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Review

Surgical site infection prevention care bundles in colorectal surgery: a scoping review

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SUMMARY

Background: Surgical site infection (SSI) prevention bundles have been used to reduce infection rates in most types of surgery. Bundles tailored to colorectal surgery have been used with success.
Aim: To identify and review the individual interventions that constitute each SSI prevention care bundle in colorectal surgery, and the reduction in SSI rate associated with their implementation.
Methods: A scoping review was conducted in PubMed, CINAHL, Web of Science Core Collection and Scopus in December 2022.
Results: This review analysed 48 of 164 identified studies on SSI prevention in colorectal surgery from 2011 to 2022. It revealed an average of 11 interventions per study, primarily in the pre-operative [mechanical bowel preparation, oral antibiotic bowel decontamination, hair removal, chlorhexidine gluconate (CHG) shower, normoglycaemia], intra-operative (antibiotic prophylaxis, normothermia, CHG skin preparation, antibiotic prophylaxis re-dosing, gown/glove change) and postoperative (normothermia, normoglycaemia, dressing removal, oxygen optimization, incision cleansing) periods. Despite these interventions, SSI rates remain high, indicating a need for further research to optimize intervention bundles and improve compliance across surgical stages.

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Conclusions: The implementation of SSI prevention bundles, tailored to colorectal surgery, has shown a reduction in SSI rates and costs. Grouping interventions according to the peri-operative phase may increase compliance.

Introduction

Surgical site infections (SSIs) are among the most common healthcare-associated infections (HAIs) worldwide, accounting for more than 30% of all HAIs, and lead to increased morbidity, length of stay, readmission rates, and healthcare costs [1—3]. SSIs can cost up to $3.2 billion each year, and place a burden on healthcare systems, limiting their response and increasing surgical waiting lists [4]. In 2014, the average cost of all SSIs was found to be £5239 in an UK hospital [2]. These costs are not only financial; SSIs also have a negative effect on patients' health-related quality of life, and occupational and societal commitments [2].

Colorectal cancer affects more than 1.9 million patients each year, causing 0.94 million deaths per year [5]. This accounts for 10% of all cases of cancer globally and 9.4% of cancer deaths, ranking it the third most common cancer in recent years, and the second leading cause of cancer death globally [5]. Colorectal surgery is paramount for the treatment of these tumours [5]. However, SSI rates in colorectal surgery are disproportionately high, ranging from 15% to 30%, versus 2.5% in all surgical procedures [1,3,6]. However, when compared with other clean-contaminated surgeries, such as gynaecological surgery (2—9.2%) [7—9] or head and neck surgery (6.6—41.8%) [10], the SSI rates are comparable. This may be attributed to the risk of wound contamination with bowel content [2].

In Europe, SSI rates in colorectal surgery varied from 2.9% to 12.5% for laparoscopic colon surgery, and from 4.1% to 16.9% for open colon surgery in 2017 [11]. For the period between 2018 and 2020, these rates increased to 3.5—16.4% and 3.6—26.8%, respectively [12]. These are the highest SSI rates amongst all types of surgical procedure surveyed in the European Centre for Disease Prevention and Control's HAI-Net SSI programme, and show a rising tendency [11,12].

The increased costs associated with colorectal SSI range from $36.429 to $144.809 per patient in the USA, according to a study which claimed that the true economic burden is under-recognized in most studies. [4]. In the UK, as colorectal surgery is a common elective procedure, the disproportionately high SSI rate leads to a substantial economic burden, with an associated 35% increase in direct healthcare costs [6]. As such, a reduction in the SSI rate for colorectal surgery has become a major objective of quality improvement initiatives [1]. In order to prevent SSIs, patient care bundles have been developed and implemented with some success. Different systematic reviews and meta-analyses have shown significant reductions in the risk of SSIs in patients who received an infection prevention care bundle compared with patients who received standard care [13,14]. A risk reduction of 40% ($P<0.001$) was recorded in one study [14].

Despite the implementation of SSI prevention bundles, the decrease in SSIs in colorectal surgery has been slow [12]. Some centres have developed and implemented patient care bundles tailored to prevent SSIs in colorectal surgery [15].

The primary aim of this study was to identify and review the individual interventions that constitute each infection prevention care bundle in colorectal surgery. The secondary aims of this study were: to identify the peri-operative period in which each intervention is performed; and to identify the SSI reduction rate related to implementation of each care bundle.

Methods

Protocol and registration

This study was based on the guidance framework for conducting scoping reviews developed by the Joanna Briggs Institute [16]. It has been reported using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews [17,18], and is registered on the OSF Database (https://doi.org/10.17605/OSF.IO/64VEY).

Eligibility criteria and search strategy

The selection of studies for this scoping review was based on the question, 'What individual interventions constitute each infection prevention care bundle in colorectal surgery?' Studies were eligible for inclusion in this scoping review if they met all of the following criteria: (i) original publication; (ii) reported on SSI prevention care bundles in patients undergoing colorectal surgery; and (iii) included adult patients alone.

