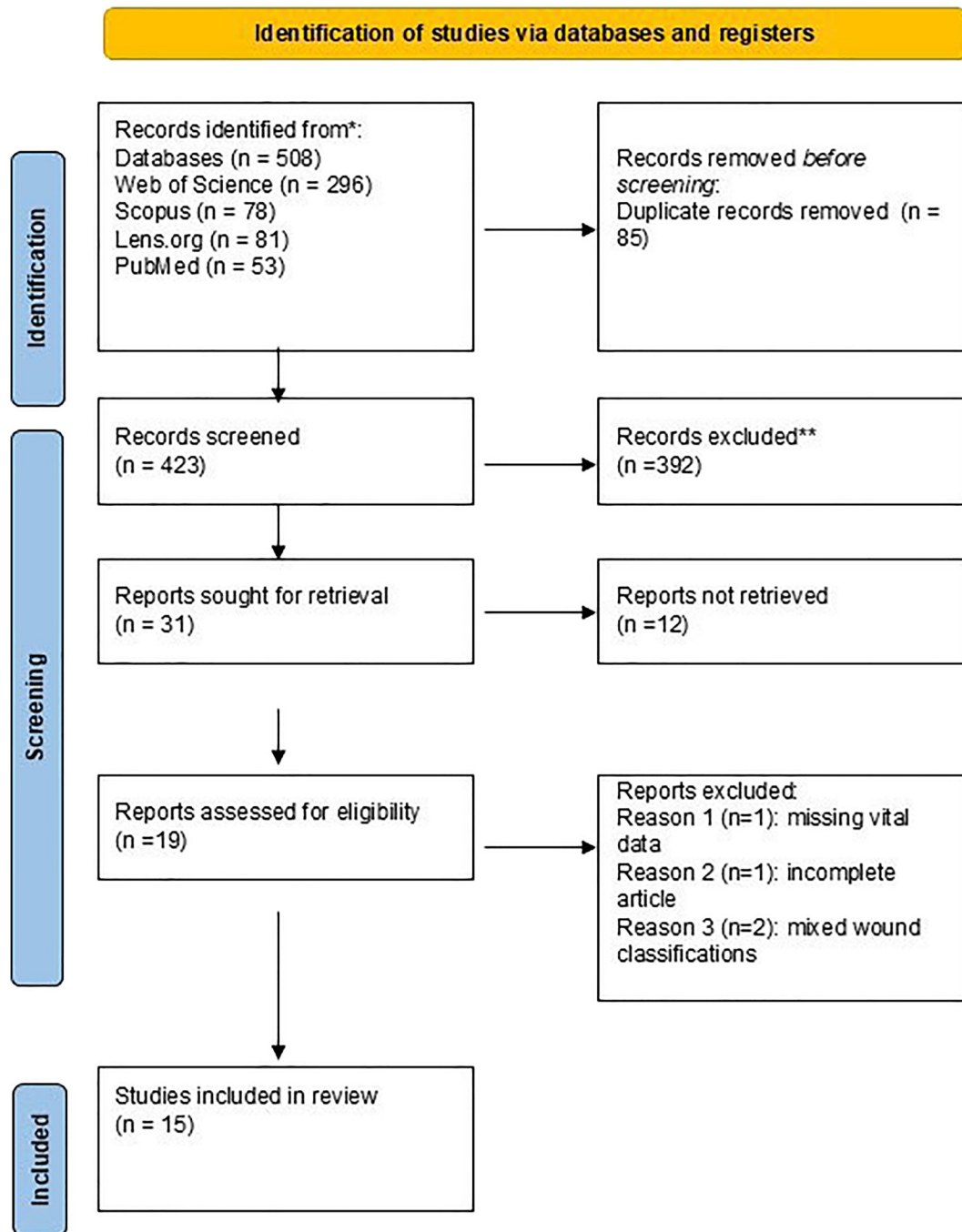


FIGURE 1 | PRISMA flow diagram. Database searches identified 508 records (Web of Science = 296, Scopus = 78, Lens.org = 81, and PubMed = 53). After removing duplicates ($n = 85$), 423 records were screened out of which 392 were excluded (wrong intervention = 156, wrong population = 134, wrong study design = 78, wrong outcome = 21, and non-English language without reliable translations = 3). Of 31 full-text articles, 12 were not retrieved. Out of 19 assessed for eligibility, 4 were excluded (mixed wound classifications = 2, inappropriate comparator = 1, and incomplete article or missing outcome data required for synthesis = 1), leaving 15 studies for review and meta-analysis.

RR ranged from 0.58 (95% CI 0.44–0.77) when excluding Takalkar et al. [11] to 0.75 (95% CI 0.58–0.98) when excluding the FALCON trial [1]. Notably, exclusion of FALCON, which contributed 68% of the total sample, resulted in a strengthened effect estimate (RR = 0.58, 95% CI 0.46–0.71, and $p < 0.001$) with maintained low heterogeneity ($I^2 = 0\%$ and $p = 0.758$), indicating that the overall conclusion of CHG-ALC superiority is not solely dependent on the FALCON study but is driven by

consistent effects across the remaining 14 studies. No single study disproportionately influenced the pooled estimate beyond the expected contribution based on sample size weighting.

All pooled effects remained statistically significant ($p < 0.001$) across scenarios, confirming the robustness of the primary finding that CHG-ALC is superior to PI in reducing SSI risk in clean-contaminated abdominal surgery within LMIC settings.

TABLE 1 | Characteristics of included studies.

