SYSTEMATIC REVIEW

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Effect of interventions on surgical site infections in Sub-Saharan Africa: a systematic review

Fekadeselassie Berhe[1*], Tefera Belachew[2] and Kalkidan Hassen[2]

Abstract

Background Surgical site infections (SSI) are a major concern due to their contributions to morbidity, economic loss, and death among individuals who underwent operations in healthcare institutions. To decrease this infection, various pharmacological and non-pharmacological interventions have been devised and implemented for major surgery patients. Pharmacological interventions include the provision of antibiotic prophylaxis and antiseptic agents, whereas non-pharmacological interventions encompass programmatic interventions such as protocols, policies, quality improvement initiatives, training, and education that are given at the institutional level. However, the effect of particularly non-pharmacological interventions on the reduction has not been comprehensively evaluated for over a decade. This systematic review attempts to synthesize a piece of evidence on the effect of non-pharmacological intervention in Sub-Saharan Africa on minimizing SSI and enhancing health outcomes.

Methods Databases including MEDLINE, Google Scholar, Cochrane Library, AJOL, Hinari, search platforms, and open-access repositories were accessed. Two investigators conducted a literature selection process, and the quality of selected articles was assessed using a JBI quality evaluation checklist.

Results A total of 11 studies that met the inclusion criteria were analyzed. Three main intervention categories were identified, which focused on improving adherence to protocol, policy change or induction, and delivery of multimodal strategies. These interventions led to a reduction in SSI rates in varying degrees (15% to 95%). Multimodal interventions are the most widely implemented and comprehensive approaches that integrate multiple evidence-based practices, which have demonstrated a substantial reduction of SSI in different surgical populations. The rates of improvement with these interventions were influenced by intervention type, patient characteristics, surgical urgency, healthcare setting, follow-up time, and criteria for measuring the outcomes that may influence the SSI rates.

Conclusion Interventions focusing on policy, protocol, and multimodal strategies can effectively reduce SSI rates, with the latter being the most effective. Patient and clinical characteristics, along with the healthcare setting, were influential factors affecting the interventions' impact on SSI. This systematic review is registered in PROSPERO, in the number CRD42024524963.

Keywords Intervention, Non-pharmacological, Prevention, Sub-Saharan Africa, Surgical site infection, Wound infection

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Background

Surgical site infection is among the prevalent healthcare-associated infections (HAIs) in healthcare institutions, and it occur postoperatively in a specific location where surgery is performed. According to the CDC, it is an infection within 30 days (or 90 days if an implant is placed) after surgery and involves the skin, subcutaneous tissue, or organ/space operated on during the surgical procedure. It is categorized as superficial, deep, and organ or space SSI [1, 2]. A study conducted in 2023 revealed a global incidence of 2.5%, with a notably higher prevalence of 7.2% observed in Africa [3]. SSI rates vary across surgical procedures, such as a 33% higher rate in neurosurgery operations [4], and demonstrate variations according to the economic status of the countries involved [5]. SSI represents the primary concern and emphasis in low-income and middle-income countries' healthcare institutions [6]. In low- and middle-income countries like Sub-Saharan Africa, SSI leads to severe complications like sepsis, unexpected hospital stays [7], and additional financial burdens [8–10]. It also increases morbidity and mortality rates among surgery patients [11].

Considering this, the World Health Organization (WHO) has introduced a guideline for healthcare workers to prevent and reduce SSI in patients [12], and it is estimated that infection prevention and control (IPC) interventions can lower HAIs like SSI by 35–70% [13].

To combat SSI effectively, both pharmacological and non-pharmacological interventions are crucial. While pharmacological interventions such as antibiotic prophylaxis and antiseptics are well-established and studied, non-pharmacological programmatic interventions beyond individual patient care are often understudied, particularly in resource-constrained settings. These interventions include IPC protocols, which are structured guidelines to reduce infections, and clear policies for SSI prevention that are necessary to ensure compliance and are often supported by regular audits and feedback mechanisms to derive improvement in adherence rates. Education and training initiatives such as workshops, simulations, and refresher courses can up-skill surgical teams and improve compliance with IP measures. Quality improvement interventions focus on systematic improvement of healthcare delivery to improve patient outcomes. A multimodal approach combines multiple strategies to address various aspects of SSI prevention simultaneously. All these programmatic interventions are key to reducing SSI by establishing structured practices across healthcare settings. By implementing IPC protocols, having clear policies, educating healthcare workers, making quality improvements, and employing multimodal interventions in healthcare settings, we can mitigate the risk of SSI.