The following exclusion criteria were selected: population — all studies without patients undergoing colorectal surgery or patients aged <18 years were excluded; study design — all revisions were excluded; intervention — all studies which only mentioned isolated interventions that were not part of a care bundle were excluded; and outcome — all studies that analysed interventions in the context of guidelines and not infection prevention care bundles were excluded.

The literature search was conducted in December 2022 using Web of Science Core Collection, PubMed, CINAHL and Scopus. It employed a comprehensive strategy using Medical Subject Heading terms and natural language keywords to ensure a thorough search of relevant articles. The search terms, which are outlined in Supplementary File I, were applied to the titles and abstracts of publications in the database. The detailed process of study selection, including the number of articles screened, assessed for eligibility and included in the review, is depicted in the PRISMA flow diagram (Figure 1). This approach was developed to capture the broadest possible range of relevant research.

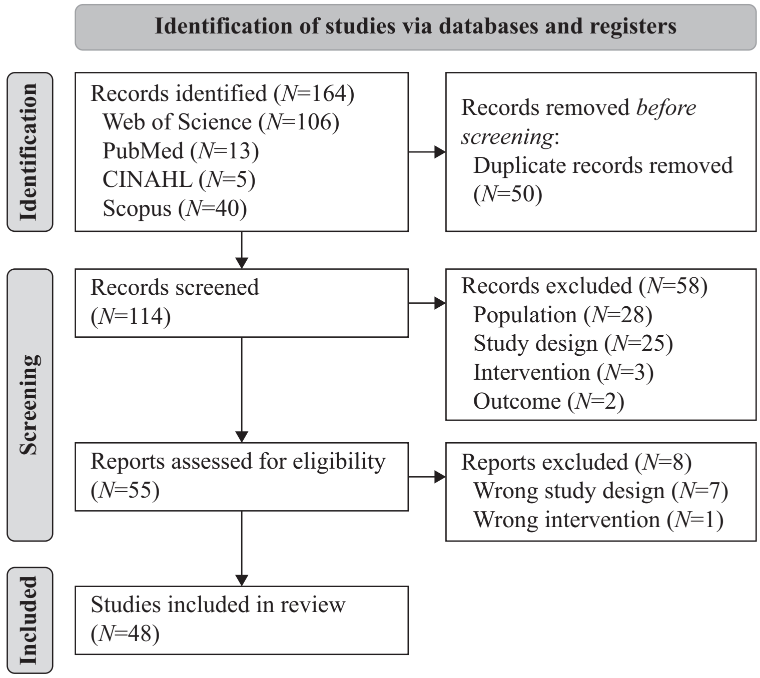

Figure 1. PRISMA flow diagram.

Extraction of data and charting

Two independent authors (TC and SM) extracted and charted data from the included studies, removed duplicates using Rayyan software, and applied the eligibility criteria, with blind screening of titles and abstracts. All disagreements passed to the next step, and full-text screening was undertaken independently by the same reviewers (TC and SM). A third reviewer (PA) was available to resolve disagreements when necessary, through discussion with the other authors. The following information was tabulated: author; country; year of publication; aims; methodology; participants; healthcare context; interventions SSI bundles; and study design. After that, interventions were grouped by period: pre-operative, intra-operative and postoperative.

Results

In total, 164 papers were retrieved. Following the removal of duplicates, the titles and abstracts of 114 papers were screened, and the full-text of 55 papers was assessed for eligibility. Forty-eight papers met the inclusion criteria as shown in the PRISMA flow diagram [17] (Figure 1).

Characteristics of included studies

Forty-eight studies met the inclusion criteria [1,2,4,6,19–62]. The included studies were published between 2011 and 2022. Sixty-four percent (*N*=30) of the studies were published between 2018 and 2022. The studies were performed in the USA (*N*=29), UK (*N*=5), Canada (*N*=2), Australia (*N*=2), Italy (*N*=2), Spain (*N*=3), Netherlands (*N*=1), Saudi Arabia (*N*=1), Switzerland (*N*=1), South Korea (*N*=1) and Thailand (*N*=1). The number of participants in the studies ranged from 86 to 107,665, with an aggregate number of participants of 229,707. In one study, it was not possible to determine the number of participants [44].

The studies included 528 interventions, with a mean of 11 interventions per study, ranging between two and 22 interventions. Details about the 48 included studies can be viewed in Supplementary File II. Regarding the study context, they can be divided into studies conducted at single hospitals (*N*=33) and studies conducted in multiple hospitals (*N*=15). In terms of study design, they can be divided into: cohort studies (*N*=17); retrospective cohort studies (*N*=13); prospective cohort studies (*N*=12); quasi-experimental studies (*N*=3); case–control studies (*N*=1); pre–post cohort studies (*N*=1); and a pragmatic study involving three phases (*N*=1).

A reduction in SSI rate was achieved in 43 studies. However, in two of these studies, the reduction was not significant. In three studies, an increase in SSI rate was witnessed. Two studies made no comparisons between the pre- and post-bundle implementation periods. These results can be found in Tables I, II and III.

