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

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.

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Authors' contribution:

All authors except AB/GM and MS provided advice and contributed to writing; AB/HL/GM/MS/JW conducted searches, evidence syntheses, and contributed to writing.

"NICE has accredited the process used by the Healthcare Infection Society to produce: 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." The NICE accreditation of HIS methodology is valid for five years from March 2020. More information on accreditation can be viewed at http://www.nice.org.uk/about/what-we-do/accreditation"

1. Executive summary

Meticillin-resistant *Staphylococcus aureus* (MRSA) infections remain a serious cause of healthcare-associated infection (HCAI) in many countries. MRSA is easily spread by multiple routes and can persist in the environment for long periods. In health and care settings, transmission via staff hands remains the most important route for patient MRSA acquisition. Infection prevention and control (IPC) measures and control of the use of antimicrobials are effective in reducing prevalence of MRSA. There have been many publications related to MRSA since the last guideline was published in 2006 and this update contains further measures that are clinically effective for preventing transmission when used by healthcare workers.

Methods for systematic review were in accordance with National Institute for Health and Care Excellence (NICE) approved methodology and critical appraisal followed Scottish Intercollegiate Guidelines Network (SIGN) and other standard checklists. Articles published between 2004 and February 2021 were included. Questions for review were derived from a stakeholder meeting, which included patient representatives in accordance with the Population Intervention Comparison Outcome (PICO) framework. Recommendations are made in the following areas: screening, management of colonised healthcare staff, environmental screening and cleaning/disinfection, surveillance, IPC precautions (including isolation and movement of patients and equipment), and patient information.

Table I: *Summary of the changes to the recommendations from previous guidelines*

Please see the separate document

2. Lay summary

‘MRSA’ stands for meticillin-resistant *Staphylococcus aureus*, which is a type of bacteria that can cause infection. Infection with MRSA mainly occurs in people who are already ill and can occur wherever care is given. This can be in hospital or in the community such as in residential or nursing care homes or in your own home. Treating MRSA is difficult because the bugs are resistant to some types of antibiotics (penicillins) that would often be used to fight *Staphylococcus aureus*. This means these types of antibiotics will not work for MRSA infections.

The good news is that the number of MRSA infections in the UK has fallen since 2008, but it does still remain a problem. This guideline is intended to help doctors and other health and social care staff to try and prevent patients from getting MRSA and becoming ill. It may also be of use to patients who already have MRSA, those who care for them (relatives, care staff, etc.) and the general public, by helping them to understand which things work and which do not work to prevent MRSA in hospitals and other care settings.

The guideline contains an explanation, scientific evidence, and a glossary of terms to make it easy to read and use (Supplementary Materials A).

3. Introduction

Infections due to meticillin-resistant *Staphylococcus aureus* (MRSA, also referred to as methicillin-resistant *Staphylococcus aureus*) have decreased significantly in the UK and elsewhere but they continue to cause significant morbidity and mortality. Hence, infection prevention and control (IPC) measures remain essential.

There has been significant progress in recent years in managing MRSA in healthcare settings. Despite these advances the control of MRSA remains demanding, and should be based on the best available evidence to ensure the appropriate use of healthcare resources. This document is an update of the previously published recommendations for the IPC of MRSA in healthcare facilities.

A Joint Working Party of the Healthcare Infection Society (HIS) and the Infection Prevention Society (IPS) has updated the previous guidelines and has prepared the following recommendations to provide advice on the procedures and precautions needed to prevent the spread of MRSA. This includes recommendations on patient and staff screening, patient management, testing strategies, decolonisation, reduction of environmental contamination, surveillance and feedback to minimise transmission and drive system improvement, and the information needs of patients and healthcare professionals.

The process used for the development of this updated version of the guidance was accredited by the National Institute for Health and Care Excellence (NICE). This is an important step in the evolution of the guidance and helps to ensure that users of the document have confidence in the underlying basis for the recommendations made. Although the guidance is most relevant in the UK context, the recommendations will be relevant to healthcare settings in other countries and are based upon a systematic review of UK-based and international literature.

4. Guideline Development Team

4.1 Acknowledgements

APRW was supported, in part, by the National Institute for Health Research University College London Hospitals Biomedical Research Centre. AD was supported by Public Health England (soon to become UK Health Security Agency, UKHSA).

4.2 Source of funding

There was no external funding for this work.

4.3 Disclosure of potential conflicts of interest

HH has been in receipt of research funding from Astella and Pfizer in recent years and has received a consultancy fee from Pfizer in the last three years.

APRW: Consultant on Drug Safety Monitoring Board for Roche, Advisory Board for Pfizer.

JRP received consultancy fee from Imperial College London.

DAE received consultancy fees and speaker fees from commercial organisations.

LB received consultancy fee from a commercial organisation.

All declarations of interest are available in Supplementary Materials B.

4.4 Relationship of authors with sponsor

The Healthcare Infection Society (HIS) and the Infection Prevention Society (IPS) commissioned the authors to undertake the Working Party Report. The authors are members of both societies.

4.5 Responsibility for guidelines

The views expressed in this publication are those of the authors and have been endorsed by HIS and IPS and following a four-week external consultation.

5. Working Party Report

Date of publication: XXX (published online XXX).

5.1 What is the Working Party Report?

The report is a set of recommendations covering key aspects of the IPC of MRSA in healthcare settings. The guidelines review the evidence for screening, surveillance and management of the individuals who are found to be colonised or infected with MRSA. The treatment of MRSA infections is outside of the scope of these guidelines.

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

The previous guidelines relating to this topic were published in 2006. MRSA is still an important healthcare-associated pathogen which can be controlled effectively by evidence-based IPC and quality improvement methods. There have been many publications on the subject since 2006 and new technologies have emerged. The effect of these studies on recommended practice needs to be reviewed.

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

The main purpose of these guidelines is to inform IPC practitioners about the current UK policy and best available options for preventing and controlling MRSA. This document also highlights current gaps in knowledge, which will help to direct future areas of research.

5.4 What is the scope of the guidelines?

The main scope of the guidelines is to provide advice for the optimal provision of an effective and safe healthcare service while reducing the risk of MRSA transmission in healthcare settings. The guidelines are suitable for patients of all age groups. These guidelines were largely developed with hospitals in mind but may be useful in other settings where MRSA is a concern, for example long-stay units. The guidelines' main focus was the prevention of transmission to patients, thus pre- and perioperative care was not included. Antibiotic stewardship and treatment are covered in a separate publication.[2]

5.5 What is the evidence for these guidelines?

Topics for these guidelines were derived from stakeholder meetings including patient representatives and were designed in accordance with the Population Intervention Comparison Outcomes (PICO) framework (Appendix 1). To prepare these recommendations, the Working Party collectively reviewed relevant evidence from peer-reviewed journals subject to validated appraisal. Methods, which were in accordance with NICE methodology for developing guidelines, are described fully below.

5.6 Who developed these guidelines?

The Working Party included infectious diseases/microbiology clinicians, IPC experts, systematic reviewers, and two lay member representatives.

5.7 Who are these guidelines for?

Any healthcare practitioner may use these guidelines and adapt them for their use. It is anticipated that users will include clinical staff and, in particular, IPC teams. These guidelines aim to provide recommendations for all health and care settings and to include available evidence for all settings where MRSA is a concern. However, the available reported studies were predominantly conducted in hospital settings. The Working Party believes that while many sections of these guidelines are particularly relevant to hospitals, some evidence and recommendations can be extrapolated to other health and social care settings (e.g. the sections on environment and equipment decontamination, use of personal protective equipment (PPE), transfer of patients and patient information).

5.8 How are the guidelines structured?

Each section comprises an introduction, a summary of the evidence with levels (known as evidence statements), and a recommendation graded according to the available evidence.

5.9 How frequently are the guidelines reviewed and updated?

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

5.10 Aim

The primary aim of these guidelines is to assess the current evidence for all aspects relating to the IPC of MRSA. A secondary aim is to identify those areas in particular need of further research to inform future MRSA guidelines.

6. Implementation of these guidelines

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

Primarily, these guidelines will inform the development of local protocols for preventing MRSA transmission and managing patients colonised or infected with MRSA. They also provide a framework for clinical audit, which will aid in improving clinical effectiveness. In addition, the future research priorities identified by the Working Party will allow researchers to refine applications to funding bodies.

6.2 How much will it cost to implement these guidelines?

Provided that existing practice follows current recommendations, it is not expected that significant additional costs would be generated by the recommendations in this document. However, failure to follow best practice, for example by not screening in a population with high prevalence, the hospital should expect to incur higher costs due to MRSA infections.

6.3 Summary of audit measures

Regular audit remains an important part of any guideline implementation. Audit is effective only when the results are fed back to staff and when there is a clear plan for the implementation of improvements. Many NHS Trusts also require that the results of audits and interventions are reported through clinical governance structures and to Hospital IPC Committees to help reduce the MRSA burden. The MRSA Working Party suggests the following aspects of patient care to be audited:

- Compliance with screening protocol.
- Compliance with decolonisation regimens.
- Compliance with prescribed isolation precautions.
- Cleaning/disinfection standards.
- Antimicrobial Stewardship (please refer to recent MRSA treatment guidelines[2]).
- Emergence of resistance, especially to mupirocin and chlorhexidine (CHG), if used extensively.
- IPC practices, e.g. hand hygiene, aseptic technique.
- Compliance with informing the receiving ward/unit/care home and the ambulance/ transport service that patient is colonised/infected with MRSA.

6.4 Supplementary tools

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

7. Methodology

7.1 Evidence appraisal

Topics for these guidelines were derived from stakeholder meetings including patient representatives. To prepare these recommendations, the Working Party collectively reviewed relevant evidence from published, peer-reviewed journals. Methods were in accordance with NICE-approved methodology for developing guidelines (Supplementary Materials B).

7.2 Data sources and search strategy

Three electronic databases (Medline, CINAHL/EMCare and EMBASE) were searched for articles published between July 2004 and February 2021. The searches were restricted to English language studies, non-animal studies and non-in vitro studies. Search terms were constructed using relevant MeSH and free text terms (provided in appendices for each question cluster). The reference lists of identified systematic reviews, guidelines and included papers were scanned for additional studies. Search strategies and the results are available in Appendix 1.

7.3 Study eligibility and selection criteria

Search results were downloaded to Endnote database and screened for relevance. Two reviewers (MS, AM, AB, GM, JW or HL) independently reviewed the title and abstracts. Disagreements were addressed by a third reviewer. Two reviewers (MS, AM, AB, GM, JW or HL) independently reviewed full texts. If there were disagreements, these were first discussed between the two reviewers and if a consensus was not reached, a third reviewer was consulted. The guidelines included any controlled trials, cohort studies, interrupted time series (ITS) studies, case-control studies, diagnostic accuracy studies (DAS) and controlled before/after (CBA) studies. Due to the limited number of studies available, uncontrolled before/after (UBA) studies were included and described narratively. These were not used to make recommendations but were included to inform the Working Party of the additional evidence that existed. Similarly, data from mathematical model studies and excluded studies which provided additional evidence were included for each section but were not used when making recommendations. Results of study selection are available in Appendix 2.

7.4 Data extraction and quality assessment

Data collection and synthesis for these guidelines started before the NICE update for guideline methodology was published in 2018. Prior to this update, some studies were assessed using the quality assessment tools previously recommended. To ensure consistency, it was decided that the same checklists would be used for the remaining studies. For the type of studies where previous methodology did not recommend the specific checklists, they were assessed using the checklists recommended in the updated methodology. The quality checklists included:

Controlled trials (Randomised Controlled Trials (RCT) and non-Randomised Controlled Trials (n-RCT)): SIGN Methodology Checklist 2: Controlled Trials.

Cohort studies: SIGN Methodology Checklist 3: Cohort Studies.

Interrupted time series (ITS): Cochrane Effective Practice and Organisation of Care (EPOC) Risk of bias for interrupted time series studies.

Case-controlled studies: SIGN Methodology Checklist 4: Case-control studies.

Controlled before/after (CBA) studies: EPOC Risk of Bias (RoB) Tool (for studies with a control group).

Uncontrolled before/after (UBA) studies: Joanna Briggs Institute (JBI) Critical Appraisal Checklist for Quasi-Experimental Studies (non-randomized experimental studies).

Diagnostic accuracy studies (DAS): SIGN Methodology Checklist 5: Studies of Diagnostic Accuracy

Studies were appraised independently by two reviewers (MS, AM, AB, GM, JW or HL) and any disagreements were resolved through discussion. Results of quality appraisal are available in Appendix 3.

Data were extracted by one reviewer and checked/corrected by another. For each question cluster the data from the included studies were extracted to create the tables of study description, data extraction and summary of findings tables (Appendix 4). The list of the studies rejected at full text stage with a reason for this decision, is included in the excluded study tables. Due to limited evidence, most of the data were described narratively. Where meta-analysis was possible, this was conducted in Review Manager 5.3 software for systematic reviews. This software only allows the entry for dichotomous data; it was not suitable for meta-analysis for decolonisation where a range of different decolonisation therapies were used. For this, the analyses were calculated manually, with sample proportion and confidence intervals [CI95%] obtained using the Wilson score interval (epitools.ausvet.com.au). For the therapies which showed a significant benefit, the risk ratios were calculated using MedCalc software (medcalc.net).