Study	Year	Country(ies)	Surgical procedure	CHG-alcohol (n)	PI (n)	Total (n)
Ademuyiwa et al. [1]	2021	Benin, Ghana, Nigeria, Rwanda, and South Africa	Abdominal (clean-contaminated)	1455	1468	2923
Bibi et al. [2]	2015	Pakistan	Clean or clean-contaminated	168	220	388
Danasekaran et al. [15]	2017	India	Clean elective abdominal	60	60	120
Elgarf et al. [4]	2022	Egypt	Laparoscopic cholecystectomy	100	100	200
Idowu et al. [8]	2024	Nigeria	General and urological (clean-contaminated)	90	90	180
Kesani et al. [9]	2019	India	Cesarean section	273	287	560
Luwang et al. [7]	2021	India	Cesarean section	153	158	311
Mukhtar et al. [16]	2019	Pakistan	Clean and clean-contaminated	125	125	250
Chirukandeth et al. [17]	2020	India	Laparotomy (elective and emergency)	128	109	237
Saqlain et al. [13]	2024	Pakistan	Abdominal hernia	150	150	300
Singh [18]	2015	India	Clean and clean-contaminated elective	100	100	200
Srinivas et al. [5]	2015	India	Upper abdominal (clean-contaminated)	162	189	351
Sufyan et al. [19]	2018	Pakistan	Abdominal (clean-contaminated)	420	420	840
Takalkar et al. [11]	2016	India	Elective clean surgery	208	191	399
Valappil [6]	2017	India	Elective midline laparotomy	100	100	200
Total				3692	3767	7459

TABLE 2 | Data extraction and individual study risk ratios.

Study	CHG-ALC N	CHG-ALC SSI N (%)	PI N	PI SSI (%)	Risk ratio	95% CI lower	95% CI upper
Ademuyiwa et al. (2021)	1455	223 (15.3)	1468	231 (15.7)	0.9740	0.8225	1.1535
Bibi et al. (2015)	168	12 (7.1)	220	22 (10.0)	0.7143	0.3640	1.4016
Danasekaran et al. (2017)	60	2 (3.3)	60	14 (23.3)	0.1429	0.0339	0.6016
Elgarf et al. (2022)	100	4 (4.0)	100	13 (13.0)	0.3077	0.1039	0.9114
Idowu et al. (2024)	90	1 (1.1)	90	5 (5.6)	0.2000	0.0238	1.6781
Kesani et al. (2019)	273	19 (7.0)	287	41 (14.3)	0.4872	0.2902	0.8179
Luwang et al. (2021)	153	8 (5.2)	158	13 (8.2)	0.6355	0.2710	1.4901
Mukhtar et al. (2019)	125	12 (9.6)	125	20 (16.0)	0.6000	0.3066	1.1742
Chirukandeth et al. (2020)	128	13 (10.2)	109	18 (16.5)	0.6150	0.3159	1.1972
Saqlain et al. (2024)	150	18 (12.0)	150	51 (34.0)	0.3529	0.2168	0.5746
Singh et al. (2015)	100	14 (14.0)	100	30 (30.0)	0.4667	0.2637	0.8257
Srinivas et al. (2015)	162	17 (10.5)	189	34 (18.0)	0.5833	0.3389	1.0041
Sufyan et al. (2018)	420	36 (8.6)	420	58 (13.8)	0.6207	0.4189	0.9197
Takalkar et al. (2016)	208	20 (9.6)	191	18 (9.4)	1.0203	0.5567	1.8698
Valappil et al. (2017)	100	10 (10.0)	100	14 (14.0)	0.7143	0.3331	1.5315
Pooled effect	3692	409 (11.1.)	3767	582 (15.5)	0.6071	0.4630	0.7952

Abbreviations: CHG, chlorhexidine alcohol; CI, confidence interval; N, number; PI, povidone-iodine; SSI, surgical site infection.

All 15 included studies were conducted in LMICs as defined by World Bank classifications at the time of publication, including lower middle-income countries (Pakistan, India, Nigeria, Ghana, Benin, Rwanda, and Egypt) and upper middle-income

countries (South Africa). The uniform distribution of effect estimates around the pooled RR and narrow confidence intervals reflect the homogeneity observed in quantitative heterogeneity statistics (Figure 2).

TABLE 3 | Pooled meta-analysis results.

Parameter	Value	95% CI lower	95% CI upper
Log risk ratio (log RR)	−0.4990	−0.7700	−0.2290
Standard error (SE)	0.1380	—	—
Risk ratio (RR)	0.6071	0.4630	0.7952
Z-statistic	−3.6100	—	—
p-value	< 0.0010	—	—
Heterogeneity statistics			
Tau (τ)	0.0000	—	—
Tau ² (τ^2)	0.0000 (SE = 0.0960)	—	—
I ²	0.00%	—	—
H ²	1.0000	—	—
Cochran's Q	10.0480 (df = 14)	—	—
p-value (Q)	0.7590	—	—

Note: Model: random effects (REML estimator), number of studies (*k*): 15, and total sample size: 7459 patients.
Abbreviation: CI, confidence interval.

TABLE 4 | Leave-one-out sensitivity analysis of the pooled effect of chlorhexidine-alcohol (CHG-ALC) versus povidone-iodine on surgical site infection prevention.

Study omitted	<i>k</i>	Total <i>N</i>	Pooled RR	95% CI	I ² (%)	Interpretation
None (primary analysis)	15	7459	0.61	0.46–0.80	0	CHG-ALC superior
Ademuyiwa et al. [1]	14	4536	0.58	0.46–0.73	0	Effect strengthened
Bibi et al. [2]	14	7071	0.60	0.46–0.80	0	Effect maintained
Danasekaran et al. [15]	14	7339	0.63	0.48–0.82	0	Effect maintained
Elgarf et al. [4]	14	7259	0.62	0.47–0.82	0	Effect maintained
Idowu et al. [8]	14	7279	0.61	0.47–0.80	0	Effect maintained
Kesani et al. [9]	14	6899	0.62	0.46–0.82	0	Effect maintained
Luwang et al. [7]	14	7148	0.61	0.46–0.80	0	Effect maintained
Mukhtar et al. [16]	14	7209	0.61	0.46–0.80	0	Effect maintained
Chirukandeth et al. [17]	14	7222	0.61	0.46–0.80	0	Effect maintained
Saqlain et al. [13]	14	7159	0.62	0.48–0.82	0	Effect maintained
Singh et al. [18]	14	7259	0.62	0.47–0.81	0	Effect maintained
Srinivas et al. [5]	14	7108	0.61	0.46–0.81	0	Effect maintained
Sufyan et al. [19]	14	6619	0.61	0.46–0.81	0	Effect maintained
Takalkar et al. [11]	14	7060	0.58	0.44–0.78	0	Effect strengthened
Valappil [6]	14	7259	0.61	0.46–0.80	0	Effect maintained

Note: All analyses used random effects models (REML).

