NATIONAL CLINICAL EFFECTIVENESS COMMITTEE

Tús Áite do Shábháilteacht Othar
Patient Safety First

Prevention and Control Methicillin-Resistant *Staphylococcus aureus* (MRSA)

National Clinical Guideline No. 2

An Roinn Sláinte
DEPARTMENT OF HEALTH

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Guideline Development Group
The Prevention and Control of Methicillin-resistant *Staphylococcus aureus* (MRSA) National Clinical Guideline was developed by the Royal College of Physicians Ireland (RCPI) Clinical Advisory Group on healthcare associated infections (HCAI) - Subgroup MRSA Guideline Committee.

Using this National Clinical Guideline
This document is intended to be relevant to all healthcare staff involved in the care of patients, residents or clients who may be at risk of or have MRSA in acute hospitals, nursing homes/long stay residential units and the community.

A summary version of the National Clinical Guideline, is available on the website:
www.patientsafetyfirst.ie

Disclaimer
The National Clinical Guideline Development Group's expectation is that healthcare professionals will use clinical judgment and knowledge in applying the general principles and recommendations contained in this document. Recommendations may not be appropriate in all circumstances and decisions to adopt specific recommendations should be made by the practitioner taking into account the circumstances presented by individual patients and available resources.

Antibiotic stewardship is the subject of on-going research and debate. Local antibiotic susceptibility data should be used to guide treatment having due regard to the clinical judgement of the prescriber and the individual circumstances of each patient. Therapeutic options should be discussed with a clinical microbiologist or infectious disease physician on a case-by-case basis as necessary.

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National Clinical Effectiveness Committee (NCEC)

The National Clinical Effectiveness Committee (NCEC) was established as part of the Patient Safety First Initiative in September 2010. The NCECs mission is to provide a framework for national endorsement of clinical guidelines and audit to optimise patient and service user care. The NCEC has a remit to establish and implement processes for the prioritisation and quality assurance of clinical guidelines and clinical audit so as to recommend them to the Minister for Health to become part of a suite of National Clinical Guidelines and National Clinical Audit.

National Clinical Guidelines are "systematically developed statements, based on a thorough evaluation of the evidence, to assist practitioner and service users' decisions about appropriate healthcare for specific clinical circumstances across the entire clinical system". The implementation of clinical guidelines can improve health outcomes, reduce variation in practice and improve the quality of clinical decisions.

The aim of National Clinical Guidelines is to provide guidance and standards for improving the quality, safety and cost effectiveness of healthcare in Ireland. The implementation of National Clinical Guidelines will support the provision of evidence based and consistent care across Irish healthcare services.

The oversight of the National Framework for Clinical Effectiveness is provided by the NCEC. The NCEC is a partnership between key stakeholders in patient safety and its Terms of Reference are to:

- Apply criteria for the prioritisation of clinical guidelines and audit for the Irish health system
- Apply criteria for quality assurance of clinical guidelines and audit for the Irish health system
- Disseminate a template on how a clinical guideline and audit should be structured, how audit will be linked to the clinical guideline and how and with what methodology it should be pursued
- Recommend clinical guidelines and national audit, which have been quality assured against these criteria, for Ministerial endorsement within the Irish health system
- Facilitate with other agencies the dissemination of endorsed clinical guidelines and audit outcomes to front-line staff and to the public in an appropriate format
- Report periodically on the implementation of endorsed clinical guidelines.

It is recognised that the health system as a whole, is likely to be able to effectively implement and monitor only a small number of new National Clinical Guidelines each year. Not all clinical guidelines will be submitted for national endorsement and clinical guideline development groups can continue to develop clinical guidelines using an evidence based methodology in response to the needs of their own organisations.

Information on the NCEC and endorsed National Clinical Guidelines is available on the Patient Safety First website at www.patientsafetyfirst.ie

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1.1 Definition of MRSA

Staphylococcus aureus (S. aureus) commonly colonises the skin and nose. Methicillin-resistant *Staphylococcus aureus* (MRSA) infection is caused by a strain of bacteria that has become resistant to the antibiotics commonly used to treat ordinary staphylococcal infections.

In the right setting MRSA can cause severe and at times fatal infections such as bloodstream infection (BSI), infective endocarditis, pneumonia and skin and soft tissue infections (SSTI).

1.2 Scope of the National Clinical Guideline

The guideline is relevant to and has been developed for all healthcare staff involved in the care of patients, residents or clients who may be at risk of or may have MRSA in acute hospitals, obstetrics and neonates, nursing homes/long stay residential units and the community. Such members of staff include medical practitioners, nurses, midwives, healthcare assistants, biomedical scientists, pharmacists and allied healthcare professionals. This guideline acknowledges changes in epidemiology, i.e. the emergence of community-acquired MRSA (CA-MRSA).

The public and patients will find this guideline of interest as it outlines the general and specific measures required to prevent and control MRSA and how these can and should be incorporated into quality measures to safeguard the quality of patient care. In addition, a summary version of this document, outlining the recommendations, is also available.

This guideline updates the last set of guidelines on MRSA which were published in 2005 by the Health Protection Surveillance Centre (HPSC).

The guideline does not address the following:

i) Issues relating to antibiotic resistance, including MRSA in the agri-farming sector
ii) The challenges of developing new drugs for the treatment of invasive MRSA infection
iii) The potential implications of laboratory modernisation which will include rationalisation and the centralisation of some services, including the laboratory diagnosis of and screening for MRSA.

The recommendations are followed by a grade. This is a consensus grade agreed by the MRSA guideline development group (Appendix III) reflecting the strength of the evidence supporting the recommendation, and discussion of the evidence amongst the MRSA guideline development group. The system below, as used in the 2005 guidelines was felt to best meet the needs of the guideline and the guideline development group, given the absence of randomised controlled trials (RCTs) in many of the areas covered.

The grades used throughout the guideline document are as follows:

Grade A Evidence from a meta-analysis of RCTs, or from at least one RCT.

Grade B Evidence based on one controlled trial without randomisation, a quasi-experimental study, or extrapolated from RCTs.

Grade C Evidence from comparative studies, correlation studies, case control studies or extrapolated from category A or B.

Grade D Evidence from expert committees, reports or opinions, the clinical experience of respected authorities, and the conclusions of the guideline development group.

A consultation process was completed (Appendix IV).

1.3 Aim of guideline

To provide practical guidance on prevention and control measures for MRSA to improve patient care, minimise patient morbidity and mortality and to help contain healthcare costs.

1.4 Objectives

The objectives of this guideline are:

- to enhance and further improve the prevention and control of MRSA since the publication of previous guidelines in 2005.
- to improve the safety and quality of patient care through reducing further the prevalence of MRSA BSI and to prevent other serious infections such as SSTI, respiratory tract, bone and joint infections caused by MRSA.
- to improve the use of antibiotics specifically for MRSA infections and to contribute to other aspects of antibiotic stewardship.
- to raise awareness of healthcare-associated infection (HCAI), amongst the public and all healthcare professionals about the measures required for prevention and control, e.g. standard precautions and the importance of their implementation.

Table 1 gives an overview of what this guideline would like to achieve in terms of MRSA prevention and control and quality and patient/resident safety issues.

