# Rituals and behaviours in the operating theatre – joint guidelines of Healthcare Infection Society and The European Society of Clinical Microbiology and Infectious Diseases.

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**Authors' contribution:**

All authors contributed to writing. All authors except AB and GM also provided advice; AB and GM also conducted searches and evidence syntheses.



*"NICE has accredited the process used by the Healthcare Infection Society to produce: "Rituals and behaviours in the operating theatre – joint guidelines of Healthcare Infection Society and The European Society of Clinical Microbiology and Infectious Diseases." The NICE accreditation of HIS methodology is valid for five years from March 2020. More information on accreditation can be viewed at http://www.nice.org.uk/about/what-we-do/accreditation"*

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# 1. Executive summary

Prevention of surgical site infection (SSI) remains a main priority in operating theatres. This has previously led to the introduction of practices, often referred to as rituals and behaviours and sometimes labelled as 'myths'. Some of them are not underpinned by sound scientific evidence, but they are established in everyday practice, and considered by many as traditional to help ensure discipline and professionalism in the operating theatre. Previous Healthcare Infection Society guidelines were published 20 years ago, and they aimed to debunk some of the practices. Since then, new technologies have emerged, and an update was required. These new updated guidelines, produced in collaboration between Healthcare Infection Society and The European Society of Clinical Microbiology and Infectious Diseases, used NICE-accredited methodology to provide further advice on which practices are unnecessary. Specifically, they discuss the current available evidence for different rituals which are commonplace in the operating theatre and highlight the gaps in knowledge with recommendations for future research. Previous guidelines divided the operating theatre rituals and behaviours into essential, preferable (optional) and those that provide no clear benefit. In the light of new evidence and in line with the new NICE principles for recommendations, these have been updated and are divided into recommendations, good practice points and recommendations against certain practices.

## Summary of recommendations and good practice points

### Theatre environment

*1 a) Does operating theatre cleanliness/disinfection have any effect on surgical site infection (SSI)? b) How important is operating theatre cleanliness outside the sterile field? c) Does clutter matter?*

**Recommendations**

**1.1:** All patient, staff and visitor hand contact surfaces must be appropriately cleaned between patients.

**1.2:** In addition to routine cleaning between patients, clean and disinfect all patient and staff hand contact surfaces after dirty or contaminated procedures as well as any areas contaminated by blood and body fluids.

**Good practice points**

**GPP 1.1:** Clean and disinfect clinical care equipment, including anaesthetic machines, before the next patient arrives in the operating room.

**GPP 1.2:** Clean and disinfect anaesthetic room hand contact surfaces before the next patient arrives.

**GPP 1.3:** Keep the operating room tidy and devoid of clutter in accordance with local housekeeping practice.

*2 If blood splashes and other forms of contamination with body fluids occur, can they be a source of infection?*

**Recommendations**

**2.1:** No recommendation

**Good practice points**

**GPP 2.1:** Wherever blood and body fluids splashes occur, clean and disinfect hand contact surfaces and floors immediately.

**GPP 2.2:** Do not stop the use of the operating room to replace the UCV canopy screens or filters if they become contaminated with blood or body fluid splashes.

*3 Does bringing in beds and associated linen from wards and other clinical areas into the operating theatre result in increased bacterial counts or increased infection post-operatively?*

**Recommendations**

**3.1:** No recommendation

**Good practice points**

**GPP 3.1:** Allow clean beds with clean linen to be brought into operating theatre complex directly from clinical areas.

*4 a) Does the order in which patients are operated on, i.e. contaminated/infected patients at the end of a list, reduce post-operative infections? b) Should these patients recover separately from other patients before going to a ward?*

**Recommendations**

**4.1:** There is no need to place contaminated/infected patients at the end of an operating list as long as the operating room is sufficiently cleaned and disinfected between patients and the theatre ventilation is running without interruption.

**Good practice points**

**GPP 4.1**: Allow patients on isolation/contact precautions to recover in the operating room or in a designated section of the recovery area.

## Preparation before the surgery

*5. What is the clinical effectiveness of pre-operative showering/bathing before elective surgical procedures using 1) Non-disinfectant bath/shower 2) Disinfectant bath/shower?*

**Recommendations**

**5.1:** No recommendation

**Good practice points**

**GPP 5.1:** Encourage patients to shower/bathe before surgery for personal hygiene reasons. Consider using alternatives (e.g. wipes) immediately before an operation for patients who are not able to shower or bathe before the operation.

**GPP 5.2:** Do not delay operations for patients who are not able to shower or bathe before the surgery.

**GPP 5.3:** Instruct patients not to shave their surgical area in the days before the surgery.

*6 What is the most effective preoperative skin antiseptic?*

**Recommendations**

**6.1:** Refer to recommendations 1.3.7, 1.3.8, 1.3.9 and accompanying Table 1 in the NICE guidelines [NG125] for advice on choosing appropriate skin preparation solution.

## Staff behaviour

*7 a) Should surgical instruments be laid up (unpacked and exposed) as close as possible to use? b) Should surgical instruments used in ultraclean ventilated theatre procedures be laid up under the canopy or in a prep room?*

**Recommendations**

**7.1:** For all surgical/operative procedures, lay up the instruments and prosthetic materials as close as possible to when they are needed.

**Good practice points**

**GPP 7.1:** For ultraclean ventilation operating theatres, lay up the instruments/prosthetic materials under the canopy in preference to the preparation room, unless local UCV exists in the preparation room.

*8 What is the most effective surgical scrub procedure for scrub staff?*

**Recommendations**

**8.1:** Refer to recommendations 1.3.1 and 1.3.2 in the NICE guidelines [NG125] for advice on choosing appropriate hand decontamination solution.

*9 Does the movement of theatre staff in and out of the operating room impact on air counts of bacteria and infection rates?*

**Recommendations**

**9.1:** Minimise non-essential staff movement and hence door openings during surgical procedures.

## Staff attire

*10 Should the surgical team remove jewellery, false nails, and nail polish before entering the operating theatre facilities?*

**Recommendations**

**10.1:** Do not allow scrubbed staff to wear jewellery below the elbows. Where jewellery cannot be removed, the area around and underneath any item of jewellery must be carefully cleaned as much as possible.

**10.2:** Do not allow scrubbed and unscrubbed staff to wear artificial or polished nails in the operating theatre.

*11 a) Should staff cover their hair? b) Should staff use facemasks?*

**Recommendations**

**11.1:** No recommendation

**Good practice points**

**GPP 11.1:** Ensure that all staff working in the operating room wear a head covering and a face mask in accordance with local policies.

*12 What is the impact of wearing operating room attire outside the operating theatre complex?*

**Recommendations**

**12.1:** No recommendation

**Good Practice Points**

**GPP 12.1:** Change or cover operating theatre attire (e.g. single-use disposable gown) and change footwear if leaving the operating theatre complex with the intention of returning.

## Patient and visitor attire

*13 Should patients remove jewellery, false nails, nail polish before being brought into the operating theatre?*

**Recommendations**

**13.1:** No recommendation

**Good practice points**

**GPP 13.1:** Refer to current hospital policy for pre-operative patient management

**GPP 13.2:** If patients are asked to remove jewellery, artificial nails or nail polish before they arrive in the operating theatre, include information about this in written patient information in advance of surgery while preparing at home.

*14 Should patients cover their hair before entering the operating theatre facilities?*

**Recommendations**

**14.1:** No recommendation

**Good practice points**

**GPP 14.1:** Refer to current hospital policy for pre-operative patient management, although be aware that covering patients' hair is not required for infection prevention reasons.

*15 a) What should parents/carers/accompanying person wear when accompanying the patient to the operating theatre? b) Do patients or other individuals dressed in ordinary (street) clothes in the operating theatre result in increased bacterial counts or increased infection post-operatively?*

**Recommendations**

**15.1:** No recommendation

**Good practice points**

**GPP 15.1:** Ask parents and carers to wear scrubs or equivalent (e.g. single-use coverall), along with head coverings and face masks, on entering operating room as per local policy. Changing shoes is not necessary.

**GPP 15.2:** Ensure that visitors (e.g. technicians or company representatives) comply with local departmental policy on theatre attire.

## 2. Plain English summary

Prevention of surgical site infection (SSI) remains a key priority in operating theatres. This has led to the introduction of practices, often referred to as rituals and as some of these practices are not based on real or sound scientific evidence, but they are now established in everyday practice. Previous Healthcare Infection Society guidelines were reviewed and published 20 years ago, and they aimed to improve some of the practices. However, new technologies and evidence have emerged, which requires these guidelines to be updated.

These new and updated guidelines were published in collaboration with the European Society of Clinical Microbiology and Infectious Diseases. Using National Institute for Health and Care Excellence (NICE)-accredited methodology, they aim to give guidance on which practices are unnecessary. They identify currently available evidence for different practices which are commonplace in the operating theatre and highlight gaps in knowledge with recommendations for future research.

Previous guidelines rated the operating theatre rituals and behaviours as essential, preferable (optional) and those that provide no clear benefit. With new evidence and in line with the new UK NICE principles for recommendations, these guidelines have been updated and divided into recommendations for use, good practice points and recommendations against certain practices.

## 3. Introduction

Surgical care is an essential part of healthcare, but it is also associated with a significant risk of complications with post-operative infections being of particular concern. Guidelines and recommendations on the prevention of surgical sites infections (SSI) generally focus on those aspects for which there is often some evidence such as skin preparation and surgical antibiotic prophylaxis.[1-3] However, there are certain behaviours and rituals that are commonplace in the operating theatre that are accepted practice, but for which the evidence may not be substantial. These are considered as part of traditional practice and regarded by some as assisting in maintaining discipline and professionalism in the operating theatre.

There are many risk factors for SSI and the operating theatre environment is considered one of the modifiable factors. For this reason, throughout the decades, different ritualistic practices and behaviours evolved in the operating theatre with the aim to reduce environmental contamination and the subsequent risk of SSI. It is now acknowledged that some of these established practices may not have a sufficient evidence base. A modern operating theatre is provided with many technologies which control microbial contamination of the air, thus, nowadays some of the rituals and behaviours

in the operating theatre may have little impact on its contamination. At best, these rituals may be harmless and somewhat inconvenient. At worst, they are time consuming and expensive, wasting valuable resources that could be used elsewhere.

Some rituals, especially those associated with pre-operative preparation, may also be intimidating and embarrassing to patients, unnecessarily increasing their anxiety before the surgery. To be able to abandon some of these rituals and staff behaviours, there is a need to demonstrate which ones do and do not have a beneficial impact on patient outcomes and staff safety.

Previous guidelines[4] on this topic were published 20 years ago and more evidence has since emerged. Since then, some guidelines have been published on preventing the contamination of an operating theatre,[5-7] especially concerning the operating staff attire, but none of these guidelines considered whether some of the common practices are still necessary to prevent SSIs. The purpose of this updated guideline is to review the evidence for these practices and to make clear recommendations on which rituals and behaviours in operating theatre need to be retained to decrease the risk of SSI and which can be safely discontinued. The guidelines have not addressed those areas for which there is a good evidence base, e.g. surgical antibiotic prophylaxis and avoiding hypothermia, as these are covered in other guidelines.

### 1.1 Definitions

The terminology used in the operating theatre environment is sometimes ambiguous therefore, to standardise some of the terms, the following definitions were used throughout this manuscript:

- *Operating theatre complex/operating theatre* – refers to the entire operating theatre facilities which include, but are not limited to, the preparation room, the anaesthetic room the operating room and the recovery area.
- *Operating room* – refers to the room in which surgical procedures are undertaken.
- *Hand contact surfaces* – refers to any surface that has or is likely to come in contact with staff or visitor hands in the preparation, anaesthetic or the operating room. This term relates to any surface that was touched during a procedure at least once.
- *Frequently touched surfaces* – implies that multiple individuals touch these surfaces multiple times.

# 4. Guideline Development Team

### 4.1 Acknowledgements

Members of the Working Party represent professional societies i.e. Healthcare Infection Society (HIS) and the European Society of Clinical Microbiology and Infectious Diseases (ESCMID) and its study group (ESCMID Study Group for Nosocomial Infections [ESGNI]), as well as clinical microbiologists, infection prevention and control (IPC) doctors, IPC nurses, and the surgeons. The authors would like to acknowledge the support from their employing institutions, which allowed them the time required for producing these guidelines. We thank the National Institute for Health Research, University College London Hospitals Biomedical Research Centre, which partly supported Professor Peter Wilson's involvement in these guidelines. We would also like to thank the following former working party members who contributed their valuable time and expertise towards the development of these

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### 4.2 Source of funding

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### 4.3 Disclosure of potential conflict of interest

All conflicts of interest are disclosed in Supplementary Materials file B.

### 4.4 Relationship of authors with sponsor

HIS and ESCMID/ESGNI commissioned the authors to undertake this Working Party report. The authors are members of the participating societies mentioned in section 4.1.

### 4.5 Responsibility for guidelines

The views expressed in this publication are those of the authors and have been endorsed by HIS and ESCMID/ESGNI and approved following a consultation with external stakeholders (Supplementary Materials file C).

## 5. Working Party Report

### 5.1 What is the Working Party Report?

This report contains recommendations and good practice points which aim to minimise the ritualistic behaviour occurring in operating theatre without increasing the risk of SSI. The Working Party recommendations have been developed systematically through a multi-professional group based on published evidence and professional experience. These recommendations and good practice points may be used in the development of local protocols for all operating theatres. Good practice points represent advice from the Working Party members' advice based on experience, common sense and biological plausibility.

### 5.2 Why do we need a Working Party Report for this topic?

The previous guidelines relating to this topic were published in 2002.[4] During the intervening time some new evidence has been published but also some new topics of concern have emerged. Updating these guidelines was necessary to keep up with the pace of technology. Additionally, processes for guidelines production have changed in the last 20 years, becoming more robust and less prone to expertise bias.