The previous review examined both pharmacological and non-pharmacological interventional studies published between 1995 and 2010 [14]. The others focus on all HAIs and specific interventions and including developed countries [15–18]. Our review focuses on targeted non-pharmacological interventions to address this gap in the literature, provide evidence-based recommendations for SSI prevention in Sub-Saharan Africa, and evaluate their effectiveness in reducing SSI risk. Pharmacological interventions were excluded to allow for a focused analysis of complementary measures that are critical for sustainable infection control.

Methods

Search strategy

The search strategy followed four critical phases designed to address the research question: "What is the effectiveness of non-pharmacological interventions employed to avert surgical site infections among patients undergoing major surgery in Sub-Saharan Africa?" The first phase started with an initial search on the PubMed database for relevant keywords; in the second and third phases, identified key and index terms used in the AJOL, Hinari, Cochrane Library, and Google Scholar databases, and repositories of Addis Ababa University and Jimma University, respectively; and in the fourth phase, references to identified papers were critically overseen and scrutinized for possible supplementary investigation. The study explored literature from 2011 to 2023 and searched published and unpublished research focusing on non-pharmacological and non-medical interventions in Sub-Saharan Africa.

In April 2024, the process of exploring literature was conducted. The literature exploration was conducted using keywords and MeSH terms in PubMed. The principal keywords are "infection, postoperative wound," "infection, surgical wound," "postoperative wound infection," "surgical site infections," "wound infection postoperative," and "wound infection, surgical." MeSH terms, including "surgical wound infection" and "Africa South of Sahara," were discerned by the aforementioned methodology. Boolean operators "AND" and "OR" were used to combine keywords and MeSH terms in the retrieved literature. The detailed search process is indicated in Annex 1. The review adhered to the PRISMA flow diagram [19] as indicated below and was registered in PROSPERO, a number CRD42024524963.

Inclusion and exclusion criteria and study selection

Inclusion and exclusion criteria were set by the PICO framework as summarized in the table below. The article assortment procedure for eligibility was overseen by two authors, FSB and KH. In this review, non-pharmacological intervention is defined by expanding based on the work of Glynn et al. [20] and Wekesah et al. [21] as interventions that involve programmatic-level interventions and do not involve the use of drugs, medications, chemicals, antiseptics, medical and non-medical instruments, and procedures. Studies were selected based on predefined inclusion and exclusion criteria, as outlined in Table 1 below.

Data extraction procedure and quality assessment procedure

FSB and KH extracted information from selected articles after brainstorming, independently appraised, and checked papers against the established standards. Discrepancies arose between the reviewers during the study selection and the extraction process was resolved in a structured way. First, the two reviewers (FSB and KH) discussed the disagreement in detail to reach a consensus. If agreement could not be reached, the third reviewer (TB) was consulted to provide an independent assessment to make the final judgment. The extracted information was filled in a table that was previously prepared, and the result was reported in narrative format. To confirm the integrity of the collected data, autonomous reviewers evaluated publications employing Joanna Briggs Institute (JBI) criteria tailored to four study designs: RCTs [23], observational cohorts [24], non-randomized trials [25], and analytical cross-sectional study designs [26]. A scoring system was used, with high quality considered when the percentage is greater or equal to 85%, moderate quality between 60 and 85%, and low quality when scored between 59 and 50%, as used in similar systematic review research [3]. The detailed quality assessment process is annexed (Annex 2).

Results

A description of the study

The PRISMA process involved 342 duplicates and 218 irrelevant papers from 644 papers. After assessing 84 full-text eligible papers for inclusion and exclusion criteria, 11 remained for analysis. This selection process involved removing some papers that originated from countries beyond Sub-Saharan Africa focused on pharmacological and medical interventions, or reported outcomes other than SSI (Fig. 1).

Characteristics of the included papers

The systematic review included 11 peer-reviewed articles from six distinct countries within Sub-Saharan Africa, except one article that encompassed multiple countries. Seven before-and-after/pre-post designs [27–33], one RCT [34], two cohorts [35, 36], and one pre-post cross-sectional [37] research were among the study designs. The study population comprised five articles focused on pregnant women who underwent CS, five on general surgery, and one study that included patients undergoing both general surgery and cesarean section. Out of 11 studies, nine (82%) examined both emergency and elective cases [27–33, 35, 36]. Six studies followed their patients for 30 days, as recommended by the CDC, to identify SSI cases [27, 30–32, 35, 36]. The studies were conducted in various healthcare settings, with a combined sample size of 18,799 (7850 control/pre-intervention/ and 10,949 intervention/post-intervention/ groups).