Table 1 Elements of a programme to prevent and control MRSA to promote safe quality care

Quality	Element
Patient/resident-centred care	Prevention and control of MRSA is a key priority for all healthcare providers Patient/resident information on MRSA prevention and control Governance and reporting systems to provide assurance Implementation of *National Standards for the Prevention and Control of Healthcare Associated Infections* produced by HIQA in 2009
Effective care	Systems and controls in place to - Monitor compliance with National Standards (HIQA, 2009) and other national standards relevant to this area - Analyse and learn from MRSA incidents when they occur with dissemination of learning and institution of controls to prevent recurrence
Safe care	Implementation of national MRSA, antimicrobial stewardship and hand hygiene guidelines Audits and assessment of guideline compliance
Better health and wellbeing	Healthcare provider education about the prevention of HCAI and MRSA Patient/resident education about the prevention of MRSA
Ensure that the healthcare system is designed to do the above	
Governance, leadership and management	Accountability and responsibility for MRSA clearly defined Performance monitoring undertaken and regularly reviewed Cluster/outbreak management Communication regarding MRSA with other healthcare providers, patients, residents and the public Microbiological services to support MRSA prevention are appropriate HCAI surveillance as a key component of the system Antimicrobial stewardship as a key component of safe and effective care
Workforce	Defined skills, competencies, education and training
Use of resources	Strategies to prevent MRSA are cost-effective Strategies to promote appropriate antimicrobial use are cost-effective HCAI Education is appropriate
Use of information	MRSA surveillance, in conjunction with other relevant indicators, e.g. hand hygiene compliance is fed back, reviewed and monitored

2.0 Recommendations

The recommendations are numbered 1 to 53 as follows:

Prevention and control (Recommendations 1-32)
- Screening
- Infection prevention and control measures in the acute hospital setting
- MRSA in the non-acute healthcare setting
- MRSA in obstetrics and neonates
- Community-associated MRSA
- MRSA decolonisation
- Antimicrobial stewardship and the prevention and control of MRSA
- Occupational health aspects of MRSA

Management (Recommendations 33-45)
- Treatment and prophylaxis

Surveillance (Recommendations 46-50)

Evaluation and audit (Recommendations 51-53)

The recommendations are linked to the best available evidence and/or expert opinion using the grades for recommendations outlined in Section 1.2. A rationale for the recommendations is outlined and practical guidance to support the delivery of the recommendations is provided.

Prevention and control of MRSA is a multidisciplinary task, involving surveillance, patient screening, decolonisation, isolation and cohorting of patients, environmental cleaning, antimicrobial stewardship, maintaining adequate staffing levels and hand hygiene. The prevention and control of MRSA are the responsibility of all those who work in the healthcare sector and not just those professionally involved in infection prevention and control.

2.1 Prevention and control (Recommendations 1-32)

The following are responsible for implementation of recommendations 1-32: clinical teams, senior management and the Infection Prevention and Control Team (IPCT). Public health professionals and medical scientists have some specific roles as outlined in the relevant recommendations.

2.1.1 Screening

Effective strategies for the prevention and control of MRSA rely on early detection so that appropriate measures may be implemented. Screening, linked to patient isolation and the use of contact precautions (CP) are important. These are precautions intended to prevent transmission of infectious agents i.e. MRSA, which are spread by direct or indirect contact with a patient or the patient's environment and have been shown to be effective in reducing the transmission of MRSA (1-4). Successfully detecting MRSA carriage is influenced by many factors including the laboratory methods used, the number of times the patient is screened, the types of samples obtained, and when they are obtained. It is generally accepted that instituting CP is appropriate for those patients known to be colonised with MRSA in the acute setting (5) although there is conflicting evidence on this particular topic (6). What follows in this section largely relates to the acute healthcare setting. However, screening may be a component of the prevention and control of CA- MRSA as outlined in section 2.1.5.

Recommendation 1
Continue with targeted MRSA screening (i.e. patients at risk of acquiring MRSA), and not universal screening (i.e. all patients on admission to acute hospitals), pending further data on its efficacy and feasibility. **Grade D**

Recommendation 2
All patients (in-patients, out-patients and other patients in the community) identified with MRSA should be informed as soon as possible of their MRSA status, which should be documented in the patients' clinical notes and information should be provided about eradication/treatment options, as appropriate. **Grade D**

Practical Guidance

Who to screen and when

a) The taking of screening samples to determine MRSA status should not adversely affect the individual patient's access to clinical care, e.g. urgent surgery should be carried out with appropriate precautions and surgical prophylaxis, and not be delayed by the taking of specimens or by waiting for results. **Grade D**

b) Patients who should be screened on admission for MRSA because they are at risk of having acquired MRSA (i.e. targeted screening) include the following:

- Patients known to be previously positive and who are being re-admitted to an acute hospital. **Grade C**
- Patients admitted directly from another hospital or healthcare facility, e.g. nursing home. **Grade C**
- Patients who have been an in-patient in another healthcare facility, i.e. in acute hospital or long term care facility, in the last six months. **Grade C**
- Patients transferred from a hospital abroad or patients who have been an in-patient in a hospital abroad during the previous 12 months. **Grade C**
- Patients with non-intact skin, including wounds and ulcers and also exfoliative skin conditions, percutaneous endoscopic gastrostomy tubes, urinary catheters and central venous catheters. **Grade C**
- Clients due to undergo elective high and medium risk surgery (e.g. cardiothoracic and vascular surgery, orthopaedic implant surgery). In addition, hospitals should assess which patient groups undergoing surgery have a relatively high risk of MRSA infection and consider pre-operative screening for those particular patient sub-sets. For example, it may be appropriate for hospitals to screen emergency orthopaedic admissions as many of these patients are elderly and have frequent contact with the healthcare system. **Grade C**
- Patients admitted to critical care areas, e.g. intensive care unit (ICU) and special care baby unit (SCBU) with at least weekly screening thereafter. **Grade D**
- Patients requiring renal dialysis. **Grade C**
- Any healthcare worker involved in direct patient contact, being admitted to an acute healthcare facility. **Grade D**

c) Patients who require screening for MRSA subsequent to hospital admission include:

- During an outbreak or cluster. **Grade D**
- Patients transferred to critical care areas e.g. ICU and SCBU with at least weekly screening thereafter. **Grade D**
- Patients requiring renal dialysis require quarterly screening. **Grade C**

- Patients who have been successfully decolonised, i.e. three negative follow-up samples at least 48 hours apart, should continue to be screened at weekly intervals while in an acute hospital setting. **Grade C**
- Other patients, as determined by local risk assessment. **Grade D**

d) Screening samples

- Swabs from the anterior nares, perineum or groin, throat, catheter specimen of urine (CSU), sputum if productive cough and any skin lesions (e.g. surgical site, PEG tube site) should be obtained. **Grade C**
- Additional samples to diagnose infection (e.g. blood, vascular catheter tip) should be taken as clinically indicated. **Grade D**

e) Laboratory methods

- Laboratories should continue with culture-based methods for the detection of MRSA. **Grade D**
- Ideally, broth-enrichment should be used but this results in an additional delay in the issuing of results and the decision needs to be assessed locally. **Grade B**
- The advent of rapid diagnostic testing for MRSA with the polymerase chain reaction (PCR) is a welcome development and it may be appropriate for individual laboratories/ hospitals to introduce rapid diagnostic testing for certain patient groups, e.g. emergency surgical or ICU admissions and to evaluate its impact. **Grade D**

f) Informing patients of MRSA status

- The responsibility of informing patients of their MRSA status lies with the clinical team (i.e. consultant) caring for the patient during their in-patient stay. **Grade D**
- Where a new MRSA case is diagnosed following patient discharge or when a patient is attending an outpatient clinic, it is the clinical team's responsibility (i.e. consultant) to inform the patient's general practitioner of his/her MRSA status and to follow up as required. **Grade D**
- If MRSA is detected upon the patient's admission to a particular healthcare facility, the facility from where the patient was originally transferred needs to be informed. **Grade D**
- An information leaflet (e.g. HPSC leaflet) should be given to all patients colonised or infected with MRSA and this should be documented in the patient's clinical notes. **Grade C**

Rationale
The NHS Scotland MRSA Screening Pathfinder Programme identified the following patients requiring screening for MRSA (7):

- Patients who are not admitted to hospital from their own home
- Patients with a previous history of MRSA
- Patients with any prosthetic device (e.g. urinary or vascular catheter) in situ or who have broken skin (e.g. ulcers).

Currently, there is an on-going discussion between the advantages and disadvantages of targeted versus universal screening, and our conclusions based on the evidence currently available are as follows (8).

Targeted screening (patients with risk factors (see above) for MRSA carriage that are likely to be positive)
Previous Irish and UK guidelines have advocated this approach.

The justification for targeted screening is that up to 75% of patients with MRSA will remain unrecognised if clinical cultures alone, e.g. swabs to confirm the diagnosis of surgical (wound) site infection, are used to detect them (8-10).