Abbreviations: CI, confidence interval; *k*, number of studies; *N*, number of participants; RR, risk ratio.

3.4 | Subgroup and Stratified Analyses

Wound classification stratification: When analyses were restricted to studies that exclusively enrolled clean-contaminated wounds (*k* = 13; *n* = 4148), the pooled effect remained significant (RR = 0.59, 95% CI 0.45–0.77; *p* < 0.001; and *I*² = 0%). This sensitivity analysis excluded studies with mixed wound classifications, including the FALCON trial [14] and Bibi et al.'s trial [2], and confirmed that the overall conclusion favoring CHG-ALC was not dependent on the inclusion of mixed wound classes. Subgroup analysis by wound classification showed consistent reductions in SSI with CHG-ALC compared with PI across studies enrolling exclusively

clean-contaminated wounds and those including mixed wound classifications (Supporting Information S1: Figure S1).

Study design stratification: Single-center trials (*k* = 13 and *n* = 4148) demonstrated a stronger protective effect of CHG-ALC (RR = 0.59, 95% CI 0.45–0.77; *p* < 0.001; and *I*² = 0%) than multicenter trials (*k* = 2 and *n* = 3311; RR = 0.83 and 95% CI 0.57–1.20; *p* = 0.318; and *I*² = 73.4%). The test for subgroup difference was statistically significant (*Q* = 3.89, *df* = 1, and *p* = 0.048), suggesting that study design may modify the observed treatment effect, with stronger and more consistent benefit seen in single-center settings, possibly reflecting greater implementation fidelity and more standardized perioperative

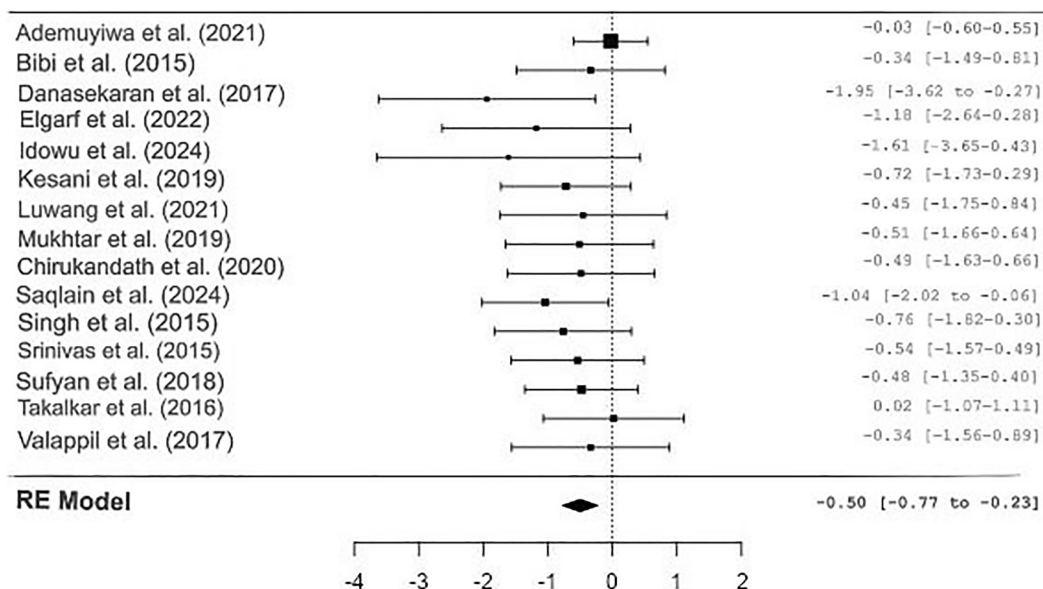


FIGURE 2 | Forest plot of the association between chlorhexidine-alcohol (CHG-ALC) versus povidone-iodine (PI) for surgical site infection (SSI) prevention in abdominal surgery in low- and middle-income countries. This figure displays the risk ratios (RRs) and 95% confidence intervals (CI) for each included study comparing CHG-ALC with PI for SSI prevention. Squares represent study-specific risk ratios, and horizontal lines indicate 95% CIs. Square size reflects study weight. The diamond represents the pooled random effects estimate. Values below 1.0 favor CHG-ALC. Overall, CHG-ALC was associated with a lower risk of SSI than PI.

care pathways. When studies were stratified by study design, the protective effect of CHG-ALC compared with PI remained evident in both single-center and multicenter trials, although the magnitude of effect varied between study types (Supporting Information S1: Figure S2).

Sample size stratification: Large studies (≥ 200 participants; $k = 13$ and $n = 7159$) showed effects (RR = 0.62, 95% CI 0.47–0.82, and $p = 0.001$; $I^2 = 0\%$) similar to smaller studies (< 200 participants; $k = 2$ and $n = 300$; RR = 0.17, 95% CI 0.05–0.56, and $p = 0.004$; and $I^2 = 0\%$), though both groups demonstrated significant benefit (test for subgroup difference: $Q = 4.23$, $df = 1$, and $p = 0.040$). This pattern is consistent with the influence of pragmatic, large-scale trials reflecting real-world variability.