The interventions were divided into three phases: pre-operative, intra-operative and postoperative (Tables I, II and III). In the pre-operative phase, 158 interventions were identified. The mean number of interventions per study was three, ranging between zero and eight interventions. In the intra-operative phase, 272 interventions were identified. The mean number of interventions per study was six, ranging between zero and 12 interventions. Finally, in the postoperative phase, 96 interventions were identified. The mean number of interventions per study was two, ranging between zero and six.

The most common interventions in each phase are shown in Table IV. Some interventions were present in all phases of the peri-operative period, such as normothermia and normoglycaemia.

Table I

Individual interventions and surgical site infection (SSI) rate reductions in the pre-operative period

Pre-operative period	Dixon et al. [2]	Arroyo-Garcia et al. [19]	Antonacci et al. [20]	Clayphan et al. [21]	Schlick et al. [22]	Brajcich et al. [23]	Jurt et al. [24]	Faragher et al. [25]	Vicentini et al. [26]	Falconer et al. [6]	Zarain-Obrador [27]	Lohsiriwat [28]	D'Andrea et al. [29]	Martinez et al. [30]	Leaper et al. [4]	Park et al. [31]	Hajirawala et al. [32]	Dean et al. [33]	D'Souza et al. [34]	Guzman-Pruneda et al. [35]	Mcgee et al. [36]	Albert et al. [37]	Hoang et al. [38]	Russell et al. [39]
Year	2022	2022	2022	2022	2022	2022	2021	2021	2021	2021	2021	2021	2020	2020	2020	2020	2020	2020	2019	2019	2019	2019	2019	2018
SSI rate reduction	-14.9%	-8.6%	-1.7%	-8.5%	n/a	n/a	0.8%	-9.5%	-6.0%	-7.0%	-1.4%	-6.5%	-9.2%	-10.6%	n/a	-5.7%	-14.5%	-10.0%	-6.4%	-11.0%	-3.1%	-7.2%	-6.2%	n/a
Mechanical bowel preparation		■	■		■	■		■			■		■						■	■	■		■	
Oral antibiotic bowel decontamination		■	■		■	■		■			■		■	■						■	■		■	
CHG shower			■		■	■			■				■				■			■	■			■
Hair removal with clippers when appropriate								■	■	■	■	■	■		■	■	■		■	■		■	■	
Normoglycaemia			■							■		■	■						■		■		■	■
Normothermia			■							■						■						■		■
CHG cloths																				■				
Skin prep with 2% CHG										■				■					■		■			
Antibiotic prophylaxis (type, timing and discontinuation)					■														■		■			
Patient education													■											■
Clear liquid diets on day prior											■		■											
Encourage smoking cessation 30 days before surgery												■												
Oral carbohydrate loading																								
Standardized urinary catheter placement																								
Standard handoffs between pre-op, OR, PACU and/or ICU																								
Maintenance of oxygen saturation at least 92%												■												
Medical handwashing																■								
MRSA screening and decolonization																								
Optimizing nutrition																								
Iodophor nares swabs to decolonize the nose for 24 h																								
SSI risk assessment provided to surgeon																								
Checklist to determine patient readiness for OR																								
Total	0	2	5	0	4	3	0	3	2	4	4	4	7	2	1	3	2	0	5	5	6	2	4	4

Pre-operative period	Vu et al. [40]	Lin et al. [41]	Weiser et al. [42]	Gachabayov et al. [43]	Harris et al. [44]	Gorgun et al. [45]	Jaffe et al. [46]	Kilan et al. [47]	Ohman et al. [48]	Bert et al. [49]	Hewitt et al. [50]	Kwaan et al. [51]	Benlice et al. [52]	Rumberger et al. [53]	Tanner et al. [54]	Keenan et al. [55]	Ghuman et al. [56]	Pérez-Blanco et al. [57]	Keenan et al. [1]	Waits et al. [58]	Cima et al. [59]	Crolla et al. [60]	Lutfiyya et al. [61]	Bull et al. [62]	Total
Year	2018	2018	2018	2018	2018	2018	2017	2017	2017	2017	2017	2016	2016	2016	2016	2015	2015	2015	2014	2014	2013	2012	2012	2011	
SSI rate reduction	-2.8%	-7.5%	-6.9%	-12.3%	-55.5%	-5.2%	-7.8%	-4.0%	-11.5%	-3.4%	-9.2%	-0.8%	-5.3%	1.1%	4.0%	-9.8%	-1.4%	-10.6%	-13.6%	-15.5%	-5.8%	-2.8%	-14.5%	-8.0%	
Mechanical bowel preparation	■	■	■	■		■	■		■		■	■	■			■	■		■	■			■		26
Oral antibiotic bowel decontamination	■	■	■			■	■		■		■	■	■			■			■	■			■		24
CHG shower		■	■	■		■			■	■		■	■		■			■	■		■				21
Hair removal with clippers when appropriate				■					■	■				■	■		■					■	■		21
Normoglycaemia		■	■	■											■			■		■			■	■	16
Normothermia											■				■							■	■	■	10
CHG cloths						■					■		■			■					■		■		7
Skin prep with 2% CHG				■												■			■						7
Antibiotic prophylaxis (type, timing and discontinuation)			■													■									5
Patient education																			■		■		■		5
Clear liquid diets on day prior											■														3
Encourage smoking cessation 30 days before surgery											■												■		3
Oral carbohydrate loading																	■								1
Standardized urinary catheter placement																■									1
Standard handoffs between pre-op, OR, PACU and/or ICU		■																							1
Maintenance of oxygen saturation at least 92%																									1
Medical handwashing																									1
MRSA screening and decolonization															■										1
Optimizing nutrition					■																				1
Iodophor nares swabs to decolonize the nose for 24 h					■																				1
SSI risk assessment provided to surgeon			■																						1
Checklist to determine patient readiness for OR				■																					1
Total	2	5	6	6	2	4	2	0	4	2	6	3	4	1	5	6	3	2	5	3	3	2	8	2	