Universal screening (all patients on admission to hospital)
This approach has been recommended in the UK i.e. Scottish Health Technology Assessment and by the NHS in England and Wales (8,9). The latter states that "*From April 2009, all elective admissions must be screened for MRSA in line with Department of Health Practical Guidance. This should be extended to cover emergency admissions as soon as possible and definitely no later than 2011*". The NHS Scotland MRSA Screening Pathfinder Programme reported on the results of a one year programme for universal screening in NHS Scotland (7). They found that 3.9% of patient admissions were colonised with MRSA. Short length of stay prevented patients from completing decolonisation regimens and in only one of 33 patients who were MRSA positive on admission was decolonisation completed. Only half of the patients found to be MRSA positive on admission could be isolated. This was due to a combination of factors including short length of stay and a lack of isolation rooms. The report suggested that clinical risk assessment may be a cost-effective first stage screening process for specialties with large numbers of patients, such as medicine and general surgery. A report on the sensitivity and specificity of this screening method is expected in the near future. In a recent study of targeted versus universal screening in 892 patients in a large Irish hospital, 8% of at risk patients were MRSA positive on screening compared to 1% of non-risk patients, i.e. an additional four patients were detected in that cohort that would not normally be screened (11). This was also associated with significant additional costs, i.e. approximately 33% increase in cost. A review of screening for MRSA in Newcastle-Upon-Tyne, England, where universal screening is now routine found that the additional laboratory costs to detect those patients not detected by targeted screening were £20,000 and the authors concluded that screening based upon clinical risk was more pragmatic and cost-effective (12).

Ideally at-risk patients for MRSA should be screened before admission if possible, such as when the admission is elective (i.e. at outpatients) and no more than three months before admission, or at the very least, on admission if emergency or urgent admission. However, every effort should be made to ensure that the process of screening before admission per se does not adversely impact on patient care such as resulting in delays in the emergency department (10). Periodic e.g. weekly surveillance cultures, should continue to be taken from patients remaining in high-risk areas of the hospital, e.g. ICUs, SCBUs, orthopaedic units, solid organ or bone marrow transplant, especially where MRSA is epidemic or where it has been endemic in the past, or in wards with long-stay patients, wards receiving transfers from high risk areas or wards where patients have devices. This will assist in minimising transmission from patients who although negative on admission, have subsequently acquired MRSA while an in-patient.

Patients, with MRSA, who have had three consecutive negative sets of screening samples, at least 48 hours apart after decolonisation regimens, can be removed from isolation. However, such patients should continue to be screened while in hospital to allow for re-acquisition of MRSA but currently there are no clear indications as to how often this should be and currently this is best decided locally according to risk assessment and laboratory resources. It is difficult to decolonise patients, with MRSA, who have wounds or large areas of non-intact skin (e.g. decubitus ulcers) or devices (e.g. urinary catheters) and such patients may require isolation until the wound is healed. When re-admitted to hospital in the future, these patients should be placed in isolation pending the results of screening samples.

Screening is dependent upon adequate laboratory infrastructure.

Screening Samples
The anterior nares is the most important site to sample but omitting sampling of the throat and perineum will miss a proportion of patients who are colonised with MRSA (13-18). While some authors suggest that the addition of throat swabs does not increase sensitivity significantly, the guideline

development group considers it appropriate to include screening the throat, notwithstanding the additional expense, to maximise the detection of MRSA in screened patients (14, 18, 19, 20-23). This becomes especially important if there is a decline overall in the number of patients detected with MRSA when detecting additional cases to drive down the numbers further becomes relevant.

(See Appendix V for details on how to obtain a nasal swab)

Laboratory Screening Methods
The screening methods currently most commonly used are:

- **Broth enrichment culture followed by agar subculture**
  Broth enrichment is followed by sub-culture to chromogenic media and is probably the current 'gold' standard as it is the most sensitive method. The disadvantage is the time delay (up to 48 hours) to a positive result.

- **Chromogenic agar plating, direct culture**
  This method is less sensitive than broth-enrichment culture but has the benefit of a more rapid result (preliminary results after overnight incubation), due to the use of a selective medium.

- **Polymerase chain reaction, i.e. rapid testing**
  There are a number of commercially available rapid diagnostic tests that perform well and are comparable to broth enrichment culture (24). Recent evidence suggests that more rapid results can impact on MRSA transmission and may improve compliance with screening recommendations (25,26). Some of these techniques have been evaluated to detect common circulating strains of MRSA in Ireland and have been shown to be accurate (27). Nonetheless, these laboratory methods are more expensive than conventional culture based methodologies and the benefits, in terms of decreased MRSA acquisition and decreased MRSA infections have not yet been conclusively shown (28). However, it is possible that the selective use of PCR may increase the efficiency of healthcare resources, due to the availability of a more rapid result but this awaits confirmation.

  Barriers to the implementation of recommended screening policies include inadequate laboratory facilities and on-going pressures on clinical staff, e.g. increased patient turn over and maintaining adequate staff numbers. However, the active involvement of IPCTs can assist in ensuring that those patients that should be screened are screened in a timely manner. On-going research is required to confirm that targeted screening remains the appropriate approach as well as indicating the role and especially the cost-effectiveness of molecular methods for MRSA detection.

Communication
Many complaints from patients, their relatives and the public about HCAI and MRSA relate to poor communication including when and if positive MRSA status was conveyed. Patient advocacy groups have prioritised the provision of enhanced information about MRSA to patients and as rapidly as possible, i.e. once confirmed. This is also consistent with clinical governance, professional and ethical standards, and is endorsed by professional bodies (29). Knowledge of positive MRSA status by patients themselves can inform when screening is required, e.g. subsequent admission to hospital. Reductions in the spread of MRSA can be accomplished by sharing information, educating personnel about MRSA, and improving hygiene practices for everyday living. If the patient has been discharged a letter should be sent to the GP (Appendix VI).

Barriers to ensuring that patients are informed of their MRSA status and that this is documented includes a lack of knowledge on the part of some clinical staff on MRSA and its implications, embarrassment that the patient has acquired MRSA and time pressures. However, this can be partly rectified by education, simplification of the documentation process and the feeding back of audits on the proportion of patients that have been notified.

2.1.2 Infection prevention and control measures in the acute hospital setting

A multifaceted approach in infection prevention and control interventions aids in preventing and controlling the spread of MRSA (1). These interventions include contact isolation, patient cohorting, hand hygiene campaigns, environmental cleaning, active surveillance and antimicrobial stewardship programs.

General Issues

Recommendation 3
Healthcare facilities should have an infection prevention and control programme which incorporates:
- Monitoring for problems, including outbreaks of infection
- Routinely assessing all residents for their risk of acquisition or transmission of infection
- Education of employees in infection prevention and control precautions
- Policy and procedure development and review
- Monitoring of care practices
- Occupational health
- Antibiotic stewardship. **Grade D**

Recommendation 4
The health service provider should take steps to prevent patient overcrowding and to maintain adequate staffing levels, in order to minimise the risk of MRSA transmission. **Grade B**

Recommendation 5
Staff members of all grades should receive appropriate training and education on standard precautions, hand hygiene and the appropriate use of personal protective equipment (PPE) etc. i.e. on induction and annually. **Grade B**

Recommendation 6
Where single rooms or a dedicated isolation unit are not available, colonised patients may be cohorted in designated areas with designated staff according to local risk assessment and the facilities available. **Grade C**

Recommendation 7
Hand hygiene should be carried out according to the World Health Organization (WHO) 5 moments of hand hygiene:
- Before patient contact
- Before aseptic task
- After body fluid exposure risk
- After patient contact
- After contact with patient surroundings. **Grade A**

Recommendation 8
Hand hygiene should be carried out regularly by patients themselves. **Grade C**

Recommendation 9
Patients/residents/visitors should be encouraged to decontaminate their hands at regular intervals with assistance given if necessary. **Grade C**

Recommendation 10
A risk assessment should be undertaken on activities undertaken in a patient's room and appropriate PPE selected. **Grade C**