## 5.3 What is the purpose of the Working Party Report's recommendations?

The main purpose of these guidelines is to inform operating theatre staff, including surgeons, other operating theatre personnel such as theatre nurses and anaesthetists, and IPC practitioners about current policy and best practice in the operating theatre. This document highlights current gaps in knowledge, which will help to direct future areas of research.

## 5.4 What is the scope of the guidelines?

These guidelines were developed with a focus on any surgical procedures performed in the operating theatres. The Working Party members believe that these guidelines are suitable for all patients in all age groups. While the focus of these guidelines is procedures in operating theatres, the Working Party acknowledge that some of these recommendations may also be relevant in other settings where minor surgical procedures are undertaken.

## 5.5 What is the evidence for these guidelines?

Topics for these guidelines were derived from stakeholder meetings and were designed in accordance with the Population Intervention Comparison Outcomes (PICO) framework (Appendix 1). In the preparation of these recommendations, systematic searches and systematic reviews of published literature were undertaken. The evidence was assessed for methodological quality and clinical applicability according to National Institute for Health and Care Excellence (NICE) protocols.[8]

## 5.6 Who developed these guidelines?

The Working Party included academic, scientific and medical experts, clinical microbiologists, clinical scientists, IPC practitioners, surgeons, systematic reviewers and two lay member representatives, many of whom were members of the HIS and ESCMID/ESGNI.

## 5.7 Who are these guidelines for?

Any healthcare practitioner working in the operating theatre environment can use these guidelines and adapt them for local use. Users should include clinical microbiologists, IPC doctors and nurses, theatre managers, surgeons, anaesthetists, surgical nurses, anaesthetic assistants, and estates staff. Theatre managers, hospital policy makers and IPC professionals should use these guidelines to develop local policies and to aid their decision-making process. The available reported studies were predominantly conducted during major general and orthopaedic surgery. The Working Party believes that while many sections of these guidelines are particularly relevant to these branches of surgery, some evidence and recommendations and good practice points can be extrapolated to minor procedures.

## 5.8 How are the guidelines structured?

Each section comprises an introduction, a summary of evidence with levels (known as evidence statements), summary of Working Party's discussions and the recommendations graded according to the available evidence. Good Practice Points are included where the Working Party believed that

certain practises should be retained even if the evidence underpinning these was absent, as it believed that they could contribute to preventing SSI. These were derived from the collective expertise of the Working Party, the experience of the individual members, and were based on common sense and biological plausibility.

### 5.9 How frequently are the guidelines reviewed and updated?

The guidelines will be reviewed at least every four years and updated if change(s) are necessary or if the evidence emerges that requires a change in practice.

### 5.10 Aim

The primary aim of these guidelines is to provide advice on which ritualistic elements of surgical IPC practices can be safely stopped. The secondary aim is to identify areas in need of further research to inform future guidelines.

## 6. Implementation of these guidelines

### 6.1 How can these guidelines be used to improve clinical effectiveness?

The guidelines can be used to inform local protocols for preventing SSI. The practices which are no longer needed can be abandoned and the resources which were used on these practices can be allocated elsewhere. In addition, future research priorities identified by these guidelines will allow researchers to refine their applications to funding bodies.

### 6.2 How much will implementation of these guidelines cost?

The Working Party agreed that there is no anticipated additional cost unless existing practice falls well below currently accepted standards. The practices recommended by these guidelines are currently used in most operating theatres. There is a potential cost saving and other benefit (e.g. reducing the carbon footprint) associated with abandoning those rituals that are no longer needed.

### 6.3 Summary of the audit measures

Regular audit remains an important part of any guideline implementation. Audit is effective only when the results are fed back to staff and when there is a clear plan for their implementation. Many organisations have already developed their own local policies and audit measures, which may need to be updated following the publication of these new guidelines. Below, the Working Party suggests some aspects that could be audited, although they acknowledge that this is not a complete list and that the staff in operating theatres may choose other aspects as appropriate for their setting.

1. Number of contaminated hand contact surfaces in the operating and anaesthetic room after cleaning.

2. Proportion of patients requiring isolation/contact precautions who recover in the operating room or in an area separate from other patients.

3. Time between the opening of operative instruments and prosthetic materials before use.

4. Proportion of procedures in which the operative instruments and prosthetic materials are opened under the ultraclean ventilation (UCV) canopy.

5. Compliance with operating theatre policy on operating theatre attire for carers and other visitors, e.g. technicians.

6. Number and the frequency of non-essential staff entering the operating room during surgical procedures.

### 6.4 Supplementary tools

Lay materials and continuing professional development questions (CPD) are available in the Supplementary Materials (files D and E).

# 7. Methodology

### 7.1 Evidence search and appraisal

Topics for these guidelines were derived from the initial discussions of the Working Party during the stakeholder meeting. To prepare these recommendations, the Working Party collectively reviewed relevant evidence from published peer-reviewed literature. Methods were followed in accordance with the NICE manual for conducting evidence syntheses.[8]

### 7.2 Data sources and search strategy

Three electronic databases (Medline, Embase, EMCare) were searched for any articles published up until January 2022. Search terms were constructed using relevant MeSH and free text terms (Appendix 1). Reference lists of identified articles were scanned for additional studies and forward reference searching (identifying articles which cite relevant articles) was performed. The searches were restricted to primary articles published in the English language.

### 7.3 Study eligibility and selection criteria

Search results were downloaded to an Endnote database and screened for relevance. One of two reviewers (AB, GM) reviewed the titles, abstracts and full text papers. As per NICE methodology, the second reviewer checked 5% of the excluded studies for discrepancies. If discrepancies were found, the second reviewer checked all excluded records. There were no discrepancies which needed to be addressed by a third reviewer. The guidelines included any controlled trials, cohort studies, interrupted time series (ITS) studies as well as case-control studies, cross-sectional studies, and controlled before-and-after (CBA) studies. Due to the paucity of the evidence on this topic, simulation studies and uncontrolled before-and-after (UBA) were also included. Where evidence was lacking, relevant excluded studies (e.g. outbreak reports or case studies), which provided additional

information, were also described in some sections with the limitations of using this information clearly highlighted. The results of study selection and the list of excluded studies are available in Appendix 2.

The Working Party acknowledged the limitations of these study designs, especially the use of UBA studies which are often excluded from systematic reviews and other guidelines because of the high risk of bias that they represent. However, the reason these studies are usually excluded is because they tend to overestimate the benefits of the intervention (i.e. they are sensitive to a type 1 error which rejects the null hypothesis and assumes that research hypothesis is correct). The UBA studies in this manuscript did not find a benefit for the interventions, therefore they further contributed towards the evidence that the null hypothesis was correct.

## 7.4 Data extraction and quality assessment

Included epidemiological studies were appraised for quality using checklists recommended in the NICE guideline development manual.[8] The quality checklists included:

- Randomised Controlled trials (RCT): RoB_2.0 for RCT
- Non-Randomised Controlled Trials (n-RCT): ROBINS for non RCTs and cohort studies
- Cohort studies: ROBINS for non RCTs and cohort studies
- Interrupted time series (ITS): EPOC RoB for ITS and before-after studies
- Case control studies: CASP for case control studies
- Cross-sectional studies: JBI checklist for analytical cross-sectional studies
- Uncontrolled before-and-after studies: EPOC RoB for ITS and before-after studies
- Outbreak studies, case series and case studies: Institute of Health Economics (IHE) checklist for case series.

Simulation studies and other non-epidemiological studies were not appraised for quality since no checklists exist for this type of studies. Critical appraisal was conducted by one reviewer (AB) and checked by the second (GM). The results of quality appraisal are available in Appendix 3.

Data were extracted by one reviewer (AB) and checked by another (GM). For each question, the data from the included studies were extracted to create the tables of study description and summary of findings tables (Appendix 4). The list of the studies rejected at full text stage with a reason for this decision, is included in the excluded study tables (Appendix 2b). Due to limited evidence, most of the data were described narratively. Meta-analyses were only possible for a limited number of questions.

## 7.5 Rating of evidence and recommendations

The strength of the evidence was defined by GRADE (Grading of Recommendations Assessment, Development and Evaluation)[9] tables (Appendix 5) and using the ratings ‘high’, ‘moderate’, ‘low’ and ‘very low’ to construct the evidence statements, which reflected the Working Party’s confidence in the evidence. The strength of recommendation was adopted from GRADE and reflects the strength of each evidence statement. In instances where no evidence was identified from searches, the statement ‘No evidence was found in studies published so far…’ indicates that no studies have assessed this as an outcome. Where there was little adequate evidence, expert-based good practice points were made

from the expert experience of members of the Working party. All disagreements were resolved by discussions and voting by members of the Working Party during the meetings.

When writing recommendations, the Working Party considered the following:

- Who should act on these recommendations?
- What are the potential harms and benefits of the intervention and any unintended consequences?
- What is the efficacy and the effectiveness of each intervention?
- Is it possible to stop another intervention because it has been superseded by the new recommendation?
- What is the potential effect on health inequalities?
- What is the cost-effectiveness of the intervention, including staff resources and other economic concerns?
- Can the recommended interventions be feasibly put into practice?
- Does the intervention have a negative impact on the environment?

The wording of the evidence statements and the recommendations reflected the strength of the evidence and its classification and are in line with NICE specifications. The following criteria were used:

- 'offer', 'measure', 'advise', 'refer', 'use' or similar wording was used if the Working Party believed that most practitioners/commissioners/service users would choose an intervention if they were presented with the same evidence: this usually means that the benefits outweigh harms, and that the intervention is likely to be cost-effective. This reflects a strong recommendation for the intervention. If there was a legal duty, or if not following a recommendation may have serious consequences, the word 'must' was used.
- 'do not offer' or similar wording was used if the Working Party believed that harms outweighed the benefits or if an intervention was not likely to be cost-effective. This reflected a strong recommendation against the intervention. If there was a legal duty, or if not following a recommendation may have serious consequences, the words 'must not' were used.
- 'consider' was used if the Working Party believed that the evidence did not support a strong recommendation, but that the intervention may be beneficial in some circumstances. This reflected a conditional recommendation for the intervention.
- The 'do not offer, unless…' or similar recommendation was made if the Working Party believed that the evidence did not support the strong recommendation, and that the intervention was likely not to be beneficial, but could be used in some circumstances, for instance if no other options were available. This reflected a conditional recommendation against the intervention.
- The 'Good Practice Points' were made when there was no evidence to support the recommendation but when the Working Party felt that although they may not have an evidence base, they were considered essential or beneficial to good clinical practice. These were derived from the collective expertise of the Working Party, the experience of the individual members, and were based on biological plausibility.

### 7.6 Consultation process

Feedback on draft guidelines was received from the participating organisations and through consultation with relevant stakeholders. The draft guideline and standard comments form were placed on the HIS website for four weeks. The availability of the draft was advertised via email and social media. Stakeholders were invited to comment on format, content, local applicability, patient acceptability, and recommendations. The Working Party reviewed stakeholder comments, and collectively agreed revisions (Supplementary Materials file C). All reviews received from individuals with a conflict of interest or those who did not provide a declaration were excluded.

# 8. Rationale for recommendations

## Operating theatre environment

### 8.1 a) Does operating theatre cleanliness/disinfection have any effect on surgical site infection (SSI)? b) How important is operating theatre cleanliness outside the sterile field? c) Does clutter matter?

Surfaces in the operating theatre are perceived by some staff as a possible source of SSI. Surfaces which have a direct contact with the patient may act as vectors for transmission of pathogenic microorganisms from one patient to another while other surfaces may contaminate staff hands during the procedures. While many studies show that operating theatre surfaces are contaminated, they do not show the evidence that this contamination may lead to infection in surgical patients. Moreover, the surfaces in peripheral areas of the operating room which are rarely touched during an operation may pose less risk than surfaces within the sterile field. Our previous guidelines[4] do not recommend which areas in operating theatre should be cleaned and disinfected and how this should be managed but they did state that cleaning and disinfection should take place, and if a 'dirty' case was present, diligence should be increased.

*Does operating theatre cleanliness/disinfection have any effect on surgical site infection (SSI)?*

There was very weak evidence from one controlled before-after (CBA)[10] and two uncontrolled before/after studies (UBA)[11,12] which assessed the effect of changing the cleaning/disinfection routine on the incidence of SSI. The CBA study[10] described an effect of installing the visible light continuous environmental disinfection (CED) system in addition to traditional cleaning/disinfection. The light was in operation 24 hours per day running in a 'white light' mode when the room was occupied and automatically switching to 'indigo light' mode when the room was empty. This was installed in one operating room (referred to as OR2), while two other rooms (OR1&3) acted as controls. All other IPC procedures remained the same in all three rooms. The authors reported that there was no significant difference in the incidence of SSI between all three operating rooms before the disinfection system was installed (OR1: 2 (0.3%); OR2: 11 (1.4%); OR3: 7 (0.9%); OR1 vs OR2: $p$=1.000; OR1 vs OR3: $p$=0.198; OR2 vs OR3: $p$=0.215). Following the installation of the CED, the incidence of SSI remained the same in operating rooms 1 and 3 (OR1: 8 (1.2%), $p$=0.108; OR3: 6 (0.8%), $p$=1.00) but was significantly lower in operating room 2 (OR2: 3 (0.4%), $p$=0.029). In one UBA study,[11] a change was made in cleaning practice from using the operating theatre staff conducting

cleaning and disinfection of operating theatre at night to introducing a dedicated cleaning personnel for terminal cleaning and addition of a pulsed-xenon (PX)-UV light device at night. During the day, between cases, operating theatre staff cleaned the surfaces in both pre- and the intervention period. The incidence of SSI did not change significantly with the change in the routine and the introduction of PX-UV device (RR=0.7537 [95%CI 0.5074-1.1196], *p*=0.1614), although the authors reported that the there was a -44.6% change in SSI rates (*p*=0.0496) for patients undergoing class I procedures (clean cases) while there was no significant change observed in patients undergoing class II procedures (dirty/contaminated, +22.9% change, *p*=0.6973). The last study[12] reported the switch from cleaning with detergent wipes and disinfectant (not specified) to cleaning and disinfection with microfibre and steam. The authors reported no change in infection rates (RR=0.5916 [0.0619-5.6575], *p*=0.6486) but recorded benefits of using microfibre and steam technology. The study reported that all staff involved in cleaning described a positive experience, there were no adverse events (chemical burns were previously recorded when detergent/disinfectant were used) and the surfaces were perceived as more visibly clean without the build-up of detergents. Additionally, the authors reported that cleaning was more efficient with microfibre and steam and this enabled staff to include more areas for routine cleaning. Cleaning with microfibre and steam was less costly than when detergent/disinfectants were used (AU$3,016 (approx. £1,704) vs AU$10,479 (approx. £5,922)). The authors also reported a possible positive environmental impact as they observed a 90% reduction in water use and they mentioned that these re-usable cloths were also recyclable.