Quality score stratification: Studies with quality scores $\geq 7/9$ ($k = 11$ and $n = 5781$) and those with scores $\leq 6/9$ ($k = 4$ and $n = 1678$) showed similar effects (RR = 0.62 vs. RR = 0.58, respectively), with no significant subgroup difference ($Q = 0.12$ and $p = 0.729$), confirming that study quality did not substantially modify treatment effects.

Surgical procedure type: Cesarean sections ($k = 2$ and $n = 871$; RR = 0.56, 95% CI 0.37–0.85, and $p = 0.006$; and $I^2 = 0\%$), specific laparotomy procedures ($k = 2$ and $n = 437$; RR = 0.67, 95% CI 0.40–1.11, and $p = 0.121$; and $I^2 = 0\%$), laparoscopic cholecystectomy ($k = 1$ and $n = 200$; RR = 0.31, 95% CI 0.10–0.91, and $p = 0.033$), abdominal hernia repair ($k = 1$ and $n = 300$; RR = 0.35, 95% CI 0.22–0.57, and $p < 0.001$), and mixed/general abdominal surgeries ($k = 9$ and $n = 5651$; RR = 0.64, 95% CI 0.46–0.89, and $p = 0.008$; and $I^2 = 0\%$) all demonstrated benefit favoring CHG-ALC. The test for subgroup heterogeneity was not significant ($Q = 2.89$, $df = 4$, and $p = 0.576$), supporting generalizability of the

intervention across diverse clean-contaminated abdominal procedures.

3.5 | Heterogeneity and Publication Bias Assessment

Low heterogeneity was observed ($I^2 = 0\%$, $Q = 10.048$, $p = 0.759$, and $\tau^2 = 0.000$), reflecting consistency in study populations and antiseptic administration protocols across included studies. Publication bias assessment yielded mixed findings (Table 5). Egger's regression test suggested possible small-study effects ($\beta = -2.289$ and $p = 0.022$), and visual inspection of the funnel plot (Figure 3) revealed slight asymmetry with smaller studies showing larger treatment effects. However, Kendall's tau correlation was nonsignificant ($\tau = -0.219$ and $p = 0.282$), and the fail-safe N of 80 suggests that 80 null studies would be required to nullify the observed effect, indicating robustness against unpublished negative trials. The observed asymmetry may reflect genuine differences in baseline SSI rates and implementation quality between larger pragmatic trials and smaller controlled studies rather than publication bias alone.

3.6 | Comprehensive Regional Subgroup Analysis

Regional subgroup analysis revealed statistically significant heterogeneity in treatment effects across geographic regions (test for subgroup differences: $Q = 6.14$, $df = 2$, and $p = 0.046$), indicating that antiseptic effectiveness varies substantially depending upon settings (Tables 6 and 7). Regional subgroup analysis demonstrated variation in effect estimates across geographic regions, with the majority of evidence originating from South Asia and smaller contributions from sub-Saharan Africa and North Africa/Middle East (Supporting Information S1: Figure S3).

TABLE 5 | Heterogeneity and publication bias assessment.

Statistic	Value	Interpretation
Tau (τ)	0.000	No between-study variation
Tau ² (τ^2)	0.000 (SE = 0.096)	Zero variance
I ²	0%	0% due to heterogeneity
H ²	1.000	Homogeneous
Cochran's Q (df = 14)	10.048	$p = 0.759 \rightarrow$ not significant
Kendall's tau	-0.219	$p = 0.282 \rightarrow$ no correlation
Egger's regression	-2.289	$p = 0.022 \rightarrow$ possible bias
Fail-safe N	80	80 null studies needed to nullify

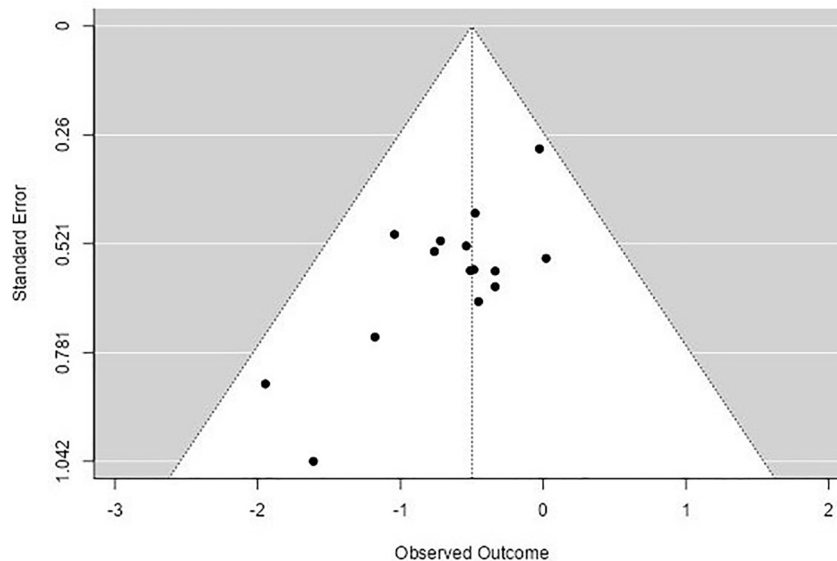


FIGURE 3 | Funnel plot for assessment of small-study effects in the meta-analysis of chlorhexidine-alcohol versus povidone-iodine. Each point represents one study plotted by effect sizes (log RR) and standard error. Visual asymmetry is observed, with smaller studies (higher standard errors) showing larger treatment effects. Egger's regression test ($p = 0.022$) suggests possible small-study effects, though this may reflect genuine heterogeneity in baseline surgical site infection rates and implementation quality rather than publication bias alone.