Practical Guidance

General issues

a) Bed spacing should be planned and managed in a way that minimises the risk of spread of MRSA as outlined by HIQA (2009) *National Standards for the Prevention and Control of Healthcare Associated Infections*. **Grade D**

b) Newly built acute hospital inpatient accommodation should comprise 100% single rooms with ensuite shower and toilet facilities as outlined by HIQA (2009) *National Standards for the Prevention and Control of Healthcare Associated Infections*. **Grade C**

c) Risk stratification should be performed locally to identify areas where MRSA infection results in high morbidity and mortality and where patient isolation or cohorting is essential (Appendix VII – Risk stratification tool). Isolation or cohorting is essential in high-risk areas, i.e. ICUs, orthopaedic units, vascular surgery units, transplant units, SCBUs and other specialised clinical areas with vulnerable patients. **Grade B**

d) Hospitals with endemic MRSA may consider the establishment of a dedicated isolation unit or control of infection ward. Control of infection wards should not be sited away from the main hospital environment to ensure that patients are not distanced from specialist care. **Grade D**

e) All national and international patient transfers to an acute setting should be isolated until MRSA screens are negative. **Grade C**

f) Every effort should be made to ensure that all patient transfers into high-risk units (critical care areas, SCBU, cardiothoracic units, orthopaedics, trauma, vascular surgical units and transplant units) from non-high risk areas (medical and care of elderly units) within the same institution should be isolated or cohorted with contact precautions (CP) until MRSA screens are negative. If this is not feasible a risk assessment should be carried out before the patient is moved into the high-risk unit. **Grade B**

g) All known MRSA cases on admission and all new MRSA cases upon identification in high-risk areas (critical care units, orthopaedics, surgical wards and transplant units) should be isolated or cohorted with CP and screened accordingly thereafter. **Grade B**

h) Patients with exfoliative skin conditions who are likely to shed MRSA in high numbers should be isolated until advised by the local infection prevention and control team. **Grade B**

i) Where a new case of MRSA is identified in a general ward area, i.e. non-single room, patients in that vicinity (e.g. ward bay) should be screened for MRSA. **Grade C**

j) Patients awaiting the results of MRSA screening should be nursed in a single room with CP if any of the following apply:

- Previously colonised or infected with MRSA
- Recent and frequent hospital admissions i.e. within 6 months
- Transferred from another healthcare institution, i.e. hospital or nursing home
- Inpatients in another healthcare institution within the previous six months
- Patients with skin ulcers or chronic wounds
- Patients transferred from hospitals abroad. **Grade C**

k) The number of healthcare staff who have direct contact with patients in isolation who are colonised or infected with MRSA should be kept to a minimum. Staff with persistent exfoliative

skin lesions should be excluded from the care of patients colonised or infected with MRSA. **Grade D**

l) Isolation and CP can be discontinued if patients with MRSA have three consecutive negative sets of screening sample, at least 48 hours apart and two days after decolonisation treatment has been concluded. **Grade C**

Hand Hygiene

a) Cuts or breaks in the skin of healthcare workers should be covered with impermeable dressings. **Grade B**

b) National recommendations on hand hygiene should be followed. **Grade D**

Personal protective equipment (PPE)

a) The use of PPE should be determined by:

- Nature of anticipated patient care intervention
- Nature of procedure
- Risk of exposure to blood or body fluids
- Risk of contamination of skin/clothes. **Grade B**

b) Gloves should be changed and the hands decontaminated between several procedures, such as surgical site care, followed by IV line inspection on the same patient. **Grade C**

c) PPE should be removed prior to leaving the isolation room, discarded into appropriate healthcare waste stream and hand hygiene performed. **Grade B**

d) There is often no need for visitors to wear PPE. The most important element for the visitor is to ensure they perform hand hygiene before and after patient contact. **Grade D**

e) Face masks are not normally required unless airborne or droplet precautions are required for other reasons e.g. viral RTI. **Grade D**

Education

a) All HCWs should receive adequate training at induction and annually on standard and transmission-based precautions on hand hygiene and the appropriate use of PPE. **Grade D**

b) Patients should be educated on the importance of hand hygiene while they are an in-patient. **Grade D**

c) Hospital management should ensure that all hospital staff (including supervisory staff) involved in environmental decontamination are trained, and certified as competent. Training should commence within the first week of employment. **Grade D**

d) The Chief Executive Officer, or equivalent, of every healthcare facility should take corporate responsibility for providing adequate resources for training for those involved in cleaning. **Grade D**

Patient movement and transfer

a) The movement and transfer of patients with MRSA both within a hospital and between hospitals should be limited to prevent spread but the patient should not in the process be deprived of necessary care. **Grade C**

Operating theatre

a) Patients colonised or infected with MRSA do not need to be placed last on the theatre list provided the theatre is adequately cleaned and disinfected afterwards. **Grade D**

b) A sign should be placed on the theatre door to notify staff of CP. **Grade D**

c) Staff and stock equipment within the operating theatre should be kept to a minimum. **Grade D**

d) The operating theatre should be cleaned and disinfected before the next patient. **Grade B**

e) Patient recovery should be in a designated area within the recovery department using CP. **Grade D**

Equipment and environmental hygiene

a) Patient care equipment such as blood pressure cuffs and stethoscopes should be designated for use only on a single patient who is colonised or infected with MRSA. **Grade C**

b) Patients' charts including observation charts and drug charts should be kept outside the patients' room. **Grade D**

c) All equipment should be cleaned and disinfected after use. **Grade B**

d) All healthcare staff should comply with best practice for the insertion of invasive medical devices such as intravascular catheters and urinary catheters. **Grade B**

e) The hospital environment should be visibly clean, free of dust and acceptable to patients, visitors and staff. **Grade C**

f) All hospital surfaces should be intact and made of a durable, washable material. This is fundamental to the control of all healthcare-associated infections, including MRSA. **Grade C**

g) Daily cleaning of an isolation room with detergent and water is sufficient with a terminal clean i.e. cleaning and disinfection being completed on transfer or discharge of the patient, paying particular attention to hand touch surfaces. **Grade C**

h) Additional cleaning and disinfection measures are necessary on the discharge of MRSA patients and in outbreak situations. **Grade C**

i) The correct colour coded system should be used for cloths/mops in isolation rooms. The National Hospitals Office Cleaning Manual for Acute Hospitals (2006) and equivalent Irish guidelines recommend white cloths for isolation rooms (47). **Grade C**

Laundry and healthcare waste

a) All laundry should be treated as potentially infectious and placed directly into an alginate or water-soluble bag at the bedside. **Grade C**

b) Risk waste i.e. gloves and aprons, unless contaminated with infectious body substances i.e. blood or sputum. **Grade C**

Rationale

General Issues

Every effort should be taken to minimise the transmission of MRSA, and other pathogens, even in the absence of specific isolation facilities. Overcrowding and understaffing have led to failures

of MRSA control programmes via decreased healthcare worker hand hygiene compliance, increased movement of patients and staff between hospital wards, decreased levels of cohorting and the overburdening of screening and isolation facilities (2,3). Increased patient/staff ratios are associated with increased transmission rates of infection as is the increased use of temporary or locum nursing staff even if this may be mitigated in part by good compliance with hand hygiene (4-7). A high MRSA incidence leads to increased inpatient length of stay and delayed discharge, exacerbating overcrowding and leading to a vicious cycle characterised by further infection prevention and control failures (3). Staff members should receive education and training in infection prevention and control initiatives i.e. hand hygiene (8). This training should be delivered during orientation/induction with regular updates.

The risks of HCAI are greatly increased by high bed occupancy and by an absence of suitable facilities to isolate infected patients (9).

The NHS recommends a minimum space of 3.6m bed centre-to-centre to minimise spread of infection (10, 11). In Ireland, the recommendation has been made that there should be a minimum floor space of 19m² around each bed (12). HIQA (2009) *National Standards for the Prevention and Control of Healthcare Associated Infections* makes recommendations regarding floor space. Sufficient space accommodates clinical activities, patient movement and visitors. This also allows for the fact that droplet spread of pathogens is generally only a risk within one meter of the source patient (13, 14).

