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Guidelines

Rituals and behaviours in the operating theatre — joint guidelines of the Healthcare Infection Society and the European Society of Clinical Microbiology and Infectious Diseases

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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 5 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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List of abbreviations

BBV	blood-borne viruses
CBA	controlled before/after
CED	continuous environmental disinfection
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
HEPA	high-efficiency particulate air
HIS	Healthcare Infection Society
HR	hazard ratio
IPC	infection prevention and control
IRR	incidence risk ratio
IQR	interquartile range
ITS	interrupted time series
NICE	National Institute for Health and Care Excellence
n-RCT	non-randomized controlled trial
OR	odds ratio
PPE	personal protective equipment
PX-UV	pulsed-xenon ultraviolet light
RCT	randomized controlled trial
RR	risk ratio
SSI	surgical site infection
UBA	uncontrolled before/after
UCV	ultraclean ventilation
UV	ultraviolet

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', that are controversial and frequently disputed. 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 the Healthcare Infection Society and the European Society of Clinical Microbiology and Infectious Diseases, used methodology accredited by the National Institute for Health and Care Excellence (NICE) to provide further advice on which practices are unnecessary. The guidelines are intended for an international audience. Specifically, they discuss the current available evidence for different rituals that 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 for use, good practice points, and recommendations against certain practices. These updated guidelines aim to minimize ritualistic behaviour without increasing the risk of SSI. The guidelines do not focus on those key prevention practices that are well researched and shown to be effective in preventing SSI (e.g. preventing hypothermia). These well-researched topics are addressed in other guidelines, and the Working Party has based their guidelines on an assumption that these evidence-based recommendations are followed.

Summary of recommendations and good practice points

Theatre environment

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

Recommendations

1.1: All patient, staff and visitor hand and body contact surfaces must be cleaned between each patient.

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

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Good practice points

GPP 1.1: Clean and disinfect clinical care equipment, including anaesthetic machines, after each patient, and 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 blood-borne virus infection?

Recommendation

2.1: No recommendation, see good practice points.

Good practice points

GPP 2.1: Wherever blood and body fluid 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 ultraclean ventilation canopy screens or filters if they become contaminated with blood or body fluid splashes.

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

Recommendation

3.1: No recommendation, see good practice point.

Good practice point

GPP 3.1: Allow clean beds with fresh, 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. patient with suspected or confirmed contact-transmissible multi-drug-resistant bacterial infection/colonization at the end of a list) reduce post-operative infection? (b) Should these patients recover separately from other patients before going to a ward?

Recommendation

4.1: There is no need to place patients with suspected or confirmed contact-transmissible multi-drug-resistant bacterial infection/colonization at the end of an operating list as long as the operating room is cleaned and disinfected to standard between patients, and the theatre ventilation is running without interruption.

Good practice point

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

Preparation before surgery

5. What is the clinical effectiveness of pre-operative showering/bathing before elective surgical procedures using (a) non-disinfectant bath/shower and (b) disinfectant bath/shower?

Recommendation

5.1: No recommendation, see good practice points.

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 surgery for patients who are not able to shower or bathe before surgery.

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

GPP 5.3: Instruct patients not to shave their surgical area in the days before surgery. Include this in any written patient information that is supplied to patients/carers in advance of surgery.

6. What is the most effective pre-operative skin antiseptic?

Recommendation

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, inspected 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 the preparation room?

Recommendation

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 point

GPP 7.1: For ultraclean ventilation operating theatres, lay up the instruments/prosthetic materials under the canopy unless there happens to be ultraclean ventilation in the preparation room, which is an alternative.

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

Recommendation

8.1: Refer to Recommendations 1.3.1 and 1.3.2 in the NICE guidelines (NG125) for advice on choosing appropriate hand decontamination solutions.

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

Recommendation

9.1: Minimize non-essential staff movement and hence door openings during surgical procedures to minimize bacterial air counts.

Staff attire

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

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Recommendations

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

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 face masks?

Recommendation

11.1: No recommendation, see good practice points.

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.

GPP 11.2: When face masks are worn, ensure that they are changed periodically.

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

Recommendation

12.1: No recommendation, see good practice point.

Good practice point

GPP 12.1: Change or cover operating theatre attire (e.g. with a 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 and nail polish before being brought into the operating theatre?

Recommendation

13.1: No recommendation, see good practice points.

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 this in written (paper or digital) patient information supplied in advance of surgery while preparing at home.

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

Recommendation

14.1: No recommendation, see good practice point.

Good practice point

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?

Recommendation

15.1: No recommendation, see good practice points.

Good practice points

GPP 15.1: Ask parents and carers to wear scrubs or equivalent (e.g. single-use coveralls), along with head coverings and face masks, on entering the 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' as some of these practices are not based on real or sound scientific evidence, that 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 are published in collaboration with the European Society of Clinical Microbiology and Infectious Diseases. Using methodology accredited by the National Institute for Health and Care Excellence (NICE), 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 health care, but it is also associated with a significant risk of complications, with postoperative infections being of particular concern. Guidelines and recommendations on the prevention of surgical site 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 and 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 to be one of the modifiable

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factors. For this reason, throughout the decades, different ritualistic practices and behaviours evolved in the operating theatre with the aim of reducing 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, such that some of these rituals and behaviours probably have little impact on air 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 for patients, unnecessarily increasing their anxiety before surgery. To be able to abandon some of these rituals and staff behaviours, there is a need to demonstrate which do and which 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 contamination of the operating theatre [5–7], especially concerning operating staff attire, but none of these guidelines have considered whether some of the common practices contribute to the prevention of SSI. The purpose of these updated guidelines is to review the evidence for these practices, and to make clear recommendations on which rituals and behaviours in the 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.

3.1. Definitions

The terminology used in relation to the operating theatre environment is sometimes ambiguous; therefore, to standardize some of the terms, the following definitions were used throughout these guidelines:

- 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. The operating theatres which were considered for these guidelines are the standard operating theatres found in most European hospitals, which have specialized ventilation and undertake major surgical procedures. The Working Party agreed that other types of operating theatres exist (i.e. those for minor procedures, endoscopy or interventional imaging suites) but these were not considered in these guidelines. However, the Working Party also agreed that some of the recommendations may still be relevant to these settings.
- 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, operating or recovery room. This term relates to any surface that was touched by staff/patients/visitors during a procedure at least once.
- Frequently touched surfaces – implies that multiple individuals touch these surfaces multiple times.
- Ultraclean ventilation (UCV) – refers to a type of ventilation which increases a dilution effect by providing a large volume of clean filtered air. This type of ventilation is sometimes referred to as 'laminar flow ventilation'.
- These guidelines are intended for healthcare workers in operating theatres; therefore, the Working Party believes that the terminology as well as other concepts (e.g. mechanism or risk factors for surgical infections) are familiar to most readers.

4. Guideline development team

4.1. Acknowledgements

Members of the Working Party represent professional societies {i.e. the 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, surgeons and peri-operative practitioners. The authors would like to acknowledge the support from their employing institutions, which allowed them the time required to produce these guidelines. The authors also wish to 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. Finally, the authors wish to thank the following former Working Party members who contributed their valuable time and expertise towards the development of these guidelines: Dr Markus Klimek, Dr Seven Johannes Aghdassi, Dr Moira Mugglestone and Ms Lynn Skelton.

4.2. Source of funding

The authors received no specific funding for this work. Financial support for the time required to obtain the evidence and write the manuscript was provided by the authors' respective employing institutions.

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 Working Party Report contains recommendations and good practice points which aim to minimize ritualistic behaviours occurring in operating theatres 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 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, and some new topics of concern have emerged. Updating these guidelines was necessary to keep up with the pace of technology. Additionally, processes for guideline 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 and IPC practitioners about current policy and best practice in the operating theatre. These guidelines highlight 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 for an international audience, with a focus on any surgical procedures performed in operating theatres, although the original guidelines were largely UK-focused [4]. 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 framework (Appendix 1, see online supplementary material). 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; peri-operative practitioners; systematic reviewers; and two lay member representatives. Many of the Working Party members were members of 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, operating department practitioners 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 other procedures. Furthermore, these guidelines may be useful for educational purposes, such as for those training in surgery and IPC.

5.8. How are the guidelines structured?

Each section comprises an introduction, a summary of evidence with levels (known as evidence statements), a summary of the 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 practices 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 and 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 4 years and updated if change(s) are necessary, or if evidence emerges that requires a change in practice.

5.10. Aims

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.

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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 benefits (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 healthcare workers, and when there is a clear plan for their implementation. Many organizations 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:

- Number of contaminated hand contact surfaces in the operating room and anaesthetic room after cleaning.
- Proportion of patients requiring isolation/contact precautions who recover in the operating room or in an area separate from other patients.
- Time between the opening of operative instruments and prosthetic materials before use.
- Proportion of procedures in which the operative instruments and prosthetic materials are opened under the UCV canopy.
- Compliance with operating theatre policy on operating theatre attire for carers and other visitors (e.g. technicians).
- Number and frequency of non-essential staff entering the operating room during surgical procedures.
- Number of times that staff return to operating theatre without changing/covering their theatre attire.

6.4. Supplementary tools

Lay materials and continuing professional development questions are available in 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. The included questions were either taken from the previous version of the guidelines where it was thought that an issue was still outstanding, or as new questions proposed by the Working Party members (sometimes after consultation with colleagues) which they observed in practice and which they thought often occurred in operating theatres without any evidence base.

To prepare the 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 and EMCare) were searched for any articles published until January 2022. Search terms were constructed using relevant MeSH and free-text terms (Appendix 1, see online supplementary material). 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, GLM) reviewed the titles, abstracts and full-text papers. As per the 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, case—control studies, cross-sectional studies and controlled before/after (CBA) studies. Due to the paucity of the evidence on this topic, simulation studies and uncontrolled before/after (UBA) studies 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 (see online supplementary material).

