Systematic Review

Influence of surgical scrubs outside the operation theatre on post-operative infections – A systematic review

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ABSTRACT

Background and Aims: Healthcare workers (HCWs), which include surgeons, anaesthesiologists, nurses, technicians, and other non-medical staff working in the operation theatre (OT), change to surgical scrubs for providing designated services. This study was intended to investigate the association of moving in and out of OT to other hospital areas without changing scrubs and its impact on bacterial infection. **Methods:** After PROSPERO registration, we performed a systematic review to compare the occurrence of surgical site infections (SSIs) with or without the movement of HCWs outside OT. We searched PubMed, Scopus, and Cochrane Library using relevant keywords. RoB-2 and ROBINS-E tools were used to assess the risk of bias in randomised controlled trials (RCTs) and observational studies, respectively. **Results:** We identified six articles that fulfilled the inclusion criteria: three RCTs and three observational studies. A risk of bias assessment revealed an overall low bias in the RCTs and an overall high bias in the observational studies. The analysis revealed a comparable incidence of bacterial infection in terms of colony-forming units when scrubs when HCWs moved in and out of OT with the same scrubs. A meta-analysis was not performed due to heterogeneity in participants and the OT set-up, as well as fewer studies and sample size. **Conclusion:** The evidence is insufficient to suggest that wearing scrubs outside the OT could increase the incidence of SSI in surgical patients or transmit the organisms to patients, causing infection. The present review neither supports nor is against wearing surgical scrubs outside OT premises.

Keywords: Bacterial infections, clothing, infection control, operating rooms, surgical attire, surgical scrub, surgical site infections, surgical wound infection

INTRODUCTION

Operation theatre (OT) scrub suits have long been essential in healthcare settings, particularly during surgical procedures, to maintain a sterile environment and reduce the risk of infections.[1] The scrub suits are intended to minimise the shedding of skin cells and microorganisms from healthcare workers, thus reducing the risk of surgical site infections (SSIs) and other patient complications.[2,3] However, a growing debate surrounds whether wearing these scrubs outside the OT poses potential risks or benefits to healthcare professionals and patients.

Many experts in infection prevention and control advise that OT scrubs be used only in the OT, especially not in high-risk places like intensive care units. Even though there is no evidence or consensus

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that OT contamination causes SSI, it is considered poor practice by many clinicians.[4] Scrubs, masks, and head coverings may decrease bacterial counts in the operating room, but there is no proof that they also lower the incidence of SSI.[5] A large study by the American College of Surgeons in two teaching hospitals comprising 6517 surgical patients concluded that the most significant predictors of SSIs were pre-operative infection, operative time more than 75th percentile, open wounds, and dirty/contaminated wounds. This conclusion was reached after imposing stringent OT attire discipline among all involved healthcare workers (HCWs).[6]

Numerous studies have investigated the presence of pathogens on scrub suits, mainly after they are worn outside the sterile environment of the OT. This review aimed to investigate the association of moving in and out of OT to other hospital areas with scrubs without changing and its impact on the occurrence of SSI.

METHODS

This systematic review was registered with the International Prospective Register of Systematic Reviews (PROSPERO registration number: CRD42023402454) and was reported as per the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) guidelines.[7]

The search for relevant keywords was done from databases starting from January 2000 till May 2023. The databases searched using relevant keywords were PubMed/MEDLINE, Scopus, Cochrane Library (CENTRAL), and clinicaltrials.gov. The details of the search strategy are provided in Supplementary File 1.

Participants

Randomised controlled trials (RCTs) and observational studies in which comparison of SSI with or without changing OT scrubs or wearing a covering gown over OT scrub by HCWs working in the OT complex were included. Studies with no control groups, case reports/series, editorials, review articles or conference abstracts were excluded.

Two authors (ASN and HHM) independently examined the titles and abstracts, removing duplicates. After careful consideration by both authors, who also read the entire text, the studies were chosen. An independent third author addressed discrepancies and inconsistencies if any (KMS). Each reviewer separately extracted the data using a pre-defined approach. The study characteristics and study results were evaluated in the completed publications. Details like the author's name, publication year, study design, number of participants, country, age, surgeries performed, primary and secondary outcomes, and conclusions were gathered. We searched according to PICO (population, intervention, comparison, outcomes) criteria.[8]

Population: Anaesthesiologists, surgeons, and operation theatre personnel like nurses wearing surgical scrubs.

Intervention: The intervention/exposure was not changing to street dress or wearing a gown over surgical scrubs outside the OT complex to clinics, wards, and other areas.