Table 1 Inclusion and exclusion criteria

Category	Inclusion criteria	Exclusion criteria
Population	A study conducted in a Sub-Saharan country in patients with major surgery, i.e., surgery that involves tissue manipulation and typically requires anesthesia [22].	A studies conducted outside Sub-Saharan countries, and patients with other surgeries like optometry, ENT, Maxillofacial, implant, and any other patients without surgery.
Intervention	Any non-pharmacological intervention that improves SSI.	Pharmacological interventional studies comparing SSI outcomes.
Comparator	Usual care or no intervention.	Studies without comparator.
Outcome	surgical site infection as defined by the CDC and National Healthcare Safety Network [2]	Studies that do not report SSI rates.
Study designs	RCT, cohort studies, pre-post cross-sectional studies.	Case reports, editorials, qualitative studies, and studies without clear methodology.
Publication time frame	2011 to 2023.	Before 2011 and after 2023.
Publication type	Published and unpublished studies	Conference abstracts, systematic reviews, guidelines, protocol.
Language	Articles published in the English language.	Articles published in languages other than English.
Study participants	Human participants.	Non-human participants.
Databases searched	AJOL, Hinari, Cochrane Library, and Google Scholar databases, and repositories of Addis Ababa University and Jimma University.	Studies not indexed in the specified databases.