South Asia (India and Pakistan): 12 studies enrolling 4156 patients demonstrated robust and consistent benefit of CHG-ALC (RR = 0.5755, 95% CI 0.4645–0.7130, and $p < 0.001$; $I^2 = 0\%$, $\tau^2 = 0.000$, $Q = 8.95$, and $p = 0.628$). This translates to a 42.5% relative risk reduction and an absolute risk reduction of 7.5% points (SSI rates: 10.3% with CHG-ALC vs. 17.8% with PI), yielding a number needed to treat of 13 (95% CI 10–20) (Table 8). Zero heterogeneity across 12 diverse studies spanning different countries (India $n = 9$ and Pakistan $n = 3$), surgical procedures (cesarean sections, laparotomy, cholecystectomy, and hernia repair), and institution types suggests genuine treatment effectiveness that is reproducible across South Asian contexts.

Sub-saharan Africa: Two studies enrolling 3103 patients yielded inconclusive results (RR = 0.8814, 95% CI 0.3518–2.2090, and $p = 0.786$; $I^2 = 90.8\%$, $\tau^2 = 0.8619$, $Q = 10.87$, and $p < 0.001$). This subgroup was dominated by the FALCON trial [1] ($n = 2,923$, RR = 0.974, and 95% CI 0.822–1.154), which showed no benefit, whereas the smaller Nigerian study [8] ($n = 180$,

RR = 0.200, and 95% CI 0.024–1.678) suggested large benefit but with wide confidence intervals. The extreme heterogeneity likely reflects fundamental differences between these studies: FALCON's pragmatic design included 40% contaminated/dirty wounds across seven countries with variable implementation fidelity, whereas the Nigerian study focused on clean-contaminated cases in a controlled single-center setting. The 11.9% relative risk reduction observed in this subgroup was not statistically significant, and the wide confidence interval (0.35–2.21) indicates substantial uncertainty. Current evidence is insufficient to recommend CHG-ALC over PI in sub-Saharan African settings.

North Africa/Middle East (Egypt): A single study [4] ($n = 200$) in laparoscopic cholecystectomy cases showed substantial benefit (RR = 0.3077, 95% CI 0.1039–0.9114, and $p = 0.033$), representing a 69.2% relative risk reduction (SSI rates: 4.0% with CHG-ALC vs. 13.0% with PI). However, single-study evidence is inherently unreliable, subject to site-specific factors, and cannot inform regional policy without replication.

TABLE 6 | Comprehensive sensitivity and subgroup analyses.

Analysis	<i>k</i>	<i>N</i>	Pooled RR	95% CI	<i>I</i> ² (%)	<i>p</i> -value
Primary analysis	15	7459	0.61	0.46–0.80	—	< 0.001
Sensitivity analyses						
Excluding FALCON trial	14	4536	0.58	0.46–0.71	—	< 0.001
Clean-contaminated wounds only	13	4148	0.59	0.45–0.77	—	< 0.001
Excluding studies with quality score < 7	11	5781	0.62	0.45–0.86	—	0.004
Fixed effects model	15	7459	0.89	0.77–1.03	N/A	0.117
Regional subgroups						
South Asia	12	4156	0.58	0.46–0.71	—	< 0.001
Sub-Saharan Africa	2	3103	0.88	0.35–2.21	91	0.786
North Africa/Middle East	1	200	0.31	0.10–0.91	N/A	0.033
Test for subgroup difference						<i>Q</i> = 6.14, <i>p</i> = 0.046
Quality score subgroups						
High quality (QS ≥ 7/9)	11	5781	0.62	0.45–0.86	—	0.004
Moderate quality (QS = 6/9)	4	1678	0.58	0.40–0.84	—	0.004
Test for subgroup difference						<i>Q</i> = 0.12, <i>p</i> = 0.729

Abbreviations: CI, confidence interval; *k*, number of studies; *n*, number of participants; RR, relative risk.

TABLE 7 | Regional subgroup meta-analysis results.

Region	<i>k</i>	<i>N</i>	SSI rate CHG-ALC (%)	SSI rate PI (%)	Pooled RR	95% CI	<i>p</i> -value	<i>I</i> ²	Tau ²	<i>Q</i>	<i>p</i> (het)
South Asia	12	4156	8.8	15.8	0.5755	0.4645–0.7130	< 0.001	0.0%	0.0000	8.95	0.628
Sub-Saharan Africa	2	3103	14.5	15.2	0.8814	0.3518–2.2090	0.786	90.8%	0.8619	10.87	< 0.001
North Africa/Middle east	1	200	4.0	13.0	0.3077	0.1039–0.9114	0.033	N/A	N/A	N/A	N/A
Test for subgroup differences										6.14	0.046

Abbreviations: CHG-ALC, chlorhexidine alcohol; CI, confidence interval; Het, heterogeneity; *k*, number of studies; *N*, number of participants; PI, povidone iodine; RR, relative risk; SSI, surgical site infection.

TABLE 8 | Regional characteristics and surgical site infection (SSI) baseline rates.

Region	Baseline SSI rate (PI group) (%)	Absolute risk reduction (%)	Number needed to treat	Statistical significance
South Asia	15.8	7.0	14	<i>p</i> < 0.001
Sub-Saharan Africa	15.2	0.7	N/A (not significant)	<i>p</i> = 0.786
North Africa/Middle East	13.0	9.0	11	<i>p</i> = 0.033

4 | Discussion

This meta-analysis of 15 studies involving 7459 patients from LMICs demonstrates that CHG-ALC reduces SSI risk by 39% compared with PI in clean-contaminated abdominal surgery. Heterogeneity was negligible (*I*² = 0% and *p* = 0.759), suggesting consistent effects across diverse LMIC settings. Sensitivity analyses confirmed robustness. Regional subgroup analysis, however, revealed significant variation, with a strong benefit in South Asia but inconclusive results in sub-Saharan Africa.

These findings emphasize that antiseptic efficacy is not universal but deeply context-dependent [1, 20].