The Working Party acknowledges 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 the research hypothesis is correct). The UBA studies in this report did not find a benefit for the interventions;

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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:

- Randomized controlled trials (RCT): RoB_2.0 for RCT
- Non-randomized controlled trials (n-RCT): ROBINS for n-RCTs and cohort studies
- Cohort studies: ROBINS for n-RCTs and cohort studies
- ITS studies: EPOC RoB for ITS studies and before/after studies
- Case—control studies: CASP for case—control studies
- Cross-sectional studies: JBI checklist for analytical cross-sectional studies
- UBA studies: EPOC RoB for ITS studies and before/after studies
- Outbreak studies, case series and case studies: Institute of Health Economics checklist for case series.

Simulation studies and other non-epidemiological studies were not appraised for quality as no checklists exist for these types of studies. Critical appraisal was conducted by one reviewer (AB) and checked by another (GLM). The results of quality appraisal are available in Appendix 3 (see online supplementary material).

Data were extracted by one reviewer (AB) and checked by another (GLM). 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, see online supplementary material). The list of the studies rejected at full-text stage, with a reason for the decision, is included in the excluded study tables (Appendix 2b, see online supplementary material). 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, see online supplementary material), 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 the Working Party members. All disagreements were resolved by discussions and consensus (voting was originally allowed but never required because all issues were resolved through discussion) amongst 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 the 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 the 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.
- 'Do not offer, unless … ' or similar recommendation was made if the Working Party believed that the evidence did not support a 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.
- 'Good practice points' were made when there was no evidence to support a 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 and 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 organizations and through consultation with relevant

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stakeholders. The draft guidelines and standard comments form were placed on the HIS website for 4 weeks. The availability of the draft was advertised via e-mail and social media. Stakeholders were invited to comment on format, content, local applicability, patient acceptability, and recommendations. The Working Party reviewed stakeholder comments, and agreed revisions collectively (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? (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 direct contact with the patient may act as vectors for transmission of pathogenic micro-organisms from one patient to another (i.e. when the surface is contaminated from one patient and staff hands come in contact with the contaminated area), while other surfaces may contaminate staff hands during the procedures. While many studies show that operating theatre surfaces are contaminated, they do not indicate 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. Clutter (i.e. items, some of which are unnecessary, and which may obstruct movement and/or prevent staff working efficiently) is visually unappealing and may affect the effectiveness of cleaning, but its effect on the risk of surgical infections is unclear. Previous guidelines [4] did not recommend which areas in the operating theatre should be cleaned and disinfected, and how this should be managed, but did state that cleaning and disinfection should take place, and if a suspected or confirmed patient with transmissible infection/colonization with multi-drug-resistant bacteria was present, diligence should be increased.

Does operating theatre cleanliness/disinfection have any effect on surgical site infection?

There was very weak evidence from one CBA study [10] and two UBA studies [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 a visible light continuous environmental disinfection (CED) system in addition to traditional cleaning/disinfection. The light was in operation 24 h/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 (OR2), while two other rooms (OR1 and OR3) acted as controls. All other IPC procedures remained the same in the three rooms. The authors reported that there was no significant difference in the incidence of SSI between the 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 installation of the CED, the incidence of SSI remained the same in OR1 and OR3 [OR1: 8 (1.2%), P=0.108; OR3: 6 (0.8%), P=1.00], but was significantly lower in OR2 [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 the operating theatre at night to introducing dedicated cleaning personnel for terminal cleaning and addition of a pulsed-xenon ultraviolet light (PX-UV) device at night. During the day, between cases, operating theatre staff cleaned the surfaces in both the pre- and intervention periods. The incidence of SSI did not change significantly with the change in routine and the introduction of the PX-UV device [relative risk (RR)=0.7537, 95% confidence interval (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 cases, e.g. abdominal abscess; +22.9% change, P=0.6973). The final 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, 95% CI 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$3016 (approx. £1704) vs AU$10,479 (approx. £5922)]. The authors also reported a possible positive environmental impact as they observed a 90% reduction in water use, and they mentioned that the 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 a UCV operating 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 [odds ratio (OR)=1.96, 95% CI 1.49–2.16, P<0.001 for bacteria and OR=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 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.

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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 patients undergoing open heart surgery. There were different types of micro-organisms including *Gordonia* spp., some Gram-positive bacteria and micro-organisms 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 SSI increased, and this prompted investigation for the factors responsible for this increase. Different environmental sites were sampled and investigated for Gram-positive and Gram-negative bacteria. When these were found, they were serotyped to establish whether similar strains were responsible for SSI. 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 the conclusion that the environment was a possible source of SSI. However, the authors also reported that instruments were not sterilized adequately, and that the operating theatre was in disrepair. The final study [16] reported an outbreak of *Klebsiella pneumoniae* which was identified in intensive care unit patients who developed sepsis. A case–control investigation showed that, in all cases, sepsis occurred within 5 days of 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 any increased risk of SSI. However, discussion with the lay members revealed that a dirty and untidy-looking operating theatre gives a bad impression and undermines patients' confidence, leading them to believe that the theatre is not safe. The Working Party agreed that cleaning of all touched areas needs to take place between patients, especially those in close proximity to the patient environment. 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 patient monitoring equipment and other specialist equipment is often missed during cleaning between patients. Staff operating this equipment may therefore act as vectors for transmitting micro-organisms between patients and causing infections, but not necessarily 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 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 staff may have become contaminated from touching the patient, or their own face or hair, and may not have been 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 surfaces before the next patient arrives. Hand hygiene is outside the scope of these guidelines, but the Working Party made the recommendations below with the expectation that appropriate hand hygiene is always in place in all operating theatres.

Recommendations

1.1: All patient, staff and visitor hand and body contact surfaces must be cleaned between each patient.

1.2: In addition to cleaning between patients, clean and disinfect all patient and staff hand and body 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, after each patient, and 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 blood-borne virus infection?

Blood and body fluid splashes occur frequently in the operating room. One study [17] reported that, following surgical procedures, blood splashes were found on 24.2% of face masks and 45.2% of protective glasses used by surgeons. Certain procedures (e.g. orthopaedic) frequently use power tools which make splashes and aerosols more likely to occur. These splashes may be potentially contaminated with pathogens such as blood-borne viruses (BBVs) (i.e. human immunodeficiency virus, and hepatitis B and C viruses). However, there is a debate on whether the presence of these micro-organisms on environmental surfaces poses a risk to patients and operating theatre staff. The most critical surfaces are disinfected between 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 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 mobilize dried blood along with any pathogens contained therein. Thus, the blood and body fluid splashes on the canopy screen and 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

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[4] did not specifically address the topic of the risk of BBVs, but made a general recommendation that, as 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 fluids on environmental surfaces in the operating theatre on the incidence of infection with BBVs.

> The Working Party refrained from making recommendations due to the lack of evidence. Instead, they provide good practice points which could guide the theatre staff in their decision making. Regarding the issue of UCV canopy screens, the Working Party agreed that the drops of blood and body fluids that land on the screens dry rapidly, remain in place and are not dispersed. 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 Health Technical Memorandum 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 the operating theatre become contaminated and where similar concerns could be raised. Thus, the Working Party agreed that it may be beneficial for operating theatre staff to judge the risk of infection based on accessibility. If the surfaces are not normally accessible to hands (e.g. any surfaces above 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, surfaces which are within the reach of the surgical team's hands need to be disinfected immediately to prevent spread to other areas and to minimize 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.

Recommendation

2.1: No recommendation, see good practice points.

Good practice points

GPP 2.1: Wherever blood and body fluid 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 ultraclean ventilation canopy screens or filters if they become contaminated with blood or body fluid splashes.

8.3. Does bringing 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 a 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 from entering the cleaner operating theatre to minimize potential microbial contamination. Patients walking to the operating theatre are seen as a source of possible contamination, potentially bringing pathogenic micro-organisms 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 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, compared with being transported on a trolley, on the incidence of SSI or on contamination of the operating theatre.

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

No studies were found which assessed the effect of patients being brought to the operating theatre on a bed or in a wheelchair, compared with being transported on a trolley, on the incidence of SSI or on contamination of the 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), compared with 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 UBA study [26] which evaluated the effect of using a transfer system vs one ward-to-theatre trolley on contamination of the 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, Theatres 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 of 111 colony-forming units (cfu)/100 cm^2 (N=20 samples) on the floors of the operating rooms with the transfer system (Hospital 1), a mean of 283.3 cfu/100 cm^2 (N=18 samples) in Hospital 2, Theatre A, and a mean of 286.7 cfu/100 cm^2 (N=10) in Hospital 2, Theatre B. The floor of the operating room in Hospital 1 was less contaminated despite the highest bacterial counts found on the floor in the protective zone (mean 469 cfu/100 cm^2 vs 336 cfu/100 cm^2 in Hospital 2, Theatre A and 347 cfu/100 cm^2 Hospital 2, Theatre B). Similar data were reported for contamination with *Staphylococcus aureus* (0.0 cfu/100 cm^2, 1.0 cfu/100 cm^2 and 0.3 cfu/100 cm^2 for Hospital 1; Hospital 2, Theatre A; and Hospital 2, Theatre B, respectively) and *Clostridium perfringens* (referred to in the study as *Clostridium welchii* (0.83 cfu/100 cm^2, 0.5 cfu/100 cm^2, 20.5 cfu/100 cm^2, respectively). Another study [26], which assessed contamination of the operating theatre for one week using a two-trolley system compared with another week when only one trolley was in operation, found no significant difference in floor contamination (cfu/plate, N=40 for two-trolley system and N=44 for one-trolley system) when assessing the total number of aerobic bacteria [72.3, standard deviation (SD)=140.2 for two-trolley system vs 56.9, SD=82.7 for one-trolley system), the total number of anaerobic bacteria (0.5, SD=0.8 vs 1.0, SD=3.0), the total number of *S. aureus* (0.32, SD=1.49 vs 0.02, SD=0.15), the total number of

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coliforms (32.8, SD=144.8 vs 6.7 SD=25.1) and the 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), the total number of anaerobic bacteria (4.7, SD=3.4 vs 10.5, SD=12.4), the total number of *S. aureus* (0.22, SD=0.86 vs 0.36 SD=1.13), the total number of coliforms (0.04, SD=0.21 vs 0.18, SD=0.58) and the 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 cleaned routinely (routine was not specified). 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 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 operating theatre complex or could be transported on a trolley, bed or wheelchair. The Working Party agreed that walking to the operating theatre could be beneficial in possibly preventing hypothermia. Allowing patients to walk to the operating theatre has become a common practice, and there is no need to make a specific recommendation. The Working Party also considered the type of footwear that should be allowed, and concluded that no type is currently considered superior and that patients can choose to wear whatever they feel is most comfortable for them. For those being brought on a bed, previous guidelines [4] stated that the bedding will carry skin fragments of the occupant, and may potentially transfer microbial contamination from the ward environment. The guidelines recommended that, if beds were to be used, the bedding should be removed and can be replaced with fresh linen immediately prior to the bed moving to the operating theatre.