Comparators: The comparator group was changing to street dress or wearing a gown over the scrubs to attend clinics, wards, and other areas.

Outcomes: The primary outcome was to investigate the occurrence of postoperative infection in patients, especially SSI (an infection that occurs after surgery in the part of the body where the surgery took place), when the surgical scrubs are worn with and without changing after entering areas outside OT. The secondary outcome was to determine the contamination of OT scrubs (positive bacterial growth of specimens sent from OT scrubs).

Methodological quality assessment

The included RCTs' methodological quality and bias risk were evaluated using the Revised Cochrane risk-of-bias assessment for RCTs (RoB 2). Five domains included are randomisation bias, divergence from intended intervention bias, missing data bias, outcome measurement bias, and selection bias for reported outcomes, which were included in the assessment of bias.[9] The observational studies were assessed for risk of bias using the ROBINS-E tool.[10] Seven parameters were considered for risk of bias assessment: confounding, measurement of the exposure, selection of participants into the study, post-exposure interventions, missing data, measurement of outcome, and selection of reported results.

Data extraction, synthesis, and analysis

Detailed planning of meta-analysis, including the use of Review Manager software (version 5.4.1), use of

relevant statistical methods, forest plots, the definition of heterogeneity, and assessment of publication bias using a funnel plot, was made and mentioned in the protocol registered in PROSPERO.[11-14]

RESULTS

Search strategy: We searched PubMed, Embase, and CENTRAL for RCTs and observational studies comparing bacterial contamination of surgical scrubs worn by HCWs moving out of OT without changing, wearing covering gowns, and switching to personal clothing. We identified 218 articles by searching the databases mentioned above and registries. After removing duplicates and articles that were not relevant, we identified 29 articles for scrutiny. A total of 20 studies were considered eligible. From these, 14 studies were excluded (study with no control group, four; review articles, eight; articles with an active control group, zero; unrelated primary and secondary outcomes, two). Finally, we included six studies with 112 participants from the three RCTs and 169 participants from the three observational studies [Figure 1].[15-20] Table 1 summarises all the studies in the analysis.

Risk of bias: Among the RCTs, bias due to the randomisation process was low in two studies[16,17], and there were concerns with one study.[15] There were concerns due to allocation concealment in all studies.[15-17] Bias due to missing outcome data was low in two studies,[16,17] and there was no information in one study.[15] Bias due to the outcome measurement was low in two studies[15,16], and one study had some concerns.[17] Bias due to the selection of reported results was low in one study[15], and there was no information in two studies.[16,17] Overall, there were some concerns regarding bias among all the RCTs [Figures 2 and 3]. In all three observational studies, bias due to confounding and selection of participants was high.[18-20] Bias