There was very weak evidence from one case-control study[13] which assessed the effect of surface contamination in the operating theatre on the incidence of SSI. The inclusion criterion for patients in this study was that the procedure was undertaken in an ultraclean ventilation (UCV) theatre. The data on surface contamination were obtained in the middle of the procedure and the sample was taken near the foot of the operating table (contact pressure method, one plate for bacteria and one for fungi). The results from the multi-variate logistic regression showed that SSI was more likely to develop after the procedures during which surfaces were found to be contaminated (OR 1.96 [95%CI 1.49-2.16], *p*<0.001 for bacteria and 1.61 [95%CI 1.22-2.58], *p*<0.001 for fungi) but this may also suggest that they became contaminated because of the type of the procedure performed (i.e. clean vs dirty).

### *How important is operating theatre cleanliness outside the sterile field?*

No studies were found in the existing literature which assessed the effect of operating theatre cleanness outside the sterile field on the incidence of SSI.

### *Does clutter matter?*

No studies were found in the existing literature which assessed the effect of clutter in the operating theatre on the incidence of SSI.

### *Additional data from excluded studies*

There were three outbreak studies[14-16] which did not meet the criteria of this review for inclusion in making any recommendation (no control group). One outbreak report[14] described infections in open-heart surgery patients. There were different types of microorganisms including *Gordonia* spp., some Gram-positive bacteria and microorganisms that do not typically cause infections. The

investigations identified lapses in IPC, one of which was inadequate cleaning of the environment. The authors reported that the environment was a 'possible' source of infections but there were other sources e.g. inadequately laundered operating theatre attire and inadequate air quality. In the second outbreak report,[15] the authors reported that the incidence of SSIs increased, and this prompted the investigation for the factors responsible for this increase. Different environmental sites were sampled and investigated for Gram-positive and negative bacteria. When these were found, they were serotyped to establish whether similar strains were responsible for SSIs. The authors reported five possible sources of infection which included plumbing and outlets, as well as the floors in the operating theatre. This led to a conclusion that the environment was a possible source of SSI. However, the authors also reported that instruments were not adequately sterilised, and that the operating theatre was in disrepair. The last study[16] reported an outbreak of *Klebsiella pneumoniae* which was identified in ICU patients who developed sepsis. A case control investigation showed that in all cases sepsis occurred within five days of the surgery. Environmental sampling in the implicated theatre was undertaken and the only contaminated items were roll boards which were used for transferring patients to and from the operating table.

*The Working Party discussed the above evidence and concluded that the peripheral areas of the operating room are not likely to contribute towards the increased risk of SSI. However, the Working Party agreed that the appropriate cleaning of all touched areas needs to take place between patients, especially those within the sterile field. This is particularly important following a dirty or contaminated procedure (e.g. abdominal surgery) or when blood and body fluids are visible. In these circumstances, the Working Party recommends that all these surfaces are disinfected before the next patient is brought to the operating room. Other areas which may also become contaminated include the anaesthetic room and the preparation room and these should also be cleaned between patients.*

*Based on the observations of clinical practice in their respective institutions, some Working Party members commented that the anaesthetic and other specialist equipment is often missed during routine cleaning because the cleaning staff are not allowed to touch these items. Staff operating this equipment may therefore act as vectors for transmitting microorganisms between patients and causing infections but which may not necessarily be those of the surgical site. Thus, the Working Party agreed that it is important that the operating theatre complex has procedures in place to ensure that this equipment is appropriately cleaned between patients. Anecdotal evidence also suggests that hand hygiene in the operating theatre complex is not always adequate. The Working Party members reported situations where the hands of the staff may have become contaminated from touching the patient, or their own face or hair, and not appropriately washed before the equipment was touched. This can also lead to a potential infection for subsequent patients. This problem may be particularly true in the anaesthetic room where there may be a high number of contacts between the environment and the patient in the short time that the patient is present in the room and where the rapid turnover of patients means that the anaesthetists may not have the opportunity to decontaminate hands, change gloves and clean the surfaces before the new patient arrives. This topic is outside the scope of these guidelines, but the Working Party made the below recommendations with the expectation that appropriate hand hygiene is always in place in all operating theatres.*

**Recommendations**

**1.1:** All patient, staff and visitor hand contact surfaces must be appropriately cleaned between patients.

**1.2:** In addition to routine cleaning between patients, clean and disinfect all patient and staff hand contact surfaces after dirty or contaminated procedures as well as any areas contaminated by blood and body fluids.

**Good practice points**

**GPP 1.1:** Clean and disinfect clinical care equipment, including anaesthetic machines, before the next patient arrives in the operating room.

**GPP 1.2:** Clean and disinfect anaesthetic room hand contact surfaces before the next patient arrives.

**GPP 1.3:** Keep the operating room tidy and devoid of clutter in accordance with local housekeeping practice.

## 8.2 If blood splashes and other forms of contamination with body tissues occur, can they be a source of infection?

Blood and body fluid splashes occur frequently in the operating room. One study[17] reported that, following the surgical procedures, blood splashes were found on 24.2% of surgical masks and 45.2% of protective glasses used by the surgeons. Certain procedures (e.g. orthopaedic) frequently use power tools which make the splashes and aerosols more likely to occur. These splashes may be potentially contaminated with pathogens such as blood-borne viruses (BBV), i.e. HIV and hepatitis B and C viruses. However, there is a debate on whether presence of these microorganisms on the environmental surfaces poses a risk to patients and operating theatre staff. The most critical surfaces are disinfected between the patients and at the end of the day, but more remote surfaces in the operating theatre may receive less attention. Little is currently known about whether these surfaces pose a risk of BBV infection to staff and patients.

A specific category of splash contamination raised on occasion by operating theatre staff is the contamination of screens and filters of the UCV canopies. Anecdotal evidence suggests that some operating theatre staff are concerned that the large amount of air flowing through the screen and filter can mobilise dried blood along with any pathogens contained therein. Thus, the blood and body fluid splashes on the canopy screen and the filter are perceived as a potential vector for transmission of BBVs between patients. However, the nature of the material from which the screens and filters are made makes it difficult to disinfect. To remove this contamination, UCV canopy screens would need to be replaced by a specialist engineer, usually brought in from outside a hospital. This is not only expensive but would result in the operating room being shut down and operations cancelled. Previous guidelines[4] did not specifically address the topic of the risk of BBV but made a general recommendation that as a part of environmental hygiene, spillages of blood or body fluids should be dealt with immediately and in line with local policy in this area.

No studies were found in the existing literature which assessed the effect of the presence of blood and body fluid on the environmental surfaces in operating room on the incidence of infection with BBVs.

*The Working Party refrained from making recommendations due to the lack of the evidence. Instead, they provide the Good Practice Points which could guide the theatres in their decision making. Regarding the issue of UV canopy screens, the Working Party agreed that the droplets of blood and body fluids that land on the screens dry rapidly. Therefore it would be unlikely for them to become a hazard if they were left untouched. The Working Party discussed the issue of perceived cleanliness of the operating room when the canopy is visibly contaminated with blood. It was agreed that, while it may be unsettling for patients or staff, it is not justified to shut the operating room and cancel operations to replace the screens. This is in line with a current HTM document which mentioned that "UCV canopies fitted with monofilament diffuser screens do not need to be removed as blood splatter does not easily penetrate".[18] Further discussions led the Working Party to consider other instances where surfaces in operating theatre become contaminated and where similar concerns could be raised. Thus, the Working Party agreed that it may be beneficial for the operating theatre staff to judge the risk of infection based on accessibility. If the surfaces are not routinely accessible to hands (e.g. any surfaces above the shoulder height), they pose little risk to staff and patients. Thus, if decontamination or replacement is not feasible, they can be safely left untouched. On the other hand, the surfaces which are within the reach of the surgical team's hands need to be disinfected immediately to prevent the spread to other areas and to minimise the risk of transmission to staff and subsequent patients. The Working Party also stressed the importance of vaccination so that staff are protected against relevant BBVs.*

**Recommendations**

**2.1:** No recommendation

**Good practice points**

**GPP 2.1:** Wherever blood and body fluids splashes occur, clean and disinfect hand contact surfaces and floors immediately.

**GPP 2.2:** Do not stop the use of the operating room to replace the UCV canopy screens or filters if they become contaminated with blood or body fluid splashes.

## 8.3 Does bringing in beds and associated linen from wards and other clinical areas into the operating theatre result in increased bacterial counts or increased infection post-operatively?

It is typical practice that patients for surgery are brought to the operating theatre on a trolley, usually accompanied by the nurse and a porter. Other patients, due to their illness, may be transferred on their beds whilst others may walk. There is a concern that bringing any items from ward areas to the operating theatre may increase bacterial contamination of the surrounding air and surfaces and may subsequently increase the risk of SSI. For this reason, some theatres may have a transfer system which prevents hospital beds and non-theatre trolleys entering the clean operating room areas therefore to potentially decrease microbial contamination. Patients walking to the theatre are seen as source of possible contamination, potentially bringing pathogenic

microorganisms from the corridors to the operating theatre on their shoes. However, existing evidence shows that patients who can walk to the operating theatre prefer to do so[19-24] and that this may reduce their anxiety before the operation.[21]

### *Patients walking into the operating theatre*

No studies were found in the existing literature, which assessed the effect of patients walking into the operating theatre as compared to being transported on a trolley, on the incidence of SSI or on the contamination of the operating theatre.

### *Patients being brought on the bed or in a wheelchair to the operating theatre*

No studies were found, which assessed the effect of patients being brought on the bed or in a wheelchair into the operating theatre without being transported on a trolley, on the incidence of SSI or on the contamination of operating theatre.

### *Two-trolley system*

No studies were found in the existing literature, which assessed the effect of a transfer (bed-to-trolley or trolley-to-trolley) as compared to the patient being transferred from a ward bed to a theatre trolley, on the incidence of SSI.

There was weak evidence of no benefit from one low quality prospective cohort study[25] and one uncontrolled before/after study,[26] which evaluated the effect of using a transfer system vs one ward-to-theatre trolley on the contamination of operating theatre. One of these studies[25] compared floor contamination during the use of a transfer system in a theatre (Hospital 1) and the use of a one-trolley system (Hospital 2, theatre A and B). Contamination of the floors was assessed using contact plates in corridors, protective zones and clean zones of the operating theatre complex and inside the operating rooms. The data showed a mean 111 colony forming units (cfu)/100cm$^2$ (n=20 samples) on the floors of the operating rooms with the transfer system (Hospital 1) and a mean 283.3cfu/100cm$^2$ (n=18 samples) in Hospital 2, theatre A and a mean 286.7cfu/100cm$^2$ (n=10) in Hospital 2, theatre B. The floor contamination in the operating room in Hospital 1 was less contaminated despite the highest bacterial counts found on the floor in the protective zone (mean 469cfu/100cm$^2$ vs 336cfu/100cm$^2$ in Hospital 2, theatre A and 347cfu/100cm$^2$ Hospital 2, theatre B). Similar data were reported for contamination with *S. aureus* (0.0cfu/100cm$^2$, 1.0cfu/100cm$^2$ and 0.3cfu/100cm$^2$ for Hospital 1 and Hospital 2 A and B, respectively) and *Clostridium perfringens* (referred in the study as *C. welchii* (0.83cfu/100cm$^2$, 0.5cfu/100cm$^2$, 20.5cfu/100cm$^2$). Another study,[26] which assessed the contamination of the operating theatre in one week using a two-trolley system compared to a second week when only one trolley was in operation, found no significant difference in floor contamination (cfu/plate, n=40 for two-trolley and n=44 for one-trolley system) when assessing the total number of aerobic bacteria (72.3, SD= 140.2 for two trolleys vs 56.9, SD= 82.7 for one trolley), total number of anaerobic bacteria (0.5, SD= 0.8 vs 1.0, SD= 3.0), total number of *S. aureus* (0.32, SD= 1.49 vs 0.02, SD= 0.15), total number of coliforms (32.8, SD= 144.8 vs 6.7 SD= 25.1), and total number of *C. perfringens* (0.05, SD= 0.22 vs 0). There was also no significant difference in air contamination (cfu/plate, n=22 for both groups) when assessing the total number of aerobic bacteria (443.8, SD= 220.8 vs 366.3, SD= 156.7), total number of anaerobic bacteria (4.7, SD= 3.4 vs 10.5, SD= 12.4), total number of *S. aureus* (0.22, SD= 0.86 vs 0.36 SD= 1.13), total number of

coliforms (0.04, SD= 0.21 vs 0.18, SD= 0.58) and total number of *C. perfringens* (no colonies were found in either group). The authors concluded that a one-trolley system was sufficient if the trolleys were routinely cleaned. The authors did not assess the frequency at which these trolleys should be cleaned but concluded that given the data on how quickly the trolley wheels became contaminated, daily or weekly cleaning may be justifiable.

### *Patient bedding being changed/removed before entering the operating theatre*

No studies were found in the existing literature, which assessed the effect of removing or changing the patient bedding before entering the operating theatre, on the incidence of SSI or on the contamination of the operating theatre.