7.5 Rating of evidence and recommendations

For each outcome of the review question the certainty/confidence in the findings was established using considered judgment forms. The evidence was considered and judged using the following ratings: high, moderate, low, and very low, based on the characteristics of the studies included in evidence tables.

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 other economic concerns?

Can the recommended interventions be feasibly put into practice?

The wording of the evidence statements and the recommendations reflected the strength of the evidence and its classification. The following criteria were used:

'offer', 'measure', 'advise', 'refer', 'use' or similar wording was used if the Working Party believed that most practitioners/commissioners/service users would choose an intervention if they were presented with the same evidence: this usually means that the benefits outweigh harms, and that the intervention is cost-effective. This reflects a strong recommendation for the intervention. If there is a legal duty, or if not following a recommendation may have serious consequences, the word 'must' was used.

'do not offer' or similar wording was used if the Working Party believed that harms outweigh the benefits or if an intervention is not likely to be cost-effective. This reflects a strong recommendation against the intervention. If there is a legal duty, or if not following a recommendation may have serious consequences, the words 'must not' were used.

'consider' was used if the Working Party believed that the evidence did not support a strong recommendation, but that the intervention may be beneficial in some circumstances. This reflected a conditional recommendation for the intervention.

The 'do not offer, unless…' recommendation was made if the Working Party believed that the evidence did not support the strong recommendation, and that the intervention was likely not to be beneficial, but could be used in some circumstances, for instance if no other options were available. This reflected a conditional recommendation against the intervention.

7.6 Consultation process

Feedback on draft guidelines was received from the HIS Guideline Committee, and final changes made. These guidelines were then opened to consultation with relevant stakeholders (Supplementary Materials E). The draft report was available on the HIS website for four weeks. Views were invited on format, content, local applicability, patient acceptability, and recommendations. The Working Party reviewed stakeholder comments, and collectively agreed revisions.

8. Rationale for recommendations

8.1 What is the clinical and cost-effectiveness of universal versus targeted screening in minimising the transmission of MRSA?

While in certain instances screening is implemented for every patient entering the healthcare unit, it is not in the current UK NICE guidelines for healthcare facilities to implement universal screening. Screening is completed largely for some pre-operative patients or other high-risk

patients, such as those entering the intensive care unit (ICU). Despite this, there is disagreement in the literature about the clinical effectiveness of targeted screening in preventing the transmission of MRSA. Moreover, there is a debate about the cost-effectiveness of universal screening. The effectiveness of universal versus targeted screening was not assessed in previous MRSA guidelines,[1] although the recommendation endorsed the use of a targeted approach.

There was weak evidence of no benefit from one ITS[3] which investigated the incidence of MRSA acquisition in all patients, excluding new-borns, admitted to hospital with the use of universal screening (n=61,782) as compared to targeted screening (n=76,273). The study found no significant difference in the incidence of MRSA acquisition in patients screened universally (47.5/100,000) as compared to those when a targeted approach was in use (41.8/100,000; p=0.923).

There was weak evidence of no benefit from one ITS study[3] and one CBA study[4] which investigated the incidence of MRSA infection in patients admitted to hospital with the use of universal screening as compared to targeted screening. One study[3] of all patients, excluding new-borns, admitted to hospital found no significant difference in the incidence of MRSA bloodstream infection (BSI) in patients screened universally (1.8/1000pd (patient days) n=61,782), as compared to those when a targeted approach was in use (2.1/1000pd n=76,273; p value not reported). Another study[4] of adult patients admitted to hospital for at least 24 hours with universal screening (n=61,782) compared to targeted screening (n=76,273) found that the rate of healthcare-associated MRSA infection (HCAI-MRSA) did not fall significantly (0.27% before versus 0.15% after the switch to universal screening), while the rate in the control hospital remained the same throughout the study period (0.10%, p=0.34).

There was weak evidence of no benefit from one CBA study[4] which investigated the cost saving from a reduced incidence of healthcare-associated MRSA acquisition per each additional dollar spent on screening in adult patients admitted to hospital for at least 24 hours with the use of universal screening (n=3255) as compared to targeted screening (n=2037). The study found lower cost savings when screening patients universally (USD 0.50 saved) as compared to those when targeted approach was in use (USD 1.00 saved).

The Working Party considered the evidence and concluded that the universal screening strategy had no benefit over targeted screening. The clinical experience of the Working Party suggests that universal screening may be easier and more time-effective for staff as it removes the need to perform additional assessments to determine whether patients require such screening. When a targeted approach is used, careful consideration is needed to establish which patients should be considered at risk and that local risk factors are taken into account. The Working Party concluded that for screening to be effective, it needs to be linked to a specific action that either attempts to eradicate or suppress the MRSA in the patients (decolonisation) or minimises contact with MRSA colonised patients (isolation).

Recommendations

1.1 Targeted or universal patient MRSA screening must be performed and must be linked to a specific point of action such as decolonisation or isolation (or both).

1.2 Use at least a targeted approach but consider using universal screening as appropriate depending on local facilities.

1.3 If a targeted approach is used, define risk factors for MRSA carriage as appropriate for your area.

Good Practice points

GPP 1.1 Establish documented local protocols for how swabs should be taken. The swabs should include a minimum of two sites from the following: nose, perineum, device entry sites, wounds, urine, and sputum, as appropriate depending on clinical presentation.

8.2 What is the clinical and cost-effectiveness of repeat screening people who screen negative/positive on pre-admission/admission to prevent the transmission of MRSA?

If patients screen negative at admission, repeat screening can identify whether they acquired MRSA during their stay, so that appropriate actions can be taken. On the other hand, for those who screen positive, repeat screening can show whether an MRSA patient was successfully decolonised. It is currently unclear whether repeat MRSA screening is clinically and cost-effective and how the repeat screening should be performed. Effectiveness of repeat screening was not assessed in previous MRSA guidelines[1] and no recommendation was endorsed for its use.

No evidence was found from the studies published since 2004, which met the inclusion criteria for the study design, and which assessed the benefit of repeat screening for people who screened negative or positive on pre-admission/admission screening to prevent the transmission of MRSA.

The Working Party additionally considered the evidence from the excluded studies, which reported some benefit of repeat screening and, together with the clinical experience of the group members, suggested that repeat screening could be beneficial in some circumstances.

Recommendations

2.1 Do not perform repeat MRSA screening for patients who screen positive at admission unless the patient undergoes decolonisation therapy.

2.2 If the patient undergoes decolonisation therapy, consider repeat MRSA screening two to three days following the therapy, to determine whether decolonisation was successful or not. Do not delay a surgical procedure if the patient still tests positive.

2.3 Do not perform repeat MRSA screening routinely.

2.4 Consider re-screening patients who previously screened negative if there is a significant MRSA exposure risk (e.g. contact with a confirmed MRSA case) or where there is a locally-assessed risk of late acquisition.

8.3 What is the clinical and cost-effectiveness of rapid molecular diagnostics versus culture in screening to prevent the transmission of MRSA in hospital and non-acute care settings?

During the screening process for MRSA at a hospital or healthcare setting, a swab is taken from the patient and is usually analysed in conventional culture-based assays. This may include enrichment in broth, the use of selective media or chromogenic agar. While this process is straightforward and is considered the gold-standard diagnostic method, the turnaround time (TAT) for results can be more than 48 hours. This delay may result in the patient or healthcare staff transmitting MRSA to others or acquiring MRSA. Moreover, while waiting for results and trying to prevent patients from potentially transmitting MRSA, healthcare workers may need to implement preventative measures such as isolating patients, which are costly. To receive rapid results, rapid diagnostic techniques such as the polymerase chain reaction (PCR) method have been used for screening samples to establish the presence of MRSA in the swab. These molecular techniques may require the use of commercial tests and as a result, they tend to be costlier than culture, although laboratories may develop their own in-house methods. It is currently unknown whether molecular diagnostic techniques are beneficial in clinical practice in comparison to conventional culture methods, in terms of diagnostic accuracy, TAT, transmission rates and costs. Effectiveness of these methods of screening was not assessed in previous MRSA guidelines[1] and no recommendation was endorsed for their use.

There was strong evidence of similar diagnostic accuracy from the meta-analysis of 61 studies[5-65] which investigated the diagnostic accuracy of PCR versus culture screening (n=72,952 samples). The results of meta-analysis demonstrated that the overall sensitivity was 91.54% [CI95% 90.75-92.28], specificity was 97.00% [CI95% 96.86-97.12], positive predictive value was 70.03% [CI95% 69.11-70.94] and negative predictive value was 99.33% [CI95% 99.27-99.39]. The overall accuracy of PCR compared to culture results was 96.61% [CI95% 96.47-96.74]. There were an additional nine studies, which were not included in meta-analysis, either because they did not report data on the number of positive and negative values but reported sensitivity and specificity[66-71] or were identified later in the review process.[72-74] All these studies reported results similar to those obtained from meta-analysis.

There was strong evidence of no benefit from the meta-analysis of three RCTs and one n-RCT[33,71,75,76] which investigated the incidence of MRSA colonisation when using PCR screening (n=16,773) versus culture (n=17,754). The results of meta-analysis showed that the incidence of colonisation did not decrease significantly in the PCR group (n=268, 1.51%) when compared

to culture (n=324, 1.94%, OR=0.86 [CI95% 0.73-1.01]). These results are consistent with the results of studies which reported colonisation per 1000pd or 1000pd at risk, with one RCT[75] reporting significantly lower incidence in the PCR group (2.86 versus 4.10/1000pd, p=0.002) while four other studies reported non-significant differences (0.39 versus 0.35/1000pd, p=0.39,[77] 4.4. versus 4.9/1000pd at risk, p=0.27,[33] 2.57 versus 2.83/1000pd at risk, p=0.66,[76] 4.60 versus 5.39/1000pd at risk p value not reported[71]).

There was moderate evidence of no benefit from two RCTs[33,76] which investigated the incidence of MRSA infection when using PCR screening versus culture. One study[33] found no difference in MRSA BSI in the group of patients where PCR was used (1/3553, 0.03%) compared to patients where culture was used (2/3335, 0.06%, p value not reported) and no difference in MRSA wound (included but not limited to surgical wound) infection (21/3335, 0.6% in PCR versus 22/3553, 0.7% in culture, p=0.77). Another study[76] found no significant difference in a rate of infection/1000pd in patients with PCR (5/1063, 4.06/1000pd) versus culture (2/1121, 1.57/1000pd, p=0.281).

There was strong evidence of benefit from 14 studies,[10,15,27,33,38,42,45,53,59,62,71,75-77] which investigated the TAT of PCR and culture. There was a high degree of heterogeneity as to how TAT was reported across these studies, but they consistently showed significantly decreased TAT for PCR samples. The studies showed that the time from patient admission to results being available for PCR was under 24 hours[33,71,76] and just over 24 hours for admission until isolation,[62,76] while results for culture using the same TAT were 40.4 hours or longer.[33,62,71,76] When TAT was defined as the time from the collection of the screening sample until results were available, it showed that these results could be available in less than two hours[38] and are typically available in under 24 hours for PCR.[27,59,75] The results of culture were available after 28 hours at the earliest[59] and sometimes took more than two days.[27,38,75] The studies which assessed TAT as the arrival of samples at the laboratory to results being available[15,27,42,45,53,62] reported the shortest time for PCR at 1.8 hours and the average time as eight hours, while the shortest time for culture was 24 hours and the average time longer than 40 hours.

There was strong evidence of no benefit from eight studies[10,15,33,56,62,76-78] investigating the cost of PCR versus culture. One UK study[15] reported that the cost of one screen is approximately 2.5 times more when using PCR than culture (£4.29 versus £1.71, total cost £14,328.60 versus £5711.40 for a total sample of 3340). Another study[10] estimated this cost to be higher: USD 6.71 and USD 7.52 (approx. £5.17 and £5.79) for culture (negative and positive result, respectively) and USD 25.50 (approx. £19.60) for PCR. This study, besides the cost of materials necessary for screening, considered the cost of staff required to process the samples (1.5-2min for culture and 5-9min for PCR per sample). Other studies reported 4-5 times higher screening costs compared to culture, although it is not possible to determine what was included in the estimation of the costs.[56,78] Two studies did not report data on the cost of culture but reported that screening with PCR required an additional €4.961 (approx.