Experience with epidemic strains of MSSA in the 1960s demonstrated that isolation was a key component in controlling the spread of staphylococci (15, 16). A study from France found that MRSA infections decreased by 17.9% with the introduction of isolation precautions (17). Jernigan *et al* demonstrated a 15.6-fold lower MRSA transmission rate when colonised patients were cared for using strict isolation precautions, compared to standard precautions (18, 19). The choice of isolation facility depends on hospital size, activity and the local MRSA rates.

Single rooms should have their own toilet en-suite, including dedicated washing/bathing facilities for patients. There should be a separate clinical hand-washing sink and alcohol hand rub dispenser in the room.

Where sufficient single rooms, or a dedicated isolation unit, are not available colonised patients may be cohorted in designated areas. This approach has been effective in controlling MRSA outbreaks (20).

Negative pressure (airborne isolation) rooms are not generally required for the care of patients colonised or infected with MRSA as MRSA transmission is generally via contact or droplet spread, rather than airborne spread.

Current financial pressures in the health sector may mean that the conversion of multi-bed rooms on older wards to single rooms is delayed but all refurbishment projects and new builds should prioritise the provision of single room accommodation. HIQA (2009) *National Standards for the Prevention and Control of Healthcare Associated Infections* makes recommendations to this end.

Dedicated isolation units, also known as control of infection wards, allow patients to be nursed in an open ward, avoiding some of the psychological impact of isolation in a single room. It also means that colonised patients are cared for by designated staff, using designated shared patient equipment. Such units are particularly useful in hospitals where MRSA is endemic, as is the case in many Irish and UK hospitals, or during large hospital outbreaks. A purpose built MRSA cohort unit in a hospital has proven effective in controlling MRSA transmission, while maintaining the overall quality of care (21). The introduction of dedicated isolation units was associated with significant reductions in MRSA transmission in a number of UK hospitals during the 1980s, although other priorities subsequently led to most of these being closed (22-25). Control of infection wards

should not be sited away from the main hospital environment, to ensure that patients are not distanced from specialist care (26).

Placing patients with MRSA who are colonised or infected under CP with designated nursing staff helps reduce patient-to-patient spread of the microorganism within the hospital (27). Healthcare associated infections are a serious patient safety issue and staff must adhere to good infection control practices in particular hand hygiene.

The patient is no longer considered infectious after three negative screens but while in hospital such patients should continue to be screened at weekly intervals as MRSA may recur, especially if the patient is exposed to the selective pressures of broad-spectrum antibiotics.

Hand hygiene

The transmission of HCAI pathogens from one patient to another via the hands of healthcare workers is well established (28, 29). Expert groups agree that the major focus on MRSA control is the prevention of hand transfer of MRSA (30-33). A recent Irish study showed that MRSA was recovered from 38/822 (5%) fingertips of 523 healthcare workers after contact with patients and their environment (34).

The World Health Organization (WHO) 2009 states that hand hygiene is concentrated in activities known as the five moments for hand hygiene www.who.int/gpsc/tools/Five_moments/en/index.html (35).

All senior medical, nursing, midwifery, allied health professional and administrative personnel, whose staff have clinical involvement, must ensure that staff understand the importance of hand hygiene, are familiar with, adhere to the national recommendations and participate in hand hygiene audit.

Another study has highlighted the role of patients and their relatives as unidentified transient MRSA carriers (36). The study showed that by encouraging patients and visitors to participate in regular hand hygiene, MRSA nosocomial rates could be reduced.

Barriers to sub-optimal compliance with hand hygiene include the lack of access to alcohol hand rubs and wash hand basins in some units, a belief that hand hygiene is not as important as it is and lack of leadership amongst opinion leaders. There is a need to change the culture on hand hygiene amongst some key healthcare staff, e.g. medical doctors and nurses through education, the feedback of audit results and through individuals and units taking responsibility for their own results. National initiatives on the publication of hand hygiene compliance in acute hospitals have been helpful in this regard. Finally, further research on psychological issues and behaviour patterns that affect hand hygiene practice is needed.

Personal protective equipment (PPE)

Personal protective equipment is required for potential contact with blood and/or body fluids. Gloves are used to prevent contamination of healthcare personnel hands when anticipating direct contact with blood or body fluids, mucous membranes, non-intact skin and other potentially infectious material (37). Having direct contact with patients who are colonised or infected with pathogens transmitted by the contact route e.g. MRSA or handling or touching visibly or potentially contaminated patient care equipment and environmental surfaces is a significant risk (37). However, gloves must be worn appropriately as illustrated in a study by Moore *et al.* (38) whereby gloves should be single use and failure to remove gloves after patient contact and/or to change them between patients can increase the risk of cross transmission via contaminated gloved hands.

Clothing and uniforms may become contaminated with potential pathogens after the care of a patient colonised or infected with an infectious agent i.e. MRSA. Although contaminated clothing has not been implicated directly in transmission, the potential exists for soiled garments to transfer

infectious agents to successive patients (37, 39). The value of wearing aprons and gowns to control the spread of MRSA is generally accepted (39-41).

Many expert groups advise that staff clothing should be protected in isolation rooms, as clothing will have contact with the patient, environmental surfaces or items within the patient's room and protection will limit the transfer of micro-organisms to other patients from such a source (30-33). The protective apron/gown should be removed before leaving the patient environment (31, 40). Long sleeved gowns may be recommended for very close patient contact (e.g. lifting), prolonged patient contact or contact with patients with exfoliative skin conditions or extensive colonisation with MRSA (31).

The use of facemasks for the control of MRSA transmission is controversial (40). In Canada it is suggested that a facemask may be required if a patient with MRSA has a superimposed respiratory viral infection (40). The routine care of patients with MRSA does not require the use of facemasks. Hand hygiene should always be performed following removal of PPE (28, 29).

Education

Adequate training for all HCWs is essential. Staff should receive training on hand hygiene and the appropriate use of PPE when they commence their employment and regular refresher courses should be available. Staff involved in cleaning should be adequately trained prior to commencement of their employment. Evidence now suggests that poor patient hand hygiene is a contributory factor in the spread of pathogens such as MRSA (41). Educating patients on the importance of hand hygiene has been shown to be beneficial.

Patient and healthcare staff education can be facilitated through the increasing use of on-line and web-based material that does not require face-to-face sessions and that can be accessed in the staff or patient's own time. It is not possible for all educational sessions of healthcare staff to be conducted by the local infection prevention and control staff and greater consideration needs to be given to a 'teach the teacher' approach where such education can be cascaded locally.

Patient movement and transfer

If the movement/transfer of the patient is necessary (including transfer to another facility), staff should ensure that the area is notified in advance of the patient's MRSA status and that precautions are maintained to minimise the risk of transmission to other patients (42). If in doubt, the local infection prevention and control team should be contacted. The receiving departments are required to clean and disinfect surfaces and equipment after they come into contact with patients with MRSA. During transportation between departments it is important to maintain patient confidentiality. If the patient requires lifting onto a trolley then the HCW should wear appropriate PPE. Once the task is completed, the HCW should remove PPE and perform hand hygiene. As patients are not normally in direct contact with the surrounding environmental surfaces or staff members' clothes during transportation, aprons or gloves are not required unless indicated by standard precautions. Transport equipment (trolley, wheelchair) used for transferring the patients should be cleaned and disinfected immediately after use paying particular attention to areas touched by the patient i.e. hand rails.

Operating theatre

MRSA positive patients do not need to be put last on the theatre list as a conventionally ventilated theatre should have a minimum of 20 air changes per hour of filtered air. This number of air changes results in very little 'contaminated' air being present after approximately 10 minutes (43). This provides sufficient protection against potential airborne spread of MRSA.

Equipment and environmental hygiene

Dedicated equipment should be used where possible and only essential equipment and supplies should be taken into the room (27). All patient care equipment/supplies must be effectively

cleaned and disinfected before use on another patient (44, 45). An outbreak of community-acquired MRSA in a hospital new-born nursery was facilitated by breaches in hygienic rules, especially when mothers changed their babies (changing table was positive for MRSA) (46).