CHG, chlorhexidine gluconate; ICU, intensive care unit; MRSA, meticillin-resistant *Staphylococcus aureus;* OR, operating room; PACU, postanaesthesia care unit.

Discussion

The current scoping review reports findings from 48 studies, published between 2011 and 2022, identified through a systematic literature search. These studies focused on the individual interventions that constitute each infection prevention care bundle in colorectal surgery.

Implementation of SSI prevention bundles

The World Health Organization (WHO) [63] and several other national entities, including the National Institute for Health and Care Excellence (NICE) [64] and the Centers for Disease Control and Prevention (CDC) [65], have designed and implemented SSI prevention bundles. Despite these efforts, SSI rates in colorectal surgery remain high. This persistent issue underscores the complexity and challenges of reducing SSI rates effectively in clinical practice. The relatively high number of articles published in the last 5 years (2018—2022), with 64% (N=29) of the studies in this review falling into this period, suggests growing interest in this subject. This increase in research may reflect both a recognition of the ongoing problem, and a commitment to improving patient outcomes in colorectal surgery.

Composition and complexity of care bundles

One of the mechanisms to translate available research evidence into clinical practice is the implementation of care bundles [66]. These bundles are structured sets of evidence-based practices that, when performed collectively and reliably, have been shown to improve patient outcomes. This scoping review found a mean of 11 interventions per study, which is higher than expected according to care bundle design guidelines. This discrepancy raises questions about the practical implementation of these bundles.

Guidelines for the design of care bundles recommend that they should contain only three to five interventions with strong clinical agreement [66,67]. This recommendation is based on evidence suggesting that simpler bundles with fewer components are more likely to be adhered to by clinical staff, thereby improving their effectiveness. Bundles with a smaller number of elements tend to have higher compliance rates. However, bundles with more than six interventions are not uncommon [66]. Such complex care bundles can pose significant challenges to adherence, particularly for multi-disciplinary teams that must coordinate and implement multiple practices [68].

Effectiveness of bundles with multiple interventions

A recent meta-analysis [69] showed that no increase in effectiveness was found when more interventions were combined. In fact, SSI prevention care bundles with a higher proportion of evidence-based interventions usually presented fewer interventions. This finding aligns with the recommendations by the Institute for Healthcare Improvement, which state that care bundles should consist of three to five evidence-based interventions [15,67]. This highlights the importance of not overcomplicating care bundles, as excessive complexity can hinder their practical application and reduce compliance.

Phase-based division of interventions

In this review, these bundles were divided into three operative phases: pre-operative, intra-operative and postoperative.

Table II

Individual interventions and surgical site infection (SSI) rate reductions in the intra-operative period