*The Working Party considered the above evidence and decided that floor contamination of the operating theatre is a poor surrogate for assessing the effect of patient transfer on the risk of post-surgical infection and, as a result, concluded that the risk to patients may be minimal. Due to the paucity of the evidence, no recommendation was made but the Working Party considered it appropriate to suggest that patients could either walk into the theatre complex or could be transported on a trolley, bed, or a wheelchair.*

**Recommendations**

**3.1:** No recommendation

**Good practice points**

**GPP 3.1:** Allow clean beds with clean linen to be brought into operating theatre complex directly from clinical areas.

## 8.4 a) Does the order in which patients are operated on, i.e. contaminated/infected patients at the end of a list reduce post-operative infections? b) Should these patients recover separately before going to a ward?

In hospital wards, contact precautions are instituted in the care of patients who are known or suspected to be colonised or infected with pathogenic microorganisms that are easily transmissible to others. These include a set of additional preventive measures such as use of personal protective equipment (PPE), placing patients in individual rooms or cohorted areas and avoiding unnecessary transfers. However, when these patients need to come to the operating theatre, some of these measures are not possible (e.g. isolation) and there is a risk of infection to others. Avoiding contact with infectious/colonised patients in the operating theatre can therefore minimise the risk to other patients.

One common practice to minimize this contact is to avoid scheduling cases with known infection before those cases that are not infected, i.e. schedule the case with infection/colonisation to last on the list. This, in theory, should minimise theatre contamination and therefore reduce the risk of infection or cross-infection to others. Another strategy allows the infected/colonised patient to recover in the operating room before they are taken to the ward for recovery, thus avoiding close

contact with other patients in the recovery room. The evidence for these practices is not well established and it is not always possible to comply with these practices due to scheduling difficulties or operating room availability. Previous guidelines[4] did not have a recommendation on whether patients requiring contact precautions could precede other patients or whether these patients should recover in a recovery room or even the operating room.

There was very weak evidence of no effect from a meta-analysis of two retrospective cohort studies[27,28] which investigated the incidence of SSI in patients undergoing arthroscopy (knee or hip) immediately after an infected case (n=177) as compared to patients undergoing arthroscopy after a non-infected case (n=31,761). The analysis found no difference in the incidence of SSI in patients following the infected case (10/177, 5.6%) as compared to non-infected case (673/31,761, 2.12%; RR=1.60 [95%CI 0.24-10.55]; *p*=0.63).

There was very weak evidence from one case series study,[29] which considered the possibility of acquiring the SSI from an infected case by assessing the outcomes of 35 patients operated immediately after revision arthroplasty took place. The study reported that one of these patients acquired SSI (2.9%) and demonstrated that the infecting microorganism matched the species isolated from the preceded infected case, although there was no genomic evaluation to establish whether these infecting microorganisms were indistinguishable.

No studies were found in the existing literature, which assessed the effect of an infected patient recovering in the operating room on the incidence of SSI.

*The Working Party considered the above evidence and concluded that some operating theatres may choose to have a policy which dictates placing patients requiring contact precautions at the end of the list. However, in the light of little evidence for the effectiveness of this practice and the potential practical constraints in terms of using operating theatres efficiently, this is not a requirement. Instead, the Working Party felt that more focus should be given to ensure that the operating room is suitably cleaned and disinfected before the next patient arrives (see section 8.1).*

*The Working Party is aware of one study[30] which did not meet the inclusion criteria for this guideline (no comparison group) which demonstrated that patients shed MRSA during surgery and that cleaning/disinfection reduces but does not always completely eradicate MRSA. In this study, the visible inspection identified that cleaning was not always adequate, which may have been a reason for the failure to eradicate the MRSA. While no evidence was found in relation to where the infected patient should recover, the Working Party felt that principles of contact precautions should be maintained in the operating theatre and that these patients should be separated from others whenever possible.*

**Recommendations**

**4.1:** There is no need to place contaminated/infected patients at the end of an operating list as long as the operating room is sufficiently cleaned and disinfected between patients and the theatre ventilation is running without interruption.

**Good practice points**

**GPP 4.1**: Allow patients on isolation/contact precautions to recover in the operating room or in a designated section of the recovery area.

## Preparation before the surgery

### 8.5 What is the clinical effectiveness of pre-operative showering/bathing before elective surgical procedures using 1) Non-disinfectant bath/shower 2) Disinfectant bath/shower?

Preoperative bathing/shower with or without an antiseptic skin wash is commonly used as a pre-operative intervention for the prevention of SSI. The rationale for this action is that washing shortly before the operation will reduce the number of microorganisms on the skin and therefore potentially prevent them from entering the surgical wound. The intervention is well accepted because it is relatively inexpensive and easy to implement. Additionally, a 'clean-looking' patient is socially more acceptable to the staff, which may be the reason for this intervention to be a common practice. However, at the moment it is still not clear whether pre-operative shower or bathing is effective in reducing SSI.

#### *Non-disinfectant bath or shower*

No studies were found in the existing literature which assessed the effect of a non-disinfectant shower on the incidence of SSI.

There was evidence from one excluded study[31] which described an improvement initiative with a bundle of interventions intended to be implemented in 49 hospitals. However, it was identified that only 23% of hospitals were compliant with all elements of the bundle and as a result, the authors analysed the data as a retrospective cohort. One of the elements was pre-operative showering. The study was excluded because the hospitals were free to decide whether their patients used regular or antibacterial soap. The overall compliance rate for implementing the shower element was 42% and ranged from 16.4% in year 2 of the programme to 85% in year 8. The authors reported that there was no difference in the SSI rates between the hospitals which were compliant with the pre-operative shower initiative and those which did not (OR 0.70 [95%CI 0.45 -1.09], $p$=0.115).

#### *Disinfectant shower or bath*

The Working Party made a decision to draw evidence for this section from the existing guidelines and systematic reviews which addressed this issue.[32-35] These reviews reported that chlorhexidine (CHG) shower/bath had no effect on SSI when compared to plain soap,[32-34] placebo[32,34] or when patients were not required to shower or bathe.[32] However, the pre-operative use of CHG wipes was reported to reduce the incidence of SSI.[33,35]

*The Working Party agreed that despite the lack of evidence for or against showering or bathing before surgery, this practice should be encouraged whenever possible. This is consistent with current practice, where hospitals ask elective patients to shower/bathe the night before or on the day of surgery and it is custom for most people to wash themselves for personal hygiene reasons. However, this practice is not essential and should not be imposed on patients who may have difficulty*

*showering or bathing. Additionally, a lay member alerted the Working Party to the issue of patients shaving the operative site on the day preceding an operation. While shaving was not a focus of these guidelines, the Working Party was concerned that this practice could put patients at risk of SSI and needs to be highlighted. There is currently sufficient evidence[1] to advise patients against shaving, hence, it may be prudent to inform the patients of the risks associated with this practice.*

*There does not seem to be evidence that disinfectant showers or baths offer any additional benefit and therefore showering/bathing with soap or shower gel is considered sufficient. The Working Party refrained from recommendations for specific patients, such as those colonised by MRSA who may benefit from a decolonisation/suppression therapy.[36] Such regimens are different to those for routine pre-operative showering or bathing. The Working Party agreed that it is in the interest of the patients to avoid any delays and for surgical procedures to be carried out as soon as possible. If patients are not able to shower or bathe, hospitals may choose to use alternatives (e.g. chlorhexidine or detergent wipes) to quickly clean patients' skin prior to surgery.*

**Recommendations**

**5.1:** No recommendation

**Good practice points**

**GPP 5.1:** Encourage patients to shower/bathe before surgery for personal hygiene reasons. Consider using alternatives (e.g. wipes) immediately before an operation for patients who are not able to shower or bathe before the operation.

**GPP 5.2:** Do not delay operations for patients who are not able to shower or bathe before the surgery.

**GPP 5.3:** Instruct patients not to shave their surgical area in the days before the surgery.

## 8.6 What is the most effective preoperative skin antiseptic?

*The Working Party agreed that the current NICE recommendations [NG125][6] provide adequate advice and should be followed.*

**Recommendations**

**6.1:** Refer to recommendations 1.3.7, 1.3.8, 1.3.9 and accompanying Table 1 in the NICE guidelines [NG125] for advice on choosing appropriate skin preparation solution.

## Staff behaviour

### 8.7 a) Should surgical instruments be unpacked and exposed as close as possible to use? b) Should surgical instruments used in ultraclean ventilated theatre procedures be laid up under the canopy or in a prep room?

Micro-organisms in the air can enter surgical wounds via two main routes: a) deposition directly into the wound or b) deposition on exposed surgical instruments that will subsequently enter the wound, transferring that contamination into the wound. There are a lot of variables, which include the area of the location of the wound, the time of exposure, the nature of the instruments and the time they are exposed. It is thought that contamination entering a wound via exposed instruments is generally the predominant route.

Conventional operating theatre ventilation dilutes airborne contamination by dilution in turbulent airflow. Ultraclean ventilation, often called “laminar flow (LAF)”, in operating theatre uses unidirectional downward airflow to remove contamination rapidly in that organised airflow zone. This results in substantially lower airborne contamination than conventional ventilation. This applies to both the wound and any instruments that are kept within the ultraclean zone, i.e. below the ceiling canopy from which that air flows – generally a 2.8 x 2.8m square in the centre of the room. Clean utility rooms intended for the lay-up of surgical instruments usually have ventilation equivalent to that in a conventionally ventilated theatre. The air is likely to be more contaminated than would the air in a UCV room’s ultraclean zone.

The first question explored in this section relates to how far in advance of use should instruments be “laid up”, that is unpacked, inspected, and be ready for use. It is often more convenient to lay up instruments far in advance of when they will be needed but this may allow excessive deposition of airborne contamination. Currently, it is not known whether some strategies, such as covering laid up instruments minimise this hazard. The second question explores whether instruments used in UCV theatres need to be laid up within the UCV zone or whether they can be laid up in advance in a clean utility (preparation) room. Lay up in the UCV zone prior to each procedure can reduce a theatre’s throughput while lay up in a clean utility room can occur for a second procedure while procedure one is in progress, thus enhancing a theatre’s throughput. Our previous guidelines[4] acknowledged that microorganisms deposited on the instruments are a potential source of infection but did not make any recommendations as to whether these instruments should be placed under UCV canopy or whether it is beneficial to leave them covered.

No studies were found in the existing literature, which assessed the effect of covering the instruments after preparation on the incidence of SSI in surgical patients.

There was weak evidence of benefit from one low quality nRCT study,[37] which evaluated the effect of covering the instruments after preparation in a conventionally ventilated operating theatre. The study used settle plates, which were placed on the instrument trolley and followed its movement, as a proxy to mirror bacterial settling on the surgical instruments. For the procedures where instruments were covered, settle plates (n=4) were covered and were opened shortly before skin incision, while in the control group the settle plates (n=4) were left uncovered. The study found a lower mean number of bacterial sedimentation on settle plates which were covered (mean 1.38cfu,

SD=1.87) when compared to those which were left uncovered after instrument preparation (mean 5.64cfu, SD=5.63, *p*=NR).

There was weak evidence of no benefit from three low quality prospective cohort studies[38-40] and one uncontrolled before/after study,[41] which evaluated the effectiveness of placing the instrument table under the UCV canopy to reduce the incidence of SSI. Three prospective cohort studies, which investigated the incidence SSI in patients undergoing orthopaedic,[38] urological[39] and neurological[40] procedures found no infections in either group. A small quality improvement project (uncontrolled before-after study),[41] investigated the effectiveness of placing floor markings to ensure instrument tables were positioned within the UCV canopy on the incidence of SSI in patients undergoing ophthalmic procedures. The study reported no reduction in the incidence of ophthalmic SSIs in two years following the placement of the floor markings (15/26,015, 0.058%) compared to four years before the markings were placed (43/50,504, 0.085%; RR=0.68 [95%CI 0.38 – 1.22], p=0.1935).

There was weak evidence of benefit from three low quality prospective cohort studies,[38-40] one low quality non-randomised controlled trial,[37] and one simulation study,[42] all of which evaluated the effectiveness of placing the instrument table under the UCV canopy to reduce the contamination of surgical instruments. These studies used proxy media to evaluate the number of cfu settling on instrument trolley. One study[42] which was a simulation of the activities in the operating room found that a similar number of sample tiles (made of either oak, stainless steel or high-density polyethylene) became contaminated with bacteria regardless of whether they were placed on the instrument trolley positioned under the UCV canopy (12/44, 27.3%) or outside it (10/44, (22.7%); *p*=0.689). However, the authors reported that the number of cfu settling on the tiles which were placed on trolleys positioned under the UCV canopy was significantly lower as compared to the tiles placed on the trolleys positioned outside it. Another study,[38] assessed the rate of bacterial settling during orthopaedic surgical procedures by placing nitrocellulose membranes on the instrument trolleys. The mean cfu settling on membranes placed on the instrument trolley and positioned under the UCV canopy was 48 (SD=153) compared to 2159 outside the canopy (SD=1337; *p*<0.001). Another study[39] reported that, during urological laparotomy, the mean bacterial sedimentation on nitrocellulose membranes placed on instrument tables was 305 (SD=382cfu/$m^2$/hr) for instrument tables placed under a mobile UCV unit and 2730 (SD=1778, *p*<0.0001) outside it. In another study,[40] air samples from the air above the instrument tables were taken during neurosurgery using the SAS Super ISO 100 impactor air sampler. The study reported that the median bacterial count settling on the instrument trolley was 0cfu/$m^3$ (min-max 0-13) for the trolleys placed within the mobile UCV unit and 11.5cfu/$m^3$ (min-max 0-104) for those placed outside it. Another study[37] reported that the sedimentation on settle plates collected during total joint arthroscopy was very low: for settle plates placed on instrument trolleys under the UCV canopy, the mean cfu was 0.20 (SD=0.27) compared to 1.38 cfu (SD=1.87, *p*=NR) outside the canopy. The authors reported that the instruments were also covered until the operation started, which may have been a reason for relatively low rate of bacterial sedimentation.