Dry conditions with dust on environmental surfaces act as reservoirs for MRSA, which facilitates the transfer to hands when such surfaces are touched. Conversely, MRSA acquired on hands and/gloves may be transferred to environmental surfaces and equipment when they come into contact with for example curtains, equipment, switches/buttons (ventilators, infusion pumps, feeding pumps), phones, touch panel screens, door handles, light switches, bed tables, bed rails, mattresses and even pens (27,30,42,48-50).

A recent study highlighted the large numbers of MSSA and MRSA from hand-touch sites with the bed, locker and over bed table being the most commonly contaminated surfaces (51). One study ascertained that computer keyboards can harbour organisms and act as potential reservoirs for nosocomial spread, another study stated that 24% of computer terminals were contaminated with MRSA (52). A Canadian study showed that 11.8% of surfaces sampled were positive for MRSA (53). These areas included chair backs, hand rails, isolation carts and sofas.

The most probable mode of transmission is via 'hand-touch' sites, since these sites offer a niche to microorganisms deposited from the hands, particularly fingertips. MRSA can survive for long periods in the environment and could present an infection risk for patients.

High bed occupancy levels, including the placing of additional beds in clinical areas to reduce over-crowding and long waiting times in emergency departments result in clutter and are a barrier to ensuring effective hygiene. Further research is required on more effective methods to decontaminate heat sensitive items of equipment and on general ward decontamination methods that do not require the area to be vacated of patients and staff for some hours.

Laundry and healthcare waste

All laundry should be managed as per national guidelines (54). Curtains should be changed on terminal cleaning of a room of a patient with MRSA.

The management of healthcare waste should be in line with national guidelines on the segregation, packaging and storage of healthcare risk waste (55).

Patients with MRSA, following a risk assessment, should be cared for in a single room using contact precautions especially in high-risk units. Contact precautions are associated with activities likely to reduce transmission of microorganisms such as better hand hygiene by healthcare workers (56).

2.1.3 MRSA in the non-acute healthcare setting

Changes in the way healthcare is delivered over the past ten to fifteen years have resulted in increases in the number of patients who are cared for in non-acute healthcare settings including adult day care centres, facilities for the homeless and special schools. A clear dividing line between acute and community hospitals does not exist. MRSA positive patients may be encountered in non-acute healthcare settings including long term care facilities, such as nursing homes, residential homes and mental health services. Also MRSA colonised and infected patients may be cared for in the home. Although the management of patients in these settings is very different to the management of patients in the acute hospital setting, as the risk of invasive infection is low, efforts, as detailed below should still be made to prevent transmission of MRSA in these settings. There is a different emphasis in these settings as the risk of invasive infection is considerably less than in acute hospitals and often, as in the case of nursing homes, the facility also represents the individual's home. For both these reasons, efforts to decolonise individuals or residents with MRSA are usually discouraged (unless as part of a work up for elective surgery), but general measures to reduce all

infections such as personal and hand hygiene, remain important. However, it is not possible to be prescriptive for all settings or for all individuals and what follows is designed to highlight the main principles but further advice should be sought as required from infection prevention and control professionals.

Recommendation 11
Good communication between healthcare facilities is essential to prevent and control MRSA. Healthcare facilities should be informed on admission and discharge of recent MRSA screening results, decolonisation treatments received and any requirement for post decolonisation screening. This should be included in the transfer documentation. **Grade D**

Recommendation 12
Good communication when discharging patients home with MRSA between hospitals and carers or family members, community and public health nurses, and general practitioners is essential in minimising spread. **Grade D**

Recommendation 13
Healthcare facilities should have an infection prevention and control programme which incorporates:
- Monitoring for problems, including outbreaks of infection
- Routinely assessing all residents for their risk of acquisition or transmission of infection
- Education of employees in infection prevention and control precautions
- Policy and procedure development and review
- Monitoring of care practices
- Occupational health
- Antibiotic stewardship. **Grade D**

Recommendation 14
Hand hygiene should be carried out according to the World Health Organization (WHO) 5 moments of hand hygiene:
- Before patient contact
- Before aseptic task
- After body fluid exposure risk
- After patient contact
- After contact with patient surroundings. **Grade A**

Recommendation 15
Standard precautions are advised for the care of all residents of long-term care settings regardless of their MRSA status. **Grade B**

Recommendation 16
All residents of long-term care setting should be encouraged to practice good hygiene and be assisted with this if required. **Grade C**

Practical Guidance

Screening

a) Expert advice should be sought before embarking on screening for MRSA. **Grade C**

b) Carriage of MRSA is not a contraindication to the transfer of a patient to a non-acute healthcare setting. **Grade C**

c) Routine screening before discharge to a non-acute healthcare facility or home is not required. **Grade D**

d) Screening before admission to an acute hospital setting may be required, especially, pre operatively for an elective procedure. The need for screening prior to admission should be determined by the patients' consultant in conjunction with the hospital infection doctor, prevention and control team. **Grade D**

e) Screening after decolonisation treatment will not normally be required after discharge. However, screening after decolonisation treatment may be requested in certain cases for example:
- pre-operatively on the advice of the hospital admitting physician/surgeon
- where a patient is to be readmitted to hospital for further treatment. **Grade D**

f) Refer to 2.1.6 for recommendations on decolonisation

Table 2 Key Components of Standard Precautions
1. Hand hygiene
2. Use of personal protective clothing
3. Respiratory hygiene/cough etiquette
4. Safe use and disposal of sharps
5. Blood and body fluid spills management
6. Management of blood and body fluid exposures.
7. Management of laundry and linen
8. Environmental hygiene
9. Client-care equipment/medical devices
10. Resident/client placement, movement and transfer
11. Safe injection practices
12. Infection control practices for lumbar punctures

g) During the delivery of healthcare hand hygiene must be performed by all staff in line with the WHO moments for hand hygiene i.e.
- Before patient contact
- Before clean /aseptic procedures
- After body fluid exposure risk
- After patient contact
- After contact with patient surroundings. **Grade A**

h) Laundry should be managed as per Standard Precautions (Table 2)
- Linen soiled with bodily fluids should be treated as contaminated by placing in a water-soluble or alginate stitched bag prior to placing in a laundry bag which is designated for contaminated linen by label or colour.
- Personal clothes should be machine-washed, preferably on a hot wash setting.
- There must be no manual washing of soiled clothing. **Grade C**

i) Isolation of a resident colonised with MRSA is not generally required as this may adversely affect rehabilitation of the resident. **Grade C**

j) The potential for transmission of infection should be considered in resident placement decisions. Local risk assessment of the individual and the environment will be required prior to placement, i.e. in the presence of an exudating wound which cannot be covered single room placement may be appropriate. **Grade C**

k) Contact precautions may be required where a resident has an infection caused by MRSA or to control outbreaks of MRSA infection. **Grade C**

Facilities

a) Routine facilities in all non-acute healthcare facilities should include adequate sinks for staff hand washing, liquid soap and paper towels in wall mounted dispensers, alcohol hand rub and hand cream. **Grade D**

b) In non-acute healthcare facilities, single rooms with hand hygiene facilities should be available which can be used for infection prevention and control purposes. **Grade D**

c) Newly built non-acute hospital inpatient accommodation should comprise a minimum of 50% single-patient rooms as detailed in the *National Standards for the Prevention and Control of Healthcare Associated Infections* (HIQA, 2009). **Grade C**

d) Bed spacing is planned and managed in a way that minimises the risk of spread of MRSA as detailed in the *National Standards for the Prevention and Control of Healthcare Associated Infections* (HIQA, 2009). **Grade D**

Education

a) Education on standard precautions and relevant national infection prevention and control policies should be provided for all staff in non-acute healthcare settings. **Grade D**

b) Education on the use of invasive devices such as urinary catheters, enteral feeding tubes and tracheostomies should be provided to healthcare staff in non-acute healthcare facilities. **Grade D**