Intra-operative period	Dixon *et al.* [2]	Arroyo-Garcia *et al.* [19]	Antonacci *et al.* [20]	Clayphan *et al.* [21]	Schlick *et al.* [22]	Brajcich *et al.* [23]	Jurt *et al.* [24]	Faragher *et al.* [25]	Vicentini *et al.* [26]	Falconer *et al.* [6]	Zarain-Obrador [27]	Lohsiriwat [28]	D'Andrea *et al.*[29]	Martinez *et al.* [30]	Leaper *et al.* [4]	Park *et al.* [31]	Hajirawala *et al.* [32]	Dean *et al.* [33]	D'Souza *et al.* [34]	Guzman-Pruneda *et al.* [35]	Mcgee *et al.* [36]	Albert *et al.* [37]	Hoang *et al.* [38]	Russell *et al.* [39]	Vu *et al.* [40]	Lin *et al.* [41]	Weiser *et al.* [42]	Gachabayov *et al.* [43]	Harris *et al.* [44]	Gorgun *et al.* [45]	Jaffe *et al.* [46]	Kilan *et al.* [47]	Ohman *et al.* [48]	Bert *et al.* [49]	Hewitt *et al.* [50]	Kwaan *et al.* [51]	Benlice *et al.* [52]	Rumberger *et al.* [53]	Tanner *et al.* [54]	Keenan *et al.* [55]	Ghuman *et al.* [56]	Pérez-Blanco *et al.* [57]	Keenan *et al.* [1]	Waits *et al.* [58]	Cima *et al.* [59]	Crolla *et al.* [60]	Lutfiyya *et al.* [61]	Bull *et al.* [62]	Total
	2022	2022	2022	2022	2022	2022	2021	2021	2021	2021	2021	2021	2020	2020	2020	2020	2020	2020	2019	2019	2019	2019	2019	2018	2018	2018	2018	2018	2018	2018	2017	2017	2017	2017	2017	2016	2016	2016	2016	2015	2015	2015	2014	2014	2013	2012	2012	2011	
SSI rate reduction	-14.9%	-8.6%	-1.7%	-8.5%	n/a	n/a	0.8%	-9.5%	-6.0%	-7.0%	-1.4%	-6.5%	-9.2%	-10.6%	n/a	-5.7%	-14.5%	-10.0%	-6.4%	-11.0%	-3.1%	-7.2%	-6.2%	n/a	-2.8%	-7.5%	-6.9%	-12.3%	-55.5%	-5.2%	-7.8%	-4.0%	-11.5%	-3.4%	-9.2%	-0.8%	-5.3%	1.1%	4.0%	-9.8%	-1.4%	-10.6%	-13.6%	-15.5%	-5.8%	-2.8%	-14.5%	-8.0%	Total
Antibiotic prophylaxis (type, timing and discontinuation)		X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X		X		X	X		X	X	X	X	X	X	X	X		X	X		X	X	X		X	X		X	X	X	X	X	39
Normothermia		X	X		X	X	X		X	X		X			X	X	X		X		X	X	X			X	X	X						X	X			X	X	X	X	X	X			X	X	X	29
Skin prep with 2% CHG	X		X	X	X	X	X	X			X	X		X	X					X	X							X		X			X		X	X		X	X		X	X			X		X		24
Antibiotic re-dosing			X	X	X	X	X	X		X	X	X	X	X				X	X		X		X				X		X			X			X							X			X		X	X	23
Gown and glove change before fascial closure			X		X	X	X	X		X		X	X	X							X	X	X					X	X	X			X		X	X	X			X	X	X	X						23
Dedicated closure tray			X		X	X		X		X		X	X	X							X	X	X			X	X		X	X					X	X				X	X		X						20
Wound protector		X	X	X	X	X	X	X		X		X						X	X		X	X						X		X						X	X			X			X						19
Normoglycaemia			X							X		X		X	X		X		X		X		X			X												X	X	X			X	X			X	X	17
Intracavity lavage			X				X						X	X			X					X								X			X		X		X				X								11
Oxygen delivery (FiO_2 ≥80%)			X									X					X						X												X			X									X	X	8
Triclosan-coated sutures	X			X								X	X		X		X		X																														7
Limited OR traffic																					X					X		X												X			X			X			6
Changing of suction and electrocautery			X										X																	X						X	X												5
Laparoscopic surgery		X																								X					X													X					4
Closure strategy							X											X										X																					3
Sterile occlusive incisional wound dressing placed in OR					X	X															X																												3
Surgical hand hygiene with hydroalcoholic solutions											X					X					X																												3
Hair removal when appropriate with clippers																					X						X								X														3
Altemeier wound classification													X								X																												2
Glove change after each intra-operative digital rectal exam																														X							X												2
Sleeve placement and glove change after anastomosis established																														X							X												2
Absorbable subcuticular suture and skin glue										X																									X														2
Use of warmed CO_2 during laparoscopic procedures	X																																																1
Subcutaneous heparin																																									X								1
Isolation technique																			X																														1
Wound re-blocked			X																																														1
Standard handoffs between pre-op, OR, PACU and/or ICU																										X																							1
Elimination of 'flash' steam sterilization of instruments																										X																							1
Short operative duration (<100 min)																																												X					1
Systolic blood pressure ≥90 mmHg																																																X	1
Double gloving for all scrubbed surgical team members																																															X		1
Pulse lavage of subcutaneous tissues for all open surgery																																															X		1
Antibacterial dressings																	X																																1
Antiseptic-impregnated incise drapes																																							X										1
Florescent imaging instrument to assess perfusion in the anastomosis and to check for microleaks																													X																				1
Ensuring surgical masks are worn at all times																												X																					1
Sticker with dressing change instructions																												X																					1
Patient education																																											X						1
Wound redraped before closure						X																																											1
Total	3	4	12	5	7	9	8	6	2	8	4	10	8	7	5	3	7	4	6	2	12	6	7	0	1	8	5	9	5	9	2	2	3	2	10	5	7	5	5	6	7	5	7	4	3	3	8	6	

CHG, chlorhexidine gluconate; CO_2, carbon dioxide; FiO_2, fraction of inspired oxygen; ICU, intensive care unit; OR, operating room; PACU, postanaesthesia care unit.