Our results align with HIC evidence favoring alcoholic chlorhexidine but show a more modest effect [3, 21]. Previous meta-analyses in HICs have reported relative risk reductions of 40%–50% with CHG-ALC compared to PI [3, 21, 22], with baseline SSI rates typically ranging from 5% to 10%. Our observed 39% relative risk reduction in LMICs occurs against substantially higher baseline SSI rates (27.7% with PI), which

are likely due to variable infection control, and resource constraint factors that amplify absolute gains but dilute relative superiority [1]. South Asian studies produced a 42.5% relative risk reduction, 7.0% absolute reduction, and number needed to treat of 13. This remarkable consistency across India, Pakistan, cesarean sections, laparotomies, and hernia repairs suggests reproducible benefit when implementation is standardized [5]. Possible drivers include commercial CHG-ALC applicators, adequate drying time, and lower gross contamination at incision.

Previous systematic reviews have generally favored chlorhexidine-based skin antisepsis but most pooled mixed procedures, mixed income settings, or different iodine comparators, and few addressed the specific question of clean-contaminated abdominal surgery in LMICs. As shown in Supporting Information S1: Table S2, the existing literature leaves an important contextual gap regarding whether benefits observed in broader or higher resource settings translate consistently to low-resource abdominal surgery, particularly across regions within LMICs.

Other studies, particularly those conducted in LMICs, have reported no statistically significant difference in SSI rates [2, 6]. For example, a multicenter trial in Pakistan observed lower SSI rates in the CHG-ALC group (7.1%) than the PI group (10.0%), but this difference lacked statistical significance ($p = 0.324$) [2, 4]. Crucially, the large-scale FALCON trial, performed across seven LMICs, found no evidence to support the superiority of 2% alcoholic chlorhexidine skin preparation to PI in preventing SSI following clean-contaminated, contaminated, or dirty abdominal surgery [1]. The varying results across studies are believed to be influenced by factors such as the microbiological flora, methodology, and control of confounding factors like the surgical wound class [2, 5].

Sub-Saharan Africa yielded inconclusive results, driven by the FALCON trial and a smaller Nigerian study that hinted at benefit but lacked power. This region bears the highest SSI burden yet has the weakest antiseptic evidence, demonstrating profound inequity. North Africa/Middle East results rest on one Egyptian trial showing 69% reduction [4], but single-study evidence is unreliable and requires replication.

The most striking tension lies with the FALCON trial, which contributed 68% of the sample size and reported no difference [1]. This null result dominates sub-Saharan Africa and challenges our pooled estimate. Several factors explain the paradox. First is wound class heterogeneity: Approximately 40% of FALCON cases were contaminated or dirty, where bacterial loads may overwhelm any topical antiseptic. Our focus on clean-contaminated surgery (Centers for Disease Control Class II) showed persistent benefit upon restriction. Second is pragmatic design—introduced site-level variability in surgical technique, antibiotic timing, theater discipline, and sterilization, masking antiseptic-specific effects. Single-center trials showed stronger benefit than multicenter ones. Third, infrastructure gaps such as unreliable power, water, and training likely negated CHG-ALC's advantages [1]. We must acknowledge that the possibility that CHG-ALC offers no meaningful edge in many African settings, where systemic failures dwarf skin preparation. Accordingly,

our main estimate should be interpreted as reflecting the available LMIC abdominal surgery literature overall, whereas the clean-contaminated sensitivity analysis provides the most direct estimate for the target wound class named in the original review question.

The differential effectiveness observed across regions likely reflects multiple contextual factors beyond the antiseptic agents themselves. Although CHG-ALC's mechanistic advantages including rapid alcohol-mediated killing combined with chlorhexidine's persistent residual activity are well established [4, 5], the translation of these properties into clinical benefit depends critically on the implementation context. In South Asian settings, where consistent benefit was demonstrated, factors such as standardized application protocols, adequate skin drying time, and controlled surgical environments may have enabled the antiseptic's full potential to be realized. Conversely, the inconclusive results in sub-Saharan Africa suggest that under conditions of high baseline contamination, variable surgical technique, and resource constraints, the marginal benefit of CHG-ALC over PI may be diminished or absent. Our findings must be interpreted in light of the specific comparison studied. We compared CHG-ALC versus PI for preoperative skin antisepsis, only one component of SSI prevention. Effective SSI reduction requires multimodal interventions including appropriate antibiotic prophylaxis, surgical technique optimization, theater discipline, and postoperative wound care [15, 23]. The observed regional variation in antiseptic effectiveness underscores that interventions do not operate in isolation but within complex healthcare systems where baseline infection control practices, resource availability, and implementation fidelity fundamentally shape outcomes.

4.1 | Clinical and Policy Implications

Our findings challenge universal guideline recommendations and support region-specific implementation strategies. For South Asian countries, CHG-ALC should be considered standard of care for clean-contaminated abdominal surgery based on high-certainty evidence. For sub-Saharan Africa, either antiseptic may be used pending further evidence, with resource allocation prioritizing interventions with clearer evidence bases. The burden of SSI is not globally uniform. As noted, patients in LMICs are disproportionately affected by higher rates of SSI. This inequity increases the risk of catastrophic expenditure and impoverishment for patients [1, 24]. Global guidelines must abandon universal claims and issue region-specific, evidence-tiered guidance with LMIC representation. Urgent research investment in African surgical trials is essential to resolve this critical knowledge gap in the region with the highest SSI burden globally.

4.2 | Strengths and Limitations

The strengths of our meta-analysis include LMIC focus, rigorous PRISMA-compliant methods, registration with PROSPERO, zero overall heterogeneity, and regional nuance. Several limitations are critical. We demonstrated possible publication bias, with small-study effects and likely unpublished negative trials. There was an 80% South Asian dominance, limiting generalizability. The studies analyzed had variable SSI definitions and various CHG-ALC formulations, which may have skewed the results. Lack of long-term follow-up and absent individual

patient data for effect modifiers limit the ability to determine the true risk. Most importantly, the scarcity of primary data from sub-Saharan Africa, with only two studies, one large pragmatic trial, and one small single-center report, severely restricts regional inference. We also restricted inclusion of English language reports or studies with usable translations. This may have reduced LMIC coverage and introduced language bias; because the three non-English reports were not fully translated and quantitatively extracted, their potential effect on the pooled estimate cannot be determined with certainty.