Recommendation

3.1: No recommendation, see good practice point.

Good practice point

GPP 3.1: Allow clean beds with fresh 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. patient with suspected or confirmed contact-transmissible multi-drug-resistant bacterial infection/colonization at the end of a list) reduce post-operative infection? (b) Should these patients recover separately from other patients before going to a ward?

In hospital wards, contact precautions are instituted in the care of patients who are known or suspected to be colonized or infected with pathogenic micro-organisms that are easily transmissible to others. These include a set of additional preventive measures, such as the 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 indirect contact with patients with suspected or confirmed contact-transmissible multi-drug-resistant bacterial infection/colonization can therefore minimize the risk to other patients who are present in the operating theatre.

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/colonization to last on the list). This, in theory, should minimize theatre contamination and therefore reduce the risk of infection or cross-infection to others. Another strategy allows the infected/colonized patient to recover in the operating room before they are returned to the ward, 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 make a recommendation on whether patients requiring contact precautions should 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) compared with patients undergoing arthroscopy after a non-infected case (*N*=31,761). The analysis found no difference in the incidence of SSI in patients following an infected case (10/177, 5.6%) compared with patients following a 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 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 micro-organism matched the species isolated from the preceded infected case, although there was no genomic evaluation to establish whether these infecting micro-organisms 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). Theatre and other staff should also be aware that placing certain patients at the end of the list leads to unnecessary stigma, making patients feel 'dirty'. Additionally, lay members raised concerns about potential delays for patients who are placed last on the list, especially if these patients are more vulnerable than others (e.g. those of older age).

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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 meticillin-resistant S. aureus (MRSA) during surgery, and that cleaning/disinfection reduces but does not always completely eradicate MRSA. In this study, visible inspection identified that cleaning was not always adequate, which may have been a reason for the failure to eradicate MRSA. While no evidence was found in relation to where the infected patient should recover, the Working Party felt that principles of isolation or contact precautions should be maintained in the operating theatre, and that these patients should be separated from others whenever possible.

Recommendation

4.1: There is no need to place patients with suspected or confirmed contact-transmissible multi-drug-resistant bacterial infection/colonization at the end of an operating list as long as the operating room is cleaned and disinfected to standard between patients, and the theatre ventilation is running without interruption.

Good practice point

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

Preparation before surgery

8.5. What is the clinical effectiveness of pre-operative showering/bathing before elective surgical procedures using (a) non-disinfectant bath/shower and (b) disinfectant bath/shower?

Pre-operative bathing/showering 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 micro-organisms 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 staff, which may be the reason for this intervention being common practice. However, currently, it is still not clear whether pre-operative showering or bathing is effective in reducing SSI.

Non-disinfectant bath/shower

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

There were data from one excluded study [31] which described an improvement initiative with a bundle of interventions intended to be implemented in 49 hospitals. However, only 23% of hospitals were compliant with all elements of the bundle; 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 were not compliant (OR=0.70, 95% CI 0.45−1.09, P=0.115).

Disinfectant shower/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 shower/bath had no effect on SSI compared with plain soap [32−34], placebo [32,34], or when patients were not required to shower or bathe [32]. However, the pre-operative use of chlorhexidine 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 customary 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. Despite this, the lay members of the Working Party suggested that patients would welcome clear instructions on when and how to wash before surgery. 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] against shaving; hence, it may be prudent to inform patients of the risks associated with this practice, and strongly advise them against shaving the surgical area in the days before the procedure.

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 colonized by MRSA who may benefit from decolonization/suppression therapy [36]. Such regimens are different to those for 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.

Recommendation

5.1: No recommendation, see good practice points.

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 surgery for patients who are not able to shower or bathe before surgery.

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

GPP 5.3: Instruct patients not to shave their surgical area in the days before surgery. Include this in any written patient information that is supplied to patients/carers in advance of surgery.

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8.6. What is the most effective pre-operative 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 laid up (unpacked, inspected 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 the preparation 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 many variables, including the area of 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 probably the predominant route.

Conventional operating theatre ventilation dilutes airborne contamination by turbulent air flow. UCV, often called 'laminar flow' or 'unidirectional air flow', in operating theatres uses unidirectional downward air flow to remove contamination rapidly in that organized 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). Preparation 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 the air in the ultraclean zone.

The first question explored in this section relates to how far in advance of use instruments should be 'laid up' (i.e. unpacked, inspected and ready for use). It is often more convenient to lay up instruments 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, minimize 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 preparation room. Lay up in the UCV zone prior to each procedure can reduce a theatre's throughput, while lay up in a preparation room can occur for a second procedure while the prior procedure is in progress, thus enhancing a theatre's throughput. Previous guidelines [4] acknowledged that micro-organisms 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 the 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 n-RCT [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 1.38 cfu, SD=1.87) compared with those which were left uncovered (mean 5.64 cfu, SD=5.63, P-value=not reported) after instrument preparation.

There was weak evidence of no benefit from three low-quality prospective cohort studies [38—40] and one UBA 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 of SSI in patients undergoing orthopaedic [38], urological [39] and neurological [40] procedures found no infections in either group. A small quality improvement project (UBA 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 SSI in 2 years following the placement of the floor markings (15/26,015, 0.058%) compared with 4 years before placement of the floor markings (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 n-RCT [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 the 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 compared with the tiles placed on trolleys positioned outside the UCV canopy. Another study [38] assessed the rate of bacterial settling during orthopaedic surgical procedures by placing nitrocellulose membranes on instrument trolleys. The mean number of cfu settling on membranes placed on instrument trolleys and positioned under the UCV canopy was 48 (SD=153), compared with 2159 for trolleys positioned 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=382 cfu/m^2/h) for instrument tables placed under a mobile UCV unit and 2730 (SD=1778, P<0.0001) for tables placed outside the UCV unit. In another study [40], air samples from the air above instrument tables were taken during

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neurosurgery using the SAS Super ISO 100 impactor air sampler. The study reported that the median bacterial count settling on instrument trolleys was 0 cfu/m^3 (range 0–13 cfu/m^3) for trolleys placed within the mobile UCV unit and 11.5 cfu/m^3 (range 0–104 cfu/m^3) for trolleys placed outside the UCV unit. Another study [37] reported that the sedimentation on settle plates collected during total joint arthroscopy was very low: the mean number of cfu for settle plates on instrument trolleys placed under the UCV canopy was 0.20 (SD=0.27), compared with 1.38 cfu (SD=1.87, *P*-value=not reported) for trolleys placed outside the UCV canopy. The authors reported that the instruments were also covered until the operation started, which may have been a reason for the relatively low rate of bacterial sedimentation.

The Working Party discussed the above evidence and concluded that instruments should 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 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 should be uncovered only after skin preparation and draping [43].

Recommendation

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 point

GPP 7.1: For ultraclean ventilation operating theatres, lay up the instruments/prosthetic materials under the canopy unless there happens to be ultraclean ventilation in the preparation room, which is an alternative.

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.

Recommendation

8.1: Refer to Recommendations 1.3.1 and 1.3.2 in the NICE guidelines (NG125) for advice on choosing appropriate hand decontamination solutions.

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

Staff movement into and out of the operating room during a surgical procedure is considered to increase the risk of SSI because each door opening results in airflow disruptions and potentially leads to airborne contamination. As airborne microorganisms can settle in the wounds or on the instruments, 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 in order to reduce airborne contamination, doors should be closed to optimize the ventilation system, and that the traffic in and out of the operating room should be reduced as much 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 SSI (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 multi-variate analysis adjusted for age and co-morbidities, patients who underwent procedures where doors were opened $\geq$100 times had a higher risk of SSI (as defined by the Centers for Disease Control and Prevention National Healthcare Safety Network) compared with those with <100 door openings [incidence risk ratio (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). In total, 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 multi-variate analysis, the hazard ratio (HR) per five-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 door openings during surgical procedures on the extent of wound contamination. Microbiological data were obtained from wounds before 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%) samples were sterile, 90 (51%) had counts of 1–10 cfu/m^3 and 37 (21%) had counts >10 cfu/m^3. Furthermore, 35/37 (95%) samples with counts >10 cfu/m^3 were from operating rooms with turbulent ventilation. Among the wound samples, 33 (56%) were sterile, 18 (30%) had 1–10 cfu/100 cm^2 and eight (14%) were >10 cfu/100 cm^2. The mean number of door openings was 49.5 (SD 39.2) per procedure, accounting for a mean time of 13.3 (SD 17.2) min per procedure, and this was not associated with the cfu count in wounds at the time of closure (Spearman's rho *r*=0.13, *P*=0.32).