This division is in line with SSI prevention guidelines from WHO [63], NICE [64] and CDC [65,70]. Such a structured approach can help streamline the implementation process, and improve compliance rates by making the steps more manageable for healthcare providers.

Following this analysis of the different interventions and allocation to the three operative phases by the study authors, some inconsistencies were identified. As such, the present authors decided to group some interventions and reorder them in the operative phase that seemed most suitable. For this endeavour, it was necessary to define each operative phase in time. The pre-operative phase was considered as the period from admission until patient handover to the operating room staff, the intra-operative phase was considered as the period from patient handover to the operating room staff until return of the patient to the surgical ward, and the postoperative phase was considered as the period from return of the patient to the surgical ward until discharge. The outcome of this analysis is shown in Table V.

Compliance and outcomes

Infection prevention care bundles have been proven to be valid tools to reduce SSIs in colorectal surgery. However, it is important to note that three of the selected studies reported an increase in SSI rates. For instance, Jurt *et al.* [24] postulated that the absence of a decrease in SSI rate could be associated with low compliance with individual bundle interventions. Tanner *et al.* [54] found that full compliance with the care bundle was only achieved in 19% of patients, resulting in similar SSI rates between the compliant and non-compliant groups. Rumberger *et al.* [53] reported that, while their SSI rate did not improve after care bundle implementation, other outcomes in colorectal surgery were enhanced.

These findings emphasize the critical role of compliance in the effectiveness of care bundles. Without high levels of adherence to all components of a care bundle, the anticipated benefits may not be fully realized. This highlights the need for ongoing education, training and support for clinical staff to ensure that all aspects of care bundles are implemented consistently.

Table III
Individual interventions and surgical site infection (SSI) rate reductions in the postoperative period

Postoperative period		Dixon et al. [2] 2022	Arroyo-Garcia et al. [19] 2022	Antonacci et al. [20] 2022	Clayphan et al. [21] 2022	Schlick et al. [22] 2022	Brajcich et al. [23] 2022	Jurt et al. [24] 2021	Faragher et al. [25] 2021	Vicentini et al. [26] 2021	Falconer et al. [6] 2021	Zarain-Obrador [27] 2021	Lohsiriwat [28] 2021	D'Andrea et al. [29] 2020	Martinez et al. [30] 2020	Leaper et al. [4] 2020	Park et al. [31] 2020	Hajirawala et al. [32] 2020	Dean et al. [33] 2020	D'Souza et al. [34] 2019	Guzman-Pruneda et al. [35] 2019	Mcgee et al. [36] 2019	Albert et al. [37] 2019	Hoang et al. [38] 2019	Russell et al. [39] 2018	Vu et al. [40] 2018	Lin et al. [41] 2018	Weiser et al. [42] 2018	Gachabayov et al. [43] 2018	Harris et al. [44] 2018	Gorgun et al. [45] 2018	Jaffe et al. [46] 2017	Kilan et al. [47] 2017	Ohman et al. [48] 2017	Bert et al. [49] 2017	Hewitt et al. [50] 2017	Kwaan et al. [51] 2016	Benlice et al. [52] 2016	Rumberger et al. [53] 2016	Tanner et al. [54] 2016	Keenan et al. [55] 2015	Ghuman et al. [56] 2015	Pérez-Blanco et al. [57] 2015	Keenan et al. [1] 2014	Waits et al. [58] 2014	Cima et al. [59] 2013	Crolla et al. [60] 2012	Lutfiyya et al. [61] 2012	Bull et al. [62] 2011	Total
	SSI rate reduction	-14.9%	-8.6%	-1.7%	-8.5%	n/a	n/a	0.8%	-9.5%	-6.0%	-7.0%	-1.4%	-6.5%	-9.2%	-10.6%	n/a	-5.7%	-14.5%	-10.0%	-6.4%	-11.0%	-3.1%	-7.2%	-6.2%	n/a	-2.8%	-7.5%	-6.9%	-12.3%	-55.5%	-5.2%	-7.8%	-4.0%	-11.5%	-3.4%	-9.2%	-0.8%	-5.3%	1.1%	4.0%	-9.8%	-1.4%	-10.6%	-13.6%	-15.5%	-5.8%	-2.8%	-14.5%	-8.0%	
Postoperative	Normoglycaemia			■							■		■	■		■				■				■		■	■					■				■				■	■		■	■	■			■		17
	Normothermia			■							■		■			■	■			■			■		■		■					■								■	■			■	■		■		■	16
	Removal of sterile dressing within 48 h					■	■													■		■									■					■	■	■			■			■						10
	Oxygen delivery (FiO$_2$ ≥80%)												■					■		■				■															■	■								■	■	8
	Washing of incisions with CHG					■	■															■			■																■			■						6
	Hand hygiene																■												■																	■				3
	SSI assessment and documentation											■																			■							■												3
	Protect primary closure incisions for 5 days with silver-impregnated or polyhexamethylene biguanide dressing																	■												■																		■		3
	Urinary catheter removal within postoperative 2 days																■												■										■											3
	Standardized wound care orders																			■																							■							2
	Wound surveillance																														■							■												2
	Patient education																								■																			■						2
	Patient shower with CHG after dressing removal																																													■				1
	Iodopovidone wound wash														■																																			1
	Short operative duration (incision to closure) <100 min																															■																		1
	Altemeier wound class documented			■																																														1
	PATOS documented			■																																														1
	ASA score documented			■																																														1
	Standard handoffs between pre-op, OR, PACU and/or ICU																										■																							1
	Standardized debriefing at the end of the case																										■																							1
	'Enhanced' recovery after surgery interventions																										■																							1
	Systolic blood pressure ≥90 mmHg																																																■	1
	Stoma bag applied before dressing if required										■																																							1
	Padded tegaderm dressing left in place for 5 days										■																																							1
	Update and assessment of surgical antibiotic prophylaxis											■																																						1
	Wound care service consultation obtained for all ostomies and complex wounds																																			■														1
	Patients asked to ambulate evening of surgery with staff																																						■											1
	Start of regular diet in evening of surgery																																						■											1
	Patients are maintained on a minimal narcotic regimen																																						■											1
	Discharge is upon laxation																																						■											1
	Low volume negative pressure to aid in healing																													■																				1
	Shower on postoperative day 2																											■																						1
	Do not leave OR in scrubs																												■																					1
	Dressing changes using sterile technique																												■																					1
	Review of wound by attending surgeon post discharge																												■																					1
	Total	0	0	5	0	2	2	0	0	0	4	2	3	1	1	2	3	2	0	5	0	2	1	2	3	1	5	1	5	2	3	3	0	0	0	3	1	3	6	3	4	0	2	5	2	2	1	3	3	