MRSA in the home

a) Patients should be asked to inform their appropriate healthcare providers, e.g. public health nurse or GP, that they have previously tested positive for MRSA, particularly when attending different/new, healthcare providers. **Grade D**

b) There is little risk of transmitting MRSA to healthy people who are at low risk of becoming infected. Patients should be informed that the risk to healthy relatives or others outside the hospital setting is extremely small, unless they are healthcare workers with patient contact when they may pose a risk to other patients. **Grade B**

c) Eradication of MRSA carriage in the community is generally not required. **Grade D**

d) If decolonisation treatment has been commenced prior to discharge it should be completed. **Grade B**

e) The need for decolonisation after discharge should be determined by the patients' consultant/doctor in conjunction with the hospital infection prevention and control team. Decolonisation may be required in certain circumstances, e.g. pre-operatively on the advice of the admitting physician/surgeon where a patient is to be readmitted for further treatment. Please refer to section 2.1.6 – Decolonisation. **Grade C**

f) In the home, the following general precautions should be followed:
- Good hand washing practice including soap and water is the single most important infection prevention and control measure
- Patients should be instructed to wash their hands with soap and water before and after touching any dressings or wounds
- Care-givers should wash their hands with soap and water or use alcohol hand rub before and after physical contact with the infected or colonised person and before leaving the home
- Disposable gloves should be worn by care givers if contact with body fluids or dressings is expected. Hands should be washed after removing gloves
- Cuts or breaks in the skin of patients and carers should be covered with impermeable dressings
- Linen should be changed and washed if it is soiled and on a routine basis
- The patient's environment should be cleaned routinely and when soiled with blood or body fluids, using a general purpose detergent and warm water
- Cutlery and crockery should be washed as normal. Separate cutlery and crockery is not required
- Items for personal hygiene such as razors, tooth brushes, face cloths, body lotions/creams, towels and soap should not be shared under normal circumstances
- Dressings and other disposable waste such as disposable gloves should be disposed of promptly by placing in a bag, and tied before disposing into the waste bag or container
- Healthcare non risk waste should be wrapped in a bag before disposing into the domestic waste bag
- Healthcare workers should adhere to standard infection prevention and control precautions when providing care to patients in their home at all times. **Grade C**

Rationale

Screening

Healthcare associated infections such as MRSA are not limited to acute care hospitals. A high prevalence of MRSA amongst residents and staff of some long term care facilities (LTCFs) is making these facilities a substantial reservoir for MRSA. The prevalence of MRSA amongst residents of LTCF varies significantly from low rates of 1.1% in Germany to rates of over 20% in the United Kingdom and 30% in the United States. (1, 2). A prevalence rate of 8.6% was reported in an Irish study in nursing homes in 2000 (3). Vast differences in rates of colonisation have been identified between different LTCFs, ranging from 0 - 73% (2). Rates of colonisation may depend on various factors including the prevalence of MRSA in the referring facilities, the resident population, the percentage of staff colonised with MRSA and the infection prevention and control practices in the facility (1-3).

Risk factors identified as predictive of MRSA colonisation and infection amongst residents of LTCFs include host factors such as advancing age, antibiotic use, poor functional status, hospitalisation and the presence of invasive medical devices (4-7).

Carriage of MRSA other than in the nose increases with the use of invasive devices and admissions of greater than 10 days to acute healthcare facilities have been shown to increase the risk (7, 8). Antibiotic use has been shown to be independently associated with MRSA colonisation (1). In LTCFs persistent carriage with MRSA between 47% and 65% has been reported, with between 19% and 25% having transient carriage and between 9% and 23% having intermittent carriage of MRSA (8,9).

Despite the high prevalence of MRSA carriage amongst residents of LTCFs the frequency of infection with MRSA in these settings appears to be low whilst colonised residents remain at the facility (10). Colonisation amongst residents of nursing homes in Belgium was associated with a higher mortality rate, but the excess mortality rate was restricted to residents with impaired

cognitive function. The findings showed that no excess mortality was found amongst residents with normal or moderately impaired cognitive function (9). A longitudinal prevalence study in the UK found that MRSA was associated with previous and subsequent MRSA infection but was not significantly associated with subsequent hospital admission or mortality (11).

Greater integration between the acute and non-acute healthcare sectors is required to optimise MRSA prevention and control through the provision of structures that provide a seamless interface, involving staff that cross-cover both. Currently, this is not possible due to inadequate numbers of personnel and current arrangements in terms of health provision.

Infection prevention and control measures

A Cochrane review of the infection control strategies for preventing the transmission of MRSA in nursing homes for older persons did not find any studies meeting its criteria. The background for this study stated that nursing homes for the elderly provide an environment likely to promote the acquisition and spread of MRSA, putting residents at increased risk of colonisation and infection. The review found no studies specific to the long term care setting (12). However the authors acknowledged that infection prevention and control practices work to prevent the spread of MRSA in acute healthcare, and that general advice based on well-established principles of infection prevention and control i.e. Standard Precautions could be applied to all healthcare environments including LTCFs (12, 13).

Data on the prevalence of MRSA in non-acute healthcare settings such as in mental health services are limited. However, a study of prevalence and risk factors for MRSA found prevalence of MRSA colonisation was 5.2% (26 of 498) amongst patients admitted to a psychiatric unit in the United States. Risk factors for MRSA colonisation included a history of abscess on admission, HIV infection and previous isolation, due to mental health (14). In general patients or clients of such services are not at high risk of MRSA infection or colonisation. A recent investigation into the management of MRSA in a closed mental health unit found that hand hygiene seemed to be sufficient to prevent the spread of MRSA (15).

In non-acute healthcare and residential settings, adherence to standard precautions is required for the care of all patients including those known to be colonised with MRSA (16). A recent study of nursing homes in Northern Ireland highlighted that compliance with standard precautions was suboptimal in the nursing homes studied, despite an intervention which included education on infection prevention and control and associated audit. The authors highlighted the importance of a full infection prevention and control programme to enhance compliance with standard precautions as a means of reducing transmission of MRSA within the nursing home setting (17).
A recent study showed a substantial decrease in the rate of MRSA nosocomial infections following an intervention which encouraged hand hygiene for patients and visitors. MRSA infections decreased by 51% and the intervention may have prevented up to 51 cases of MRSA infection over a period of one year (18).

Two clustered randomised controlled trails in long term care facilities showed that the implementation of the WHO multimodal strategy to promote hand hygiene increased compliance with hand hygiene and reduced the risk of infection. Ho at al showed that the risk of MRSA infections which required hospitalisation was reduced alongside an increase in hand hygiene compliance by staff (19).The study by Yeung showed an increase in hand hygiene compliance with a reduction in the incidence of serious infection (20). Pocket sized containers of alcohol hand rubs were provided to staff in both studies as a part of a multifaceted hand hygiene program.

Similarly a comprehensive hand hygiene program which involved the use of alcohol based hand rubs showed a statistically significant reduction in lower respiratory tract infections (LRTIs). Rates of LRTI were reduced from 0.97 to 0.53 infections per 1,000 resident days (P0.01, reductions in skin soft tissue infection (SSTIs) were also observed (21).

The removal of MRSA from clothing has been shown to occur at low temperatures of 30° with the addition of a detergent (22).

Facilities
National and international guidance on hand hygiene highlights the importance of the availability of hand hygiene facilities at the point of care to optimise compliance (21, 22). National guidance recommends that non-acute hospitals have 50% single room (23). HIQA (2009) *National Standards for the Prevention and Control of Healthcare Associated Infections* makes recommendations to this end.

Education
A recent trial to assess the impact of an infection prevention and control education and training programme on MRSA prevalence in nursing homes in Northern Ireland found that the intervention did not reduce the prevalence of MRSA amongst staff or residents (17). However, a significant improvement was seen in the infection control audit score for the intervention nursing homes. The authors highlighted the need for more intensive training in infection prevention and control in nursing homes. Compliance remained poor, particularly in the area of hand hygiene and equipment cleaning, measures which are essential to the control of MRSA (17). Hand hygiene remains essential in this setting as well as in the acute care environment (24-26). A large prospective study assessed the effectiveness of improving infection prevention knowledge on MRSA colonisation in UK care homes for the elders (11). Authors reported that the intervention improved knowledge and practice of staff but did not reduce the prevalence of MRSA and suggested that additional measures will be required to reduce endemic MRSA colonisation in care homes. As the aged population increases there is a great need for more research on infection prevention measures in nursing homes and other non-acute units as to date control strategies have been guided by what has been considered appropriate in the acute setting without allowing for differences in risk and the fact that such units also represent a home for the individual. Appendix VIII provides some information for staff in LTCF.