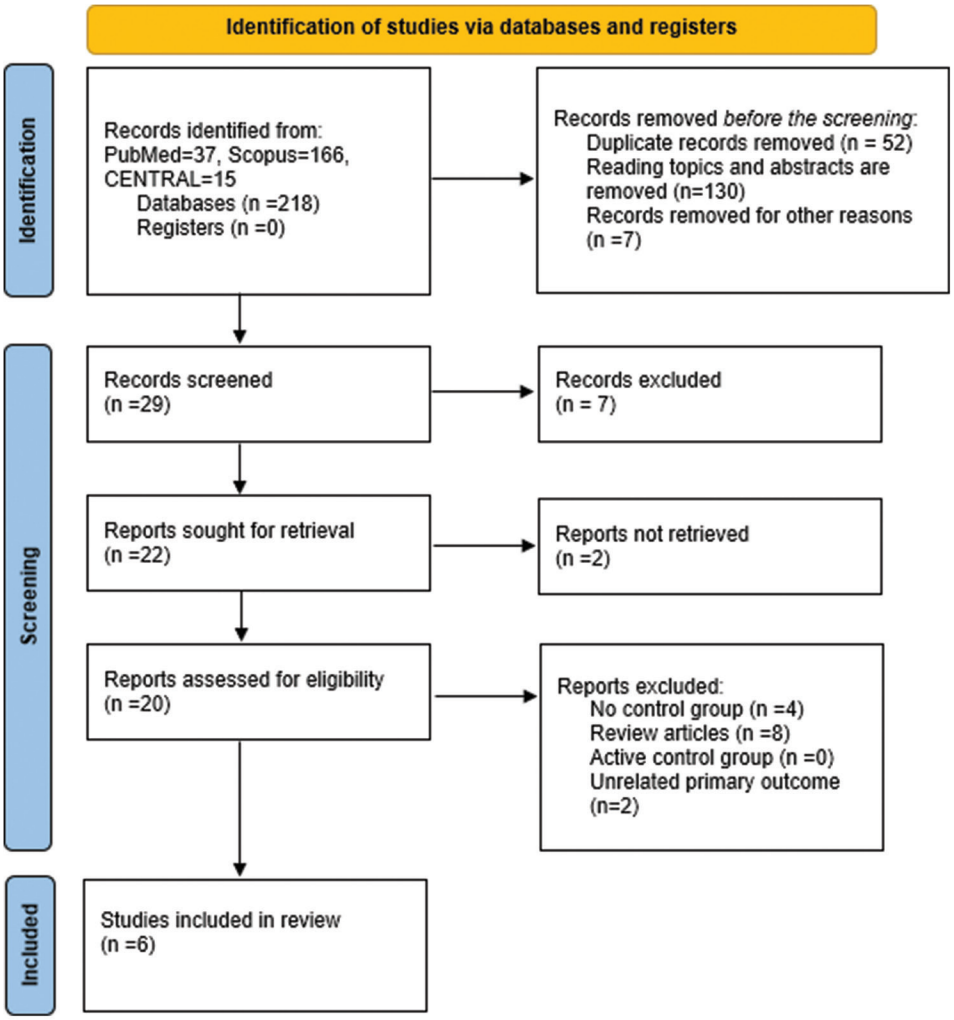

Figure 1: Study selection flowchart

Table 1: Summary table of various studies (RCTs and observational studies)

Author (s)/ Year	Country	Type of Study	Participants	Number of participants	Primary outcome	Bacterial contamination	Conclusions
Kaplan *et al.*/2003	USA	RCT	Obstetric residents, midwives, physicians' assistants, and medical students	75 in three groups of 25 each	To determine the difference in bacterial contamination of surgical apparel between those medical providers adhering, and those not adhering to wearing covered gowns over the scrub suits	Sixty-four percent of agar samples had growth at 48 hours, the most frequent being Gram-positive non-haemolytic cocci in clusters. One sample had Gram-positive haemolytic cocci in clusters, and one had Gram-positive cocci in chains.	Wearing covering garments over scrub suits does not reduce rates of contamination.
Hee *et al.*/2014	Singapore	RCT	Anaesthetists	Sixteen	To evaluate the bacterial contamination of surgical scrub suits worn outside the operating theatre.	The CFU of the total specimens was from 0 to 199.1 CFU/cm^2 (mean 16.4, SD 32.1, median 4.0).	Visits to the ward and office did not significantly increase bacterial contamination of scrub suits.
Slizewski *et al.*/2018	USA	RCT	Obstetrics and gynaecology resident physicians	Twenty-one	To quantify the effect of dressing in surgical scrubs at home versus at the hospital on bacterial contamination at the beginning of a scheduled shift.	No difference between the home and hospital-dressed cohorts in the percentage of samples demonstrating any bacterial growth after 72 h (60% vs 76%, *P*=0.14), nor in median bacterial burden at the beginning of a shift [2 (interquartile range, 0–7) vs 1 (interquartile range, 1–5) CFUs, *P*=0.62].	There was no significant difference in the total bacterial burden of surgical scrubs at the start of a shift between cohorts who dressed at home versus at the hospital.
Sivanandan *et al.*/2011	United Kingdom	Case-control study	Orthopaedic surgeons, Anaesthetists	Twenty	To compare the level and type of contamination of OT scrub inside and outside the theatre	CFU was 15.4+/-16.1 (participants in OT) and 25.2 +/-22.3 (participants outside OT), *P*=0.03. The CFU was not statistically significant in either group at 0, 4, 6, and 8.	The level of contamination of theatre clothes is similar inside and outside the theatre setting.
Wiener-Well *et al.*/2011	Israel	Non-randomised, with convenience sampling, along with a questionnaire	Surgeons and nurses	238 samples from 135 personnel were investigated	To determine the rate of contamination of hospital uniforms with pathogenic bacteria, comparing attire worn by nurses and physicians and semi-quantitatively determined the bacterial load on uniforms	The highest mean bacterial load (number of CFU per culture plate) was found for S aureus (14+/-18 CFU), with a higher load for MRSA than for methicillin-sensitive S aureus (21+/-28 CFU vs 11+/-13 CFU).	Up to 60% of hospital staff's uniforms were colonised with potentially pathogenic bacteria, including drug-resistant organisms. It was unclear if these bacteria could be transferred to patients and cause clinically relevant infections.
Ilibman *et al.*/2020	Israel	Descriptive and questionnaire-based	Surgeons	One hundred and thirty-three	To provide further data on bacterial contamination of surgical scrubs.	The total CFU with scrubs had a mean of 52 +/- 50 standard deviation and a median of 39 (0-363), with control (clean uniforms) a mean and standard deviation of 5+/-5 and a median of 3 (0-16); *P*<0.001.	Even in less-than-optimal situations when scrubs are worn outside the OR, surgical scrubs are contaminated with a low bacterial load and only a few pathogenic bacteria.