*The Working Party discussed the above evidence and concluded that instruments should only be opened and laid out as close to their use as possible. The Working Party also concluded that the same principles apply to other materials which are inserted into the surgical wound, such as orthopaedic or intravascular prostheses, which should only be opened immediately before they are needed. This is in*

*line with the position of the British Orthopaedic Association which recommends that instrument trays are prepared in a UCV environment, and the instruments be uncovered only after skin preparation and draping.*[43]

**Recommendations**

**7.1:** For all surgical/operative procedures, lay up the instruments and prosthetic materials as close as possible to when they are needed.

**Good practice points**

**GPP 7.1:** For ultraclean ventilation operating rooms, lay up the instruments/prosthetic materials under the canopy in preference to the preparation room, unless local UCV exists in the preparation room.

## 8.8 What is the most effective surgical scrub procedure for scrub staff?

*The Working Party agreed that the current NICE recommendations [NG125][6] provide adequate advice and should be followed by the operating theatre team.*

**Recommendations**

**8.1:** Refer to recommendations 1.3.1 and 1.3.2 in the NICE guidelines [NG125] for advice on choosing appropriate hand decontamination solution.

## 8.9 Does the movement of theatre staff in and out of the operating room impact on air counts of bacteria and infection rates?

Staff movement into and out of the operating room during a surgical procedure is considered to increase a risk of SSI because each door opening results in airflow disruptions and potentially leads to airborne contamination. Since airborne microorganisms can settle into the wounds or on to the instruments, the control of the movement of personnel is recommended. It is still not clear whether door opening and staff movement have an effect on air quality close to the operating table and at the periphery of the room, and whether this increased contamination has an effect on SSI. Previous guidelines[4] recommended that to reduce airborne contamination, doors should be closed to optimise the ventilation system and that the traffic in and out of the operating room should be reduced as far as possible.

There was weak evidence of risk from two case control studies[44,45] which investigated the effect of door openings during surgical procedures on the incidence of SSI. One study,[44] described observing a total of 358 procedures in patients undergoing abdominal surgery (81% classified as contaminated or dirty) and collecting data on a number of staff behavioural factors (including number of door openings). There was no information provided about the ventilation facilities of the operating theatre. Patients were followed up for 30 days and were grouped into those who developed SSIs

(58/358, 16.2%) and those who did not (300/358, 83.8%), for a nested risk factor analysis. The authors reported that there were a total of 32,684 door openings (average 91 per procedure) and 81% of them were considered unnecessary. In a multivariate analysis adjusted for age and co-morbidities, patients who underwent the procedures where doors were open 100 times or more had a higher risk of SSI (as defined by the Centers for Disease Control and Prevention (CDC) National Healthcare Safety Network) than those with less than 100 openings (IRR=2.25 [95%CI 1.09-4.66], *p*=0.028). Another study,[45] conducted over a period of 16 months, recruited consecutive patients undergoing cardiac surgery in two UCV operating rooms equipped with automatic door-counting devices. Doors were either external (opening towards the clean perimeter corridor) or internal (opening towards the clean instrument preparation room, also equipped with UCV). A total of 688 patients were recruited of whom 24 (3.5%) developed SSI within 30 days. The authors reported that they observed a total of 87,676 door openings during the time the surgery was taking place (from incision to skin closure). In the multivariate analysis, the hazard ratio per 5-unit increment for the increased mean number of door openings was 1.49 [95%CI 1.11-2.0], *p*=0.008). However, when stratified into the internal and external door openings, the risk was only associated with opening the internal doors (HR 2.14 [95%CI 1.29-3.55, *p*=0.003) and there was no risk associated with opening the external doors (HR 1.32 [95%CI 0.82-2.11], *p*=0.25).

There was very weak evidence of no effect from one environmental survey[46] which investigated the effect of the door openings during surgical procedures on the extent of wound contamination. Microbiological data were obtained from wounds before the closure during surgical (orthopaedic and cardiac) procedures in theatres with either turbulent ventilation (n=8) or UCV (n=5). The number of door openings during each procedure (from opening to closure of the wound) was monitored using inertial sensors attached to the doors. The authors observed a total of 59 procedures and obtained microbial counts from 177 air samples (3 x 59). It was reported that 50 (28%) of the samples were sterile, 90 (51%) had counts of 1-10cfu/$m^3$ and 37 (21%) had counts >10cfu/$m^3$. Furthermore, 35/37 (95%) of the samples with counts >10cfu/$m^3$ were from operating rooms with turbulent ventilation. Among the wound samples, 33 (56%) were sterile, 18 (30%) had 1-10cfu/100$cm^2$ and 8 (14%) were >10cfu/100$cm^2$. Mean number of door openings was 49.5 (39.2) per procedure accounting for total duration of mean 13.3 (17.2) minutes per procedure and was not associated with the cfu found in wounds at the time of closure (*r*=0.13, *p*=0.32).

There was weak evidence of risk from six environmental surveys[46-51] and three simulation studies[52-55] (one study reported in two separate articles[53/54]), which investigated the effect of door openings during surgical procedures on the extent of air contamination. One study, which was previously mentioned in relation to wound contamination,[46] reported that, in the multivariate analysis the mean estimate of proportionality co-efficient for the number of door openings and air microbial count was 0.07 (SD 0.03, *p*=0.03). This means that one door opening per period of five minutes is estimated to raise the microbial count in the air by 0.07cfu/$m^3$. Another study,[47] which assessed air counts during a total of 30 orthopaedic procedures, found a weak, positive correlation between the number of cfu/$m^3$ in air and the number of door openings per each 20-minure interval of the surgery (Spearman's rho *r*=0.309, *p*=0.003). There was a strong, positive correlation between the total cfu/$m^3$ in the air samples and the total number of door openings (Pearson's product-moment correlation coefficient *r*=0.74, *p*=0.001) when controlled for the duration of the surgery in the analysis. In this study the authors reported that the operating rooms were equipped with an upward air-displacement system and were maintained at positive air pressure at approximately 3kPa. The

group used these data in another study[48] which compared the effect of door openings in air-displacement and UCV theatres and they reported that the incidence risk ratio for the changes in air cfu/$m^3$ per one door opening was significant in air displacement ventilated operating rooms (IRR=1.033 [95%CI 1.014-1.05], $p$<0.001) but not in UCV operating rooms (IRR=0.990 [95%CI 0.927-1.058], $p$=0.78). Another environmental survey,[49] which collected data during general and orthopaedic surgeries, found that the mean cfu on settle plates which were placed inside the UCV area on an instrument table were not associated with the number door openings (20-39 door openings: mean 0.50 (min-max: 0.00-2.00), 40-59 door openings: mean 1.27 (min-max: 0.00-12.0), 60-79 door openings: mean 0.39 (min-max: 0.00-2.00), >80 door openings: mean 1.29 (min-max: 0.50-2.50); $p$=0.73) while the ones placed outside UCV area by the door were more likely to be contaminated when the number of door openings increased (20-39 door openings: mean 2.20 (min-max: 0.00-7.00), 40-59 door openings: mean 3.26 (min-max: 0.50-9.50), 60-79 door openings: mean 4.78 (min-max: 1.00-15.0), >80 door openings: mean 5.93 (min-max: 1.50-9.50); $p$=0.0012). Another study[50] which collected data during 124 (non-implant) surgical procedures in operating rooms without UCV but equipped with HEPA filters reported that in the multivariate linear mixed effects model, the estimated number of cfu/$m^3$ in the air was 0.002 ([95%CI 0.0004-0.004], $p$=0.02) per hour. This can be interpreted as 0.2% rise in cfu/$m^3$ from a single door opening for each hour of the surgery. In the last environmental survey,[51] which used recordings of the surgical procedures obtained from the cameras installed in operating rooms (information on ventilation not provided), the hierarchical regression was used to identify factors associated the increase of cfu/$m^3$ in air as well as the number of cfu on settle plates. The authors reported that the door openings were not significant in any models for either air or settle plate counts and they estimated that the door openings would increase the cfu by approximately 0.05 $\log_{10}$ during one procedure. Based on the data obtained from the observations (four of 27 procedures), the authors also conducted a follow-up simulation study[55] based on the typical movements of each operating theatre team member during one procedure. The activities were simulated for 30 minutes where a member of staff was performing similar activities, at either higher or lower levels than what was considered 'normal'. The effect of these activities on air contamination was measured by placing settle plates (blood agar and Sabouraud dextrose agar) in eight different locations throughout the operating room and a t-test was used to compare mean cfu for higher and lower levels of procedures. The authors reported that higher than usual number of door openings had no effect on the number of cfu (data not reported). This was also observed when data were stratified into bacteria and fungi (data not reported). However, they also reported that long door openings resulted in higher microbial loads than short door openings ($p$=0.032) and that wider door openings resulted in higher microbial loads than narrow door openings ($p$=0.047). In another simulation study,[52] mock orthopaedic surgery was performed for 90 minutes with doors opening 100 times during the procedure (estimated by observing previous orthopaedic surgery in the same operating room). There was also a control operating room which remained closed for 90 minutes during which time only a researcher collecting data was present in the room. The authors reported that for the control operating room, 4/6 brain heart infusion agar plates grew 1cfu and the remaining two showed no growth. On the other hand, the settle plates obtained from the mock surgery grew between 4 and 22 cfu. Additionally, the authors reported that mannitol salt agar, used for growing *Staphylococcus* species and pseudomonas isolation agar used for growing *Pseudomonas* species showed no growth in the control operating room and between 4-266 and 1-19 cfu respectively, after the mock surgery. Lastly, a simulation study,[53/54] collected data from an empty operating room under different conditions: door always open, door always closed and doors swinging open 50 times per hour. During each experiment, a team of ten people dressed in operating theatre attire paced throughout the hallway to simulate the regular traffic. The authors reported that the counts in the operating room were not

statistically different when comparing the swinging and open conditions and swinging and closed conditions but that there was a significant difference in mean number of cfu/ft$^2$/hour when comparing open vs closed conditions (mean 24.8 (SD 58.8) vs 13.3 (SD 30.9) respectively, $p$<0.05).

There was very weak evidence of risk from one environmental survey[56] which investigated the effect of door openings during surgical procedures on the extent of surface contamination. In this study, surface samples were taken during orthopaedic procedures inside and outside the UCV area using RODAC plates. Samples were obtained at the start of the procedure and at 30-minute intervals until the end of the procedure. The authors reported that a total of 642 samples were taken during 81 orthopaedic procedures, the doors had electronic counters installed and that these were used to obtain the data on the number of door openings during the procedure. There was also a control operating room which was sterile and remained closed with only a research fellow collecting samples. The average number of door openings was 54.6 per procedure and the estimate of the final binomial model with cfu on surfaces dependent on door opening in UCV room was 1.693 [95%CI 1.078-2.660]. This means that if the doors are opened, it is expected that the number of cfu on environmental surfaces in operating room will increase by 69.3%.

There was additional information from one excluded quality improvement project[57] which aimed to reduce operating room foot traffic. The study was excluded because it did not provide any data on microbial contamination of the operating room or the rate of SSI. The authors reported that they tested the effectiveness of different door opening deterrents and the implementation of these measures resulted in a 50% reduction of door openings. They also mentioned that the improvements had no effect on infection rate, but no other information was provided.

*The Working Party reviewed the above evidence and concluded that the door opening itself is not likely to have an effect on the rate of surgical infections. The slightly increased microbial counts observed with door openings are more likely to be a result of increased staff movement associated with staff passing in and out of the operating room rather than the incoming air contaminating the room environment. However, the Working Party agreed that door opening should be limited to essential activities as each additional individual whose presence in the operating room is not required for the surgical procedure increases the bacterial air counts and potentially leads to an increased risk of SSI. The Working Party also agreed that minimising the number of door openings would have other benefits such as protecting patient dignity and resulting in fewer distractions for the surgical team.*

**Recommendation**

**9.1:** Minimise non-essential staff movement and hence door openings during surgical procedures.

## Staff attire

### 8.10 Should theatre staff remove jewellery, false nails and nail polish before entering the operating theatre facilities?

The presence of bacteria on a surgeon's hands can influence the risk of SSI in patients. The areas around and under the nails tend to harbour higher number of microorganisms in spite of thorough

washing. There is a concern that the presence of jewellery may interfere with the appropriate hand scrubbing technique of the operating staff and that the microorganisms from the artificial nails or nail polish may be more difficult to remove. Local operating room guidelines traditionally recommended that all jewellery, including necklaces and earrings, should be removed by staff without any evidence base for this practice. Previous guidelines[4] highlighted this gap in knowledge and recommended that all jewellery be removed but that simple wedding bands without the stones could be worn by scrubbed and non-scrubbed staff. However they also mentioned that surgeons may need to remove wedding bands, especially if working with metal prostheses. The guidelines also recommended that the artificial nails should not be worn by the operating theatre staff.

### *Effect of jewellery*

There was very weak evidence of no effect from one UBA study[58] which assessed the risk of a surgeon wearing a simple wedding band on the risk of post-operative infections in patients. The study reported no increase in the incidence of infection in patients operated by a surgeon in the period after he started wearing a wedding band when compared to a period before the wedding band was worn (6/1140 (0.5%) after vs 16/987 (1.6%) before, $p$=0.0163). The authors reported that the surgeon paid particular attention to hand scrubbing, sliding the ring proximally and distally on the finger, to ensure that the scrub solution was under the ring and that the area of skin below the ring was thoroughly cleansed.