£4.27)[76] and €56.22/€69.62 (approx. £48.45/£59.99)[62] depending on the assay. Three studies reported[33,62,78] a potential cost saving when screening with PCR. One of these studies[78] of 232 participants reported that while the PCR screening cost itself was higher (additional CHF104,328.00, approx. £80,332.56 for universal screening and CHF11,988.00 approx. £9,230.76 for targeted screening), there is potential for reducing the costs of pre-emptive isolation by CHF38,528.00, approx. £29,666.56. Hence, while the net cost of universal isolation was still higher (CHF91,509.00, approx. £70,461.93), the targeted screening reduced the net costs by CHF14,186.00 (approx. £10,923.22). Another study,[62] using targeted screening reported a reduction in the daily cost of isolation as €95.77 (approx. £73.74) and €125.43 (approx. £96.58) when using two PCR screening methods compared to culture. One study,[33] which used a universal screening approach reported that PCR screening reduced the number of inappropriately used isolation days from 399 to 277. While the authors did not report the cost analysis, they suggested that there was a potential to counterbalance the cost of PCR screening with the benefit from reducing the number of isolation days. Last study[77] reported that the total cost of screening with PCR was more expensive (CAN 3,656.92, approx. £2,281.92) than culture methods (CAN 2,937.06, approx. £1,832.73), although they did not report any information on how this cost was estimated.

Further evidence came from UBA studies, three of which reported a decrease in the incidence of MRSA acquisition when PCR screening was introduced,[79-81] and four of which reported a decrease in reducing TAT.[11,79,81-83]

There was strong evidence from a total of 45 studies,[5,7-11,13,14,16,17,19,22-24,27,29-32,35,37-41,43,45,47-51,53,57,58-61,62,64,65,67,69,72,73,78,84] which reported the occurrence of PCR inhibition rates. This is important because sometimes these can be mistaken for negative results. Overall, the inhibition rate was 2.98% [CI95% 2.80-3.17], although one study[73] which used a Point-of-Care Testing device, reported the inhibition rates as high as 8.1%.

The Working Party considered the evidence and concluded that diagnostic accuracy of PCR is similar to culture and there is a benefit in obtaining results in a shorter time. However, these benefits do not translate into clinical benefit of reducing the incidence of MRSA acquisition or infection and PCR screening may incur higher cost.

Recommendation

3.1 Use either PCR or traditional culture methods for MRSA screening as you consider appropriate depending on the local laboratory facilities.

Good practice point

GPP 3.1 If using PCR methods, maintain access to culture methodology for specific circumstances such as outbreak investigation or sensitivity testing, and to support molecular technologies.

8.4 What is the clinical and cost-effectiveness of screening staff to prevent the transmission of MRSA?

Members of staff in healthcare settings are not routinely screened for MRSA. Usually, they will undergo screening if an MRSA outbreak persists, staff are suspected to be carriers or when the source of the outbreak is unclear. MRSA can be traced back to staff if the strain of MRSA is the same as in patients. Screening under these three circumstances is the most common approach to staff screening, but there are some who argue that screening should be expanded, although the clinical and cost-effectiveness of this approach is not established. Our previous MRSA guidelines[1] did not recommend routine screening of staff, but the Working Party considered that it could be valuable under certain circumstances (e.g. when transmission of MRSA continues despite implementing preventative measures and epidemiological data suggest staff carriage).

No evidence was found in studies published since 2004 which met the inclusion criteria for the study design, and which assessed the benefit of performing staff screening on any patient-related outcomes.

There was weak evidence from one UBA study[85] which assessed the benefit of performing staff screening on the prevalence of staff MRSA carriage. The authors reported that a total of 27/566 (4.77%) of the staff were colonised with MRSA at their first screening, while 14/445 (3.15%) of staff were colonised at least once at subsequent screenings. While it is not possible to directly compare the before/after prevalence (some staff were screened more than once at subsequent screenings), the authors reported that 9/201 (4.48%) staff were colonised in 2005 and the prevalence from 2006-2008 was 12/207 (5.80%), 11/237 (4.64%) and 7/186 (3.76%) respectively. This suggests that overall, the prevalence did not change. The authors reported that for the staff who were screened more than once (n=221) and were given the decolonisation treatment following the positive screen, the colonisation rate dropped for this group from 5.88% to 2.71% (p=0.55) and the odds ratio of being colonised at second screen was 0.45 (CI95% not reported) compared to the first screen. It is not possible to determine whether the staff were subsequently recolonised at the follow-up screenings.

The Working Party considered the evidence from the excluded studies, which did not meet the inclusion criteria for study design and reported no benefit in routine staff screening, and together with the clinical experience of the Working Party members, concluded that staff screening is not beneficial except in certain circumstances described above.

Recommendations

4.1 Do not routinely screen staff for MRSA.

4.2 Consider screening staff for MRSA if there is an epidemiological reason for suspecting a staff member as a source of MRSA, e.g. if transmission continues on a unit despite active control measures, if epidemiological aspects of an outbreak are unusual, or if they suggest persistent MRSA carriage by staff.

Good practice points

GPP 4.1 Screen staff at the beginning of their shift to avoid mistaking transient carriage for persistent carriage. Appropriate sampling sites for staff screening include anterior nares and any areas of abnormal or broken skin.

GPP 4.2 For staff who test positive, consider additionally screening throat, hairline, and groin/perineum as these if positive, increase the risk of shedding into the environment and transmission.

GPP 4.3 If possible, involve the Occupational Health Team in the process of staff screening and management.

8.5 What approaches to the management of healthcare staff who are colonised with MRSA are most practical and effective at minimising the risk to patients?

If a member of staff tests positive for MRSA, the hospital is required to comply with appropriate governance to ensure that the risk of acquisition, and potentially infection, is minimised among the patients. This includes sending staff home, reducing their interaction with patients or treatment with topical antimicrobials. The cost-effectiveness and clinical benefit of these management strategies have not been established. Effectiveness of managing staff who screen positive for MRSA was not assessed in previous MRSA guidelines,[1] although the Working Party recommended developing local protocols which assess the individual staff member's risk of transmission to patients when agreeing their continuation or return to work. It was recommended that only staff members with colonised or infected hand lesions should be off work while receiving courses of decolonisation therapy, but this decision should be based on local risk assessments. To aid staffing resources, it was recommended to temporarily re-allocate staff carriers to low-risk tasks or to non-patient contact activities. The management of staff with nasal carriage was not included in previous guidelines.

No evidence was found in the studies published since 2004 which met the inclusion criteria for the study design and, which assessed the management of staff who tested positive for MRSA carriage.

The Working Party considered previous recommendations from MRSA guidelines and, together with the clinical experience of the members, suggested that staff who are identified

as MRSA positive may need a course of decolonisation therapy and sometimes may need to be excluded from clinical areas.

Recommendations

5.1 Consider excluding staff from work, reducing their interaction with patients, or offering decolonisation therapy as deemed appropriate.

5.2 Consider investigating the risk factors for staff MRSA carriage. Investigate staff members with persistent carriage in a multi-disciplinary setting to determine any associated factors.

Good practice points

GPP 5.1 For staff members with nasal carriage only: offer decolonisation therapy, exclusion is not required. For staff with infected lesion/skin rash: offer decolonisation therapy AND carry out a risk assessment to consider re-deploying them to low-risk areas or excluding them from work.

GPP 5.2 Develop local policies to guide the decision of when staff should be excluded from work and when they should return, taking into consideration the individual's risk of transmission to patients (e.g. a staff member colonised with MRSA who is working in an ICU or neonatal unit represents a greater potential risk to patients than a staff member with MRSA working in an outpatients' department).

8.6 What is the evidence that topical decolonisation therapy is clinically and cost-effective in minimising the transmission or eradication of MRSA? What is the evidence that the selected strategy for topical decolonisation results in resistance?

The most common topical decolonisation therapy offered to patients and staff is CHG and mupirocin, either as combination or alone. There is some disagreement in the literature over the clinical effectiveness of topical decolonisation in preventing MRSA colonisation or its eradication. It is generally acknowledged that complete eradication is not always possible, but a temporary suppression may be sufficient in some circumstances (e.g. prior to surgery). Moreover, there are risks that overuse of topical decolonisation therapies leads to resistance. This has led some healthcare facilities to implement other interventions such as putting patients in single rooms to prevent transmission to others. There is a need to understand clearly the clinical and cost-effectiveness as well as antimicrobial resistance risks of different decolonisation (defined here as a therapy which aims to eradicate or temporarily suppress the MRSA growth) therapies compared to the best standard of care, including those from no decolonisation therapy. Previous MRSA guidelines[1] recommended prophylactic use of mupirocin in conjunction with CHG for patients undergoing some operative procedures. This

was also recommended in outbreak situations. Throat decolonisation with systemic therapy was recommended only on the advice of the consultant microbiologist and was recommended in conjunction with nasal and skin decolonisation therapy with mupirocin and CHG. Skin decolonisation was recommended for pre-operative patients who were found positive for the carriage of MRSA. Skin decolonisation with 4% CHG wash, 7.5% povidone-iodine (PVP) or 2% triclosan was recommended.

Chlorhexidine (CHG)

There was strong evidence of benefit from twelve RCTs,[86-98] four controlled trials,[99-102] eleven ITS studies,[103-113] two retrospective cohort studies[114,115] and one CBA study[116] which investigated the effectiveness of CHG washing on the prevalence of MRSA colonisation, incidence of MRSA acquisition, incidence of MRSA infection and the eradication of MRSA. The results of the meta-analyses showed that decolonisation therapy with CHG, either alone or in combination with another agent (PVP, polysporin or mupirocin), was consistently better than the comparison group (either no decolonisation or placebo) for all outcomes, except for incidence of MRSA acquisition when CHG was used alone. When CHG was used alone, the prevalence of MRSA was 2.1% in CHG group versus 25.5% in control group ($p<0.001$), the incidence of MRSA acquisition was 3.55% versus 3.04% ($p<0.0001$), the incidence of MRSA acquisition/1000pd was 2.35 versus 3.10, p=0051, incidence of infection was 1.11% versus 1.49%, p=0.0361 and the incidence of infection per 1000pd was 0.22 versus 0.46, $p<0.0001$. When CHG was used alone or in combination with another therapy (PVP or mupirocin), the prevalence of MRSA was 5.3% versus 25.5%, $p<0.0001$, the incidence of MRSA acquisition was 1.57% versus 3.04%, $p<0.0001$, the incidence of acquisition per 1000pd was 0.89 versus 3.10, the incidence of infection was 1.11% versus 1.49%, p=0.0361, the incidence of infection per 1000pd was 0.08 versus 0.46, $p<0.0001$ and the rate of MRSA eradication was 60.5% versus 34.5%, $p<0.0001$, thus showing that CHG performs better when used in combination with nasal decolonisation therapy. The results remained significant when stratified by different types of setting (e.g. surgical, ICU, general ward) or when using a selective (only for MRSA positive patients) or universal (blanket) approaches, although there was large heterogeneity in the reported results between the individual studies. Additional evidence from the studies which provided data not compatible for entry into metanalysis, did not show a significant benefit of using CHG. One small ITS,[112] which used nasal mupirocin and 4% CHG wipes for patients colonised with MRSA in neonatal ICU did not report a significant decrease in the incidence of MRSA acquisition in the intervention period in comparison to pre-intervention (2.00 versus 2.38 events/1000pd, IRR=1.85 (incidence rate ratio) [CI95% 0.80–1.73], p=NR). An RCT[98] conducted in adult ICU patients with a treatment group receiving a daily 4% CHG wash and a control group receiving a daily soap and water wash reported no significant decrease in the incidence of HCAI-MRSA (2/226, 0.9% or 1.08/1000pd versus 6/223, 2.7% or 3.80/1000pd, RR=0.33, [CI95% 0.07-1.61], p=0.1704). Considering the small sample sizes, these two studies were likely underpowered, resulting in type I error. Further evidence came from eighteen UBA studies[117-134] which used CHG either in combination or alone. These other

studies showed heterogenous results with 11 studies reporting a benefit[118,120-124,128,130-132,134] and seven reporting no significant change.[117,119,125-127,129,133]

There was inconsistent evidence from two RCTs[86,95] which assessed the effectiveness of CHG mouth rinse on the presence of MRSA in the oral cavity in patients admitted to ICUs. One study reported no effect of CHG on the presence of MRSA in dental plaque,[86] while another found a significantly lower prevalence of MRSA in both dental plaque (15.2 versus 37.3%, p=0.006) and oral mucosa (18.6 versus 39.7%, p=0.011).[95] The difference may be explained by the differences in CHG concentrations with 0.2% and 2% used, respectively. A small study assessing the effectiveness of CHG on the incidence of MRSA acquisition in patients with a peritoneal catheter found a benefit, although the sample size was too small to show a significant effect.[96]

There was strong evidence from the meta-analysis of five studies[97,102,105,108,132] and one narratively-described cross-sectional study[135] which investigated resistance to CHG. Meta-analysis showed a high proportion of isolates which were resistant to CHG in the group of patients with CHG bathing, although the rates were still high (27.7%) in the comparison group where CHG was not used. The use of CHG significantly increased the incidence of resistant isolates (OR=2.79 [CI95% 1.81-4.26], p<0.0001). There were not enough data to establish whether a universal approach to decolonisation carried a higher risk of developing resistance. One cross-sectional study,[135] which evaluated MRSA isolates obtained from the patients for resistance patterns, reported that those patients who were exposed to CHG were more likely to carry MRSA isolates with disinfectant resistance genes *qacA/B* and *qacC* than those who were not exposed (70.0% versus 43.4%, AOR=7.80 [CI95% 3.25-18.71], p<0.001 and AOR=0.18 [CI95% 0.04-0.94], p=0.04 respectively). Additionally, authors reported that a higher proportion of isolates obtained from patients previously exposed to CHG had a reduced susceptibility to CHG (minimum inhibitory concentration (MIC) levels ≥4 mg/L) than the isolates from patients with no exposure history AOR=3.15, [CI95% 1.14-8.74], p=0.03.