RCT=Randomised controlled trial, CFU=Colony forming units, OT=Operation theatre, MRSA=Methicillin-resistant Staphylococcus Aureus, SD=Standard deviation, vs=versus, OR=Operation room

from the measurement of exposure was high in two studies,[19,20] and there were some concerns in one study.[18] Bias due to post-exposure interventions was high in one study[18], and there was bias due to some concerns in two studies.[19,20] There was no information about bias due to missing data in two studies,[19,20] and there were some concerns in one study.[18] There were some concerns regarding bias due to the measurement of outcomes in all three studies.[18-20] Bias due to the selection of reported results was low in two studies,[19,20] and there was no information in one study.[18] The overall bias was high in the included observational studies.

The comparison of bacterial contamination of scrubs with or without protection (62 participants in each group) was reported by three RCTs.[15-17] Kaplan *et al*.[15] reported the growth in percentages.

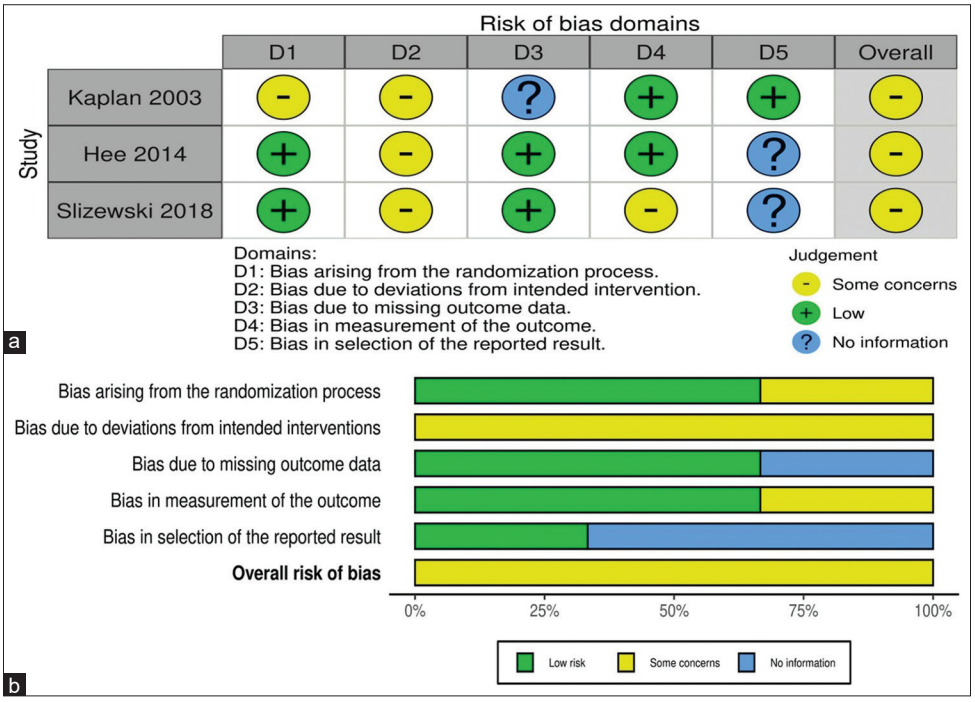

Figure 2: (a) Traffic-light plot showing the risk of bias assessment for RCTs; (b) Summary plot showing the risk of bias assessment for RCTs