There was weak evidence from four simulation studies,[59-62] which assessed the effect of wearing a ring, signet or a watch on bacterial counts of the skin. One study[59] compared cfu on the left hands of surgeons and anaesthetists (n=19) with a single plain wedding band to the cfu on the right hands with no rings. The authors reported that there was no significant difference in the median number of cfu (obtained by swabbing the area under the ring and the corresponding area of the control hand) between left and right hand (median 2cfu (min-max 1-300) vs 5cfu (min max 1-120), respectively [$p$=0.260]) after the hand scrub was performed. The authors also reported that there was only one ring that was contaminated after the scrubbing and that it contained 2cfu of bacteria. Similar data were obtained in a study of 18 veterinary students,[62] some of whom wore simple rings with no stones. The authors reported that before the students scrubbed their hands, the mean number of cfu (obtained by the glove juice method) was 129cfu x $10^2$/ml (SD 0.3-1020) on the hands with the ring and 369cfu x $10^2$/ml (SD 0.25-2580) on the hands without the ring ($p$=0.70). It was also reported that there was no significant difference in bacterial counts after the students scrubbed and performed a 3-hour surgical procedure (mean 5.1 cfu x $10^2$/ml (SD 0-33) on hands with the ring vs 8.5 x $10^2$/ml (SD 0-133) on hands without the ring, $p$=0.58). Another study[60] assessing the contamination of the skin under the rings, signets and watches worn by dental surgeons reported that there was a significantly higher contamination from the swabs obtained from the skin under the rings and signets when compared to the corresponding area on the opposite hand (mean number of cfu 212 vs 86.7 respectively, $p$=0.001) as well as from the skin under the watch when compared to the opposite wrist (mean cfu 262.7 vs 55.9, $p$=0.006). These measurements were taken in the morning before the first scrub and there were no further data after scrubbing or after the surgical procedures. The last study[61] assessed skin contamination under the rings of the operating staff with swabs taken before scrubbing, after scrubbing and after a surgical procedure. The authors reported that before scrubbing the area under the ring harboured significantly more bacteria (median 4cfu, min-max 0-1001) than the rings themselves (median 0cfu, mix-max 0-100), the area near the ring

(median 1cfu, min-max 0-510) and the corresponding area on the opposite hand (median 0cfu, min-max 0-1004; *p*=0.05). After scrubbing, the area under the finger was significantly more contaminated than the corresponding area of the opposite hand (median 0, min-max 0-15 vs median 0 (min-max 0-0); *p*=0.025). When the ring was removed for scrubbing, the area under the ring still harboured more bacteria than the area on the opposite hand (data not provided; *p*=0.05). Finally, after the surgical procedure, the area under the ring had significantly more bacteria (median 0cfu, min-max 0-23) than the corresponding area of the opposite hand (median 0cfu, min-max 0-4; *p*=0.01). However, the authors reported that there was no difference in contamination of the skin under the ring when it was removed for the procedure compared to the corresponding area of the opposite hand (data and *p*-value not provided).

There was additional evidence from three excluded studies.[63-65] The first study[63] did not fit the inclusion criteria because it compared the incidence of glove perforations for single and double gloving protocols. However, the authors mentioned that there were many glove perforations at the base of the finger in surgeons who wore rings. They did not provide any data on the type of the rings (e.g. rings with stones vs single bands) the surgeons wore. Another study[64] was excluded because the participants were not part of the operating theatre department and the authors only stated that the findings can be extrapolated to this setting. The study showed that the skin under the jewellery (rings, earrings, and nose piercings) contained significantly higher numbers of bacteria than the jewellery pieces and the adjacent area of the skin which was used as a control. The authors reported that the removal of jewellery may be even more detrimental and recommended that the theatre staff either wear no jewellery or cover them appropriately during surgical procedures. The last study[65] was an outbreak report and was excluded because it had no control group. The authors reported that six cases of *S. marcescens* occurred following cardiothoracic surgery. Despite extensive investigations, no source was identified, and the decision was made to screen the scrub nurse and the surgeon, both of whom were present during all six surgical procedures. The surgeon was found to have two rings which he was not able to remove and sampling under the rings revealed the growth of *S. marcescens* which was identical to the strains obtained from the patients.

### *Effect of nail polish and artificial nails*

No studies were found in the existing literature which assessed the effect of operating staff wearing nail polish or artificial nails on the incidence of SSI.

There was weak evidence from one randomised controlled trial (RCT),[66] one cross-over RCT,[67] one prospective cohort[68] and one simulation study[69] which assessed the effect of operating theatre staff wearing nail polish during the surgical procedures on bacterial counts obtained from the nails. One study[66] assessed the bacterial counts on freshly applied nail polish (less than two days), chipped nail polish (visibly chipped or painted more than four days before) or natural nails (no polish, n=34 in each group). Nurses were randomised into one of the groups and agreed to prepare their nails according to the randomisation allocation for the day of the data collection. The authors reported that there was no significant difference in the median cfu in any of the groups before scrubbing occurred (median cfu 25, 80 and 100 for freshly applied nail polish, chipped nail polish, and natural nails respectively; *p*=0.122). After scrubbing, the authors reported that the chipped nails yielded more bacteria (median 35cfu) than freshly applied nail polish and natural nails (median 10cfu each; *p*=0.035). In a cross-over RCT,[67] veterinary surgery staff (n=96) at a veterinary hospital were

randomised into a group who wore a single coat of nail polish for a week and a group with no polish. In the following week, the participants changed their assignment groups. The authors reported no significant differences in the number of bacteria obtained from the participants when they compared the weeks when the nail polish was worn vs not worn, either before scrubbing (mean cfu 2.1 (SD 1.04) vs 2.0 (SD 0.91) respectively, *p*=0.76), after scrubbing (mean cfu 0.84 (SD 0.68) vs 72 (SD 0.62) respectively, *p*=0.50), or following the surgical procedure (mean cfu 0.50 (SD 0.52) vs 0.66 (SD 0.54) respectively, *p*=0.35). A prospective cohort study[68] obtained samples from 31 operating theatre female staff who regularly wore nail polish and 31 operating theatre female staff who did not. The authors reported that there were no significant differences between the groups before scrubbing (mean 9.9cfu (SD 2.84) in the nail polish group and mean 8.7cfu (SD 2.89) in the natural nails group; *p*=0.100). However, the counts were significantly higher in participants wearing the nail polish after scrubbing (mean 9.6cfu (SD 2.45) in the nail polish group with a mean of 7.3cfu (SD 2.93) in the natural nails group; *p*=0.008). In the last study,[69] circulating nurses (n=33) in operating theatre were asked to scrub their hands. After this, nail polish was applied to the right hand, the nurses were asked to perform their usual duties for one hour and then scrub again. The authors reported that the mean cfu was not significantly increased on hands with the nail polish when compared to hands without nail polish (mean 7.88cfu (SD 88.05) vs 63.64cfu (SD 213.33), respectively; *p*-value not reported). The authors also reported that the right hand had lower cfu counts before the nail polish was applied (mean 0.61 (SD 95.15) vs 48.48 (SD 182.21); *p*-value not reported).

There was very weak evidence from one prospective cohort[68] study which assessed the effect of operating theatre staff wearing artificial nails during surgical procedures on bacterial counts obtained from nails. The study obtained samples from 27 operating theatre female staff who regularly wore artificial nails and 31 operating theatre female staff who did not. The authors reported that the bacterial counts obtained from the staff who wore artificial nails were higher than those obtained from the staff who did not. These differences between the groups were significant before scrubbing (mean 12.2cfu (SD 2.94) in the artificial nails group with a mean of 8.7cfu (SD 2.89) in the natural nails group; *p*<0.001), as well as after scrubbing (mean 11.4cfu (SD 2.67) in the artificial nails group and a mean of 7.3cfu (SD 2.93) in the natural nails group; *p*<0.001).

There was additional evidence from one excluded study[70] which did not meet the inclusion criteria because it did not have a control group. This was an outbreak report which described three patients with a confirmed post-laminectomy deep SSI caused by identical strains of *Candida albicans*. Investigations revealed that one operating room technician scrubbed on all three infected cases but on only 32% of the uninfected controls. The technician was reported to have worn artificial nails for a 3-month period during which time these patients were operated. It was reported that *C. albicans* was also isolated from the technician's throat, although no typing was done to confirm whether this was the same strain. After the technician was treated and the artificial nails were removed, no subsequent cases occurred.

*The Working Party concluded that the evidence which exists, however weak, suggests that jewellery encourages the growth of bacteria on the skin and prevents staff from disinfecting their hands effectively. The Working Party also agreed that any jewellery which is difficult to remove increases the growth as these pieces will also make scrubbing more difficult. Wearing jewellery violates recommendations for appropriate hand hygiene as well as bare below the elbow policy. There is a*

*risk of glove perforation by jewellery, which also may predispose to an increased risk of infection. For these reasons, the Working Party agreed that the policy for the scrubbed team should be to ban jewellery worn on fingers and anywhere below the elbow, when they are present in the operating room. They also acknowledged that some pieces of the jewellery may not be possible to remove. In these cases, the policy should state that appropriate hand hygiene must be performed to ensure that the area under and around the item is adequately cleaned (e.g. to move the ring upwards and forwards so that the skin underneath is exposed to the scrub solution).*

*The Working Party also discussed the evidence from the excluded study which highlighted that broad wedding bands may harbour bacteria different than those usually found as part of the skin flora, and which may not be removed by routine cleaning. While no inferences can be made from this study, the Working Party agreed that it is important to highlight that wedding bands do pose a potential infection risk. For staff such as nurses working in the theatre complex or porters bringing patients to the theatre but who are not involved in surgical procedures and have no direct contact with patients' wounds, the removal of the jewellery is less important. However, the Working Party agreed that it may be more convenient for theatres to have a similar policy for all staff entering the operating theatre complex. For other items of jewellery (e.g., earrings), the Working Party agreed that there is no infection risk associated with them and therefore they have no reason to recommend any restrictions, however, the hospitals may choose to do so for reasons other than infections.*

*Regarding artificial nails and nail polish, the Working Party agreed that this is rarely seen in practice but that there exists evidence, however weak, that allowing staff to wear artificial nails or nail polish potentially increases the risk of SSI as the bacterial count on such nails is often higher. The Working Party also agreed that, as with jewellery worn on fingers, these nails prevent the staff from scrubbing their hands appropriately and that they are also a violation of the bare below the elbows policy. Because of this, the banning of artificial nails and nail polish should apply to scrubbed as well as unscrubbed staff in the operating theatre.*

**Recommendations**

**10.1:** Do not allow scrubbed staff to wear jewellery below the elbows. Where jewellery cannot be removed, the area around and underneath any item of jewellery must be carefully cleaned as much as possible.

**10.2:** Do not allow scrubbed and unscrubbed staff to wear artificial or polished nails in the operating theatre.

**Good practice points**

None

## 8.11 a) Should staff cover their hair? b) Should staff use facemasks?

Surgical face masks and surgical headgear are a standard part of surgical attire. The primary function of these garments is to protect the patient from contamination of the surgical site. The practice of

wearing the face mask was first introduced at the end of 19th century and was reinforced when studies showed that bacteria from the mouth and nose can be dispersed during normal conversation. Similarly, headgear was introduced to prevent hair, skin scales and other particles falling into a sterile area. Historically, skullcaps were worn to cover most of the hair on the head but recently some guidance required the surgical team to use the headgear that covers all the head and ears (bouffant style) or covers the entire head, neck and parts of the face (hood style). However, despite their widespread use, the effectiveness of face masks and the headgear in preventing SSI and contamination of the operating room has not been demonstrated. Previous guidelines[4] concluded that face masks were not likely to be effective in preventing SSI, but they recommended that they should be worn during prosthetic implant operations to protect the scrub team from potential infection arising from the blood and body fluids of the patients. They also recommended that hats must be worn during prosthetic implant operations but mentioned that headgear was not required for non-scrubbed staff.

### *Effect of head coverings*

No studies were found in the existing literature which compared the effect of operating theatre staff wearing head coverings vs not wearing head coverings on the incidence of SSI.

There was very weak evidence from three simulation studies[71-73] which compared the effect of operating theatre staff wearing head coverings vs not wearing head coverings on the contamination of the operating room. In the first study,[71] the surgical team were asked to sit under UCV area and over settle plates positioned on the operating table for 30 minutes. The team were asked to wear different types of head gear or no headgear during the experiments. The authors reported that when no head gear was worn, the mean number of cfu/$m^2$/hr was 8318, which was higher than when the team wore surgical hoods (0.00 cfu/$m^2$/hr) or a surgical cap (8.42cfu/$m^2$/hr). The authors did not provide a *p*-value but reported that the difference between the contamination arising from the hood and the cap was not significant. Another study[72] carried out a similar experiment with the surgical team wearing different types of head gear with or without masks for 30 minutes while speaking and moving their hands. Settle plates for this experiment were positioned at waist-high to represent the contamination near the surgical site. The authors reported that when the team wore no mask or hat, the mean cfu/$m^2$/hr was 472 but when wearing a disposable hat with no mask, it was 324cfu/$m^2$/hr. When masks were worn but the team wore no hat, the mean number of colonies was 84cfu/$m^2$/hr. Wearing masks with a disposable hat, resulted in mean 21cfu/$m^2$/hr and wearing masks with cloth (washable hat) resulted in a mean of 32cfu/$m^2$/hr. The authors did not report whether any of these results reached statistical significance. In the last experiment,[73] six volunteers, representing casual non-scrubbed personnel, were dressed in surgical attire (including masks) and were asked to wear a disposable surgical hood or no hood for 30 minutes. During the last five minutes of the experiment, air samples were taken using a Casella slit sampler with blood agar settle plate. The authors reported no significant difference in mean air counts regardless of whether the operating room was ventilated (0.53cfu/$m^3$ vs 0.66 cfu/$m^3$ in experiments involving the staff wearing the hood vs not wearing the hood, *p*-value not reported) or not ventilated (1.55 cfu/$m^3$ vs 0.35 cfu/$m^3$ for hood vs no hood, *p*-value not reported). The authors found that no *Staphylococcus aureus* was isolated in either group. Thus, the authors concluded that wearing head gear by casual staff makes no difference to air counts in the operating theatre.