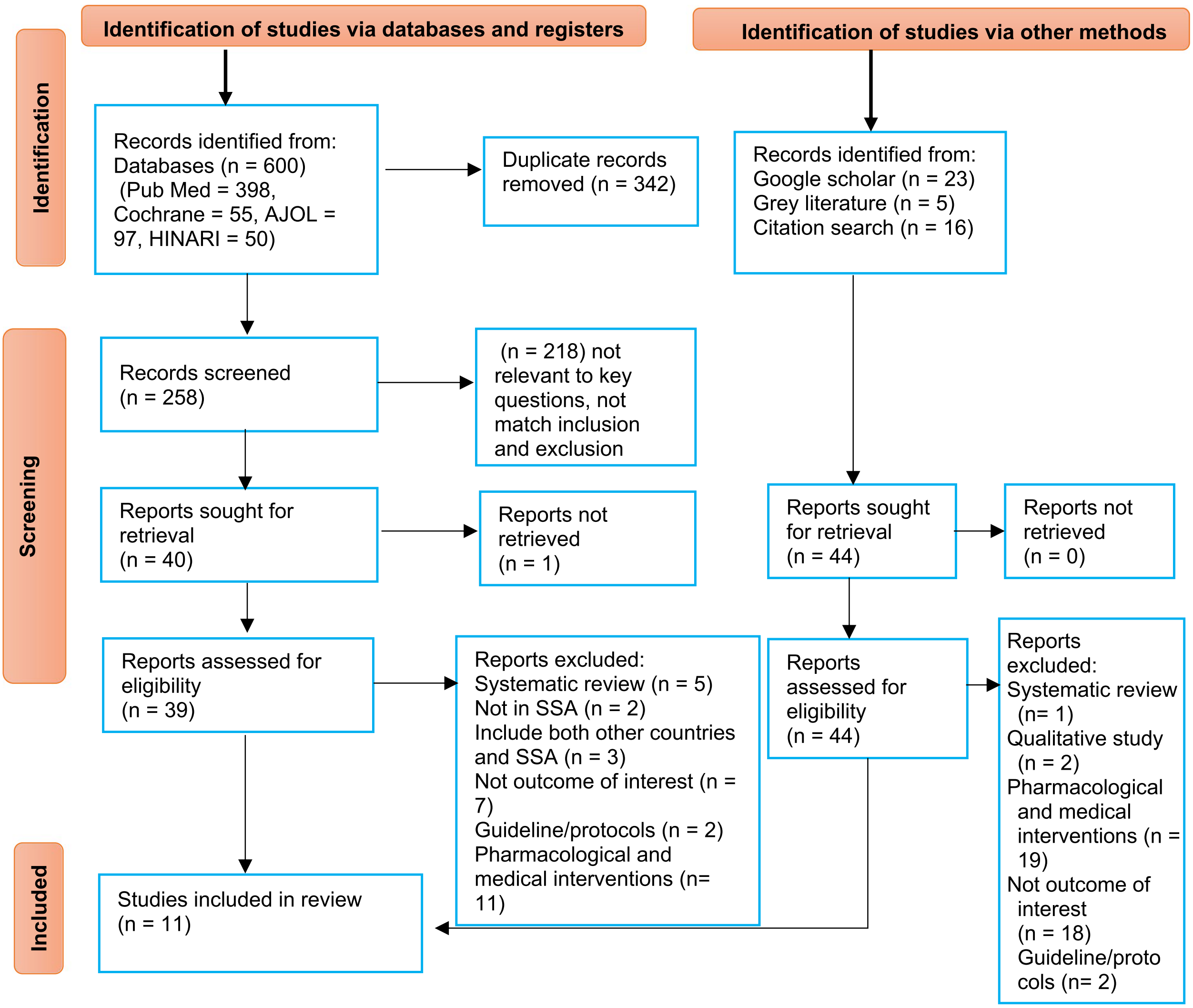

Fig. 1 PRISMA flow diagram paper selection for a systematic review of interventional studies in the prevention of SSI in Sub-Sahara Africa

The CDC`s criteria for SSI were explicitly defined in eight research articles [27, 29, 30, 32, 34–37] (Table 2).

As demonstrated in the above features of the papers, the identified studies are substantially heterogeneous including variations in study design, target populations, sample sizes, interventions, and outcome measures. Given this diversity, we concluded that meta-analysis would not be appropriate. Rather, we opted for a narrative synthesis of the findings like other systematic reviews [14, 15, 18, 38, 39], which enabled us to examine and discuss the variability in a more nuanced manner.

Interventions characteristics

The rate of SSI can be influenced by factors like characteristics of interventions [27, 29, 31, 34, 37], study population [28, 29, 31, 34, 36], surgical urgency [27, 34, 37], hospital setting [27–29, 31–37], follow-up time [27, 28, 34], and SSI identification criteria [28, 33, 34]. Despite the limitations, interventions focusing on preventing SSI reduce infection at varying rates, emphasizing their substantial impact.

Adherence to protocol intervention

A Sudanese RCT study [34] found a significant reduction in the SSI rate among general surgery patients after education and surgical antibiotic prophylaxis protocol interventions in the tertiary hospital. The protocol was developed by the clinical pharmacist and surgical team and pursued strict protocols for the intervention group supported by the clinical pharmacist, whereas the control group received the usual traditional services. The study utilized the guidelines established by the Centers for Disease Control and Prevention (CDC) to identify SSI among 226 elective patients between 18 and 65 years

Table 2 Protocol intervention

S no	Authors, country, year	Study type	Type of surgery	Study populations	Hospital setting	Study group size		Intervention			Outcome (SSI)%		Source of SSI definition
						Control/pre-intervention	Treatment/post-intervention	Comparator	Type/treatment /study group/	Follow-up duration	Control group /before Interventions	Treatment group/ After interventions	
1	Elnour *et al.*, Sudan, 2022 [34]	RCT	Elective	General surgery patient	Tertiary hospital	113	113	Without strict adherence to protocol	Strict adherence to SAP protocol	14 day	42.5	25.7	CDC

Table 3 Policy interventions

S no	Authors, country, year	Study type	Type of surgery	Study populations	Hospital setting	Study group size		Intervention			Outcome (SSI)%		Source of SSI definition
						Control /pre-intervention	Treatment/ post-intervention	Comparator	Type/ treatment /study group/	Follow-up duration	Control group /before Interventions	Treatment group/ After interventions	
1	Aiken et al., Kenya, 2013 [27]	Before and After Intervention	Elective & Emergency	Surgical patients	Level 5 hospital	1206	2137	No comparator but compares post-incision antibiotic administration	Antibiotic prophylaxis policy (strict to pre-incision antibiotic prophylaxis)	30 day	8.3	5.6	CDC
2	Brisibe et al., Nigeria, 2015 [28]	Pre-post intervention	Elective & Emergency	Pregnant women underwent CS	Teaching hospital	410	416	Pre-SSI policy and other comparable hospital	Applying hospital infection control policy	Admission period	13.17	10.34	Not indicated

Key: *AB* Antibiotics, *AMR* Anti-Microbial Resistance, *CDC* Center for Disease Control, *CS* Cesarean Section, *IP* Infection Prevention, *OR* Operation Room, *PPE* Personal Protective Equipment, *RCT* Randomized Control Trial, *SAP* Surgical Antibiotic Prophylaxis, *SSC* Surgical Safety Checklist old. However, it is important to note that the duration of the follow-up period did not align with the recommendations set forth by the CDC. These strict protocol adherence interventions significantly decrease SSI from 42.5% to 25.7%, and the authors suggested the potential benefit of protocol implementations (Table 2).