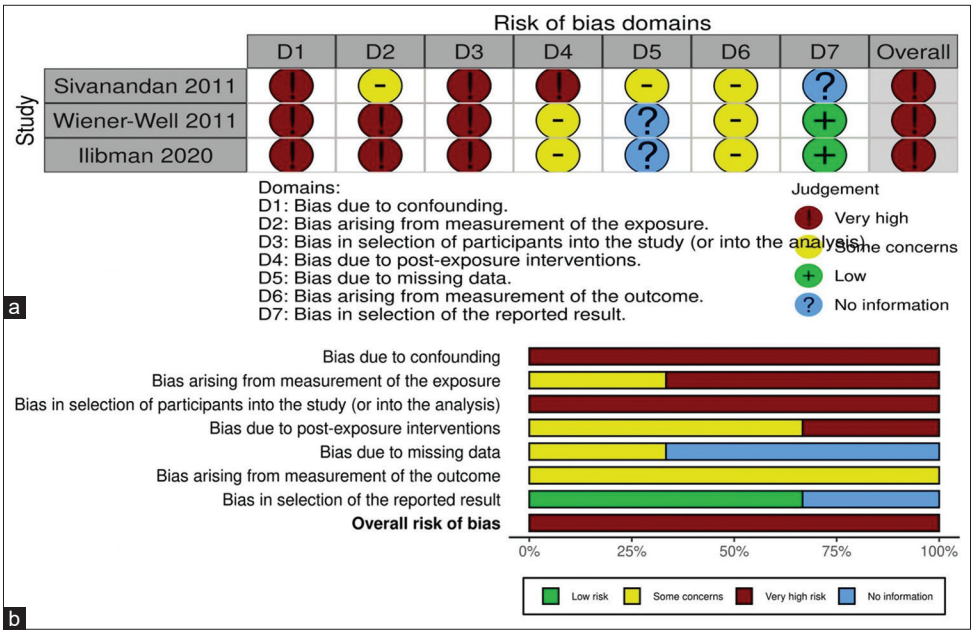

Figure 3: (a) Traffic-light plot showing the risk of bias assessment for observational studies; (b) Summary plot showing the risk of bias assessment for observational studies

Participants without coats had less growth in a broth at 24 and 48 hours; the difference was not statistically significant (P = 0.35). With broth and agar, participants without coats had less growth at 24 and 48 hours, but this was not statistically significant (P = 0.43). In the study by Hee *et al*.,[16] the primary outcome was reported as a comparison of colony-forming units (CFU) [16.8 (9.8, 23.8) CFU/cm^2] in a group restricted to the operation theatre when compared to the group which moved across office and ward [17.1 (10.1, 24.1) CFU/cm^2], which was not statistically significant (P = 6.16). In the study by Slizewski *et al*.,[17] there was no difference between the home- and hospital-dressed participants in the percentage of samples demonstrating any bacterial growth after 72 hours (60% vs 76%, P = 0.14) nor in median bacterial burden at the beginning of a shift (P = 0.62). Hee *et al*.[16] reported secondary outcomes such as evaluating the impact of time, sites of sampling, and wearing stethoscopes and lanyards on bacterial contamination of scrub suits. There were no secondary outcomes of interest in the other two studies; hence, they are not described here.[15,17] The RCTs' limitations were the participants' heterogeneity[15] and the small sample size.[16,17]

In the observational studies that fulfilled inclusion criteria,[18-20] the primary outcome was bacterial contamination of the scrubs with or without protection. The contamination was reported as CFU. The comparison of CFU in the study by Sivanandan *et al*.[18] at 2 hours was significant [15.4 (16.1)] versus [25.2 (22.3)] with P = 0.03. The CFU were comparable at 0, 4, 6, and 8 hours ($P > 0.05$). In the study by Wiener-Well *et al*.,[19] the highest CFU was found for *Staphylococcus aureus* 14 (18) CFU, with a higher load for methicillin-resistant *Staphylococcus aureus* (MRSA) than for methicillin-sensitive *S. aureus*, 21 (28) CFU vs 11 (13) CFU. The study did not explore the association of this contamination with adverse perioperative outcomes. In the study by Ilibman *et al*.,[20] the median CFU count was higher (39 CFU/plate) for scrubs that were not changed than for clean scrubs worn by the control group (3 CFU/plate, $P < 0.001$). However, there was no significant difference between the study and control groups in the rate of carriage of pathogenic bacteria (13% and 9%). The limitations of the observational studies were the lack of randomisation, a small sample size, inconsistent methodologies, and no investigation into contaminations leading to adverse perioperative outcomes.[18-20]

In certain circumstances, a meta-analysis of effect estimates is either impossible or inappropriate.[21] A quantitative meta-analysis was not feasible for this qualitative systematic review due to heterogeneous participants, different OT set-ups, and the small sample size in the included studies; therefore, it was not performed. We applied the Synthesis without meta-analysis (SWiM) reporting standards in addition to the PRISMA checklist. SWiM comprises nine items, seven in methods and one in each of the results and discussion, to help publish systematic reviews without meta-analysis.[22]

DISCUSSION

On performing a qualitative systematic review of six eligible articles (three RCTs and three observational studies), it was evident that although there could be contamination of surgical scrubs when worn out of the OT complex and wearing the same scrubs again inside the OT after going out with or without a cover gown, no increases in the incidence of SSI have been observed in the surgical patients.