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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 mentioned previously in relation to wound contamination [46], reported that the mean estimate of proportionality coefficient for the number of door openings and air microbial count was 0.07 (SD=0.03, P=0.03) in the multi-variate analysis. This means that one door opening per 5-min period was estimated to raise the microbial count in the air by 0.07 cfu/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 20-min interval of the surgery (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 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 a positive air pressure at approximately 3 kPa. The group used these data in another study [48] which compared the effect of door openings in air-displacement and UCV theatres, and reported that the IRR 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 surgery, found that the mean number of cfu on settle plates which were placed inside the UCV area on an instrument table was not associated with the number of door openings [20–39 door openings: mean 0.50 (range 0.00–2.00), 40–59 door openings: mean 1.27 (range 0.00–12.0), 60–79 door openings: mean 0.39 (range 0.00–2.00), >80 door openings: mean 1.29 (range 0.50–2.50), P=0.73], while the settle plates placed outside the 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 (range 0.00–7.00), 40–59 door openings: mean 3.26 (range 0.50–9.50), 60–79 door openings: mean 4.78 (range 1.00–15.0), >80 door openings: mean 5.93 (range 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 high-efficiency particulate air (HEPA) filters, reported that the estimated number of cfu/m^3 in the air was 0.002 (95% CI 0.0004–0.004, P=0.02) per hour in the multivariate linear mixed effects model. This can be interpreted as a 0.2% increase in cfu/m^3 from a single door opening for each hour of surgery. In the last environmental survey [51], which used recordings of surgical procedures obtained from cameras installed in operating rooms (information on ventilation not provided), the hierarchical regression was used to identify factors associated with 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 min 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 the mean number of cfu for higher and lower levels of procedures. The authors reported that a 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 longer door openings resulted in higher microbial loads than shorter door openings (P=0.032), and that wider door openings resulted in higher microbial loads than narrower door openings (P=0.047). In another simulation study [52], mock orthopaedic surgery was performed for 90 min 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 min, during which time only a researcher collecting data was present in the room. The authors reported that for the control operating room, four of six brain heart infusion agar plates grew 1 cfu and the remaining two plates showed no growth. On the other hand, the settle plates obtained from the mock surgery room grew between 4 and 22 cfu. Additionally, the authors reported that mannitol salt agar, used for growing *Staphylococcus* spp., and pseudomonas isolation agar, used for growing *Pseudomonas* spp., showed no growth in the control operating room and between 4–266 and 1–19 cfu, respectively, in the mock surgery room. Finally, a simulation study [53,54] collected data from an empty operating room under different conditions: door always open, door always closed, and door swinging open 50 times per hour. During each experiment, a team of 10 people dressed in operating theatre attire paced throughout the hallway to simulate regular traffic. The authors reported that the counts in the operating room were not significantly different when comparing the swinging and open conditions and swinging and closed conditions, but that there was a significant difference in the mean number of cfu/ft^2/h 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-min 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 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 the 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 the operating room will increase by 69.3%.

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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 in door openings. They also mentioned that the improvements had no effect on infection rates, but no other information was provided.

> The Working Party reviewed the above evidence and concluded that door opening itself is not likely to have an effect on the rate of SSI. The slightly increased microbial counts observed with door openings are more likely to be the result of increased staff movement from 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 count and potentially leads to an increased risk of SSI. The Working Party would like to stress that the presence of students for the purpose of teaching and education is considered essential, and that these individuals should be allowed to enter the operating theatre when appropriate. The Working Party also agreed that minimizing the number of door openings would have other benefits, such as protecting patient dignity (regardless of whether the patient is under general or local anaesthetic), and fewer distractions for the surgical and anaesthetic team.

Recommendation

9.1: Minimize non-essential staff movement and hence door openings during surgical procedures to minimize bacterial air counts.

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 numbers of micro-organisms in spite of thorough washing. There is a concern that the presence of jewellery may interfere with hand scrubbing of the operating staff, and that micro-organisms from 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 should be removed, but that simple wedding bands without 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 artificial nails should not be worn by 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 on by a surgeon in the period after he started wearing a wedding band when compared with a period before the wedding band was worn; instead, the incidence fell from 16/987 (1.6%) before wearing a wedding band to 6/1140 (0.5%) after starting to wear a wedding band (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 cleansed thoroughly.

There was weak evidence from four simulation studies [59–62] which assessed the effect of wearing a ring, signet or watch on bacterial counts of the skin. One study [59] compared the number of cfu on the left hands of surgeons and anaesthetists (N=19) with a single plain wedding band with the number of 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 the left and right hands [median 2 cfu (range 1–300) vs 5 cfu (range 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 scrubbing, and it contained 2 cfu 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 129 cfu x 10^2/mL (SD=0.3–1020) on hands with a ring and 369 cfu x 10^2/mL (SD=0.25–2580) on hands without a 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-h surgical procedure [mean 5.1 cfu x 10^2/mL (SD=0–33) on hands with a ring vs 8.5 x 10^2/mL (SD=0–133) on hands without a ring, P=0.58]. Another study [60] assessing contamination of the skin under rings, signets and watches worn by dental surgeons reported that there was significantly higher contamination from swabs obtained from the skin under rings and signets compared with the corresponding area on the opposite hand (mean 212 cfu vs 86.7 cfu, respectively, P=0.001), as well as from the skin under watches when compared with the opposite wrist (mean 262.7 cfu vs 55.9 cfu, 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 final study [61] assessed skin contamination under the rings of 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 4 cfu, range 0–1001) than the rings themselves (median 0 cfu, range 0–100), the area near the ring (median 1 cfu, range 0–510) and the corresponding area on the opposite hand (median 0 cfu, range 0–1004, P=0.05). After scrubbing, the area under the ring was significantly more contaminated than the corresponding area of the opposite hand (median 0, range 0–15 vs median 0, range 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 0 cfu, range 0–23) than the corresponding area of the opposite hand (median 0 cfu, range 0–4, P=0.01). However, the authors reported that there was

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no difference in contamination of the skin under the ring when it was removed for the procedure compared with the corresponding area of the opposite hand (data and *P*-value not provided).

There was additional information 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 types of rings (e.g. rings with stones vs single bands) worn by the surgeons. 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 hypothesized that the removal of jewellery may be even more detrimental, and recommended that theatre staff should either wear no items of jewellery or should cover them during surgical procedures. The final study [65] was an outbreak report and was excluded because it did not have a control group. The authors reported that six cases of *Serratia 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 RCT [66], one crossover RCT [67], one prospective cohort study [68] and one simulation study [69] which assessed the effect of operating theatre staff wearing nail polish during surgical procedures on bacterial counts obtained from nails. One study [66] assessed the bacterial counts on freshly applied nail polish (<2 days), chipped nail polish (visibly chipped or painted >4 days before) or natural nails (no polish) (N=34 in each group). Nurses were randomized into one of the groups and agreed to prepare their nails according to the randomization allocation for the day of data collection. The authors reported that there was no significant difference in the median number of cfu in any of the groups before scrubbing occurred (median 25, 80 and 100 cfu 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 35 cfu) than freshly applied nail polish and natural nails (median 10 cfu each, P=0.035). In a crossover RCT [67], veterinary surgery staff (N=96) at a veterinary hospital were randomized into a group who wore a single coat of nail polish for 1 week and a group with no nail 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 2.1 cfu (SD=1.04) vs 2.0 cfu (SD=0.91), respectively, P=0.76], after scrubbing [mean 0.84 cfu (SD=0.68) vs 72 cfu (SD=0.62), respectively, P=0.50] or following the surgical procedure [mean 0.50 cfu (SD=0.52) vs 0.66 cfu (SD=0.54), respectively, P=0.35]. A prospective cohort study [68] obtained samples from 31 operating theatre female staff who wore nail polish regularly and 31 operating theatre female staff who did not. The authors reported that there were no significant differences between the groups before scrubbing [mean 9.9 cfu (SD=2.84) in the nail polish group and mean 8.7 cfu (SD=2.89) in the natural nails group, P=0.100]. However, the counts were significantly higher in participants wearing nail polish after scrubbing [mean 9.6 cfu (SD=2.45) vs 7.3 cfu (SD=2.93) in the natural nails group, P=0.008]. In the final study [69], circulating nurses (N=33) in the 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 1 h and then scrub again. The authors reported that the mean number of cfu was not increased significantly on hands with nail polish compared with hands without nail polish [mean 7.88 cfu (SD=88.05) vs 63.64 cfu (SD=213.33), respectively, *P*-value not reported]. The authors also reported that the right hand had lower cfu counts before 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 study [68] 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 wore artificial nails regularly 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 12.2 cfu (SD=2.94) in the artificial nails group vs 8.7 cfu (SD=2.89) in the natural nails group, P<0.001] and after scrubbing [mean 11.4 cfu (SD=2.67) in the artificial nails group vs 7.3 cfu (SD=2.93) in the natural nails group, P<0.001].

There was additional information 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 bacterial growth, as these pieces will make scrubbing more difficult. Wearing jewellery (including watches) violates recommendations for hand hygiene as well as the bare below

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the elbow policy that is strongly recommended or mandated in some countries. There is a risk of glove perforation by jewellery, which may also predispose to increased risk of infection. For these reasons, the Working Party agreed that the policy for the operating team should be to ban jewellery worn on fingers and anywhere below the elbow when scrubbed. They also acknowledged that some pieces of jewellery may not be possible to remove (e.g. for religious/cultural reasons or because the jewellery is embedded into the skin). In these cases, the policy should state that thorough hand hygiene must be performed to ensure that the area under and around the item is cleaned adequately (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 information from the excluded study which highlighted that broad wedding bands may harbour bacteria different from those usually found as part of the skin flora, and which may not be removed by scrubbing. 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 risk of infection. For staff such as nurses working in the operating theatre complex or porters bringing patients to the operating theatre but who are not involved in surgical procedures and who do not touch patients' wounds, the removal of jewellery is less important. However, the Working Party agreed that it may be more convenient for operating theatres to have a similar policy for all staff entering the operating theatre complex. This is also important for patients who, while accepting that jewellery is sometimes worn for religious or cultural reasons, see the removal of jewellery as paramount for their safety. These patients may not be aware of who will be working outside the operating room and in the periphery of the operating theatre complex, and may therefore perceive some members of staff as 'unsafe' if jewellery is worn. For other items of jewellery (e.g. earrings), the Working Party agreed that there is no risk of infection 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 evidence exists, 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 effectively and they are also a violation of the bare below the elbows policy in some countries. As such, 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 elbow. Where jewellery cannot be removed, the area around and underneath any item of jewellery must be carefully cleaned as much as possible during the scrubbing process.