Adherence to policy interventions

Two policy interventional studies assess their effect on SSI reduction. The first, in Kenya [27], was a before-and-after interventional study of elective and emergency surgical patients at a level 5 hospital. The intervention focused on implementing a strict antibiotic prophylaxis policy, which compared the administration of pre-incision antibiotics to traditional post-incision practices. The study used the CDC definition to identify the outcome, SSI. Prior to the intervention, less than 2% of patients received pre-operative antibiotics. However, after extensive training of medical staff on the implementation of the new antibiotic prophylaxis policy, the practice of administrating pre-operative antibiotics significantly increased. The overall results indicated an SSI rate of 8.3% for patients receiving post-incision antibiotics compared to 5.6% for those given pre-incision antibiotics; however, there was a statistical difference observed in superficial surgical site infections compared to deep and organ-space surgical site infections at the 30-day follow-up. The second study, a pre-post interventional study conducted in Nigeria [28], involved 826 pregnant women undergoing cesarean sections in a tertiary hospital. This comparative study included a concurrent control hospital, and data were collected by reviewing the records of cesarean section operations during the hospitalization period before and two years after the implementation of an infection control policy, and the outcome SSI were not defined well in the study. Following the implementation of the infection prevention policy, SSI were reduced to 22%, demonstrating a reduction from 13.17% to 10.34% during the hospitalization follow-up period (Table 3).

Multimodal interventions

All eight multimodal studies [29–33, 35–37] surveyed various interventions targeted at reducing SSI across different populations and settings as indicated in Table 4. Six of these studies [29, 30, 32, 35–37] followed standard definitions for SSI from the CDC, which ensured consistency across the studies. Most studies followed study subjects for 30 days, except for three studies. [29, 33, 37]. Quality improvement interventions, including education, SAP, SSC, and antiseptics, were tested in three studies [32, 33, 36]. Except for one study by Alidina et al.. [31], all the other studies incorporated surgical antibiotic prophylaxis as a key component among their interventions. Other significant interventions implemented included appropriate surgical site preparation [32, 35–37], maintaining discipline and safety in the OR [30, 35, 36], and providing training and education on IP for healthcare workers [29–31, 33, 37]. The use of an SSC checklist [31–33, 36, 37], audit and feedback mechanisms [29, 33], and ensuring safe equipment and a safe surgery process [31, 32, 36] were also emphasized to alleviate SSI. Collectively, these interventions focused on optimizing the surgical process, adhering to evidence-based guidelines, and employing multimodal strategies.

In contrast, control groups underwent baseline assessments or usual care. All studies in this category used multiple interventions to decrease SSI. The reduction rate of SSI varied based on factors such as study design, surgery urgency, characteristics of study subjects, and follow-up period. For instance, a multi-center study by Allegranzi et al. [35] reported 52.2%, Abubakar et al. [29] 15%, Gentilitti et al. [30] > 65%, Nagonzi et al. [33] 28%, Alidina et al. [31] 38%, Forrester ta al. [32] 35% risk reduction, and Starr et al. [36] 34% risk reductions in SSI rates following different interventions. Additionally, Ernest et al. [37] in a pre-post cross-sectional study indicated a substantial reduction of 95% in SSI among pregnant women undergoing emergency CS after the implementation of especially safety checklists and others in a comprehensive emergency and obstetric center in Tanzania. The overall reduction in SSI observed among intervention groups highlights the effectiveness of employing multiple evidence-based practices that can reduce SSI and improve surgical outcomes.

Discussion

It was found that a limited number of articles done in Sub-Saharan countries that focused on non-pharmaceutical and non-medical interventions decreased surgical site infection. This discussion compares the findings to the existing studies with similar studies conducted somewhere, providing context and insights into the effectiveness of various interventions in decreasing SSI.