Future research should prioritize large African RCTs restricted to clean-contaminated wounds, implementation studies on training and supply, pathogen susceptibility profiling, LMIC-specific cost-effectiveness models, and individual patient data meta-analysis to identify modifiers. Until such evidence emerges, the superiority of CHG-ALC over PI must be considered with caution. CHG-ALC is more superior in systems that support its use. In many LMICs, infrastructure challenges limit effectiveness of antiseptics.

5 | Conclusion

Chlorhexidine-alcohol demonstrates superior effectiveness to povidone-iodine for preventing surgical site infections in clean-contaminated abdominal surgery in low- and middle-income countries, with high-certainty evidence of consistent benefit across South Asian settings. Sensitivity analyses confirm robustness of this finding across multiple analytic approaches. However, results in sub-Saharan Africa remain inconclusive due to heterogeneity between controlled single-center evidence and a large pragmatic trial that included higher wound classifications. These findings support region-specific, conditional recommendations rather than universal guidelines.

Author Contributions

John Turyagumanawe: conceptualization, data curation, supervision, writing – original draft. **Enock Mukibi:** conceptualization, methodology, writing – original draft. **Jackson Kakooza:** conceptualization, data curation, writing – original draft. **Michael Mugenyi:** conceptualization, validation, writing – review and editing. **Bienfait V. Mumbere:** data curation, writing – original draft. **Abass Alao Safiriyu:** data curation, methodology, validation, writing – original draft. **Ahmed Kiswezi Kazigo:** data curation, methodology, writing – original draft. **Umaru Kabuye:** data curation, validation, writing – original draft, writing – review and editing. **Ibrahim Bwaga:** data curation, writing – original draft. **Luis Nyende:** data curation, writing – original draft. **Sedrick Bukyana:** conceptualization, data curation, writing – original draft. **Emmanuel Ibudi:** data curation, validation, writing – original draft, writing – review and editing. **Rashid Naziru:** data curation, writing – review and editing. **Denis Bitamazire:** data curation, validation, writing – review and editing. **Catherine R. Lewis:** data curation, validation, writing – original draft, writing – review and editing. **Prosper Akankwasa:** conceptualization, methodology, writing – original draft. **Theoneste Hakizimana:** data curation, methodology, validation, writing – review and editing.

Acknowledgments

The authors thank the librarians who assisted with the literature search and obtaining articles.

Funding

The authors have nothing to report.

Ethics Statement

The authors have nothing to report.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

All available data are presented in this manuscript.

References

1. A. O. Ademuyiwa, P. Hardy, E. Runigamugabo, P. Sodonougbo, H. Behanzin, and S. Kangni, “Reducing Surgical Site Infections in Low-Income and Middle-Income Countries (FALCON): A Pragmatic, Multicentre, Stratified, Randomised Controlled Trial,” *Lancet* 398, no. 10312 (2021): 1687–1699, [https://doi.org/10.1016/S0140-6736\(21\)01548-8](https://doi.org/10.1016/S0140-6736(21)01548-8).
2. S. Bibi, S. A. Shah, S. Qureshi, et al., “Is chlorhexidine-Gluconate Superior Than Povidone-Iodine in Preventing Surgical Site Infections? A Multicenter Study,” *Journal of Pakistan Medical Association* (2015).
3. Q. Yang, J. Sun, Z. Yang, S. Rastogi, Y.-Feng Liu, and B.-bin Zhao, “Evaluation of the Efficacy of Chlorhexidine-Alcohol Versus Aqueous/Alcoholic Iodine Solutions for the Prevention of Surgical Site Infections: A Systematic Review and Meta-Analysis,” *International Journal of Surgery* 110, no. 11 (2024): 7353–7366, <https://doi.org/10.1097/js9.0000000000002024>.
4. S. Elgarf, T. Elmahdy, M. Eissa, H. Barakat, and A. Swelam, “Chlorhexidine Alcohol Versus Povidone Iodine for Prevention of Surgical Site Infection in Laparoscopic Cholecystectomy,” *Benha Medical Journal* (2022), <https://doi.org/10.21608/bmfj.2022.119137.1539>.
5. A. Srinivas, L. Kaman, P. Raj, et al., “Comparison of the Efficacy of Chlorhexidine Gluconate Versus Povidone Iodine as Preoperative Skin Preparation for the Prevention of Surgical Site Infections in Clean-Contaminated Upper Abdominal Surgeries,” *Surgery Today* 45, no. 11 (2014): 1378–1384, <https://doi.org/10.1007/s00595-014-1078-y>.
6. R. K. Valappil, “Preoperative Skin Preparation With Chlorhexidine Alcohol and Povidone Iodine: A Comparative Study,” *Journal of Medical Science and Clinical Research* 5, no. 12 (2017), <https://doi.org/10.18535/jmscr/v5i12.129>.
7. A. L. Luwang, P. K. Saha, M. Rohilla, P. Sikka, L. Saha, and V. Gautam, “Chlorhexidine–Alcohol Versus Povidone–Iodine as Preoperative Skin Antisepsis for Prevention of Surgical Site Infection in Cesarean Delivery—A Pilot Randomized Control Trial,” *Trials* 22, no. 1 (2021): 540, <https://doi.org/10.1186/s13063-021-05490-4>.
8. N. A. Idowu, O. O. Akanbi, T. A. Akinloye, et al., “Effectiveness of Chlorhexidine—Alcohol Compared With Povidone Iodine for Preventing Surgical Site Infection: A Randomized Trial,” *Sierra Leone Journal of Medicine* 1, no. 2 (2024): 75–79, <https://doi.org/10.69524/sljm.v1i2.46>.
9. V. P. Kesani, S. Talasila, and S. R. Sheela, “Chlorhexidine-Alcohol Versus Povidone-Iodine-Alcohol for Surgical Site Antisepsis in Caesarean Section,” *International Journal of Reproduction, Contraception, Obstetrics and Gynecology* 8, no. 4 (2019): 1359, <https://doi.org/10.18203/2320-1770.ijrcog20191181>.
10. S. Deeming, X. Dolja-Gore, J. Gani, et al., “Optimal Antiseptic Skin Preparation Agents for Minimizing Surgical Site Infection Following Surgery: Cost and Cost-Effectiveness Analysis,” *BJS Open* 8, no. 1 (2024): zrad160, <https://doi.org/10.1093/bjsopen/zrad160>.