There was moderate evidence from fourteen studies,[86,88-94,96,97,99,100,102,109,121] which reported adverse events associated with the use of CHG. These included rash,[91,94,100] burning sensation,[92,97] itching,[92,94,97,100,109] redness,[92,109] dryness,[92] irritation,[97] fissures[97]and other not-specified skin reactions.[90] Three studies reported allergy to CHG[88/89,96,102] and two reported discontinuation of CHG due to adverse events.[97,100] Another three studies reported adverse events, but did not specify what they were.[86,93,99] Despite the many studies reporting adverse events, meta-analysis showed that the overall rate of occurrence was low (0.15%) and not significantly different than the rate reported for studies which did not use skin decolonisation therapy or used a placebo (0.12%, OR=1.30 [CI95% 0.97-1.76], p=0.0811). The use of oral CHG was associated with a higher risk of adverse events (24% versus 0% in comparison group, OR=85.07 [CI95% 5.08-1424.00], p=0.0020) including burning sensation, unpleasant taste, dryness of the mouth and tenderness. These results are based on one

study[92] which reported the side effects when 2% CHG was used. Another study[86] which used 0.2% CHG reported no adverse events.

No evidence was found from the studies published since 2004 meeting the inclusion criteria for the study design, which assessed the cost-effectiveness of CHG bathing.

Mupirocin

There was strong evidence of benefit from the meta-analyses of ten RCTs,[88/89,91-94,96,136-139] two control trials,[140,141] three ITS,[104,105,111] and two retrospective cohort studies,[115,142] which investigated the effectiveness of nasal mupirocin on the prevalence of MRSA colonisation, incidence of MRSA acquisition, incidence of MRSA infection and eradication of MRSA. The results of the meta-analyses showed that mupirocin was not effective when used alone but was effective when used in combination with a skin decolonisation agent (e.g. CHG, triclosan or octenidine). When mupirocin was used alone, the prevalence of MRSA was 21.1% in the mupirocin group versus 25.5% in the control group (p=0.1636), the incidence of infection was 2.54% versus 1.49%, p=0.1100, and the eradication rate was 60.5% versus 34.5%, p<0.0001. When mupirocin was used alone or in combination with another therapy, the prevalence of MRSA was 15.5% versus 25.5%, p=0.0001, the incidence of MRSA acquisition was 1.12% versus 3.04%, p<0.0001, the incidence of acquisition per 1000pd was 0.62 versus 3.10, p<0.0001, the incidence of infection was 0.20% versus 1.49%, p<0.001, the incidence of infection per 1000pd was 0.02 versus 0.46, p<0.0001 and the rate of MRSA eradication was 63.2% versus 34.5%, p<0.0001. The two studies included a follow-up period (one month or longer) after successful decolonisation and reported that in a large proportion of patients, MRSA was redetected at follow-up.[93,97] Both studies used mupirocin in combination with CHG, but this finding needs to be considered as a possible outcome for other protocols such as mupirocin alone or in combination with other agents. There was additional evidence from one small ITS,[112] which used nasal mupirocin and 4% CHG wipes for patients colonised with MRSA in a neonatal ICU and did not report a significant decrease in the incidence of MRSA acquisition in the intervention period in comparison to pre-intervention (2.00 versus 2.38 events/1000pd, IRR=1.85 [CI95% 0.80–1.73], p=NR). This study had a small sample size; thus, it was likely to be underpowered and at risk of type I error. Further evidence was obtained from thirteen UBA studies,[119,121,122,123,124,126,130-132,134,143-146] which found similar results. Introduction of mupirocin itself was beneficial in one study[144] and not significantly reduced in another.[145] Application of mupirocin in combination with a skin decolonisation agent was beneficial in eight studies[122,123,124,130-132,134,143] while three studies[119,126,146] reported no significant benefit.

There was strong evidence of no relationship between mupirocin use and resistance from eight studies.[92,93,97,105,132,138,141,147] Meta-analysis showed that the prevalence was slightly higher in the group where mupirocin alone was used as compared to the no mupirocin group

(13.27% versus 11.18%), although the difference was not significant (OR=1.21 [CI95% 0.64-2.29]).

There was moderate evidence from 12 studies,[88/89,92-94,111,126,131,137,139,142] which reported adverse events associated with the use of mupirocin. The studies reported discomfort,[88/89] burning sensation,[92] itching,[92] dryness,[92] rhinorrhoea,[94] nasal irritation,[94] nose bleeds,[139] headaches,[94] congestion,[94] cough,[94] pharyngeal pain[94] and unspecified adverse events.[92,93,111,126,131,137,138,142] Two studies reported that treatment had to be discontinued due to adverse events associated with mupirocin use in some patients[94,138] and one study reported that 38% of the patients considered the treatment to be unpleasant, regardless of whether they experienced adverse events.[94] The results of meta-analysis showed that the use of mupirocin was associated with an over-six-times higher risk of experiencing adverse events when compared to a group that used no decolonisation or placebo (RR=6.44 [CI95% 4.85-8.54], p<0.0001). When comparing to nasal placebo only, the incidence of adverse events with mupirocin was significantly lower (RR=0.30 [CI95% 0.16-0.57], p=0.0002).

No evidence was found from the studies published since 2004 meeting the inclusion criteria for the study design, which assessed the cost-effectiveness of mupirocin.

Octenidine

There was moderate evidence of benefit from one ITS,[104] one controlled trial[148] and one CBA study[101] which investigated the effectiveness of skin decolonisation with octenidine on the incidence of MRSA acquisition and the incidence of MRSA infection. The results of the meta-analyses showed that octenidine alone or in combination with a nasal decolonisation agent was more effective when compared to no decolonisation or placebo. For octenidine alone, the incidence of MRSA acquisition was 2.96% in the octenidine group versus 3.04% in the control group (p=0.7361), and the incidence of infection was 0.81% versus 1.49%, p=0.001. When octenidine was used in combination with a nasal decolonisation agent, the incidence of MRSA acquisition/1000pd was 0.19 versus 3.10, p<0.001, and the incidence of infection per 1000pd was 0.01 versus 0.46, p<0.0001.

There was weak evidence of benefit from one CBA study[101] and one ITS[113] which investigated the effectiveness of nasal decolonisation with octenidine gel in combination with either CHG[101,113]or octenidine wash.[101] The CBA study[101] reported that octenidine gel significantly reduced the MRSA prevalence rates as compared to the MRSA rates before decolonisation was in place (19.3% versus 38.5%, p=0.007 and 34.4% versus 48.1%, p=0.001 for octenidine wash and CHG wash, respectively) while the prevalence on the control ward where no decolonisation was in place remained the same (38.9% versus 43.4%, p=0.554). Another study,[113] conducted in extended care facilities for stroke and trauma patients reported that the incidence of MRSA acquisition decreased from 7.0 to 4.4 events per 1000pd (p<0.0001).

There was weak evidence of resistance from one cross-sectional study,[135] which evaluated MRSA isolates obtained from patients. The study reported that those patients who were exposed to octenidine were more likely to carry MRSA isolates with disinfectant resistance genes *qacA/B* than those who were not exposed (AOR=11.79, [CI95% 5.14-27.04], p<0.001) but not more likely to carry the isolates with the *qacC* genes (AOR=0.55 [CI95% 0.23-1.31], p=0.18). The authors reported that a higher proportion of isolates obtained from patients previously exposed to octenidine had reduced susceptibility to octenidine (MIC levels ≥2 mg/L) than the isolates from patients with no exposure history AOR=0.27, [0.08-0.95], p<0.01.

There was moderate evidence from two studies[101,148] which reported adverse events associated with the use of octenidine. One study which assessed adverse events when using octenidine soap reported no events in a sample of 5277 patients[148] while another assessing octenidine nasal gel reported one case (1/731, 0.14%) of adverse events (not specified) which resulted in discontinuation of use of the nasal gel in the affected patient.[101]

No evidence was found from the studies published since 2004 meeting the inclusion criteria for the study design, which assessed the cost-effectiveness of octenidine.

Povidone-iodine (PVP)

There was weak evidence from one RCT,[94] which investigated the effectiveness of 5% PVP versus 2% nasal mupirocin alone and in combination with CHG wash on the incidence of deep surgical site infections (SSI) caused by MRSA in surgical patients (no denominator). The study reported a very low incidence of MRSA SSI and eradication of MRSA, with one case (0.12%) occurring in each group. There was further evidence from UBA studies, two of which reported a benefit of introducing PVP in combination with CHG when compared to CHG alone[149] or to no decolonisation protocol.[120] The remaining UBA study[150] reported no difference in clinical outcomes when mupirocin was replaced by PVP while reporting better patient experience in PVP group.

No evidence was found from the studies published since 2004 meeting the inclusion criteria for the study design, which assessed the resistance of MRSA to PVP.

There was weak evidence from one RCT[94] which reported adverse events associated with the use of PVP. The study reported some adverse events including headache, rhinorrhoea, nasal irritation, congestion, cough and pharyngeal pain. These were less prevalent than those for mupirocin (1.78% versus 8.90%, p<0.0001). The authors reported that significantly fewer patients considered the treatment unpleasant (3.6% versus 38% in mupirocin group, p<0.0001), and concluded that this was possibly related to the fact that PVP was applied only twice on the day of the surgery as opposed to two applications for five days for the standard mupirocin treatment.

No evidence was found from the studies published since 2004 meeting the inclusion criteria for the study design, which assessed the cost-effectiveness of PVP.

Other decolonisation therapies

There was weak evidence from nine other studies, which investigated the effectiveness of other agents on the prevalence of MRSA colonisation, the incidence of MRSA acquisition, the incidence of MRSA infection and the eradication of MRSA. The studies used a skin decolonisation regimen with 1% triclosan,[138,151] 5% tea tree oil,[152] polyhexanide cloths,[153] 3% hexachlorophene[139] as well as the nasal application of 30% medical grade honey ointment,[138] polyhexanide gel,[152] polysporin triple ointment,[93] ofloxacin drops for eradication of MRSA in the ears,[136] gentamicin cream for peritoneal catheter exit sites[140] and alcohol-based nasal antiseptic.[154] One of these studies,[154] a UBA, suggested a potential benefit when using selective alcohol-based nasal antiseptic administered twice daily in addition to CHG bathing in place of extensively used contact precautions (CP) for all MRSA colonised patients. The authors reported that the incidence of MRSA BSI remained the same (data not reported) while they successfully reduced the number of isolation days by 88.33% ($p<0.0001$) as well as a reduction in glove and gown use, which provided a saving of USD 430,604 (approx. £314,315) for the 10-month period in seven hospitals participating in the intervention. None of the therapies were reported to be effective.

The Working Party considered the evidence and concluded that high quality studies support the use of CHG and mupirocin, either used alone or in combination. Octenidine may be used as an alternative when CHG is not feasible. The effectiveness of alternative agents, including octenidine, PVP and triclosan needs to be adequately assessed. Concern remains about resistance associated with the use of CHG and mupirocin. Whilst the meta-analysis for mupirocin did not show that the risk of resistance increased with mupirocin use, the Working Party concluded that this most likely reflected the ecology of changing MRSA strains and not the evidence that the resistance is not resultant from the excessive use.

Recommendations

6.1 Use mupirocin for nasal decolonisation, either selectively (i.e., for those who are colonised) or universally (i.e., for all high-risk patients).

6.2 Use chlorhexidine, either selectively or universally, for body decolonisation to reduce MRSA carriage.

6.3 Consider alternatives (e.g. octenidine) where mupirocin and chlorhexidine are not feasible.

6.4 Monitor the emergence of resistance, especially to mupirocin and chlorhexidine, if used extensively.

Good Practice Points

GPP 6.1 Follow manufacturers' guidance when using decolonisation products.

GPP 6.2 For skin decolonisation, if 4% chlorhexidine wash is used, moisten the skin, apply the wash, and leave for 1-3min before rinsing off; if 2% chlorhexidine wipes are used, do not rinse off.

GPP 6.3 For skin decolonisation, pay special attention to known carriage sites such as the axilla, groin, and perineal area.

GPP 6.4 After each bath and wash, provide clean clothing, bedding, and towels.

GPP 6.5 Consider using chlorhexidine in neonates only if there is no alternative and there is no broken skin present (for evidence on CHG safety in neonates, see Appendix 5).

GPP 6.6 Make healthcare workers and patients aware that decolonisation therapy does not necessarily result in complete eradication but that achieving temporary suppression is sufficient in many circumstances.

8.7 What is the clinical and cost-effectiveness of environmental screening/sampling in minimising the transmission of MRSA?