There was weak evidence from one retrospective cohort[74] and three UBA studies,[75-77] which compared the effect of wearing a bouffant hat vs a surgical cap[74] or an effect of the change of the policy which involved banning skull caps and making bouffant hats or hoods mandatory,[75-77] on the incidence of SSI. A retrospective cohort study[74] used the data previously collected for a RCT which assessed the effect of pre-operative shaving on the risk of SSI. After the study concluded, the authors asked the surgeons about their preference for head coverings and stratified the patients into those who were operated on by the surgeons who wore bouffant hats and those who wore caps. The study reported that there was no benefit in wearing bouffant hats (8.1% for bouffant hats and 5.0% for surgical caps, $p$=0.016). All three UBA studies also reported that the policy change had no effect on the incidence of SSI. One of the studies[75] included patients undergoing general surgery and the authors reported that the incidence of SSI was 5.3% before the introduction of the policy and 5.5% after ($p$=0.801). Another study[76] reported no difference in the incidence of SSI for patients undergoing class I (clean procedures 0.77% and 0.84% for rates before and after, respectively, $p$=0.62), for patients undergoing spinal procedures (0.79% vs 0.82%, $p$=1.00) or patients undergoing craniotomy and craniectomy procedures (0.95% vs 0.75%, $p$=1.00). The last study[77] reported that the incidence of SSI in patients undergoing any surgical procedures was 0.99% after a bouffant style hat was made mandatory vs 0.88% when the staff were able to choose their own headgear ($p$=0.28).

There were further data from two studies,[78,79] which were excluded because they involved the change of head coverings as well as other elements of the operating room attire, and it is difficult to separate the impact of the head coverings. Both reported no difference in SSIs after the new policy was introduced, thus implying that the change to the head coverings on its own is not likely to have an effect either.

There was very weak evidence from one simulation study,[80] which compared the effect of operating theatre staff wearing different types of head coverings on the contamination of the operating room. In this study, the research team consisting of a surgeon, a medical student, a scrub nurse, a microbiologist, a ventilation engineer, and an air hygienist, who performed one-hour mock operations in a HEPA filtered operating room. The team wore a disposable bouffant, a disposable cap or a cloth cap. Air contamination was assessed using a SAS180 air sampler placed in the operating field, and passive contamination was assessed by settle plates (blood agar) which were distributed in the sterile field for the duration of mock surgery. The authors reported that active air sampling showed no difference between the groups (data provided in graph, approximately 10cfu/m$^3$). The settle plates yielded a median 3cfu (IQR 5) for the bouffant hat, 1cfu (IQR 1) for the disposable cap and 1cfu (IQR 3) for the cloth cap. The authors did not provide the $p$-values but reported that the differences in contamination between bouffant vs disposable cap and bouffant vs cloth cap were significant but that there was no significant difference between the disposable and cloth cap.

### *Effect of face masks*

There was moderate evidence from two randomised controlled trials (RCT),[81,82] one non-randomised trial (n-RCT),[83] two prospective cohort studies,[84,85] two UBA studies,[86,87] one case control study,[88] and one retrospective cohort study,[89] which assessed the effectiveness of mask wearing in operating theatre. The studies assessed the wearing of face masks by the entire surgical team,[81-83,85-87] non-scrub teams,[84] surgeon and scrub nurse[88] and the surgeon only.[89] Two of these nine studies reported

a benefit in wearing face masks. One very small n-RCT[83] reported that they abandoned the trial when three of 16 (19%) patients in the 'no mask' group developed SSI while no patients (0/25, 0%) developed infections in the group where masks were worn. The authors reported that all patients who developed infections underwent major abdominal surgery and, when limiting the results to this type of surgery, the incidence of SSI was 60% (3/5). However, they also reported that neither of the strains isolated from the wounds of the affected patients (two *Staphylococcus aureus* and one *Gardnerella vaginalis*) matched the micro-organisms isolated from the surgical team. A case control study,[88] which included 214 patients who developed SSI after cataract surgery and 445 matched controls reported that, in multivariate analysis controlling for other patient characteristics and theatre conditions, the surgeon not wearing a face mask was a significant risk factor for the patient developing an infection (OR=3.34 [95%CI 1.94-5.74]. However, when the results of eight studies[81-88] were included in the meta-analysis the overall OR was 1.04 [95%CI 0.86-1.27]. One study which was not included in the meta-analysis,[89] because it did not provide the number of patients who developed SSI, also did not report any benefit in the use of masks. The authors of this study reported that the incidence of SSI was 30% for emergency patients and 15% for elective patients in both masked and unmasked groups.

There were additional data from one study[90] which was excluded because it had no control group. The authors described an outbreak of *Staphylococcus aureus* infections in three patients following surgery. The isolated MSSA strain was identical in all three patients and was also isolated from the nose of the surgeon who operated on these patients. The authors reported that this surgeon consistently wore a mask covering the mouth but leaving the nose exposed.

There was weak evidence from one RCT,[91] one prospective cohort study,[92] and seven simulation studies[53,72,93-97] which assessed the effect of wearing and not wearing masks on the contamination of the operating room. Seven of nine studies showed more contamination in the experiments where masks were not worn. In one RCT,[91] patients undergoing cataract surgery were randomly assigned to groups where a mask or no mask was worn by the surgeon. A settle plate was placed next to the patient's head on the side of the surgery. In some patients, additional plates were placed on the chest or abdomen (outside the operating field) as controls. The authors reported that in 22 of 112 (19.6%) operations where the surgeon was not wearing a mask, the plates grew more than 1cfu/min while this contamination was significantly lower in procedures where masks were worn (5/109 4.6%, $p$=0.0006). In a prospective cohort study[92] of patients undergoing cardiac catheterisation, 96.7% of settle plates collected during unmasked procedures were positive for bacterial cultures compared to 86.7% procedures in which the surgeon was fully masked and 90% of procedures where the surgeon's mask was placed above their mouth but with the nose exposed. The authors reported no statistical difference in the number of positive settle plates between the procedures when a mask was worn fully or partially ($p$-value not provided) but they reported a significant difference when comparing masks not being worn to when the masks were worn partially ($p$=0.02) and fully ($p$<0.02). One simulation study,[72] which reported mock operations carried out in UCV theatre for 30 minutes while wearing or not wearing hats and masks, reported that the settle plates positioned near the subjects who wore no hat and no mask grew mean 472cfu/$m^2$/hr while the settle plates for the subjects who wore no hat but wore a mask only grew 84cfu/$m^2$/hr. Similarly, for the subjects who wore a disposable hat but did not wear a mask, the settle plates grew a mean 324cfu/$m^2$/hr and the plates where subjects wore a disposable hat and the mask grew 21cfu/$m^2$/hr. The authors did not

report the *p*-value, but they considered these results to be significant. In another study,[93] orthopaedic surgeons inhaled black pepper and sneezed over sheep blood agar plates either masked or unmasked. In the unmasked experiment, the plate was positioned 30-50cm in front of the surgeon. In masked experiment, one plate was positioned in front of the surgeon and two additional plates were positioned by each shoulder of the surgeon angled forward to capture bacteria which potentially escape via the sides of masks. The authors reported that all plates in the experiment where the surgeons were not wearing a mask grew at least one colony, while this was the case in 67% of plates positioned in front of surgeons wearing masks and 71% of the plates positioned at the sides of the surgeons who were wearing masks. When considering heavy growth (>15cfu) as an outcome, 75% of the plates were heavily contaminated in the unmasked experiment but only 8% in the experiments where surgeons were wearing masks ($p<0.01$). In another experiment,[94] which assessed the effect of talking, ten anaesthetists were sitting 30cm from agar plates wearing or not wearing masks. The authors reported that when the subjects were sitting silently without the masks, only one plate became contaminated (0.1cfu/subject) while talking resulted in five of ten plates becoming contaminated (mean 4.4cfu/subject). Talking with the mask resulted in three agar plates becoming contaminated (0.3cfu/subject). The authors reported that there was no significant difference between the plates obtained from the experiments where subjects were silent and where subjects were talking while wearing masks but there was a significant difference when the masks were not worn. Another study assessed the effect of a new mask worn for a prolonged time.[95] In this experiment 25 anaesthetists sat in a room with blood agar plates placed directly in from of them at a distance of 30cm. The subjects were asked to speak directly at an agar plate for five minutes, after which time they were asked to put on a fibre-glass surgical face mask and speak for a further 15 minutes. The authors reported that when a mask was not worn, 13 (52%) of 25 agar plates exposed for five minutes (0-5min) were contaminated with at least 1cfu. When a mask was worn, only three (12%) of 25 plates exposed for five minutes (0-5min) were contaminated. However, when the mask was worn for ten minutes and the plates were then exposed for five minutes (10-15min interval), nine plates grew at least 1cfu. When comparing the mean number of microorganisms grown on these agar plates, the plates which were exposed to the subjects who wore masks for a 10-15min interval, yielded significantly less microorganisms (mean 1cfu min-max: 0-10) than the plates exposed to subjects with no masks (mean 3.6cfu, min-max: 0-24cfu, $p<0.05$). Another study[96] assessed the effect of the surgeons wearing masks standing next to the operating table and one meter away from it. The study reported that no colonies were grown on the agar plates placed 1m away from the table, regardless of whether the mask was work or not. For the surgeons standing next to the operating table, the agar plates for the masked group did not grow any colonies and the plates in the no mask group grew 29 and 12cfu each. There were two simulation studies which showed no effect of wearing masks in operating theatre. One[97] was a small study of five plastic surgeons who were asked to wear no mask, surgical mask or FFP3 valved respirator for a mock surgical procedure in a sterile operating room. Surgeons were asked to read a sentence from an e-reader once per minute to simulate talking during the surgery. Sabouraud agar and blood agar settle plates were placed on operating tables to capture the microorganisms disseminated from the surgeons' mouths. The authors reported that two of five plates were contaminated when the surgical mask was worn and when it was not, although the plates in the masked group only grew 2cfu each while the plates from the unmasked subjects grew 11 and 12 cfu. In the last study,[53] five subjects representing operating theatre staff, scrubbed and wearing operating theatre attire walked uniformly in a ventilated theatre for 30 minutes. Air settle plates were placed at the height of four

feet from the floor to capture contamination near the surgical site. The authors reported that the facemasks did not reduce the number of micro-organisms released into the environment by the wearer. Thus, they considered wearing masks unnecessary in corridors or in operating room when surgery is not being performed (mean (SD) cfu/ft$^2$/hr were 447.3 (186.6) and 449.7 (183) for masked and non-masked groups respectively, *p*-value not reported). However, they acknowledged that that there is a possibility that while the number of microorganisms is not reduced by masks, the mask may redirect airflow to the sides and therefore it may still be potentially useful during the surgery.

There was additional evidence from a study[17] which was excluded because it did not have a comparison group and did not report the incidence of SSI or contamination of the operating room. The study assessed a potential beneficial effect of masks in protecting the surgeons from blood splashes, and thus potentially protecting them from acquiring a BBV infection. The authors reported that in 93/384 (24.2%) operations, blood was found on the surgeon's mask with vascular surgery (reported as any operation which involved vascular system e.g. during amputations) presenting the highest risk to surgeons (47% masks contaminated). The authors did not attempt to translate these findings into the relative risk of infection, but the blood would have landed up in susceptible areas around the nose and mouth which could potentially lead to BBV infection.

### *Effect of head gear and face masks combined*

No studies were found in the existing literature which assessed the effect of wearing surgical headgear together with a facemask on the incidence of SSI.

There was very weak evidence from one simulation study,[98] which assessed the effectiveness of wearing surgical head gear and a face mask during mock arthroscopy operations. These operations were undertaken by two team members wearing a squire-type hood which was tucked under a gown with the face mask, compared to no hood and no mask. Mock operations in UCV operating room lasted 30 minutes each, during which time spoken commands and physical movements were performed frequently to mimic the conditions during real operations. Agar plates were placed around the area where a surgical site might have been found. The authors reported that the mean number of cfu/m$^2$/hr in settle plates collected during the mock surgeries when the hood and masks were worn was 69 (SD 35cfu) while it was 6253cfu (SD 3219) when no head gear was worn.

*The Working Party discussed the above evidence which discusses hair being a source of contamination and potentially being a source of infection. It is a common belief in operating theatre that people disperse copious quantities of bacteria from their hair and head, but there does not seem to be any evidence that this is occurring. They agreed that, unless a staff member has a scalp condition that makes the skin flaky, the risk of bacteria from the hair contaminating the surgical wound is relatively low. The above epidemiological evidence suggests that head coverings have little or no effect on SSI or in contaminating the operating room. However, the inclusion of the head coverings in the operating theatre attire may help in maintaining discipline among the operating theatre staff. Therefore, the Working Party agreed that for peripheral as well as for scrubbed staff it may be prudent to continue wearing the head coverings, but individuals can be given a choice to wear the head gear that they prefer.*

*The evidence shows that masks have no effect on SSI, therefore the Working Party concluded that there is no need for anyone in the operating theatre to wear them for protecting patients from infection. However, as with other aspects of attire, they reinforce discipline in the operating theatre and ensure that the culture of the operating theatre does not become too lenient. Additionally, the surgical team may want to wear a face mask to protect themselves from blood and body fluids dispersed during the surgical procedures.*

**Recommendations**

**11.1:** No recommendation

**Good practice points**

**GPP 11.1:** Ensure that all staff working in the operating room wear a head covering and a face mask in accordance with local policies.