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 face masks?

Face masks and surgical head gear 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 a 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, head gear was introduced to prevent hair, skin scales and other particles falling into a sterile area. Historically, skull caps were worn to cover most of the hair on the head, but recently some guidance required the surgical team to use head gear 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 head gear in preventing SSI and contaminating 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 head gear 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 contamination of the operating room. In the first study [71], the surgical team were asked to sit under the UCV area and over settle plates positioned on the operating table for 30 min. The team was asked to wear different types of head gear or no head gear during the experiments. The authors reported that when no head gear was worn, the mean number of cfu/m^2/h was 8318, which was higher than when the team wore surgical hoods (0.00 cfu/m^2/h) or a surgical cap (8.42 cfu/m^2/h). The authors did not provide a *P*-value but reported that the difference between 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 face masks for 30 min while speaking and moving their hands. Settle plates for this experiment were positioned at waist height to represent contamination near the surgical site. The authors reported that when the team did not wear face masks or hats, the mean cfu/m^2/h was 472 but when wearing a disposable hat and not wearing a face mask, it was 324 cfu/m^2/h. When wearing a face mask but not wearing a hat, the mean number of colonies was 84 cfu/m^2/h. Wearing a face mask and a disposable hat resulted in a mean of 21 cfu/m^2/h, and wearing a face mask and a cloth (washable) hat resulted in a mean of 32 cfu/m^2/h. The authors did not report whether any of these results reached significance. In the final study [73], six volunteers, representing casual non-scrubbed personnel, were dressed in surgical attire (including face masks) and were asked to wear or not wear a disposable surgical hood for 30 min. During the last 5 min of the experiment, air samples were taken using a Casella slit sampler with a blood agar settle plate. The authors reported no significant difference in mean air counts regardless of whether the operating room was ventilated (0.53 cfu/m^3 vs 0.66 cfu/m^3 in experiments involving the staff wearing a hood vs not wearing a hood,

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P-value not reported) or not ventilated (1.55 cfu/m^3 vs 0.35 cfu/m^3 for wearing a hood vs not wearing a hood, *P*-value not reported). The authors found that *S. aureus* was not isolated in either group. Thus, the authors concluded that the use of head gear by casual staff makes no difference to air counts in the operating theatre.

There was weak evidence from one retrospective cohort study [74] and three UBA studies [75–77] which compared the effect of wearing a bouffant hat vs a surgical cap [74], or the effect of a change in 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 data collected previously for an 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 surgeons who wore bouffant hats and those who were operated on by surgeons 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 and 5.5% after introduction of the policy (P=0.801). Another study [76] reported no difference in the incidence of SSI for patients undergoing class I procedures (clean procedures 0.77% and 0.84% for rates before and after, respectively, P=0.62), patients undergoing spinal procedures (0.79% vs 0.82%, P=1.00), and patients undergoing craniotomy and craniectomy procedures (0.95% vs 0.75%, P=1.00). The final study [77] reported that the incidence of SSI in patients undergoing any surgical procedure was 0.99% after a bouffant-style hat was made mandatory vs 0.88% when staff were able to choose their own head gear (P=0.28).

There were further data from two studies [78,79] which were excluded because they involved a change of head covering as well as other elements of the operating room attire, and it was difficult to separate the impact of the change of head covering. Both reported no difference in SSI after the new policy was introduced, implying that a change in head covering alone is unlikely to have an effect.

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 contamination of the operating room. In this study, the research team consisted of a surgeon, a medical student, a scrub nurse, a microbiologist, a ventilation engineer and an air hygienist, who performed 1-h mock operations in a HEPA-filtered operating room. The team wore a disposable bouffant hat, a disposable cap or a cloth cap. Air contamination was assessed using an 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 10 cfu/m^3). The settle plates yielded a median 3 cfu [interquartile range (IQR) 5] for the bouffant hat, 1 cfu (IQR 1) for the disposable cap and 1 cfu (IQR 3) for the cloth cap. The authors did not provide *P*-values but reported that the differences in contamination between the bouffant hat and the disposable cap, and the bouffant hat and the cloth cap were significant, but that there was no significant difference between the disposable cap and the cloth cap.

Effect of face masks

There was moderate evidence from two RCTs [81,82], one 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 theatres. 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 surgeon alone [89]. Two of these nine studies reported a benefit of 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 compared with no patients (0/25, 0%) in the group where face 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 *S. aureus* and one *Gardnerella vaginalis*) matched the micro-organisms isolated from the surgical team. A case–control study [84] which included 214 patients who developed SSI after cataract surgery and 445 matched controls reported that, in multi-variate 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, did not report any benefit in the use of face masks. The authors of this study reported that the incidence of SSI was 30% for emergency patients and 15% for elective patients in both the masked and unmasked groups.

There were additional data from one study [90] which was excluded because it did not have a control group. The authors described an outbreak of *S. aureus* infections in three patients following surgery. The isolated meticillin-susceptible *S. aureus* 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 face 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 face masks on contamination of the operating room. Seven of nine studies showed more contamination in the experiments where face masks were not worn. In one RCT [91], patients undergoing cataract surgery were assigned at random to groups where a face mask was worn by the surgeon or a face mask was not worn by the surgeon. A settle plate was placed next to the patient's head on the side of 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 face mask, the plates grew >1 cfu/min, whereas contamination was significantly lower in procedures

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where face masks were worn (5/109, 4.6%, P=0.0006). In a prospective cohort study [92] of patients undergoing cardiac catheterization, 96.7% of settle plates collected during unmasked procedures were positive for bacterial cultures, compared with 86.7% of procedures in which the surgeon was fully masked and 90% of procedures where the surgeon's face mask was placed above their mouth but with the nose exposed. The authors reported no significant difference in the number of positive settle plates between the procedures when a face mask was worn fully or partially (P-value not provided), but they reported a significant difference when comparing procedures when face masks were not worn with procedures when face masks were worn partially (P=0.02) and fully (P<0.02). One simulation study [72], which reported mock operations carried out in a UCV theatre for 30 min while wearing or not wearing hats and face masks, reported that the settle plates positioned near the subjects who did not wear a hat or a face mask grew a mean 472 cfu/m^2/h, while the settle plates for the subjects who wore a face mask but did not wear a hat only grew 84 cfu/m^2/h. Similarly, for the subjects who wore a disposable hat but did not wear a face mask, the settle plates grew a mean 324 cfu/m^2/h and the plates where subjects wore a disposable hat and a face mask grew 21 cfu/m^2/h. 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 30–50 cm in front of the surgeon. In the 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 face masks. The authors reported that all plates in the experiment where the surgeons were not wearing a face mask grew at least one colony, while this was the case in 67% of plates positioned in front of surgeons wearing face masks and 71% of plates positioned at the sides of surgeons who were wearing face masks. When considering heavy growth (>15 cfu) as an outcome, 75% of the plates were heavily contaminated in the unmasked experiment, but only 8% in the experiments where surgeons were wearing face masks (P<0.01). In another experiment [94], which assessed the effect of talking, 10 anaesthetists were sitting 30 cm from agar plates wearing or not wearing face masks. The authors reported that when the subjects were sitting silently without face masks, only one plate became contaminated (0.1 cfu/subject), but five of 10 plates became contaminated when talking (mean 4.4 cfu/subject). Talking while wearing a face mask resulted in three agar plates becoming contaminated (0.3 cfu/subject). The authors reported that there was no significant difference between the plates obtained from the experiments where subjects were silent and those obtained where subjects were talking while wearing face masks, but there was a significant difference when face masks were not worn. Another study assessed the effect of a new face 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 30 cm. The subjects were asked to speak directly at an agar plate for 5 min, after which time they were asked to put on a fibreglass surgical face mask and speak for a further 15 min. The authors reported that when a face mask was not worn, 13 (52%) of 25 agar plates exposed for 5 min (0–5 min) were contaminated with at least 1 cfu. When a face mask was worn, only three (12%) of 25 plates exposed for 5 min (0–5 min) were contaminated. However, when the face mask was worn for 10 min and the plates were exposed for 5 min (10–15-min interval), nine plates grew at least 1 cfu. When comparing the mean number of micro-organisms grown on these agar plates, the plates which were exposed to the subjects who wore face masks for a 10–15-min interval yielded significantly fewer micro-organisms (mean 1 cfu, range 0–10) than the plates exposed to subjects who did not wear face masks (mean 3.6 cfu, range 0–24 cfu, P<0.05). Another study [96] assessed the effect of surgeons wearing face masks standing next to the operating table and 1 m away from it. The study reported that no colonies were grown on the agar plates placed 1 m away from the table, regardless of whether or not a face mask was worn. For surgeons standing next to the operating table, the agar plates for the masked group did not grow any colonies and the two plates in the no-mask group grew 29 and 12 cfu. There were two simulation studies which showed no effect of wearing face masks in operating theatres. One [97] was a small study of five plastic surgeons who were asked not to wear face masks, to wear face masks (surgical) or to wear FFP3 valved respirators 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 micro-organisms disseminated from the surgeons' mouths. The authors reported that two of five plates were contaminated when a face mask was worn, and when it was not, the plates in the masked group each grew 2 cfu, while the two plates from the unmasked subjects grew 11 and 12 cfu. In the final study [53], five subjects representing operating theatre staff, scrubbed and wearing operating theatre attire, walked uniformly in a ventilated theatre for 30 min. Air settle plates were placed 4 feet from the floor to capture contamination near the surgical site. The authors reported that face masks did not reduce the number of micro-organisms released into the environment by the wearer. Thus, they considered wearing face masks to be unnecessary in corridors or in an operating room when surgery is not being performed [mean 447.3 (SD=186.6) cfu/ft^2/h and 449.7 (SD=183) cfu/ft^2/h for masked and non-masked groups respectively, P-value not reported]. However, they acknowledged that there is a possibility that while the number of micro-organisms is not reduced by face masks, they may redirect air flow to the sides, and therefore face masks may still be potentially useful during surgery.