MRSA resists desiccation and can survive in hospital dust for up to a year. It is found throughout the hospital environment, particularly around patients known to be colonised or infected with the bacterium. Environmental contamination with MRSA may contribute to transmission when healthcare workers contaminate their hands or gloves by touching contaminated surfaces, or when patients come into direct contact with contaminated surfaces. There is little understanding of whether environmental screening/sampling has a beneficial effect on environmental MRSA contamination or clinical outcomes. Previous MRSA guidelines did not assess this outcome and did not provide any recommendation.

No evidence was found in the studies published since 2004 which met the inclusion criteria for the study design, and which assessed the benefit of environmental screening/sampling on the prevalence of MRSA colonisation or the incidence of MRSA acquisition.

There was weak evidence from one stepped wedge trial[155] which assessed the effectiveness of the cleaning/disinfection bundle on the rates of BSI in hospitals with ICUs. The bundle consisted of training and providing advice on the use of cleaning/disinfection agents and the feedback to staff after cleaning and disinfection. The study reported a beneficial improvement in overall cleanness, but no effects on MRSA BSI (n=22, 0.17/10,000pd versus n=66, 0.19/10,000pd, p=0.7674). Further evidence came from one UBA study[156] which reported an

intervention where the environmental services staff received training, following which audits were periodically conducted. General cleanness was assessed using adenosine triphosphate (ATP) bioluminescence assay and results were fed back to the staff. The authors reported that no changes were observed in the incidence of MRSA acquisition in the pre- and post-intervention periods (n= 171 acquisitions versus=178 respectively, p value not reported).

No evidence was found in the studies published since 2004 which met the inclusion criteria for the study design, and which assessed the cost-effectiveness of environmental screening/sampling.

The Working Party considered the evidence and, together with clinical experience of the Working Party members, concluded that there is currently insufficient evidence to support the routine use of screening/sampling of equipment. However, it was recognised that there may be circumstances (e.g. outbreaks) where this may be beneficial.

Recommendations

7.1 Do not screen/sample the environment routinely.

7.2 Consider using environmental screening/sampling as part of targeted investigation of an outbreak.

8.8 What are the most effective cleaning/disinfection agents and technologies for reducing environmental contamination in the near patient environment and minimising transmission of MRSA?

There is evidence supporting the role of cleaning and disinfection in hospitals as an important intervention in the control of MRSA. Unfortunately, it often constitutes part of an overall IPC package in response to an outbreak and its importance as a stand-alone activity remains undetermined. There are a variety of cleaning and disinfection agents and technologies available for reducing environmental contamination but guidance regarding the best approaches is limited and the policies vary considerably between hospitals. Disinfection agents include alcohols (e.g. isopropyl, ethyl alcohol, methylated spirit), quaternary ammonium compounds (QAC) (e.g. alkyl dimethyl benzyl ammonium chloride, alkyl dimethyl ethyl benzyl, ammonium chloride), phenolics (e.g. benzyl-4-chlorophenol, amylphenol, phenyl phenol) and sodium hypochlorite (e.g. sodium dichloroisocyanurate). It is not known which agents are efficient for decontamination (decontamination relates to a process where microbial contamination is removed to render the environment or an item safe; please see the glossary). Previous guidelines recommended that cleaning regimens and products should be in accordance with local policy, and that they should include products able to remove organic material.[1] Additionally, new approaches have been proposed, including room decontamination with ultraviolet (UV) irradiation or hydrogen peroxide vapour (HPV) systems or the use of antimicrobial surfaces, but their effectiveness in preventing MRSA acquisition and infection was not discussed by the previous guidelines.[1]

There was moderate evidence for benefit from two controlled trials[157,158] and one ITS[159] which investigated the effectiveness of HPV on hospital cleanness. All studies reported that using HPV in addition to the standard cleaning and disinfection regimen (i.e., what was used in the hospital before an intervention was introduced) resulted in a significantly lower number of sites contaminated with MRSA. One study[157] in particular showed that the terminal cleaning (this term is used to describe a process of thorough cleaning and disinfection; please refer to glossary in Supplementary Materials file) with standard sanitiser (details not reported) resulted in 66.1% of sites still being contaminated with MRSA as opposed to 1.2% when HPV was added to post-manual cleaning and disinfection (OR=0.02 [CI95% 0.00-0.13], p<0.0001). Another trial[158] which assessed the number of rooms contaminated with MRSA found a lower rate of contamination in rooms where HPV was used in conjunction with manual cleaning and disinfection with QAC, concentration not reported), although the difference was not significant (2.02% versus 3.80%, OR=0.53 [CI95% 0.21-1.31], p=0.1708) compared to the rooms terminally cleaned with QAC only. The last study[159] showed a significantly lower proportion of sites contaminated with MRSA (6.2% versus 7.2%, OR=0.86 [CI95% 0.79-0.94], p=0.0008). This translated to a significant reduction of MRSA acquisition (186 versus 334 cases, p<0.0001) and a small, non-significant decrease in MRSA BSI (0.11 versus 0.16 cases/1000pd, p=0.58). Further evidence came from one UBA study[160] which reported that significantly fewer sites were contaminated with MRSA following the use of HPV when compared to a standard cleaning/disinfection with QAC (concentration not reported) and 0.5% sodium hypochlorite (0.06% versus 2.14%, OR=0.03 [CI95% 0.01-0.11], p<0.0001).

There was inconsistent evidence of the benefit from one RCT,[161-163] one controlled trial,[164] one ITS[165] and two CBA studies[166,167] which assessed the effectiveness of UV devices on the colony counts and the reduction of MRSA contamination[163,164] and MRSA acquisition rates.[161,162,165-167] One RCT, which was described in three separate articles[161-163] reported that MRSA acquisition and infection rates were not affected using UV-C light devices. This was regardless of whether the outcomes were assessed on the whole hospital population[162] (n=259, 0.31% in QAC + UV-C light arm, n=242, 0.29% hypochlorite + UV-C arm versus n=204, 0.27% in QAC arm) or just patients in rooms previously occupied by MRSA carriers[161] (n=54, 1.6% in QAC + UV-C light arm, n=89, 2.3% hypochlorite + UV-C arm versus n=73, 2.1% in QAC arm). These studies showed that UV-C light may be used as a part of an IPC strategy due to their benefits in controlling bacteria other than MRSA. The authors collected environmental samples and published the data in a separate article.[163] The mean number of colony forming units (cfu) in rooms and bathrooms was 8.52 in the QAC group, 4.34 in hypochlorite group and 0.11 and 0.85 for QAC and hypochlorite with UV-C groups, respectively (significance not reported). Another controlled trial[164] reported that the colony counts and the reduction of MRSA contamination from baseline did not improve following the introduction of the UV-C light system (99.4% versus 91.1% hypochlorite (1:10) alone). This study reported a high variation in colony counts in the manual cleaning/disinfection arm, which was attributed to inconsistencies in cleaning and disinfection by the personnel. Two low-quality CBA

966 studies[166,167] conducted in ICUs and one ITS[165] showed the benefit of adding pulsed-xenon UV
967 (PX-UV) device to standard cleaning and disinfection with either QAC (concentration not
968 reported),[166] hypochlorite (concentration not reported),[167] or standard cleaning and
969 disinfection (details not reported).[165] The first CBA study[166] reported that the incidence of
970 MRSA acquisition in the intervention ICUs decreased from 3.56 to 2.21 events per 1000pd
971 (IRR=0.556 [CI95% 0.309–0.999], p=0.0497) following the use of PX-UV device, while it
972 significantly increased from 0.33 to 0.38 events per 1000pd (IRR=10.967 [CI95% 7.061–
973 17.033], p<0.0001) in other hospital wards. The second study[167] reported a decrease from
974 14.02 to 9.5 MRSA acquisitions per 10,000pd (IRR=0.71 [CI95% 0.57-0.88], p<0.002) in the
975 intervention ICUs using a PX-UV device, while reporting that the neighbouring high care units
976 and the general wards did not experience a decrease in MRSA acquisitions (IRR=0.85 [CI95%
977 0.65-1.12], p=0.283 and IRR=1.14 [CI95% 0.62-2.12], p=0.663 respectively). Finally, one ITS[165]
978 reported a benefit of adding a UV-C device to standard cleaning and disinfection (not
979 described) in general acute wards. The device resulted in the incidence of HCAI-MRSA
980 decreasing from 0.7% (91/12,747 or 1.42/1000pd) to 0.5% (61/13,177, RR=0.65 [CI95% 0.47-
981 0.70], p=0.0087 or 0.98/1000pd), which in ITS analysis corresponded to a 30.79% reduction,
982 p=0.02. The authors reported annual savings of USD 1,219,878 (approx. £889,474) mostly due
983 to a decreased length of stay (LOS). Further evidence came from two UBA studies which used
984 UV-C devices and found no effect on MRSA colonisation[168] or infection.[169]

985 There was weak evidence of no benefit from one controlled study with crossover[170] and
986 RCT[171] which assessed the effectiveness of adding copper fittings to high-touch surfaces to
987 prevent MRSA transmission. One study[171] reported no difference in the incidence of MRSA
988 infections in patients admitted to isolation rooms with copper surfaces (2/36) as compared
989 to standard surfaces (3/34, OR=0.63 [CI95% 0.10-.4.00], p=0.6240). Another study[170] reported
990 that adding copper fixtures did not result in a decrease in the number of sites being
991 contaminated with MRSA (2.3% versus 3.7% for the sites without copper, OR=0.621, [CI95%
992 0.306-1.262], p=0.217). Both studies concluded that copper surfaces can be used as a part of
993 an IPC strategy due to their benefits in controlling bacteria other than MRSA.

994 There was weak evidence of benefit from one RCT of acceptable quality[172] and low-quality
995 controlled trial[173] which assessed the effectiveness of antimicrobial curtains. The RCT[172]
996 compared the MRSA contamination (no patient outcomes) of standard curtains and
997 antimicrobial curtains impregnated with halamine (BioSmart®) with or without hypochlorite
998 spray twice weekly. The authors described that halamine curtains can be 're-charged' with
999 hypochlorite, during which process amine polymers impregnated into the fabric are able to
1000 bind the chlorine ions, which in turn provide an antimicrobial benefit. The study reported no
1001 decrease in the number of curtains contaminated with MRSA when comparing the halamine
1002 and standard curtains (7/14, 50% versus 7/13, 53.8%, not significant). There was no decrease
1003 when comparing the standard curtains to curtains pre-sprayed in halamine with the
1004 hypochlorite group (7/13, 53.8% versus 6/14 (42.9%, not significant). The number of
1005 contaminated curtains after spraying reduced from six (42.9%) to one (7.1%, significance not

reported). Another study, which was a low-quality controlled trial[173] compared two different types of antimicrobial curtain (impregnated with either silver, or QAC combined with polyorganosiloxane) to a standard curtain. There was a significant decrease in the number of curtains contaminated when comparing curtains impregnated with QAC and polyorganosiloxane (3/580, 0.5%) and a standard curtain (204/507 (40.2%), RR=0.02 [CI95% 0.00-0.04], p<0.0001, a difference of 39.7% [CI95% 34.8–44.0%], but no decrease in the number of curtains contaminated with MRSA when comparing silver impregnated (137/267, 51.3%) and the standard curtain (204/507 (40.2%), RR=1.28 [CI95% 1.09-1.49], p=0.0025.

There was weak evidence from one UBA study[174] assessing the effectiveness of titanium dioxide-based photocatalyst reactive to visible light, which was painted to the walls and high-touch surfaces in medical ICU rooms. The authors reported a significant decrease in the number of MRSA acquisitions by patients (4/280, 1.4% or 2.57/1000pd) from the pre-intervention period (15/341, 4.4% or 9.30/1000pd, p=0.01; IRR=0.26 [CI95% 0.06–0.81]).

There was inconsistent evidence of benefit reported by one RCT[161/162], three controlled trials[175-177] and two ITS[178,179] studies investigating different types of cleaning and disinfection agents. One ITS,[178] which replaced hypochloric acid (concentration 1000ppm) with chlorine dioxide (concentration 275 ppm) reported a significant change in MRSA acquisition per 100 bed days/month at 12 months from the start of the intervention. Another ITS[179] reported that switching from cleaning with detergent wipes followed by alcohol wipes (details on ingredients and concentration not reported) to one wipe system (containing <0.5% benzalkonium chloride, <0.5% didecyl dimethyl ammonium chloride and <0.10% polyhexamethylene biguanide) in a general hospital setting, resulted in the reduction of the incidence of MRSA acquisition from 26.8 per 100,000pd to 9.4 per 100,000pd (p<0.0001). The authors reported that there was no significant difference in the incidence of MRSA BSI between the pre- and post-intervention periods (1.8 and 0.2 per 100,000pd respectively, p value not reported). One controlled trial[176] reported beneficial effects of 10% bleach (not specified, presumably hypochlorite) compared to Biomist® (QAC in 58.6% alcohol), with the proportion of sites contaminated with MRSA in Biomist® group reported as 5/23 (21.7%), while there were no contaminated sites in the bleach group (0/40, 0%, p=0.0007). Other controlled trials did not report any difference in cleaning and disinfection or clinical outcomes when using a disinfectant with QAC (0.25% QAC, referred to as ammonium arm) versus bleach arm (1:10 hypochlorite wipes),[161/162] or QAC (concentration not reported) versus 0.5% hydrogen peroxide wipes[175] or when comparing QAC (concentration not reported), 10% hypochlorite, hydrogen peroxide with peracetic acid (concentration not reported) or standard detergent (i.e., what was previously used in practice, details not reported) to each other.[177] Further evidence came from two UBA studies. One study[180] reported no change in environmental contamination after switching from standard detergent (details not reported) to sodium hypochlorite with 1000ppm chlorine (13.2% versus 10.1%, OR=1.31 [CI95%0.70-2.46], p=0.4021). Another study[181] used JUC® spray, a polymeric surfactant containing QAC (concentration not reported), which was sprayed on the surfaces following the cleaning. The

study found that none of the bed units (0/18, 0.0%) were contaminated with MRSA following the treatment. This was in contrast to 4/18 (22.2%) of sites cleaned with hypochlorite, concentration not reported (OR=0.11 [CI95% 0.01-2.21], p=0.1501). The study was too small to draw inferences, but authors concluded that JUC® spray may be beneficial in controlling staphylococcal load for up to four hours following its application.