ASA, American Society of Anaesthesiologists; CHG, chlorhexidine gluconate; FiO$_2$, fraction of inspired oxygen; ICU, intensive care unit; OR, operating room; PACU, postanaesthesia care unit; PATOS, (infection) present at time of surgery.

Table IV
Most common interventions in each peri-operative phase

Pre-operative	Intra-operative	Postoperative
Mechanical bowel preparation	Antibiotic prophylaxis (type, timing and discontinuation)	Normothermia
Oral antibiotic bowel decontamination	Normothermia	Normoglycaemia
Hair removal with clippers when appropriate	Skin preparation with 2% CHG alcoholic solution	Removal of sterile dressing within 48 h
Shower with 2% CHG	Antibiotic re-dosing	Oxygen delivery (FiO$_2$ ≥80%)
Normoglycaemia	Gown and glove change before fascial closure	Washing of incisions with 2% CHG alcoholic solution
	Dedicated closure trays	
	Wound protectors	
	Normoglycaemia	

CHG, chlorhexidine gluconate; FiO$_2$, fraction of inspired oxygen.

Strengths and limitations

This scoping review has several strengths, including a comprehensive search strategy and robust inclusion criteria, ensuring a thorough examination of the literature on SSI prevention bundles in colorectal surgery. However, there are limitations to this research that should be acknowledged.

Firstly, the search was limited to four databases (PubMed, CINAHL, Web of Science Core Collection and Scopus). While these databases are extensive and widely used, the exclusion