There is mounting evidence suggesting that wearing surgical scrubs outside operating rooms can lead to contamination and potential transmission of pathogens.[23-25] Copp *et al*.,[26] hypothesised that if scrub suits are worn outside OT without a cover gown, there is an increased risk of bacterial contamination. However, the contamination is reduced in the presence of a cover gown, and if scrubs are changed to new ones after going out, the contamination can be lessened.

In another study by Perry *et al*.,[27] 57 nursing staff from various surgical wards (except obstetrics) were enroled, and samples from their uniform were analysed at the beginning and end of a 24-hour shift. On analysis, the authors found that *Staphylococcus aureus*, Clostridium difficile, and vancomycin-resistant enterococci were detected on uniforms both before and after the duty. However, the study did not investigate if these staff transmitted these organisms to any patient under their care. One of the primary concerns associated with the contamination of surgical scrubs is the potential spread of multi-drug-resistant organisms (MDROs).[20,23] However, none of the studies demonstrating bacterial contamination have had MDRO.

Roxburgh *et al*.[28] enroled 17 staff from three hospitals for 1 month in another exploratory study. Seventy-five

samples were randomly collected on various occasions and analysed for bacterial contamination. The authors mentioned that current evidence is insufficient to proclaim that wearing a cover gown or changing to a new scrub on re-entry to OT could potentially reduce the risk of bacterial contamination of scrubs. McHugh *et al*.[3] published a review on the practice of surgical attire and its role in SSI. The authors mentioned that there was no evidence that moving in and out of OT in sterile scrubs could lead to an increase in SSI. A working party report published by Woodhead *et al*.[29] reported that there was no evidence from studies suggesting that dressing in surgical attire outside of the operating room and then entering the operating room without changing into clean theatre suits increases the risk of surgical wound infection. The Association of periOperative Registered Nurses (AORN) advises using tightly woven and low-lint or lint-free, stain-resistant, and durable scrubs in the OT.[30] The Association for Perioperative Practice (AfPP) in the UK strongly recommends using a clean, single-use gown or coat completely secured by ties or button fasteners and discarded after use.[31] The updated AORN guidelines also recommend wearing a long-sleeved scrub top or a jacket when moving with the OT scrubs in restricted areas.[32]

To mitigate the contamination risks, healthcare facilities can implement several preventive measures like having separate scrubs for OT and other hospital areas, on-site laundering, strict hand-hygiene protocols, and adequately storing clean scrubs.[33-37] Another approach involves changing into clean scrubs designated exclusively for use within the operation theatre and using a separate set of scrubs for other hospital areas. Despite the growing evidence and guidelines, achieving full compliance with not wearing scrub suits outside the operation theatre has been challenging. Several factors contribute to this issue, including cultural norms, convenience, and individual beliefs regarding the significance of scrub suit contamination.

There are several limitations in this review. The number of studies included were less and were a mix of RCTs and observational studies. Although the bias in the RCTs was low, it was very high in the observational studies. Secondly, the participants were quite heterogeneous, with variable designations and responsibilities. The hand hygiene status of the participants was either not documented or not standardised. The sampling areas were also not uniform in all the studies.

CONCLUSION

The evidence is insufficient to suggest that these scrubs could increase the incidence of SSI in surgical patients or transmit the organisms to patients, causing infection. There is not enough evidence available to make strong conclusions at present. Until the results of well-designed studies are available, healthcare institutions must follow local guidelines by the infection control department.

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Conflicts of interest

There are no conflicts of interest.

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Supplementary file 1: Search details for various databases	
Source	**Search string**
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Scopus search details:	TITLE-ABS -KEY "Operating Rooms" AND "Surgical Attire" OR "Clothing" AND "Bacterial Infections" OR "Surgical Wound Infection"
Cochrane (CENTRAL)	"operating-rooms" in Title Abstract Keyword AND "surgical-site infections" in Title Abstract Keyword AND surgical scrubs in Title Abstract Keyword (Word variations have been searched) "operating-rooms":ti, ab, kw AND "surgical-site infections":ti, ab, kw AND surgical scrubs: ti, ab, kw (Word variations have been searched)