No evidence was found in the studies published since 2004 which met the inclusion criteria for the study design, and which investigated the cost-effectiveness of different cleaning and disinfection agents or hands-free devices.

The Working Party considered the data above and, together with clinical experience of the Working Party members, concluded that there is no evidence that antimicrobial surfaces can control MRSA. Some new technologies can be used as a part of wider IPC strategy to eliminate the inconsistencies associated with manual cleaning and disinfection, while HPV/UV-C/PX-UV may be beneficial as a part of terminal cleaning. The Working Party considered that the disinfection agents have similar efficacy against MRSA.

Recommendations

8.1 Continue using currently utilised products approved for use in healthcare.

8.2 Consider hydrogen peroxide vapour (HPV) or ultraviolet (UV-C, PX-UV) devices as an adjunct to terminal cleaning as a part of a wider IPC strategy.

8.9 What is the evidence that local surveillance and feedback to staff is effective in minimising the transmission of MRSA?

Surveillance plays two roles with respect to IPC: it allows detection of infected/colonised individuals necessary for their removal from the general population, and it allows quantification of control success. Many hospitals have introduced surveillance systems to monitor MRSA cases. This surveillance can be used to assess the infection risk of people in hospital and inform the response. Since the last guidelines were published, mandatory national surveillance of MRSA cases has been set up in many countries, with hospitals being required to report infections to public health bodies (for example, in England, acute trusts are required to report all cases of BSI). This not only allows monitoring on a hospital level, but also allows the hospitals to compare their data to other facilities and to the national average.

There was moderate evidence from one RCT[182] and two ITS[183,184] studies which assessed the effectiveness of hospital surveillance on the incidence of MRSA BSI or MRSA acquisition.

One study,[182] which recruited three units in participating hospitals and randomly assigned one unit into each intervention, used statistical process control charts (SPC) to monitor and feedback the MRSA acquisition rates to the staff on participating units. The authors reported

a decrease in the average MRSA acquisition rates in the units which used either SPC charts alone or SPC charts with Pareto charts, which promoted IPC improvements on the units in comparison to the wards which did not use the charts. For the SPC group, the authors reported that the MRSA rate was stable during the baseline period with a possible increase in acquisition as observed from the last six points on the chart before the intervention was introduced. A monthly average of 48 cases was observed during the baseline period, which fell to 30 cases per month post-intervention. For SPC + Pareto charts, continuous post-intervention improvements were observed with the average MRSA acquisition reduced from 50 to 26 cases per month. Lastly, the control arm experienced a slight pre-intervention reduction and a more significant post-intervention reduction from an average of 49 cases to 36 per month. This decrease was not sustained, and in the last six out of seven points shown on SPC charts, an increase in the number of MRSA acquisitions was observed. One ITS[183] showed a marked reduction in BSI in ICU as well as other hospital patients even though the surveillance was limited to ICU only. The authors did not report a p value, but the prevalence rate was 1.6/1000pd in ICU and 0.6/1000pd in hospital. These rates are substantially lower than those predicted by ITS analysis which would have been 4.1/1000pd and 1.4/1000pd, respectively, if surveillance was not in place. The authors did not report any information about the interventions which were introduced following the surveillance. The last ITS study,[184] which used SPC charts to feed the data back to staff to drive the improvement across the hospital, reported that the incidence of MRSA acquisition across the hospital decreased from 3.0 [CI95% 2.8-3.2] to 1.7 [CI95% 1.6-1.8] events per 100 patient admissions ($p<0.001$). The decrease was also observed in ICUs (9.3 [CI95% 7.5-11.2] versus 6.7 [CI95% 5.2-8.5], $p=0.047$). The authors reported that a significant decrease was observed in hospital MRSA BSI (0.45 [CI95% 0.38-0.52] pre-intervention versus 0.27 [CI95% 0.24-0.32] per 100 patient admissions, $p=0.02$ post-intervention) as well as in ICU central line-associated MRSA BSI (CLABSI) (2.0 [CI95% 1.3-3.0] versus 1.1 [CI95% 0.7-1.7] per 100 device days, $p=0.018$ for pre- and post-intervention respectively).

Further evidence of the benefit came from a total of eight UBA studies.[185-192] Two of these studies reported a decreased prevalence of MRSA colonised patients in their hospitals.[186,187] One study,[185] which reported a very low baseline prevalence of MRSA demonstrated that five years after the start of a mandatory surveillance of MRSA BSI cases, the prevalence of MRSA did not decrease significantly in their hospital (4.3% versus 12.2%, $p=0.317$) when comparing all MRSA isolates. A significant change was observed when only non-BSI isolates were included (3.5% versus 8.6%, $p<0.001$). While the rate of MRSA BSI remained unchanged throughout the five years (data not reported, $p=0.555$), the rate of non-BSI isolates decreased each quarter by 0.47-1.61 cases/1000 patient episodes, which was significant ($p=0.007$). The authors concluded that since the rate of MRSA BSI was very low in their setting, surveillance of non-BSI cases may be more beneficial. Furthermore, of the UBA studies which reported incidence of MRSA infection, four reported that the incidence of MRSA BSI declined following the introduction of surveillance,[187,190-192] two reported no benefit[185,189] and, one reported the benefit on some but not all units in the hospital.[188]

The Working Party considered the evidence from the included studies and together with the evidence from previous guidelines and the clinical experience of the Working Party members, concluded that hospital surveillance must remain a component of any strategy to prevent and control MRSA infections.

Recommendation

9.1 Undertake surveillance routinely as part of the hospital's infection prevention and control strategy and to comply with mandatory national requirements.

8.10 What is the evidence that local and/or national surveillance for MRSA is effective in driving service/ system improvement?

Beyond the hospital-wide surveillance system further extensive surveillance of MRSA cases may be performed at unit level. Previous MRSA guidelines concluded that surveillance must be undertaken routinely as part of the hospital's IPC programme and that it must be a recognised element of the clinical governance process. Thus, there should be clear arrangements identifying those responsible for acting on the results in individual hospital directorates. This question was not assessed in our previous MRSA guidelines and no recommendation was made.

No evidence was found in the studies published since 2004 which met the inclusion criteria for the study design, and which assessed the effectiveness of local versus national surveillance for MRSA in driving service or system improvement.

Other sources of evidence were considered. One excluded study,[193] which did not meet the criteria for this review, reviewed the data of the mandatory surveillance of MRSA in England. Since 2001 when mandatory surveillance was introduced, all acute trusts reported the data quarterly. This data was publicly published, and the feedback was given to the trusts. Additionally, the trusts were given a target to reduce their MRSA BSI rates by 50% by 2008 and all trusts not meeting their trajectories were audited. The overall rate of BSI in England decreased by 56% between 2004 and 2008 and further decreased by 50% from 2008 to 2011, reaching 1.8 cases per 100,000pd. The authors reported that mandatory surveillance and feedback from the surveillance drove the implementation of interventions which ultimately contributed to reduced incidence of MRSA BSI.

Data on MRSA BSI surveillance for England, Scotland, Wales and Northern Ireland as well as all European Union countries are available (https://www.gov.uk/government/statistics/mrsa-BSI-annual-data; https://ecdc.europa.eu/en/antimicrobial-resistance/surveillance-and-disease-data/report).

The Working Party considered the evidence from the above study, and together with the evidence from previous guidelines and the clinical experience of the Working Party members, concluded that recommendation cannot be made based on current knowledge.

Recommendation

10.1 No recommendation

Good Practice Point

GPP 10.1 Consider using local surveillance of MRSA acquisition (colonisation and infection) as a component of local strategies to prevent and control MRSA and to drive improvement where needed.

8.11 To what extent are contact precautions effective in minimising the transmission of MRSA? To what extent does the isolation or cohorting of patients minimise the transmission of MRSA and what are the costs?

Staphylococcus aureus is a commensal organism of human skin occupying body sites such as nose, axilla, and groin. Patients with MRSA are commonly colonised at these body sites and the organism may contaminate their immediate environment.[194] Transmission of MRSA in healthcare settings occurs when *Staphylococcus aureus* is acquired on the hands of staff and then transferred to other patients, surfaces or equipment.[195] Hand hygiene with either soap and water or alcohol hand rub removes microorganisms including MRSA from hands, and interrupts transmission.[196] Standard precautions[197] and recommendations from the WHO Hand Hygiene guidelines[196] require that staff wash their hands before and after direct contact with the patient and their immediate environment, and any susceptible site on the patient. Standard precautions are therefore essential to prevent transmission of MRSA to other patients and protect susceptible sites on the patient from infection.[196]

The previous MRSA guidelines[1] found consistent weaknesses in studies reporting the use of screening and isolation interventions for the prevention of MRSA because many reports describe the simultaneous implementation of multiple interventions, making it difficult to draw clear conclusions about the effect of any intervention independently. They concluded that there was some acceptable evidence that screening and isolation of patients contribute to reductions in MRSA outbreak and endemic situations. The recommendations in the previous guidelines were therefore that ‘a standard approach to isolation precautions should be adopted in accordance with the general principles of IPC, rather than introducing specific guidance for the management of MRSA that may lead to differing standards.’ The guidelines recommended that patients were managed in accordance with the type of setting, the resources available locally (e.g. numbers of isolation rooms), and the risk that they pose to others or that is posed to them.

Since then, the US guideline for isolation precautions has been published[198] which recommended the use of CP for the management of patients with some multidrug-resistant organisms (MDRO), although not specifically MRSA. This guidance recommends that, to contain pathogens, staff don PPE on room entry and discard it on exit, and more specifically that gloves and gowns should be worn when touching patients' intact skin or surfaces in close proximity to the patient. The recommendations are based on a theoretical rationale rather than epidemiological evidence that the use of PPE in this way prevents transmission of MDRO.[198] These guidelines recommended that room cleaning and disinfection is prioritised for patients on CP. The use of CP for the management of patients with MDRO is now widespread but in the UK setting plastic aprons are used in place of gowns. Evidence for the efficacy of CP in reducing transmission of MRSA is uncertain as there are limited acceptable studies that compare CP versus the absence of CP independently.

There was inconsistent evidence from two cluster RCT[199,200] and three ITS[201-203]studies which investigated the effectiveness of CP on MRSA acquisition and infection. One study,[199] which used active surveillance combined with CP for MRSA positive patients and universal gloving until patients were confirmed as MRSA negative, reported no significant difference in the incidence of new MRSA acquisitions. This study used CP in both groups, with one arm extending the application of CP (universal gloving) to a broader set of potential carriers in combination with enhanced surveillance and screening. Another study[200] compared universal gloving for all patient contacts with CP (gloves/gowns) for patients known to be MRSA positive. Universal gloving was associated with a significant decrease in new MRSA acquisitions (-2.98 risk difference between intervention and control group; p=0.46) but the effect of CP versus no CP was not tested. One ITS[201] found no difference in MRSA acquisition in MRSA colonised or infected patients placed in a single room or nurse cohorted patients as compared to patients with no single room or cohorting. Standard precautions were used with all patients, but this included elements of CP (aprons for all patient contact, gloves for all devices and washing patients). Another ITS[202] found a 60% reduction in MRSA acquisition associated with rapid screening, CP and isolation, compared to no isolation and standard precautions (adjusted HR=0.39, [CI95% 0.24-0.62]; p<0.001; segmented regression change in slope p<0.001). This study was sensitive to bias as a stricter screening method was used during the intervention period, the separate effect of single room and CP were not distinguished, and the study was conducted in an ICU where MRSA was endemic, and decolonisation was not a routine practice. One very low-quality ITS[203] in an acute hospital found a decrease in MRSA device-associated infection rates associated with discontinuing CP for known MRSA positives, but other practice changes were introduced at the same time.