The effectiveness of interventions was evaluated with scientifically proven robust designs, such as RCTs, which are considered a gold standard due to their ability to minimize bias and establish causality [40]. Observational cohorts also offer insights into the long-term effects of interventions and can give conclusions comparable to those of RCTs. However, they do have limitations such as selection bias, measurement bias, and inadequate control of confounding factors [41, 42]. Before-after intervention studies allowed the researchers to observe trends and effects over time where randomization is not possible [43], and analytical cross-sectional studies, which can allow investigators to assess the relationship between

Table 4 Multimodal interventions

S no	Authors, country, year	Study type	Type of surgery	Study populations	Hospital setting	Study group size		Intervention			Outcome (SSI)%		Source of SSI definition
						Control /pre-intervention	Treatment/ post-intervention	Comparator	Type/ treatment /study group/	Follow-up duration	Control group /before Interventions	Treatment group/ After interventions	
1	Allegranzi et al., Kenya, Uganda, Zambia, 2018 [35]	Before and After cohort	Elective & Emergency	Surgical patients	Tertiary & mission hospitals	1604	1827	Baseline	Multimodal interventions (pre-operative bath, hair removal, skin and hand antiseptics, SAP, OR discipline	30 day	8	3.8	CDC
2	Abubakar et al.. Nigeria, 2019 [29]	pre-post intervention	Elective & Emergency	Women undergoing obs. & gyn. surgery	Tertiary hospital	226	238	Pre-intervention	Antibiotic stewardship intervention (SAP protocol, education, audit, and feedback)	Hospitalization period	4	3.4	CDC
3	Gentilotti et al., Tanzania, 2020 [30]	Before and After Intervention	Elective & Emergency	Pregnant women underwent CS	Regional hospital	467	573	Pre-intervention	Education on AMR, training on IPC, SAP, Hand hygiene, OR discipline, multidiscipline team	30 day	48.2	16.6	CDC

Table 4 (continued)

S no	Authors, country, year	Study type	Type of surgery	Study populations	Hospital setting	Study group size		Intervention			Outcome (SSI)%		Source of SSI definition
						Control /pre-intervention	Treatment/ post-intervention	Comparator	Type/ treatment /study group/	Follow-up duration	Control group /before Interventions	Treatment group/ After interventions	
4	Ngonzi et al.. Uganda, 2021 [33]	pre-post intervention	Elective & Emergency	Pregnant women underwent CS	Referral and teaching hospital in Gyn. Dept	200	248	Pre-intervention	Quality improvement interventions (education, audit, and feedback on WHO SSC, pre-operative antibiotics)	During hospitalization	14.5	10.5	Clinical charts
5	Alidina et al. Tanzania 2021 [31]	pre-post intervention	Elective & Emergency	CS & major surgeries	Health center, district & regional Hos	1539	1626	Pre-intervention and control facilities	Training and infrastructure support	30 day	7.3	4.5	Not indicated
6	Forrester et al., Ethiopia, 2021 [32]	pre-post intervention	Elective & Emergency	Surgical patients	Teaching regional, and district hospital	374	1839	Pre-intervention	Quality improvement SSC use, gauze count, antibiotic use, sterile field, and skin antisepsis)	30 day	7.4	5.8	CDC
7	Starr et al., Ethiopia, 2023 [36]	Cohort	Elective & Emergency	General surgery for > 18 age	Referral & district hospital	1575	1789	Before the quality improvement program	Quality improvement program (SSC use, surgical instrument safety, OR safety, SAP, hygiene, appropriate PPE)	30 day	23.2	17.4	CDC

Table 4 (continued)

S no	Authors, country, year	Study type	Type of surgery	Study populations	Hospital setting	Study group size		Intervention			Outcome (SSI)%		Source of SSI definition
						Control /pre-intervention	Treatment/ post-intervention	Comparator	Type/ treatment /study group/	Follow-up duration	Control group /before Interventions	Treatment group/ After interventions	
8	Ernest et al., Tanzania, 2021 [37]	Pre/ /post cross-sectional	Emergency	Pregnant women underwent CS	Comprehensive emergence & obstetric center	136	143	Pre-intervention	Multicomponent safe surgery intervention (training for HCW on IP bundles, WHO SSC, Hygiene, SAP)	7 day	13.9	0.7	CDC

Key: *AB* Antibiotics, *AMR* Anti-Microbial Resistance, *CDC* Center for Disease Control, *CS* Cesarean Section, *IP* Infection Prevention, *OR* Operation Room, *PPE* Personal Protective Equipment, *RCT* Randomized Control Trial, *SAP* Surgical Antibiotic Prophylaxis, *SSC* Surgical Safety Checklist exposure and outcome at a single point in time [44] [45], despite certain limitations like inabilities to establish causality. Overall, these study designs vary in quality, ranging from moderate to high, and provide valuable insight into the results they indicate.