## 8.12 What is the impact of wearing operating room attire outside the operating theatre complex?

Non-sterile operating theatre attire, often referred to as scrub suits, is frequently worn outside the operating theatre. This practice has been questioned because there are some concerns that it represents an infection risk. To remedy this potential problem, some hospitals ask their theatre staff to either change their attire or to wear cover gowns before leaving the theatre complex. Our previous guidelines[4] concluded that there was insufficient evidence to support the wearing of cover gowns over surgical attire to prevent infection when theatre staff leave the theatre area temporarily. However, the guidelines recommended that local policy reflected aesthetic and discipline requirements. Recent guidelines from the NICE in the UK on the prevention of SSI[6] state that the operating theatre team should wear sterile gowns and that the staff wearing non-sterile operating theatre attire should keep their movements in and out of the operating area to a minimum. The Centres for Disease Control and Prevention guidelines on preventing SSI[99] focus little on the attire except to state that there is no recommendation regarding orthopaedic surgical space suits and that this issue remains unresolved.

No studies were found in the existing literature, which assessed the effect of wearing the operating theatre attire outside the operating theatre on the incidence of SSI or the contamination of the operating room.

There was weak evidence from one low quality crossover trial (reported in two articles),[100/101] and one very low quality non-randomised trial[102] which investigated the contamination of the operating theatre attire which was worn covered vs uncovered outside the operating theatre complex. One of these studies[102] found no benefit when staff wore a clean laboratory coat over their attire. In this study, bacterial contamination was assessed by attaching small fabric tags to the operating theatre attire and assessing the proportion of these tags which became contaminated when the attire was

worn outside the operating theatre. When the attire was covered by the gown, 56% of the tags (n=25) became contaminated while 70% (n=25) of the tags became contaminated when the attire was not covered. The authors did not provide the *p*-value, but they reported that the difference was not significant. One low quality crossover trial[100/101] reported that the bacterial contamination of the attire did not increase when staff (n=19) wore protective cover gowns (mean 11cfu when leaving the theatre and 8cfu when returning) but increased when they did not (mean 9cfu when leaving and 19cfu when returning). The change in bacterial counts was significant when comparing the scenarios for cover gowns being worn and not worn ($p<0.02$). Wearing cover gowns required the staff to wear a new gown each time and tie it in the back at the neck and waist level. The authors reported that the hospital policy mandated the use of cover gowns as indicated in the trial protocol but that the staff were not compliant with this practice.

There was weak evidence from one low quality crossover trial,[100/101] which investigated the contamination of operating theatre attire when staff (n=19) changed into street clothes. In this experiment, when leaving the theatre complex during the shift, the staff were asked to either store their used attire and don it upon return, or dispose of their used attire in the laundry bins and wear new attire when they returned. The authors reported that the bacterial counts were lower when new attire was donned (mean 21cfu when leaving operating theatre and 8 cfu upon return) while they increased when the same attire was worn upon return (mean 14cfu when leaving the theatre and 26cfu on return). The change in bacterial counts was significant when comparing the scenarios for new and used attire being worn ($p<0.001$). The authors reported no significant difference between the scenarios when the staff donned the used attire or when they wore the attire outside the operating theatre complex without covering with the protective gowns.

There was moderate evidence of no effect from two moderate quality crossover trials,[103,104] which investigated contamination of operating theatre attire worn either in the operating theatre complex alone or when it was permitted outside the operating theatre. One of these studies[103] which assessed the bacterial contamination of fabric samples attached to the attire of the anaesthetists (n=16), reported that bacterial counts increased progressively during the day. However, visits of any duration to the ward or to a departmental office did not result in higher bacterial counts (mean 25.2cfu/cm$^2$ (±43.5) in the scenario when the attire was worn in the theatre only vs 18.5cfu/cm$^2$ (±25.9) for attire worn in theatre and on the wards, and 17.9cfu/cm$^2$ (±31.0) for attire worn in theatre and offices, $p=0.370$). Another study[104] investigated theatre clothing worn by doctors (n=20) exclusively in orthopaedic operating theatre complex compared to the attire worn on the wards or in clinics in addition to the theatre. Contamination was assessed by pressing horse blood agar plate against the attire and counting the colony forming units 18 hours after incubation. A significant increase in bacterial colony counts was found two hours after donning the attire when worn outside the theatre, but not when the attire was first donned or at four, six and eight hours after donning.

*The Working Party concluded that the above evidence does not suggest that operating theatre attire worn outside the theatre complex contributes to SSI. One finding that may be worth noting is that compliance with this in the studies was sometimes poor, which may have had an effect on the results. The Working Party previously acknowledged[105] that conducting a study which would either confirm or refute these findings would be logistically challenging. However, the Working Party also agreed that different areas of the hospitals may pose different risks, e.g. visiting ICU and isolation*

*areas, where significant organisms e.g. Group A streptococci or multidrug-resistant organisms (MDRO) might be present, would potentially be more hazardous than, for example, visiting offices or canteens. It is not feasible to monitor staff movement outside the theatre complex to determine whether they enter higher risk areas. Therefore, the Working Party agreed that a uniform policy could be introduced where staff either change their attire or cover it outside the operating theatre complex. The Working Party see no reason for challenging staff who enter any areas outside the operating theatre complex (e.g. canteen) wearing clean operating theatre attire including footwear. Instead, they agree that the staff should be challenged if they do not comply with the policies upon returning to the operating theatre complex.*

**Recommendations**

**12.1:** No recommendation

**Good Practice Points**

**GPP 12.1:** Change or cover operating room attire (e.g. single-use disposable gown) and change footwear if leaving the operating theatre complex with the intention of returning.

## Patient and visitor attire

### 8.13 Should patients remove jewellery, false nails and nail polish before entering the operating theatre facilities?

The literature often suggests that patients should remove jewellery, artificial nails and nail polish before the surgery. The rationale for this is that these items potentially interfere with appropriate skin decontamination and can be a possible source of microorganisms in the operating theatre. Previous guidelines[4] did not find any relevant literature on the topic of patient jewellery and, as a result, concluded that there was no reason to continue the practice where patients were required to remove jewellery unless it was in the operative or anaesthetic field. The previous guidelines did not attempt to assess the effect of patients' artificial nails or nail polish and thus no recommendations were made.

No studies were found in the existing literature which assessed the effect of patients wearing jewellery, artificial nails or nail polish in the operating theatre.

*Due to the lack of the evidence the Working Party decided to refrain from making recommendations about patients wearing jewellery, artificial nails, and nail polish in relation to infection risk. However, the Working Party agreed that there may be other reasons why these items may not be worn in the operating theatre. Some of these reasons include preventing pieces of jewellery becoming lost, preventing the risk of injury during electrocautery, or interfering with the anaesthetist being able to monitor the nail bed for the detection of cyanosis. Some items of jewellery, especially those which are sharp may also be a potential hazard as these could perforate drapes and compromise the sterile field. The Working Party agreed that, since there is no evidence specific for infection, there is no reason to change current hospital policies.*

**Recommendations**

**13.1:** No recommendation

**Good practice points**

**GPP 13.1:** Refer to current hospital policy for pre-operative patient management.

**GPP 13.2:** If patients are asked to remove jewellery, artificial nails or nail polish before they arrive in the operating theatre, include information about this in written patient information in advance of surgery while preparing at home.

## 8.14 Should patients cover their hair before entering the operating theatre facilities?

Hair contains large number of microorganisms which can potentially cause SSI if the hair falls into the wound. For this reason, it is often recommended that operating theatre staff and patients cover their hair before surgical procedures. While the reason for this practice may be understandable for staff (see section 8.11), there is little evidence or rationale for patients doing the same. Previous guidelines[4] stated that there was no evidence to suggest that the patients' hair was the cause of an increase in SSI and that this unnecessary practice should no longer be recommended.

No studies were found in the existing literature which assessed the effect of patients covering their hair on the incidence of post-operative infection or on the contamination of the operating theatre.

No studies were found in the existing literature which described the patient experience of covering their hair for surgical procedures.

*There is currently no evidence for or against the policy covering patient's hair. The Working Party members reported that most operating theatres no longer follow this policy and there seems to be no increased risk of SSI associated with this practice. A potential issue was raised that hair coverings might be required when the surgery is close to the patient's head or the neck. However, the clinical experience of the Working Party members suggested that draping around the surgical site would be sufficient to cover the hair in these circumstances. As a result, the Working Party concluded that, for IPC reasons, there is no need for patients' hair to be covered. There may be reasons other than for IPC that some operating theatres may have this policy in place. In these situations, the operating theatre can follow the current local policies that they have in place.*

**Recommendations**

**14.1:** No recommendation

**Good practice points**

**GPP 14.1:** Refer to current hospital policy for pre-operative patient management, although be aware that covering patients' hair is not needed for infection prevention reasons.

## 8.15 a) What should parents/carers wear when accompanying the patient to the operating theatre? b) Do patients or other individuals dressed in ordinary (street) clothes in the operating room result in increased bacterial counts or increased infection post-operatively?

The practice of parental/carer presence at the beginning of the surgical procedure is seen as beneficial for the patient (especially if a child) as well as the family as it potentially decreases the anxiety of the patient and the carers. From an IPC perspective, the presence of the additional person, however briefly, means that more microorganisms are introduced into the operating room environment. The current culture of the operating theatre is that everyone entering the complex should be wearing scrubs and that street clothes are not allowed. The ritual of donning scrubs is extended to everyone except the patient. This includes staff, parents who accompany a child to the theatre, birthing partner going into the delivery suite or any visitors entering the theatre complex (e.g. technicians or company representatives). This is not always logical because there are some staff groups who do not wear scrubs but move in and out of the operating theatre complex. Since parents and carers are only allowed to enter the theatre complex and anaesthetic room, but not the operating room itself, questions have been raised whether these individuals are required to wear scrubs. An argument against this practice may be that donning the scrubs, masks and other gear may increase anxiety in a patient, especially a child. Previous guidelines[4] stated that there was no evidence to support the practice of visitors wearing over-gowns and overshoes in the anaesthetic room. However, if visitors were to enter the operating room itself it was recommended that they should change into theatre suits.

Patients entering an operating theatre are often required to remove their clothing and wear a freshly laundered surgical gown, but this may also be unnecessary and potentially uncomfortable, especially when a person is asked to remove more intimate garments. Little evidence is available whether the practice of changing into appropriate theatre attire helps to reduce SSI. In previous guidelines,[4] no recommendation was made as to patients wearing their personal clothes in the theatre, but these guidelines acknowledged that it may not always be necessary for patients to remove all their clothing.

No studies were found in the existing literature which assessed the effect of parents/carers/visitors wearing any type of protective clothing on the incidence of SSI or on the contamination of the operating theatre.

No studies were found in the existing literature which described parent/carer or patient experience of wearing protective clothing when entering the operating theatre.

*Based on expert opinion, the Working Party concluded that the practice of parents and carers being required to wear operating theatre scrubs and PPE (e.g. masks, hats, gloves) may not be necessary from the IPC perspective. In current practice, the accompanying parents or carers would only be permitted to enter the anaesthetic room, not the operating room itself, and they are only allowed to do that for the shortest time possible. Thus, there is no need for them to wear scrubs or any PPE. For birthing partners of women who are undergoing caesarean procedures, or anyone else who enters the operating room itself, they may still pose very little hazard as they are most likely going to be a safe distance from the operating field. It is important to remember that even tightly woven scrubs*

*may not prevent the penetration of liquid or the dispersal of bacteria in the operating room, but they do help in ensuring that the garments that are worn are clean and they also help in maintaining theatre discipline. Therefore, the Working Party agreed that it may be a good practice to ask that parents, carers or birthing partners who enter an operating room itself, wear scrubs, hair coverings and masks so that their attire is in line with the attire worn by all staff. Changing shoes is not necessary. The Working Party agreed that, in the absence of the evidence, other visitors to an operating theatre complex (e.g. technicians, company representatives) should observe the existing operating room attire policies for staff. Additionally, while PPE may be unnecessary in most circumstances, the recent pandemic highlighted that these requirements may vary depending on situations and therefore any visitors entering the operating theatre complex should defer to local policies present at the time.*

**Recommendations**

**15.1:** No recommendation

**Good practice points**

**GPP 15.1:** Ask parents and carers to wear scrubs or equivalent (e.g. single-use coverall), along with head coverings and face masks, on entering operating room as per local policy. Changing shoes is not necessary.

**GPP 15.2:** Ensure that visitors (e.g. technicians or company representatives) comply with local departmental policy on theatre attire.

# 9. Further research

As highlighted above, gaps in the evidence are evident for almost every topic presented in these guidelines. The Working Party made some recommendations for research which they thought were feasible to conduct and which represented research priorities. They also acknowledged that these are not an exhaustive list of possible research topics but are only examples. There are many other pressing topics which could be researched to fill the gaps in the evidence.

**RR 1.1:** Studies which investigate the relationship between the premature opening of operative instruments and prosthetic materials before they are needed and whether opened under the canopy on the one hand and the risk of SSI.

**RR 1.2:** Studies which investigate whether premature opening and the laying out of instruments not under the canopy possibly negate the benefits of UCV.

**RR 1.3:** Studies which investigate the relationship between the frequency of unnecessary door openings and SSI in selected procedures.

**RR 1.4:** Studies which investigate whether unnecessary interruptions can be used as a proxy measure for predicting SSI.

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# List of abbreviations

CBA – controlled before/after

CDC – Centers for Disease Control

CHG – chlorhexidine gluconate

CI – confidence interval

CPD – Continuing Professional Development

ESCMID – European Society of Clinical Microbiology and Infectious Diseases

ESGNI – ESCMID Study Group for Nosocomial Infections

GRADE – Grading of Recommendations Assessment, Development and Evaluation

HIS – Healthcare Infection Society

ITS – interrupted time series

LAF – laminar flow

NICE – National Institute for Health and Care Excellence

nRCT – non-randomised controlled trial

OR – odds ratio

PCR – polymerase chain reaction

PICO – Population-Intervention-Comparison-Outcome

PPE – personal protective equipment

PVP – povidone-iodine

PX-UV – pulsed-xenon ultraviolet light

RCT – randomised controlled trial

RR – risk ratio

SSI – surgical site infection

UBA – uncontrolled before/after

UCV – ultraclean ventilation

UK – United Kingdom

UV – ultraviolet

UVC – ultraviolet C light

WHO – World Health Organization