There was moderate evidence of a negative effect of CP on the patient experience and mental wellbeing from five qualitative studies.[204-207] These studies focused specifically on the impact of isolation for MRSA colonisation or infection. These studies concluded that isolation had an impact on patient experience and resulted in increased anxiety and low mood.[203-207] Additionally, in a study of 57 Dutch MRSA colonised patients,[208] it was reported that a

substantial proportion of MRSA carriers reported stigma due to MRSA, and stigma was associated with poor mental health. These studies were all small scale, in different populations and for varying durations of isolation. They reported mixed findings but suggested that isolation should be of as short a duration as possible to avoid anxiety and potential depression.

No evidence was found from the studies published since 2004 meeting the inclusion criteria for the study design, which assessed the cost-effectiveness of CP.

Additional evidence was obtained from national guidelines[197] and seven UBA studies[154,209-214] which attempted to discontinue CP in hospitals (including ICU and general wards). In one of these studies a nurse cohorting area was associated with a significant decrease in MRSA transmission.[209] Another study[210] found no effect of including gowns as part of CP on risk of MRSA transmission. The remaining studies[154,211-214] found no difference in the rate of MRSA acquisition associated with discontinuation of CP for known MRSA patients.

The Working Party considered the evidence from the included studies together with the evidence from previous guidelines and the clinical experience of the Working Party members, and concluded that the decision to isolate or cohort patients colonised with MRSA should be based on risk assessment and patient experience. Currently there is little evidence that CP are necessary, but the Working Party acknowledged that they are widely used in health and care settings and that some facilities may decide to continue with this practice.

Recommendations

11.1 Use standard infection prevention and control precautions in the care of all patients to minimise the risk of MRSA transmission.

11.2 For patients known to be colonised/infected with MRSA, consider using contact precautions for direct contact with the patient or their immediate environment. If contact precautions are used, gloves and aprons must be changed between care procedures and hand hygiene must be performed after glove removal.

11.3 Consider placing patients colonised or infected with MRSA in a single room. The decision to use a single room should be based on a risk assessment that considers the risk of transmission associated with the patient's condition and the extent of colonisation or infection (e.g. sputum, exfoliating skin condition, large open wounds) and the risk of transmission to other patients in the specific care setting e.g. in burns units.

11.4 Where isolation is deemed necessary, isolate patients for the shortest possible time to minimise feelings of stigma, loneliness, and low mood.

11.5 Provide clear information to patients about the need for the use of protective equipment to reduce feelings of stigma.

11.6 Be consistent in the use of protective equipment to ensure that patients have confidence in the decision to place them in isolation.

Good Practice Points

GPP 11.1 Advise visitors about the need and available facilities for hand hygiene.

GPP 11.2 Where applicable, advise visitors about the use gloves and aprons.

GPP 11.3 When considering the need to isolate a patient with MRSA in a single room, other demands on single-room use may take priority and alternative strategies such as nurse cohorting may be appropriate.

GPP 11.4 If isolation or cohorting of MRSA patients is not possible, use decolonisation therapy to temporarily suppress MRSA and prevent transmission to other patients.

GPP 11.5 Prioritise room cleaning and disinfection for MRSA patients placed in isolation or on contact precautions.

8.12 What is the evidence that the transfer of patients who are colonised or infected with MRSA between wards/ other care settings contributes to the transmission of MRSA?

Patients who are colonised or infected with MRSA have the potential to transmit MRSA to other patients in the same clinical area. Frequent movement of patients within a single healthcare setting or movement between related healthcare settings has the potential to increase the transmission of MRSA within the healthcare population and between different care settings such as a hospice or residential home. The evidence is currently lacking in establishing the effect of intra- and inter- hospital transfers of patients with MRSA on the rate of new acquisition of MRSA. Evidence for the impact that transferring patients between different units has on the transmission of MRSA can be derived from studies that have used genotyping of isolates to track the transmission of MRSA between patients. In this way, epidemiological links can be established to provide evidence for the extent to which the transfer of patients within and between healthcare facilities contributes to the transmission of infection. Previous MRSA guidelines recommended that patient transfers should be kept to a minimum.

There was moderate evidence from two cross-sectional surveys[215,216] one prospective cohort study[217] and one surveillance study[218] which investigated the effect of patient transfer on MRSA transmission. One study[215] using whole genome sequencing (WGS) to investigate the origins of 685 MRSA isolates identified in a 13-month period from a total of 610 patients in a single healthcare network comprising of three hospitals, outpatients and community settings, found that 41% (248/610) of MRSA patients were linked in a total to 90 transmission clusters (defined as at least two patients), most of which (68%, 61/90) involved multiple settings. Of these clusters, 42 (38%) involved different settings within one hospital and 30% (n=27) involved more than one hospital. One transmission cluster involved 32 patients between all three. Complex patterns of frequent hospital stays resulted in 81% (26/32) of the MRSA patients who were identified having had multiple contacts with one another during ward stays at any hospital but no outpatient contact, and had shared a GP (general practitioner) or residential area, suggesting that MRSA was transmitted on the wards and spread to other settings as a result of transfers. Another study[216] used a social network approach by analysing Hospital Episode Statistics (HES) data in England from April 2006 to March 2007 to determine how movements between healthcare institutions, which were derived from patient admissions, affected the incidence of BSI. The MRSA incidence rate for a hospital (adjusted for cluster-specific mean MRSA BSI rates) was found to be contingent on the number of patients it shared with other hospitals within its cluster. The incidence of MRSA BSI increased as the interconnectedness of the hospitals surveyed increased, with strongly connected hospitals in large clusters found to have significantly higher MRSA BSI rates than less connected hospitals. Another study[217] obtained genotypes and matched the MRSA screening results from admission and discharge from all patients previously admitted to 36 general specialty wards at two Scottish hospitals. The prevalence of MRSA in discharge screens was 2.9% [CI95% 2.43-3.34] and in the set of 2724 patients with paired screens, the odds ratio of acquiring MRSA was 2.64 for patients who stayed on four or more wards compared to those who stayed in three or less. In the last study,[218] surveillance cultures were obtained from 584 residents admitted to nursing facilities within one healthcare network, representing approximately half of the residents who were admitted to these facilities during the study period. Surveillance cultures were obtained at admission together with data on healthcare contact and antimicrobial use. WGS was performed and the analysis focused on isolates which appeared genetically similar. The gene flow in these facilities was estimated based on single nucleotide variants using Wright's F statistic. A total of 89/117 (76%) MRSA isolates belonged to ST5 or closely related isolates. The authors observed a positive correlation between patient sharing between hospitals and nursing facilities and concluded that the burden of antibiotic resistant organisms (including MRSA) was endemic in their healthcare network and driven by patient sharing in these institutions.

There was moderate evidence from five epidemiological investigations of outbreaks,[219-223] which assessed the effect of patient transfers on transmission of MRSA. These studies involved specific outbreak clones, which facilitated investigation of transmission events, and

provided data on the role of hospital transfers. One study[222] reported an outbreak of an unusual New York/Japan epidemic MRSA clone in Western Australia in 22 patients and two healthcare workers who acquired the MRSA. Transfers between another acute hospital (n=3 patients), a community hospital (n=4 patients) and regional care facility (n=3 patients) illustrated how patients acted as vectors and contributed to the transmission of infection. Another study[219] reported transmission of four new cases of a Panton-Valentine leucocidin (PVL) MRSA strain from a patient transferred from another hospital, while another study[220] identified MRSA transmission to 13 patients and nine healthcare workers from patients transferred from another hospital. One outbreak investigation[223] identified that transfer of patients between neonatal and paediatric ICU was a key factor in the transmission of MRSA with a total of 13 patients in paediatric ICU and 14 patients in neonatal ICU acquiring the same MRSA strain. In another outbreak investigation,[221] a total of 16 cases of MRSA transmission occurred from a baby, which was transferred from another hospital.

There was moderate evidence from eleven risk factor studies[224-234] which investigated the risk of MRSA acquisition related to transfers between healthcare settings. The studies found that admissions from other acute settings[224,225,227,229] and long-term settings[224-229] were significant risk factors for detection of MRSA on admission. In a logistic regression model analysis of 81,000 admissions to acute care in Scotland,[231] admission 'not from home' was a significant risk factor for MRSA colonisation on admission (OR=3.025 [CI95% 2.685-3.407] and the risk of colonisation increased with the frequency of previous admissions (four or more previous admissions OR=2.484 [CI95% 2.111-2.923]. Although there was a higher incidence of MRSA acquisition for patients who stayed in more wards, this was not statistically significant (OR=1.91 [CI95% 0.97-3.98], p=0.061). Another multivariate analysis of 12,072 admissions (399 with MRSA) to a university hospital in Switzerland[226] found patients who were admitted as an inter-hospital transfer had an odds ratio of 2.4 [CI95% 1.3-4.4] for MRSA carriage. Another Swiss study[233] of 1621 patients admitted to a geriatric unit, identified an increased risk of MRSA on admission screening associated with intra-hospital transfer (adjusted OR=2.5; [CI95%1.2–5.3] p=0.02) and hospitalisation within the last 2 years (adjusted OR=2.7 [CI95% 1.1–6.0], p=0.03) and in a small case-control study of 187 admissions to surgical wards of a limited resource hospital in Indonesia, transfer from another hospital was associated with an increased risk of MRSA carriage (OR=7.7 [CI95% 1.2-9.1]).[232] One case-control study,[234] which investigated risk factors for MRSA acquisition in a neonatal ICU identified bed transfer as a potential risk factor, but this was insignificant in the multivariate analysis (43/67, 64% versus 103/201 (51%), OR=1.83 [CI95% 0.97–3.49], p=0.06).

Further cross-sectional studies investigated prevalence and reasons for MRSA acquisition. These studies reported higher prevalence of MRSA in patients previously exposed to another ward,[235] another hospital,[236] or a long-term facility.[237] Another cross-sectional study[238] compared the incidence of MRSA acquisition for the patients who stayed in two, three or four and more wards to the patients who were in one ward during their hospital stay. When the groups of multiple wards were combined, there was a higher incidence of MRSA acquisition

than for patients who stayed in one ward, although this was not significant (OR=1.91 [CI95% 0.97-3.98], p=0.061). When the groups were compared separately, the risk increased with the number of wards the patients stayed in, although this was still not significant. Lastly, one case-control study[239] which investigated the incidence of MRSA infection reported no increased risk in patients transferred to another hospital when compared to those who remained in one hospital throughout their stay.

The Working Party considered the above evidence and the recommendations from previous guidelines and concluded that evidence suggests that patient transfers contribute to transmission of MRSA.

Recommendations

12.1 Do not transfer patients between wards, units, hospitals, or other clinical settings unless it is clinically necessary.

12.2 Inform the receiving ward/unit/care home and the ambulance/transport service that the patient is colonised/infected with MRSA.

Good Practice Point

GPP 12.1 MRSA colonisation is not a barrier to discharging patients to another health care setting, their home or residential care.

8.13 What role does shared equipment have in the transmission of MRSA and how should shared equipment be decontaminated?

One of the risks for transmitting MRSA to patients within healthcare premises or long-term care facilities is the use of improperly cleaned and disinfected medical equipment. When equipment is shared and not cleaned in between patient use, transmission of organisms such as MRSA can occur. Examples of equipment that may be shared between patients include venepuncture tourniquets, stethoscopes, ultrasound transducers, thermometers, blood pressure cuffs, dermatoscopes, pulse oximeters, hoists, hand-held devices, and keyboards. Such equipment needs to be decontaminated after each patient use. Decontamination is the use of physical or chemical means (e.g. alcohol/detergent wipes/sprays, chlorine tablets) to remove, inactivate or destroy pathogens on an item to prevent transmission of infectious agents and render the item safe for use on other patients. Previous MRSA guidelines recommended that patient shared equipment should either be suitable for decontamination or should be single-patient use and discarded as clinical waste after use.

There was weak evidence of potential risk of MRSA transmission from eight studies[239-246] which evaluated microbial contamination of shared equipment. One experiment[239] involved

the contamination of stethoscope diaphragms with a known inoculum of MRSA. These were then a) pressed directly onto selective agar and b) onto a pig skin surface and then selective agar. The number of MRSA transferred directly to the agar was approximately 2 Log_{10}, with 1 to 1.5 Log_{10} fewer transferred by indirect transfer. Following simulated auscultation on 57 patients colonised with MRSA, stethoscopes were pressed onto selective agar and the same procedure was conducted with a sterile gloved hand for comparison. The stethoscope was less likely to transfer MRSA from the patients' skin to agar than gloved hands (11/57 (19%) versus 15/57 (26%); p=0.05), with a mean of 5.9 (+/-8.6) versus 14.3 (+/-11.4) (p=0.01) acquired and transferred by stethoscopes compared to gloved hands. Wiping the diaphragm with 70% isopropyl alcohol, 70% ethanol, or sterile water, removed 100%, 100% and 94% of the MRSA respectively. Although this study provides evidence that MRSA are potentially transferred by stethoscopes, the number of organisms transferred is lower than would be transferred on hands. A 10-second wipe with alcohol removed all MRSA from the stethoscope and even wiping with water removed over 90% of the contamination. A similar study[245] tested a stethoscope disinfection UV device in comparison to wiping the diaphragm with 70% alcohol during examinations of MRSA patients (six skin locations around heart and abdomen for 5-sec contact each). The authors reported that 17/45 (38%) of stethoscopes were contaminated with MRSA, and that after using the UV device, the number reduced to four (9%) (p<0.01). The mean number of colonies fell from 4.00 to 0.08 colony forming units (cfu, p=0.45). In the 70% isopropyl alcohol pad group, a total of 7/20 (35%) stethoscopes were initially contaminated and cleaning with the pad removed microorganisms from all (0.0%) (p<0.01). The sample size was too small to make any inferences between the UV and the alcohol group.