The selected papers centered on evaluating the effectiveness of various non-pharmacological and non-medical interventions designed to mitigate surgical site infections. This comprehensive analysis found three distinct categories of interventional research that were carried out in Sub-Saharan countries: adherence to protocols [34], adherence to policies [27, 28], and multimodal strategies [29–33, 35–37]. This review revealed significant variability among the identified studies. The complexity of comprehensively understanding and comparing SSI in Sub-Saharan African countries is compounded by different factors, such as the diversity of interventions, designs, countries, characteristics of study populations, duration of the follow-up period, types of healthcare facilities, definitions used to evaluate SSI, and varying quality of the identified papers. Given the complexities discussed earlier, summarizing the impact of interventions poses challenges, and this analysis serves to offer an overview and emphasize these existing gaps.

Protocol intervention

The result of the Sudanese study [34] emphasizes the need to follow strict surgical antibiotic prophylaxis protocols and showed a reduction of SSI among intervention group surgical patients by nearly 40%. In line with this, a study conducted in Turkey found that implementing protocol intervention significantly reduced SSI to nil, and compliance to standards was 94% to 100% [46]. The same finding was also observed, showing SSI reduction from 25.6% to 15.9% after the implementation of a multidisciplinary wound management protocol in Virginia [47]. The implications of these findings for SSI prevention are profound; protocols, as standardized procedures or guidelines, when developed and strictly followed, can ensure consistency and quality in clinical practice. This suggests that the adoption of evidence-based protocols might significantly decrease infection rates by standardizing surgical practices and ensuring that all healthcare providers adhere to best practices for infection control. This is particularly vital in resource-constrained institutions, where explicit protocols may facilitate the standardization of care and enhance patient outcomes. Overall, these findings highlight the importance of adhering to rigorous protocols to effectively reduce SSI rates.

Policy interventions

The implementation of the pre-antibiotic prophylaxis and hospital infection control policy resulted in a moderate drop in the SSI rate among general surgical and pregnant women who underwent CS in Kenya [27] and Nigeria [28]. A simulation study conducted by Jiang and his colleagues estimated the effect of health policy interventions and found that health outcomes declined following the policy`s implementations [48]. The modest improvement in SSI rates may be attributed to the multifactorial nature of these infections, with hospital infrastructure and healthcare workers` adherence to the policies playing crucial roles.

A systematic review conducted in 2022 identified three main factors that influence policy effectiveness in healthcare settings: clear policy formulation, adequate infrastructure for policy implementation, and careful consideration of context and setting for alignment with infection prevention strategies [49]. Additionally, variations in the follow-up periods and SSI identification criteria may lead to underestimation of the incidence rates in the studies, such as that by Brisibe et al. [28]. Although the observed reduction in SSI rates was not statistically significant, it suggests that while policy interventions can be beneficial, they may require more robust enforcement and compliance to achieve the required outcome.

Policies serve as a framework established by healthcare organizations to guide decision-making and behavior in clinical settings. They emphasize the importance of organizational commitment to patient safety and quality care, effective resource allocation, and regulatory compliance, and they promote interdisciplinary collaboration among healthcare professionals in infection prevention measures. The implications for SSI prevention are substantial; by fostering a culture of safety and adherence to best practices via policy changes, healthcare institutions may significantly lower infection rates and improve overall patient safety.

Multimodal modal interventions

The studies [29–33, 35–37] emphasized that using multimodal interventions such as preoperative preparations, SAP, OR discipline, audit and feedback, onsite education, and training for healthcare workers on IP and SSC use is effective in decreasing SSI in various populations and healthcare settings. Consistent with these findings, a systematic review found a bundle of interventions such as audit and feedback, monitoring performance, educational meetings, quality improvement initiatives, providing guidelines, managerial supervisions, surgical site preparations, timing and dosing of antibiotics, and like decreased SSI significantly [18, 50]. In addition, a quasi-experimental study found that multimodal strategies like training, educational reminders, and posters increased knowledge among healthcare workers and decreased the multidrug resistance organism transmission rate from 25% to 0 [51].