There was additional information 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 face masks in protecting 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 the 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 RR of infection, but the blood would have landed in susceptible areas around the nose and mouth which could potentially lead to BBV infection.

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Effect of head gear and face masks combined

No studies were found in the existing literature which assessed the effect of wearing surgical head gear together with a face mask 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 a face mask, compared with no hood and no mask. Mock operations in a UCV operating room lasted 30 min 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/h in settle plates collected during the mock surgeries when a hood and face mask were worn was 69 cfu (SD=35), compared with 6253 cfu (SD=3219) when no head gear was worn.

> The Working Party reviewed the above evidence which discusses hair being a source of contamination and potentially being a source of infection. It is a common belief in the 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 the case. 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 head coverings in the operating theatre attire may help in maintaining discipline among operating theatre staff. There was also a strong preference among the lay members who see head coverings as an important part of a surgeon's uniform worn to protect patients from infections. Therefore, the Working Party agreed that for peripheral as well as scrubbed staff, it may be prudent to continue wearing head coverings, but individuals can be given a choice to wear the head gear that they prefer.
>
> The evidence shows that face 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. The importance of wearing a face mask was also stressed by the lay members who, as with head coverings, see face masks as an essential part of a surgeon's uniform.

Recommendation

11.1: No recommendation, see good practice points.

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.

GPP 11.2: When face masks are worn, ensure that they are changed periodically.

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 a 'scrub suit', is frequently worn outside the operating theatre. This practice has been questioned because there are some concerns that it represents a risk of infection. To remedy this potential problem, some hospitals ask their theatre staff to either change their attire or to wear cover gowns when leaving the operating theatre complex. 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 NICE guidelines on the prevention of SSI [6] state that the operating theatre team should wear sterile gowns, and that staff wearing non-sterile operating theatre attire should keep their movements in and out of the operating area to a minimum. The Centers for Disease Control and Prevention guidelines on preventing SSI [99] focus little on 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 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 n-RCT [102] which investigated the contamination of 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 protective 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 11 cfu when leaving the operating theatre and 8 cfu when returning), but increased when they did not (mean 9 cfu when leaving the operating theatre and 19 cfu 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 at the back at the neck and at 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 operating 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 21 cfu when leaving the operating theatre and 8 cfu when returning), while they increased when the same attire was worn when returning (mean 14 cfu when leaving the operating theatre and 26 cfu

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when returning). The change in bacterial counts was significant when comparing the scenarios for new and used attire ($P<0.001$). 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 protective gowns.

There was moderate evidence of no effect from two moderate-quality crossover trials [103,105] which investigated the 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 25.2 cfu/cm^2 (SD=43.5) in the scenario when attire was worn in the operating theatre alone vs 18.5 cfu/cm^2 (SD=25.9) for attire worn in the operating theatre and on the wards vs 17.9 cfu/cm^2 (SD=31.0) for attire worn in the operating theatre and offices, $P=0.370$]. Another study [104] investigated operating theatre clothing worn by doctors ($N=20$) exclusively in the orthopaedic operating theatre complex compared with attire worn on the wards or in clinics in addition to the operating theatre. Contamination was assessed by pressing horse blood agar plate against the attire and counting the number of cfu 18 h after incubation. A significant increase in bacterial colony counts was found 2 h after donning the attire when worn outside the operating theatre, but not when the attire was first donned or at 4, 6 or 8 h after donning.

The Working Party concluded that the above evidence does not suggest that operating theatre attire worn outside the operating 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. The lay members' perspective was that the scrubs of healthcare workers worn outside the operating theatre were likely to be viewed as 'contaminated' and unsafe to patients and visitors. However, the Working Party also agreed that different areas of the hospitals may pose different risks; for example, visiting intensive care unit and isolation areas, where significant organisms (e.g. Group A streptococci or multi-drug-resistant organisms) may be present, would potentially be more hazardous than, for example, visiting offices or canteens. These micro-organisms can be transferred to clothing and shoes, and dispersed in the operating theatre. It is not feasible to monitor staff movement outside the operating 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 sees no reason for challenging staff who enter any areas outside the operating theatre complex (e.g. canteen) wearing clean operating theatre attire. Instead, they agree that staff should be challenged if they do not comply with the policies upon returning to the operating theatre complex.

Recommendation

12.1: No recommendation, see good practice point.

Good practice point

GPP 12.1: Change or cover operating room attire (e.g. with a 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 surgery. The rationale for this is that these items potentially interfere with skin decontamination and can be a possible source of micro-organisms 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 evidence, the Working Party decided to refrain from making recommendations about patients wearing jewellery, artificial nails and nail polish in relation to risk of infection. 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 or the use of a finger probe for pulse oximetry. 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, as there is no evidence specific for infection, there is no reason to change current hospital policies.

Recommendation

13.1: No recommendation, see good practice points.

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 this in written (paper or digital) patient information supplied in advance of surgery while preparing at home.

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

Hair contains a large number of micro-organisms 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 should 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

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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 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.

Recommendation

14.1: No recommendation, see good practice point.

Good practice point

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 carer. From an IPC perspective, the presence of an additional person, however briefly, means that more micro-organisms 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 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 operating theatre, birthing partner going into the delivery suite, or any visitors entering the operating 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. As parents and carers are only allowed to enter the operating theatre complex and anaesthetic room, but not the operating theatre itself, questions have been raised about whether these individuals are required to wear scrubs. An argument against this practice may be that donning scrubs, face 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 cover gowns and overshoes in the anaesthetic room. However, if visitors were to enter the operating theatre 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 regarding whether the practice of changing into 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 acknowledge 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 contamination of the operating theatre.

No studies were found in the existing literature which described the 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 and 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. For visitors, the safety of their relative or close one is of paramount importance, and they would be happy to comply with any uniform requirements imposed by operating theatre management and staff. 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 face masks so that their attire is in line with the attire worn by all staff. Changing shoes is not necessary because, unlike staff, visitors are not likely to visit high-risk areas where multi-drug-resistant organisms are present. 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.

Recommendation

15.1: No recommendation, see good practice points.

Good practice points

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

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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 acknowledge that this is not an exhaustive list of possible research topics but 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 instruments opened under the ultraclean ventilation canopy reduce the risk of surgical site infection.

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

RR 1.3: Studies which investigate the relationship between the frequency of unnecessary door openings and surgical site infection in selected procedures.

RR 1.4: Studies which investigate whether unnecessary interruptions can be used as a proxy measure for predicting surgical site infection.

Author contributions

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

Conflict of interest statement

None declared.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jhin.2023.06.009.

References

[1] Allegranzi B, Bischoff P, de Jonge S, Kubilay NZ, Zayed B, Gomes SM, et al.; WHO Guidelines Development Group. New WHO recommendations on preoperative measures for surgical site infection prevention: an evidence-based global perspective. Lancet Infect Dis 2016;16:e276–87.

[2] Allegranzi B, Zayed B, Bischoff P, Kubilay NZ, de Jonge S, de Vries F, et al.; WHO Guidelines Development Group. New WHO recommendations on intraoperative and postoperative measures for surgical site infection prevention: an evidence-based global perspective. Lancet Infect Dis 2016;16:e288–303.

[3] Fields AC, Pradarelli JC, Itani KMF. Preventing surgical site infections: looking beyond the current guidelines. JAMA 2020;323:1087–8.

[4] Woodhead K, Taylor EW, Bannister G, Chesworth T, Hoffman P, Humphreys H. Behaviours and rituals in the operating theatre. A report from the Hospital Infection Society Working Party on Infection Control in Operating Theatres. J Hosp Infect 2002;51:241.

[5] Hafiani EM, Cassier P, Aho S, Albaladejo P, Beloeil H, Boudot E. Guidelines for clothing in the operating theatre 2021. Anaesth Crit Care Pain Med 2022;41:101084.

[6] National Institute of Health and Care Excellence. Surgical site infections: prevention and treatment. NICE Guideline 125. London: NICE; 2020. Available at: https://www.nice.org.uk/guidance/ng125/chapter/recommendations#antiseptic-skin-preparation [last accessed November 2022].

[7] Association of Peri Operative Registered Nurses. AORN guidelines for perioperative practice 2019. Denver, CO: AORH; 2019.

[8] National Institute for Health and Care Excellence. Developing NICE guidelines: the manual. Process and methods. London: NICE; 2014 (last updated 2022). Available at: https://www.nice.org.uk/process/pmg20/chapter/introduction [last accessed November 2022].

[9] Schünemann H, Brożek J, Guyatt G, Oxman A, editors. GRADE handbook for grading quality of evidence and strength of recommendations. GRADE Working Group; 2013. Available at: https://gdt.gradepro.org/app/handbook/handbook.html [last accessed November 2022].

[10] Murrell LJ, Hamilton EK, Johnson HB, Spencer M. Influence of a visible-light continuous environmental disinfection system on microbial contamination and surgical site infections in an orthopedic operating room. Am J Infect Control 2019;47:804–10.

[11] Catalanotti A, Abbe D, Simmons S, Stibich M. Influence of pulsed-xenon ultraviolet light-based environmental disinfection on surgical site infections. Am J Infect Control 2016;44:e99–101.

[12] Gillespie E, Brown R, Treagus D, James A, Jackson C. Improving operating room cleaning results with microfiber and steam technology. Am J Infect Control 2016;44:120–2.

[13] Alfonso-Sanchez JL, Martinez IM, Martín-Moreno JM, González RS, Botía F. Analyzing the risk factors influencing surgical site infections: the site of environmental factors. Can J Surg 2017;60:155–61.

[14] Nguyen DB, Gupta N, Abou-Daoud A, Klekamp BG, Rhone C, Winston T, et al. A polymicrobial outbreak of surgical site infections following cardiac surgery at a community hospital in Florida 2011–2012. Am J Infect Control 2014;42:432–5.