11. Y. Takalkar, M. Garale, S. Somasundaram, K. Venkataramani, K. Gothwal, and S. Pandrowala, "Comparison of Efficacy of Chlorhexidine Alcohol Scrub and Povidone Iodine Scrub in Hand Cleansing in Elective Clean Surgery," *International Surgery Journal* (2016): 1937–1941, <https://doi.org/10.18203/2349-2902.isj20163180>.
12. M. L. Hemani and H. Lepor, "Skin Preparation for the Prevention of Surgical Site Infection: Which Agent Is Best?," *Reviews in Urology* (2009), <https://doi.org/10.3909/riu0467>.
13. M. Saqlain, M. Imran, M. D. Yousaf, et al., "A Comparative Study of Prevalence of Surgical Site Infection Using Povidone Iodine Versus Chlorhexidine Alcohol in Preoperative Skin Preparation in Abdominal Hernias," *Insights-Journal of Health and Rehabilitation* 2, no. 2 (Health & Rehab) (2024): 288–294, <https://doi.org/10.71000/ijhr126>.
14. GS Collaborative, "FALCON: Protocol for a Pragmatic Multicentre Factorial Randomised Controlled Trial Testing Measures to Reduce Surgical Site Infection in Low and Middle Income Countries," *International Journal of Surgery* (2018), <https://doi.org/10.1016/j.ijso.2018.05.168>.
15. G. Danasekaran, S. Rasu, and M. Palani, "A Study of Comparative Evaluation of Preoperative Skin Preparation With Chlorhexidine-Alcohol Versus Povidone Iodine in Prevention of Surgical Site Infections," *Journal of Evidence Based Medicine and Healthcare* 4, no. 41 (2017): 2453–2460, <https://doi.org/10.18410/jebmh/2017/485>.
16. Q. Mukhtar, "A Cross Sectional Study to Evaluate if Chlorhexidine More Effective than Povidone Iodine in Controlling Surgical Site Infections," *Indo American Journal of Pharmaceutical Sciences* (2019).
17. R. Chirukandath, M. P. Elangovan, B. Agil, et al., "Does Skin Preparation Influence Surgical Site Infection in Laparotomy Wounds: Comparative Evaluation of Preoperative Skin Preparation With 4% Chlorhexidine With 5% Povidone Iodine in Laparotomy Wounds: A Prospective Trial," *European Journal of Medical and Health Sciences* 2, no. 4 (2020), <https://doi.org/10.24018/ejmed.2020.2.4.415>.
18. C. Singh, "Efficacy of Chlorhexidine Alcohol Over Aqueous Povidone Iodine in Prevention of Surgical Site Infection," *International Journal of Science and Research* (2015), <https://doi.org/10.21275/v4i12.NO152442>.
19. A. Sufyan, M. Tariq, R. Bano, et al., "Comparison Between Chlorhexidine-Alcohol and Povidone-Iodine in Preventing Surgical Site Infection in Clean Contaminated Cases," *Pakistan Armed Forces Medical Journal* 68, no. 4 (2018): 802–806, <https://www.pafmj.org/PAFMJ/article/view/86>.
20. A. Bhangu, A. O. Ademuyiwa, M. L. Aguilera, P. Alexander, and S. W. Al-Saqqa, "Surgical Site Infection After Gastrointestinal Surgery in High-Income, Middle-Income, and low-income Countries: A Prospective, International, Multicentre Cohort Study," *Lancet Infectious Diseases* 18, no. 5 (2018): 516–525, [https://doi.org/10.1016/S1473-3099\(18\)30101-4](https://doi.org/10.1016/S1473-3099(18)30101-4).
21. R. G. Wade, N. E. Burr, G. McCauley, G. Bourke, and O. Efthimiou, "The Comparative Efficacy of Chlorhexidine Gluconate and Povidone-Iodine Antiseptics for the Prevention of Infection in Clean Surgery," *Annals of Surgery* 274, no. 6 (2020): e481–e488, <https://doi.org/10.1097/sla.0000000000004076>.
22. R. O. Darouiche, M. J. Wall Jr., K. M. F. Itani, et al., "Chlorhexidine-Alcohol Versus Povidone-Iodine for Surgical-Site Antisepsis," *New England Journal of Medicine* 362, no. 1 (2010): 18–26, <https://doi.org/10.1056/nejmoa0810988>.
23. S. I. Berríos-Torres, C. A. Umscheid, D. W. Bratzler, et al., "Centers for Disease Control and Prevention Guideline for the Prevention of Surgical Site Infection, 2017," *JAMA Surgery* 152, no. 8 (2017): 784, <https://doi.org/10.1001/jamasurg.2017.0904>.
24. M. G. Shrima, A. J. Dare, B. C. Alkire, K. O'Neill, and J. G. Meara, "Catastrophic Expenditure to Pay for Surgery Worldwide: A Modelling

Study," supplement, *Lancet Global Health* 3 (2015): S38–S44, [https://doi.org/10.1016/s2214-109x\(15\)70085-9](https://doi.org/10.1016/s2214-109x(15)70085-9).

Supporting Information

Additional supporting information can be found online in the Supporting Information section.

Supporting Information S1: wjs70409-sup-0001-suppl-data.docx.