Another study[240] cultured the handles of 300 wall-mounted and portable digital thermometers in an acute and long-term care hospital; 8% were contaminated with one or more pathogens, although only 1% of these pathogens were MRSA. To test the risk of cross-contamination from contaminated thermometer handles, six handles on digital thermometers in portable units were inoculated with a DNA marker (generated from a mosaic virus) and an additional fluorescent marker was applied to assess if the thermometer handles were cleaned. The handles were checked at day one and two (acute setting) and 14 (long-term care setting) to assess if the fluorescent marker had been removed. High-touch surfaces (e.g. bed rails, call buttons), other portable equipment and ward areas (e.g. nursing stations) and patient hands (acute setting) were sampled for the presence of the DNA marker on day one and two 2 (acute) and day 14 (long-term care). In the long-term care area, the DNA marker was detected on high-touch surfaces in 21% of 14 rooms sampled and 80% (4/5) of shared portable equipment not previously inoculated with the marker. In the acute setting, the marker was detected in 33% (2/6) of rooms and on the hands of one of six patients. None of the fluorescent markers were removed by day two (acute setting) or 14 (long-term care setting). This study provides evidence that reusable patient equipment does become contaminated with pathogens, although the frequency of contamination with MRSA was very low. If thermometer handles are contaminated, the model suggested there was a risk of

transfer to both the patient and other sites in the care environment. Although not possible to generalise, in the study sites, this shared equipment did not appear to be cleaned.

Four studies evaluated methods of decontamination of shared equipment to minimise the risk of transmission of MRSA. Two used UV light-based devices and one a hydrogen peroxide cabinet. All studies were laboratory-based experiments, and the findings are difficult to apply to a clinical setting. In one study,[241] an UV-C cabinet designed to deliver large amounts of UV-C radiation for the disinfection of individual pieces of clinical equipment up to approximately $1m^3$ in size, was evaluated against known pathogens. Eight items were tested (blood pressure gauge and cuff, patient call button, infusion pump, tympanic thermometer, oximeter base unit, keyboard, TV remote control). They were inoculated at nine sample points with a known concentration of test organisms (including a clinical MRSA isolate) and exposed to UV-C for two 30-second doses of 1590 L/m^2. Additional tests were conducted using bovine serum albumen to represent soiling with organic matter and performance was compared with wiping with an antimicrobial wipe. The cabinet cycle consistently reduced the number of organisms by at least 4.7 Log_{10} or below 10 cfu on 80% of sample sites but contamination persisted on other sites. The authors reported that efficacy was not affected by organic soil and that a thorough cleaning (4 strokes) with a wipe achieved similar Log^{10} reductions as the cabinet for some items. The authors concluded the cabinet could provide a means of rapidly decontaminating patient-related equipment but that these laboratory-based findings might not be replicated in use. Another study[242] involved testing the efficacy of a portable, hand-held UV irradiation device (Sterilray) designed to be held over surfaces while emitting UV-C radiation. In the laboratory, a known concentration of MRSA was inoculated onto a plastic surface and at $100mJ/cm^2$ the UV device reduced MRSA cfu by 5.4 Log_{10}. A range of surfaces in 27 rooms where a patient was MRSA positive (call light, bedside table, telephone, bed rail) were tested, by culturing before and after the use of the UV-device. A total of 106 sites were cultured and the number positive after use of the device was reduced from 46% to 27% ($p=0.007$). The less effective reduction associated with in-use items may reflect the effect of organic contamination on the efficacy of the method.

The efficacy of a cabinet that uses 35% hydrogen peroxide mist to disinfect ultrasound transducers in an automated seven-minute cycle was evaluated in simulated use tests in the laboratory.[243] Standardised carrier tests included MRSA inoculated onto a hard plastic surface in combination with organic challenge (5% v/v horse serum). The process successfully eliminated MRSA from 20 carriers. In another study,[244] decontamination of ultrasonographic probes inoculated with a known concentration of MRSA was evaluated using a three-step decontamination process (1. cleaning with a dry towel, 2. saline moistened towel, 3. QAC germicidal wipe) or by germicidal wipe alone. In surveillance cultures from probes used in the emergency department taken prior to the experiment, only one of 164 cultures recovered MRSA and only 1.2% of the probes were contaminated by clinically significant pathogens. In the 3-step decontamination process, MRSA was not eliminated after wiping with the towel

but the germicidal wipe in both the 3-step and single step process, eliminated 100% and 90% of MRSA, respectively.

Finally, one study[246] described an outbreak investigation involving MRSA and meticillin-sensitive *Staphylococcus aureus* (MSSA) strains. Using the data from clinical isolates, environmental sampling and patient records, together with WGS analysis which helped to identify the clusters, the authors were able to trace the outbreak to contaminated anaesthesia equipment, which following disinfection of an operating room and equipment, was not a source of further cases.

Recommendations

13.1 Clean and disinfect shared pieces of equipment used in the delivery of patient care after each use, utilising products as specified in a local protocol.

Good Practice Points

GPP 13.1 Make all healthcare workers aware of the importance of maintaining a clean and safe care environment for patients. Every healthcare worker needs to know their specific responsibilities for cleaning and decontaminating the clinical environment and the equipment used in patient care.

GPP 13.2 Introduce policies for staff, patients, and visitors to clean their hands before and after they use the shared equipment.

8.14 What information do patients and relatives require in relation to screening, decolonisation and management to minimise anxiety and improve the patient experience? What information do patient's, families and primary/ home care professionals need when a patient is discharged home?

Opinion polls have demonstrated that the fear of developing MRSA is the single greatest concern of people who need to go into hospital for treatment. MRSA has received considerable media coverage, which has helped to shape public awareness. Unfortunately, most of the reporting has been negative and alarmist, so patients due for hospital admission are often anxious about the risk of MRSA infection. Much of the anxiety that patients with MRSA feel stems from the fact that they are not fully or appropriately informed. Lay people do not appear to access credible sources of information, or, if they do access them, are unable to understand their messages. Organisations that provide patient-focused information about MRSA are generic in scope, so that specific information may take time and effort to locate.

There was moderate evidence from a retrospective matched cohort study,[247] one retrospective case-control study,[248] one survey,[249] and five qualitative studies,[250-254] all undertaken in North America, which investigated the quality of care and other adverse

outcomes potentially associated with isolation for MRSA colonisation or infection. One survey, which evaluated the use of CP in patients with MRSA,[249] indicated that patients who were subject to isolation for MRSA were as satisfied with their care as patients who were not isolated. The authors reported that, in this hospital, an infection preventionist made frequent visits to patients placed on CP so that they would be reassured. In a retrospective case control study[248] in a tertiary care setting, the authors reported that non-isolated patients had a slightly shorter hospital stay of 6.0 versus 7.0 days but isolated patients received significantly fewer bedside visits (p=0.01) and showed a tendency toward more preventable complications (p=0.06). Isolated patients had less documented care and less bedside visits from medical staff, which could hamper the therapeutic relationship. In a retrospective matched cohort study[247] to examine the effect of isolation precautions on hospital related outcomes and the cost of care, the authors reported no significant differences in 30-day emergency department visits, formal complaints, or inpatient mortality rates between the cohorts. Similar to patients with respiratory illness, patients isolated for MRSA stayed 30% longer (LOS 11.9 days versus. 9.1 days [CI95%: 1.22-1.39]), were hospitalised 13% longer than expected, (LOS/ELOS [estimated LOS], 1.3 versus. 1.2; [CI95%: 1.07-1.20]) and had 43% higher costs of care (direct cost, CAD 11,009 versus. CAD 7670 [CI95% 1.33-1.54]) compared to matched controls.

Five qualitative studies included findings that related to the patient experience of isolation.[250-254] The studies suggested that patients had a poor understanding of the reason for their isolation and were confused about the need and variation in the use of protective equipment (gloves, aprons, gowns). This confusion led to feelings of anger and frustration toward healthcare staff and the healthcare institution. Isolation in a side room was perceived to have both positive and negative aspects; positives were greater freedom from routine, greater privacy and solitude, and the perception that visitors were given greater freedom. The negative characteristics were a lack of attention from staff and feeling lonely and stigmatised. Isolation also indicated to some the severity (or not) of the condition.

Recommendations

14.1 Make patients aware of the reasons for MRSA screening and decolonisation.

14.2 Inform patients of their screening result as soon as it is available.

14.3 For patients who are identified as MRSA positive, provide consistent and appropriate information about:

- The difference between colonisation and infection
- The microorganism
- How MRSA is acquired and transmitted
- How MRSA is treated
- The reasons for contact precautions or isolation.

14.4 On discharge provide consistent and appropriate information about:

The risks to household members, friends, and family.
The implications for future health and health care.
Persons who need to be notified about their MRSA colonisation status.
If applicable, instructions on decolonisation regimen with the information that the results may not be permanent.

14.5 Provide information in a format and language that the patient and their family is able to understand.

Good Practice Points

GPP 14.1 Use patient leaflets provided in the Supplementary Materials of this guideline.

GPP 14.2 Inform patients about the possibility of re-colonisation and the importance of changing linen, towels, and clothes daily.

8.15 What needs to be considered by healthcare professionals when a person who is colonised or infected with MRSA dies?

MRSA colonisation or infection in a deceased person is not a risk, but can cause concern amongst funeral directors with some even refusing to take the body. There is negligible risk to mortuary staff or funeral directors provided that standard IPC precautions are employed. An approach to address this problem should include staff training and education. IPC guidelines for funeral directors do exist for many hospital trusts but there is inconsistency in the contents of such guidelines as well as in their implementation. Consistent guidance on what needs to be considered by healthcare professionals when a person who is colonised or infected with MRSA dies, would facilitate the deceased's family obtaining funeral services and protect the involved personnel to minimise the risks of transmission of MRSA. Our previous MRSA guidelines recommended that the IPC precautions for handling deceased patients should be the same as those used in life.

No evidence was found in the studies published since 2004 which met the inclusion criteria for the study design, and which investigated the handling of deceased patients who were colonised or infected with MRSA.

Recommendation

15.1 Follow national guidance for managing infection risks when handling the deceased.

9. Further research

Research recommendations:

RR 1.1 Studies showing cost-effectiveness and practicality of performing targeted versus universal screening.

RR 1.2 Validation studies for targeted screening tools.

RR 3.1 Further studies assessing the clinical and cost-effectiveness of molecular diagnostic methods.

RR 3.2 Studies that describe the real-life, clinically relevant TAT (i.e., the time between when the patient should be screened, and when the test results are available to the clinician).

RR 4.1 Well-described reports discussing staff implicated in outbreaks.

RR 6.1 Rigorous comparative studies assessing the effectiveness of alternatives to mupirocin and chlorhexidine.

RR 7.1 Studies which show whether environmental sampling and feedback to cleaning staff has a role in reducing MRSA transmission.

RR 8.1 Studies that assess the effectiveness of antimicrobial surfaces and touch-free devices on the environmental contamination with MRSA as well as MRSA transmission.

General research recommendation Studies conducted in health and social care settings other than the acute hospital sector.

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Abbreviations

AOR – adjusted odds ratio

ATP – adenosine triphosphate

BSI – bloodstream infection

CBA – controlled before/after (study)

cfu – colony forming units

CHG – chlorhexidine gluconate

CI – confidence intervals

CLABSI – central line-associated bloodstream infection

CP – contact precautions

DAS – diagnostic accuracy study

ELOS – estimated length of stay

GP – general practitioner

HCAI – healthcare-associated infection

HES – Hospital Episode Statistics

HPV – hydrogen peroxide vapour

HR – hazard ratio

ICU – intensive care unit

IPC – infection prevention and control

IRR – incidence rate ratio

ITS – interrupted time series (study)

LOS – length of stay

MDRO – multidrug-resistant organism

MIC – minimum inhibitory concentration

MRSA – Meticilin-resistant *Staphylococcus aureus*

MSSA – Meticilin-sensitive *Staphylococcus aureus*

NICE – National Institute for Health and Care Excellence

NR – not reported

OR – odds ratio

PCR – polymerase chain reaction

pd – patient days

PICO – Population-Intervention-Comparator-Outcome (framework)

PPE – personal protective equipment

PVL – Panton-Valentine leucocidin

PVP – povidone-iodine

PX-UV – pulsed-xenon ultraviolet

QAC – quaternary ammonium compound

RCT – randomised controlled trial (RCT)

RR – risk ratio

SIGN – Scottish Intercollegiate Guidelines Network

SPC – statistical process control (chart)

SSI – surgical site infections

TAT – turnaround time

UBA – uncontrolled before/after (study)

UV-C – ultraviolet-C

WGS – whole genome sequencing