[15] Thomas ME, Piper E, Maurer IM. Contamination of an operating theatre by Gram-negative bacteria. Examination of water supplies, cleaning methods and wound infections. J Hyg 1972;70:63–73.

[16] van't Veen A, van der Zee A, Nelson J, Speelberg B, Kluytmans JAJW, Buiting AGM. Outbreak of infection with a multiresistant *Klebsiella pneumoniae* strain associated with contaminated roll boards in operating rooms. J Clin Microbiol 2005;43:4961–7.

[17] Davies CG, Khan MN, Ghauri AS, Ranaboldo CJ. Blood and body fluid splashes during surgery-the need for eye protection and masks. Ann R Coll Surg Engl 2007;89:770–2.

[18] NHS England. Health Technical Memorandum 03-01. Specialised ventilation for healthcare premises. Part B: The management, operation, maintenance and routine testing of existing healthcare ventilation systems. London: NHS England; 2021. Available at: https://www.england.nhs.uk/publication/specialised-ventilation-for-healthcare-buildings/ [last accessed November 2022].

[19] Humphrey JA, Johnson SL, Patel S, Malik M, Willis-Owen CA, Bendall S. Patients' preferred mode of travel to the orthopaedic theatre. World J Orthop 2015;6:360–2.

[20] Keegan-Doody M. Walk or be driven? A study on walking patients to the operating theatre. J Perioper Pract 2005;15:529–31.

[21] Kojima Y, Ina H, Fujita T, Mitono H. Relieving anxiety by entering the operating room on foot. Can J Anaesth 2002;49:885–6.

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[22] Ball DR, Clark M. Which patients would prefer to walk to theatre? Ann R Coll Surg Engl 2006;88:607–8; author reply 607–8.
[23] Maharjan SB, Shah S, Dahal R, Gurung R, Shah JN. Elective surgery patients walk to operating room instead of wheeled in on trolley: patient centered care. J Patan Acad Health Sci 2018;5:35–9.
[24] Turnbull LA, Wood N, Kester G. Controlled trial of the subjective patient benefit of accompanied walking to the operating theatre. Int J Clin Pract 1998;52:81–3.
[25] Ayliffe GA, Babb JR, Collins BJ, Lowbury EJ. Transfer areas and clean zones in operating suites. J Hyg 1969;67:417–25.
[26] Lewis DA, Weymont G, Nokes CM, Cribb J, Prothero DL, Marshall DW, et al. A bacteriological study of the effect on the environment of using a one- or two-trolley system in theatre. J Hosp Infect 1990;15:35–53.
[27] Abolghasemian M, Sternheim A, Shakib A, Safir OA, Backstein D. Is arthroplasty immediately after an infected case a risk factor for infection? Clin Orthop Relat Res 2013;471:2253–8.
[28] Chen AF, Kheir MM, Greenbaum JM, Restrepo C, Maltenfort MG, Parvizi J. Surgical case order has an effect on the risk of subsequent periprosthetic joint infection. J Arthroplasty 2017;32:2234–8.
[29] Namdari S, Voleti PB, Baldwin KD, Lee GC. Primary total joint arthroplasty performed in operating rooms following cases of known infection. Orthopedics 2011;34:e541–5.
[30] Kanamori H, Rutala WA, Gergen MF, Weber DJ. Perioperative bacterial contamination from patients on contact precaution in operating room environment. Open Forum Infect Dis 2020;7:ofaa508.
[31] Vicentini C, Corradi A, Scacchi A, Elhadidy HSMA, Furmenti MF, Quattrocolo F, et al. Impact of a bundle on surgical site infections after hip arthroplasty: a cohort study in Italy (2012–2019). Int J Surg 2020;82:8–13.
[32] Webster J, Osborne S. Preoperative bathing or showering with skin antiseptics to prevent surgical site infection. Cochrane Database Syst Rev 2015;2:CD004985.
[33] World Health Organization. Web Appendix 2. Summary of a systematic review on preoperative bathing. In: Global guidelines for the prevention of surgical site infection. Geneva: WHO; 2018. Available at: https://www.ncbi.nlm.nih.gov/books/NBK536394/ [last accessed August 2022].
[34] Franco LM, Cota GF, Pinto TS, Ercole FF. Preoperative bathing of the surgical site with chlorhexidine for infection prevention: systematic review with meta-analysis. Am J Infect Control 2017;45:343–9.
[35] Forget V, Azzam O, Khouri C, Landelle C. What is the benefit of preoperative washing with chlorhexidine gluconate-impregnated cloths on the incidence of surgical site infections? A systematic review and meta-analysis. Infect Dis Now 2022;52:185–92.
[36] Coia JE, Wilson JA, Bak A, Marsden GL, Shimonovich M, Loveday HP, et al. Joint Healthcare Infection Society (HIS) and Infection Prevention Society (IPS) guidelines for the prevention and control of meticillin-resistant *Staphylococcus aureus* (MRSA) in healthcare facilities. J Hosp Infect 2021;118:S1–39.
[37] Chosky SA, Modha D, Taylor GJ. Optimisation of ultraclean air. The role of instrument preparation. J Bone Joint Surg Br 1996;78:835–7.
[38] Diab-Elschahawi M, Berger J, Blacky A, Kimberger O, Oguz R, Kuelpmann R, et al. Impact of different-sized laminar air flow versus no laminar air flow on bacterial counts in the operating room during orthopedic surgery. Am J Infect Control 2011;39:e25–9.
[39] Pasquarella C, Sansebastiano GE, Ferretti S, Saccani E, Fanti M, Moscato U, et al. A mobile laminar airflow unit to reduce air bacterial contamination at surgical area in a conventionally ventilated operating theatre. J Hosp Infect 2007;66:313–9.
[40] von Vogelsang AC, Förander P, Arvidsson M, Löwenhielm P. Effect of mobile laminar airflow units on airborne bacterial contamination during neurosurgical procedures. J Hosp Infect 2018;99:271–8.
[41] de Korne DF, van Wijngaarden JD, van Rooij J, Wauben LS, Hiddema UF, Klazinga NS. Safety by design: effects of operating room floor marking on the position of surgical devices to promote clean air flow compliance and minimise infection risks. BMJ Qual Saf 2012;21:746–52.
[42] Da Costa AR, Kothari A, Bannister GC, Blom AW. Investigating bacterial growth in surgical theatres: establishing the effect of laminar airflow on bacterial growth on plastic, metal and wood surfaces. Ann R Coll Surg Engl 2008;90:417–9.
[43] British Orthopaedic Association. Helping consultants get things right. The BOA Advisory Book. London: BOA; 2014. Available at: https://www.boa.ac.uk/standards-guidance/consultant-advisory-book.html [last accessed November 2022].
[44] Bediako-Bowan A, Mølbak K, Kurtzhals J, Owusu E, Debrah S, Newman M. Risk factors for surgical site infections in abdominal surgeries in Ghana: emphasis on the impact of operating rooms door openings. Epidemiol Infect 2020;148:E147.
[45] Roth JA, Juchler F, Dangel M, Eckstein FS, Battegay M, Widmer AF. Frequent door openings during cardiac surgery are associated with increased risk for surgical site infection: a prospective observational study. Clin Infect Dis 2019;69:290–4.
[46] Birgand G, Azevedo C, Rukly S, Pissard-Gibollet R, Toupet G, Timsit JF, et al. Motion-capture system to assess intraoperative staff movements and door openings: impact on surrogates of the infectious risk in surgery. Infect Control Hosp Epidemiol 2019;40:566–73.
[47] Andersson AE, Bergh I, Karlsson J, Eriksson BI, Nilsson K. Traffic flow in the operating room: an explorative and descriptive study on air quality during orthopedic trauma implant surgery. Am J Infect Control 2012;40:750–5.
[48] Erichsen Andersson A, Petzold M, Bergh I, Karlsson J, Eriksson BI, Nilsson K. Comparison between mixed and laminar airflow systems in operating rooms and the influence of human factors: experiences from a Swedish orthopedic center. Am J Infect Control 2014;42:665–9.
[49] Perez P, Holloway J, Ehrenfeld L, Cohen S, Cunningham L, Miley GB, et al. Door openings in the operating room are associated with increased environmental contamination. Am J Infect Control 2018;46:954–6.
[50] Stauning MT, Bediako-Bowan A, Andersen LP, Opintan JA, Labi AK, Kurtzhals JAL, et al. Traffic flow and microbial air contamination in operating rooms at a major teaching hospital in Ghana. J Hosp Infect 2018;99:263–70.
[51] Taaffe K, Lee B, Ferrand Y, Fredendall L, San D, Salgado C, et al.; Realizing Improved Patient Care through Human-Centered Design in the Operating Room (RIPCHD.OR) Study Group. The influence of traffic, area location, and other factors on operating room microbial load. Infect Control Hosp Epidemiol 2018;39:391–7.
[52] Lansing SS, Moley JP, McGrath MS, Stoodley P, Chaudhari AMW, Quatman CE. High number of door openings increases the bacterial load of the operating room. Surg Infect (Larchmt) 2021;22:684–9.
[53] Ritter MA, Eitzen H, French ML, Hart JB. The operating room environment as affected by people and the surgical face mask. Clin Orthop Relat Res 1975;111:147–50.
[54] Ritter MA. Operating room environment. Clin Orthop Relat Res 1999;369:103–9.
[55] Taaffe KM, Allen RW, Fredendall LD, Shehan M, Stachnik MG, Smith T, et al. Simulating the effects of operating room staff movement and door opening policies on microbial load. Infect Control Hosp Epidemiol 2021;42:1071–5.