Quality improvement initiatives, which are one component of a multimodal strategy, like SSI surveillance, use of SSC, patient and staff education, the appointment of facilitators, bathing, antiseptic use, and appropriate hair removal, and SAP decreased SSI risks significantly. Calderwood et al., Khan et al., and Horgan et al. [52–54] observed similar positive outcomes in their analysis. Moreover, a quality improvement study conducted in Zimbabwe prevented healthcare workers from occupational needle stick injuries [55]. The aforementioned multimodal interventions are components of the WHO`s guidelines for preventing SSI [12, 56]. The implications of multimodal interventions for SSI prevention are especially noteworthy; they underscore the significance of addressing the multifaceted nature of infection risk via the integration of multiple strategies or efforts across multiple components of surgical care. By integrating diverse preventive approaches, healthcare forces may create a more robust defense against SSI, thereby boosting patient outcomes.

Our results demonstrate the effectiveness of non-pharmacological interventions in decreasing SSI rates, particularly in resource-limited settings. The implications of protocols, policies, and multimodal interventions in the prevention of SSI are significant. Protocols standardize care and improve adherence to evidence-based practices; policies specify organizational commitments and resource allocations, and multimodal interventions offer a comprehensive approach that addresses a variety of risk factors. Collectively, these elements contribute to enhanced patient safety and improved surgical results.

Future research areas and improvements

Depending on our review, some areas emerged as potential avenues for future research. These may focus on large-scale, multi-center studies to validate findings and assess the long-term sustainability of multimodal interventions. Integrating patient-centered outcomes, such as quality of life, patient satisfaction with care, and patient-reported outcomes, into SSI prevention studies can provide a wide understanding of the effect of interventions on patients' experiences and outcomes. While our study focused on evaluating the effectiveness of interventions, future research should explore the implementation process of these interventions, including barriers and facilitators, to scale and sustain evidence-based practice in low-resource settings. Furthermore, incorporating meta-analysis could further reinforce the understanding of these interventions.

Limitations of included studies

The included studies have limitations, including a short follow-up period, i.e., contrary to the recommended 30 days by the CDC, five studies [28, 29, 33, 34, 37] followed less than the recommended days, which may underestimate the true incidence and affect the accuracy of the findings. In addition, some studies did not indicate SSI identification criteria. Our systematic review also has some limitations, such as the inability to perform a meta-analysis due to significant heterogeneity among the included studies that make us not provide a quantitative summary, inconsistent findings across studies, and the inclusion of studies with varying follow-up and SSI identification criteria may introduce bias and affect the comparability of results. Sample size variations ranging from 113 to 2137 participants may influence the statistical power to detect significant differences. In addition, our review restriction to the English language may introduce bias by excluding related evidence published in other languages, and this may influence the findings of our review.

Conclusion

This systematic review found that all three categories of interventions: protocol, policy, and multimodal non-pharmacological interventions, showed their effectiveness in decreasing SSI to varying degrees; the multimodal approach tends to yield significant improvements. Despite variations in methodologies (different study designs, follow-up durations, and settings), common themes and trends were shown, providing useful insight into interventions for SSI prevention and control. Multimodal interventions consistently reduced SSI throughout the studies, regardless of variations. The findings are comparable and consistent with global evidence, highlighting the importance of comprehensive and multifaceted strategies in surgical site infection prevention and control.

Recommendations

Based on the result of this review, we recommend the following strategies to decrease SSI in the region: Adopt multimodal interventions: implement comprehensive multimodal strategies that combine preoperative, intraoperative, and postoperative actions, develop and enforce standardized IPC policies, and monitoring and feedback mechanisms to ensure adherence and enhance surveillance and reporting systems that help to identify gaps and take possible solutions.

Abbreviations

ASA	American Society of Anesthesiologists
HAI	Healthcare-associated infections
IPC	Infection Prevention and Control
JBI	Joanna Briggs Institute

PRISMA Preferred Reporting Items for Systematic Review and Meta-Analysis
RCT Randomized control trial
SAP Surgical Antibiotic Prophylaxis
SSI Surgical site infection
WHO World Health Organization

Supplementary Information

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Supplementary Material 1.

Supplementary Material 2.

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FSB, TB, and KH developed the protocol, design selection, FSB and KH involved in data extraction and quality assessment, TB participated in dispute management during extraction and assessment, FSB, TB, and KH prepared and edited the final draft of the manuscript. All authors read and approved the manuscript.

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