Table V
Distribution of interventions by peri-operative phase

Pre-operative	*N*		*N*
• CHG shower/cloths	28	• Checklist to determine patient readiness for OR	1
• Mechanical bowel preparation	26	• SSI risk assessment provided to surgeon	1
• Oral antibiotic bowel decontamination	24	• PATOS documented	1
• Hair removal with clippers when appropriate	24	• MRSA screening and decolonization	1
• Normoglycaemia	16	• Iodophor nares swabs to decolonize the nose for 24 h	1
• Normothermia	10	• Medical handwashing	1
• Patient education	5	• Maintenance of oxygen saturation at least 92%	1
• Clear liquid diets on day prior	3	• Optimizing nutrition	1
• Encourage smoking cessation 30 days before surgery	3	• Oral carbohydrate loading	1
• Standard handoffs between pre-op, OR, PACU and/or ICU	1		
Intra-operative	***N***		***N***
• Antibiotic prophylaxis (type, timing and discontinuation) and re-dosing	44	• Absorbable subcuticular suture and skin glue • Use of warmed CO_2 during laparoscopic procedures	2
• Skin prep with 2% CHG	31	• Elimination of 'flash' steam sterilization of instruments	1
• Normothermia	29	• Standard handoffs between pre-op, OR, PACU and/or ICU	1
• Drapes, gown and glove change before fascial closure	25	• Short operative duration (<100 min)	1
• Dedicated closure tray	20	• Systolic blood pressure ≥90 mmHg	1
• Wound protector	19	• Standardized urinary catheter placement	1
• Normoglycaemia	17	• ASA score documented	1
• Intracavity lavage	11	• Double gloving for all scrubbed surgical team members	1
• Oxygen delivery (FiO_2 ≥80%)	8	• Pulse lavage of subcutaneous tissues for all open surgery	1
• Triclosan-coated sutures	7	• Antibacterial dressings	1
• Limited OR traffic	6	• Antiseptic-impregnated incise drapes	1
• Changing of suction and electrocautery	5	• Florescent imaging instrument to assess perfusion	1
• Laparoscopic surgery	4	in the anastomosis and to check for microleaks	1
• Closure strategy	3	• Subcutaneous heparin	1
• Sterile occlusive incisional wound dressing placed in OR	3	• Isolation technique	1
• Surgical hand hygiene with hydroalcoholic solutions	3	• Ensuring surgical masks are worn at all times	1
• Altemeier wound classification documented	3	• Sticker with dressing change instructions	
• Glove change after each intra-operative digital rectal exam	2	• Do not leave OR in scrubs	1
• Sleeve placement and glove change after anastomosis established	2		
Postoperative	***N***		***N***
• Normoglycaemia	17	• Iodopovidone wound wash	1
• Normothermia	16	• Low volume negative pressure to aid in healing	1
• Removal of sterile dressing within 48 h	10	• Dressing changes using sterile technique	1
• Oxygen delivery (FiO_2 ≥80%)	8	• Shower on postoperative day 2	1
• Washing of incisions with CHG	6	• Patients asked to ambulate evening of surgery with staff	1
• Hand hygiene	3	• Start of regular diet in evening of surgery	1
• SSI assessment and documentation	3	• Patients are maintained on a minimal narcotic regímen	1
• Protect primary closure incisions for 5 days with silver-impregnated or polyhexamethylene biguanide dressing	3	• Padded tegaderm dressing left in place for 5 days • Update and assessment of surgical antibiotic prophylaxis • Wound care service consultation obtained	1
• Urinary catheter removal within postoperative 2 days	3	for all ostomies and complex wounds	1
• Standardized wound care orders	2	• Standardized debriefing at the end of the case	1
• Wound surveillance	2	• 'Enhanced' recovery after surgery interventions	1
• Patient education	2	• Systolic blood pressure ≥90 mmHg	1
• Standard handoffs between pre-op, OR, PACU and/or ICU	1	• Stoma bag applied before dressing if required	1
• Review of wound by attending surgeon post discharge	1	• Discharge is upon laxation	1
• Patient shower with CHG after dressing removal	1		1

ASA, American Society of Anaesthesiologists; CHG, chlorhexidine gluconate; CO_2, carbon dioxide; FiO_2, fraction of inspired oxygen; ICU, intensive care unit; MRSA, meticillin-resistant *Staphylococcus aureus*; OR, operating room; PACU, postanaesthesia care unit; PATOS, (infection) present at time of surgery.

of other databases may have resulted in the omission of relevant studies. This limitation could affect the comprehensiveness of the review and potentially bias the findings.

Secondly, the included studies exhibited considerable heterogeneity in terms of population size, study design and geographical distribution. This variability can complicate comparison and synthesis of the results. Moreover, a significant proportion of the studies were conducted in the USA, which may limit the generalizability of the findings to other healthcare settings with different practices and resources.

This review provides valuable insights into the implementation and effectiveness of SSI prevention bundles in colorectal surgery, highlighting areas for future research and potential improvements in clinical practice.

Research on infection prevention care bundles has increased significantly in recent years, reflecting a growing recognition of their potential to improve clinical outcomes in colorectal surgery. Despite this progress, there remains a lack of consensus on the most effective interventions within the pre-operative, intra-operative and postoperative periods. The diversity of approaches underscores the need for standardized protocols to ensure consistency and effectiveness across different healthcare settings.

Implementing SSI prevention bundles is a critical strategy for enhancing the quality of care and improving surgical outcomes. These bundles are designed to reduce SSI rates systematically, thereby lowering associated healthcare costs. This scoping review has identified the most prevalent interventions utilized in each period, providing valuable insights that can inform the design and development of future care bundles tailored specifically for colorectal surgery.

This review demonstrates that while SSI prevention care bundles are generally effective in reducing SSI rates in colorectal surgery, their success is highly dependent on consistent and comprehensive compliance with the prescribed interventions. This finding highlights the importance of adherence to all components of the care bundles to achieve the desired outcomes.

Overall, this scoping review identified the most common interventions used in care bundles across the different periods in colorectal surgery. Further research is essential to optimize the implementation and compliance rates of these interventions. Such efforts will facilitate their wider dissemination and more effective use in clinical practice, ultimately contributing to the reduction of SSI rates in colorectal surgery.

Future research should also aim to determine the optimal composition of care bundles for SSI prevention. This will involve identifying which specific interventions, when combined, yield the greatest effectiveness while maintaining feasibility and ease of implementation in various clinical settings. Establishing such evidence-based standards will be crucial for advancing the efficacy of infection prevention strategies, and improving patient outcomes in colorectal surgery.

Conflict of interest statement
None declared.

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Appendix A. Supplementary data

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