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[56] Smith EB, Raphael IJ, Maltenfort MG, Honsawek S, Dolan K, Younkins EA. The effect of laminar air flow and door openings on operating room contamination. J Arthroplasty 2013;28:1482–5.
[57] Rovaldi CJ, King PJ. The effect of an interdisciplinary QI project to reduce OR foot traffic. AORN J 2015;101:666–78; quiz 679–81.
[58] Stein DT, Pankovich-Wargula AL. The dilemma of the wedding band. Orthopedics 2009;32:86.
[59] Al-Allak A, Sarasin S, Key S, Morris-Stiff G. Wedding rings are not a significant source of bacterial contamination following surgical scrubbing. Ann R Coll Surg Engl 2008;90:133–5.
[60] Field EA, McGowan P, Pearce PK, Martin MV. Rings and watches: should they be removed prior to operative dental procedures? J Dent 1996;24:65–9.
[61] Kelsall NK, Griggs RK, Bowker KE, Bannister GC. Should finger rings be removed prior to scrubbing for theatre? J Hosp Infect 2006;62:450–2.
[62] Waterman TR, Smeak DD, Kowalski J, Hade EM. Comparison of bacterial counts in glove juice of surgeons wearing smooth band rings versus those without rings. Am J Infect Control 2006;34:421–5.
[63] Nicolai P, Aldam CH, Allen PW. Increased awareness of glove perforation in major joint replacement. A prospective, randomised study of Regent Biogel Reveal gloves. J Bone Joint Surg Br 1997;79:371–3.
[64] Bartlett GE, Pollard TC, Bowker KE, Bannister GC. Effect of jewellery on surface bacterial counts of operating theatres. J Hosp Infect 2002;52:68–70.
[65] Jepson AP, McDougall C, Clark A, Bateman A, Williamson G, Kaufmann ME. Finger rings should be removed prior to scrubbing. J Hosp Infect 2006;64:197–8.
[66] Wynd CA, Samstag D, Lapp AM. Bacterial carriage on the fingernails of OR nurses. AORN J 1994;60:796–805.
[67] Hardy JM, Owen TJ, Martinez SA, Jones LP, Davis MA. The effect of nail characteristics on surface bacterial counts of surgical personnel before and after scrubbing. Vet Surg 2017;46:952–61.
[68] Edel E, Houston S, Kennedy V, LaRocco M. Impact of a 5-minute scrub on the microbial flora found on artificial, polished, or natural fingernails of operating room personnel. Nurs Res 1998;47:54–9.
[69] Tank DY, Celik S. Effect of use of nail polish on bacterial colonization after surgical handwashing in operating room nurses: a preliminary study. Cukurova Med J 2018;43:698–705.
[70] Parry MF, Grant B, Yukna M, Adler-Klein D, McLeod GX, Taddonio R, et al. Candida osteomyelitis and diskitis after spinal surgery: an outbreak that implicates artificial nail use. Clin Infect Dis 2001;32:352–7.
[71] Gordon RJ, Bannister GC, Bowker KE, Mason AC, Cheung LL, Eames R. Headwear in laminar flow operating theatres. J Hosp Infect 2009;73:289–91.
[72] Hubble MJ, Weale AE, Perez JV, Bowker KE, MacGowan AP, Bannister GC. Clothing in laminar-flow operating theatres. J Hosp Infect 1996;32:1–7.
[73] Humphreys H, Russell AJ, Marshall RJ, Ricketts VE, Reeves DS. The effect of surgical theatre head-gear on air bacterial counts. J Hosp Infect 1991;19:175–80.
[74] Kothari SN, Anderson MJ, Borgert AJ, Kallies KJ, Kowalski TJ. Bouffant vs skull cap and impact on surgical site infection: does operating room headwear really matter? J Am Coll Surg 2018;227:198–202.
[75] Rios-Diaz AJ, Chevrollier G, Witmer H, Schleider C, Cowan S, Pucci MJ, et al. The art and science of surgery: do the data support the banning of surgical skull caps? Surgery 2018;164:921–5.
[76] Shallwani H, Shakir HJ, Aldridge AM, Donovan MT, Levy EI, Gibbons KJ. Mandatory change from surgical skull caps to bouffant caps among operating room personnel does not reduce surgical site infections in class I surgical cases: a single-center experience with more than 15 000 patients. Neurosurgery 2018;82:548–54.
[77] Wills BW, Smith WR, Arguello AM, McGwin G, Ghanem ES, Ponce BA. Association of surgical jacket and bouffant use with surgical site infection risk. JAMA Surg 2020;155:323–8.
[78] Farach SM, Kelly KN, Farkas RL, Ruan DT, Matroniano A, Linehan DC, et al. Have recent modifications of operating room attire policies decreased surgical site infections? An American College of Surgeons NSQIP review of 6,517 patients. J Am Coll Surg 2018;226:804–13.
[79] Kuritzkes BA, Cao Y, Baser O, Thomas N, Forde KA, Kiran RP. New barrier attire regulations in the operating room: a mandate without basis? Am J Surg 2019;218:447–51.
[80] Markel TA, Gormley T, Greeley D, Ostojic J, Wise A, Rajala J, et al. Hats off: a study of different operating room headgear assessed by environmental quality indicators. J Am Coll Surg 2017;225:573–81.
[81] Tunevall TG. Postoperative wound infections and surgical face masks: a controlled study. World J Surg 1991;15:383–7; discussion 387–8.
[82] Webster J, Croger S, Lister C, Doidge M, Terry MJ, Jones I. Use of face masks by non-scrubbed operating room staff: a randomized controlled trial. ANZ J Surg 2010;80:169–73.
[83] Chamberlain GV, Houang E. Trial of the use of masks in the gynaecological operating theatre. Ann R Coll Surg Engl 1984;66:432–3.
[84] Rao GG, Harman J, Pollard R. Face masks and postoperative infection. J Hosp Infect 1992;20:55–7.
[85] Singh B, Wani AA, Malik A. Myth breaker about surgical face mask. JK Pract 2000;7:129e30.
[86] McGinn FP, Farrands P, Davis T. Trial of the use of masks in the gynaecological operating theatre. Ann R Coll Surg Engl 1985;67:211.
[87] Orr NW. Is a mask necessary in the operating theatre? Ann R Coll Surg Engl 1981;63:390–2.
[88] Kamalarajah S, Ling R, Silvestri G, Sharma NK, Cole MD, Cran G, et al. Presumed infectious endophthalmitis following cataract surgery in the UK: a case–control study of risk factors. Eye 2007;21:580e6.
[89] Wright JE, Henniessy EJ, Bissett RL. Wound infection: experience with 12,000 sutured surgical wounds in a general hospital over a period of 11 years. Aust NZ J Surg 1968;41:107e12.
[90] Gaillard T, Gaillard C, Martinaud C, Védy S, Pons S, Brisou P. Epidemic surgical site infections attributable to incorrect use of face masks. J Hosp Infect 2009;71:192–3.
[91] Alwitry A, Jackson E, Chen H, Holden R. The use of surgical facemasks during cataract surgery: is it necessary? Br J Ophthalmol 2002;86:975–7.
[92] Berger SA, Kramer M, Nagar H, Finkelstein A, Frimmerman A, Miller HI. Effect of surgical mask position on bacterial contamination of the operative field. J Hosp Infect 1993;23:51–4.
[93] Graham D, Parkinson B, Evans M, Keijzers G, Derrington P. Nothing to sneeze at! A study into intra-operative contamination. Aust NZ J Surg 2009;79:909–12.
[94] O'Kelly SW, Marsh D. Face masks and spinal anaesthesia. Br J Anaesth 1993;70:239.
[95] Philips BJ, Fergusson S, Armstrong P, Anderson FM, Wildsmith JA. Surgical face masks are effective in reducing bacterial contamination caused by dispersal from the upper airway. Br J Anaesth 1992;69:407–8.
[96] Mitchell NJ, Hunt S. Surgical face masks in modern operating rooms – a costly and unnecessary ritual? J Hosp Infect 1991;18:239–42.
[97] Joseph M, Permain M, Hodgkinson PD. A preliminary evaluation of surgical field contamination risk from surgeon's oro-nasopharyngeal commensal organisms while using reusable FFP3 respirator masks and power hoods with relevance to the COVID

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19 pandemic — a pilot study. J Plast Reconstr Aesthet Surg 2022;75:1261—82.
[98] Friberg B, Friberg S, Ostensson R, Burman LG. Surgical area contamination — comparable bacterial counts using disposable head and mask and helmet aspirator system, but dramatic increase upon omission of head-gear: an experimental study in horizontal laminar air-flow. J Hosp Infect 2001;47:110—5.
[99] Berríos-Torres SI, Umscheid CA, Bratzler DW, Leas B, Stone EC, Kelz RR, et al. Centers for Disease Control and Prevention guideline for the prevention of surgical site infection 2017. JAMA Surg 2017;152:784—91.
[100] Copp G, Mailhot CB, Zalar M, Slezak L, Copp AJ. Covergowns and the control of operating room contamination. Nurs Res 1986;35:263—8.
[101] Mailhot CB, Slezak LG, Copp G, Binger JL. Cover gowns. Researching their effectiveness. AORN J 1987;46:482—90.
[102] Hee HI, Lee S, Chia SN, Lu QS, Liew APQ, Ng A. Bacterial contamination of surgical suits worn outside the operating theatre: a randomised crossover study. Anaesthesia 2014;69:816—25.
[103] Kaplan C, Mendiola R, Ndjatou V, Chapnick E, Minkoff H. The role of covering gowns in reducing rates of bacterial contamination of scrub suits. Am J Obstet Gynaecol 2003;188:1154—5.
[104] Sivanandan I, Bowker KE, Bannister GC, Soar J. Reducing the risk of surgical site infection — a case control study of contamination of theatre clothing. J Periop Pract 2011;21:69—72.
[105] Humphreys H, Bak A, Mugglestone MA, Pinkney TD, Skelton L, Vos MC, et al. Operating theatre attire (scrub suits) worn outside the operating theatre: infection risk or not? J Hosp Infect 2021;108:209—11.

Please cite this article as: Humphreys H et al., Rituals and behaviours in the operating theatre — joint guidelines of the Healthcare Infection Society and the European Society of Clinical Microbiology and Infectious Diseases, Journal of Hospital Infection, https://doi.org/10.1016/j.jhin.2023.06.009