MRSA in the home
People with MRSA colonisation can be returned safely to their own homes without significant risk to the community. Simple hygienic precautions usually suffice in the home setting (27). As in the acute healthcare setting, patients at home should be informed of their positive MRSA status and provided with a patient information leaflet (28). See also Appendix IX for information on MRSA in schools and day care facilities for children.

2.1.4 MRSA in obstetrics and neonates

Recommendation 17
Neonates in high risk units should be screened for MRSA, similar to all high risk patients, on admission and weekly thereafter. Screening in neonates <28 days old should include the umbilical site, in addition to other recommended sites. **Grade B**

Recommendation 18
If MRSA carriage is detected in a pregnant woman during the antenatal period, decolonisation is recommended before delivery. A standard decolonisation regimen including topical nasal mupirocin should be considered between 35-37 weeks gestation, and earlier if risk of preterm birth. **Grade D**

Recommendation 19
If a lactating mother has known MRSA mastitis, the mother can usually continue to breastfeed a healthy term baby in the community and receive antibiotic therapy, unless the antibiotics prescribed are contraindicated in lactation. **Grade C**

Practical Guidance

MRSA during pregnancy

a) If known MRSA carriage antenatally, surgical prophylaxis for caesarean section (elective and emergency) should include a glycopeptide antibiotic as part of the prophylaxis regimen. **Grade A**

Breastfeeding and MRSA colonisation/infection

b) If a lactating mother has known MRSA mastitis:
- The mother can usually continue to breastfeed a healthy term baby in the community, receiving antibiotic therapy (unless the antibiotics prescribed are contraindicated in lactation). **Grade C**
- If the baby is in the NICU and at significant risk of developing an invasive MRSA infection, consider withholding breast milk until the MRSA mastitis has resolved. **Grade C**
- In other circumstances such as a baby in a special care nursery, a risk assessment should occur based on the likelihood that the baby will develop an invasive MRSA infection. Risk factors such as IV catheters, ventilation, recent surgery or being immunocompromised should be considered. **Grade D**

c) If a lactating mother is colonised or infected with MRSA at another site:
- The mother can continue to breastfeed a healthy term baby in the community. **Grade C**
- In other circumstances such as a baby admitted to a healthcare institution, clinical staff caring for the baby should be informed of the mother's MRSA status as soon as possible. In the absence of mastitis, it is usual for a lactating mother to continue to breastfeed her baby. Individual cases should be risk-assessed and discussed with the neonatologist and/or infection prevention and control team. **Grade D**

Rationale

MRSA during pregnancy

The prevalence of MRSA carriage in pregnant women in Ireland was found to be 1.6% following a three year study in the Coombe Women's and Infants University Hospital (personal communication, Dr. N O'Sullivan, 2010). A large study in the U.K. found 0.5% of pregnant women were nasal carriers of MRSA (1). In the USA, carriage rates generally vary from zero to 4%, although one study reported a rectovaginal MRSA carriage rate of 10.4% (2-10). Where analysed, most of the pregnant women in the USA found to be carrying MRSA had community-acquired-MRSA (CA-MRSA) (2,6). These studies may have limited relevance to Ireland where CA-MRSA (see section 2.1.5) remains relatively uncommon and few women without traditional risk factors are expected to carry MRSA.

MRSA is associated with surgical site infection following caesarean section, mastitis and late-onset infections in the neonatal intensive care unit (NICU) (3, 11-18). There may be a benefit to both mother and baby in attempting to decolonise the MRSA colonised pregnant woman before delivery. Decolonisation may also reduce transmission within the hospital. MRSA is rarely implicated in antenatal infection, chorioamnionitis, puerperal sepsis or early-onset sepsis in the newborn (3, 14, 18-19). Thus, with regard to the optimal timing of decolonisation, ideally one should avoid this during the first trimester and wait until close to term at 35-37 weeks gestation to attempt de-colonisation (or earlier if risk of preterm delivery). Topical nasal mupirocin is not licensed for use in pregnancy and the manufacturer advises against its use in pregnancy and during lactation unless the benefit outweighs the risk. However, in the U.K. a full risk assessment of decolonisation regimens in pregnancy concluded that nasal mupiricin should be used for MRSA decolonisation in pregnancy (17). If the pregnant woman is colonised with MRSA in the throat, ensure any oral antibiotics used for eradication are compatible with pregnancy. Consult a microbiologist or infectious disease physician on a case-by-case basis. See section 2.1.6 for decolonisation regimen.

If a mother is known to be MRSA positive antenatally, antibiotic prophylaxis for caesarean section (elective and emergency) should include a glycopeptide antibiotic and should be discussed with a clinical microbiologist or infectious disease physician. Standard antibiotic prophylaxis for caesarean section operations do not provide cover against MRSA and must be modified for a known carrier.

Breastfeeding and MRSA colonisation/infection

Mothers with known MRSA carriage, with and without mastitis, can continue to breastfeed a healthy term baby in the community (20-21). Acquisition of MRSA by the infant is expected, but the vast majority of such acquisitions are not followed by infection, unless the baby is in the intensive care setting. For treatment of MRSA mastitis antibiotic therapy that is considered safe in lactation e.g. clindamycin, should be used if the organism is susceptible (22). Therapeutic options should be discussed with a clinical microbiologist or infectious disease physician. If susceptibility results necessitate prescribing an antibiotic which should not be used during lactation, the mother should be advised to express breast milk and discard for the duration of the treatment course. Breast milk has been associated with the transmission of MRSA to neonates in the NICU and subsequent infection (23-24). Mothers with known MRSA mastitis may be advised not to feed a baby in the NICU who is at risk of developing an invasive MRSA infection, until maternal symptoms have resolved and antibiotic therapy is complete. Individual cases should be discussed with the neonatologist, clinical microbiologist or infectious disease physician.

MRSA screening in neonates

Skin colonisation with *S. aureus* can occur within 24-48 hours of birth from contact with the skin of carers and the environment. Although MRSA is not endemic in most maternity and neonatal units in Ireland, vigilance is recommended because;

- MRSA is endemic in many other healthcare institutions in Ireland
- Infants known to be colonised with MRSA are more likely to develop MRSA infection than those without colonisation (26% vs. 2%) and therefore appropriate empiric antibiotic therapy should be commenced in MRSA colonised infants who develop signs of sepsis (15)
- Clinical MRSA isolates are indistinguishable from the colonising isolate in >90% of episodes in a NICU (15)
- *S. aureus* is the second most common cause of late-onset (>48-48 hours of age) sepsis in NICUs (25-26)
- MRSA-negative infants in a neonatal ICU are at increased risk of acquiring MRSA if a sibling (e.g. twin) is colonized or from other patients if they share nursing care (27).

MRSA screening should occur on admission and at least weekly thereafter in NICUs, paediatric ICUs and in other high risk units. In neonates, as in older patients, the nares are the most important site of colonisation. Screening at multiple sites provides significantly improved sensitivity and specificity compared to one site. In neonates, the combination of nasal and umbilical sites achieves a sensitivity >90% (25-28). A USA consensus paper only recommends screening of the nares in neonates <28 days (29). However, the paper states that many centres screen multiple sites including various combinations of the nares, throat, umbilicus, and rectum. Overall, the evidence favours inclusion of the umbilicus as a screening site in infants <28 days in addition to screening sites used for all other patients.

There have been reports of the emergence of community-associated Panton-Valentine Leukocidin-positive (PVL) MRSA in neonatal ICU's in Ireland and the U.K. which may be associated with international transmission (30-31). Vigilance should be observed for MRSA cases associated with significant skin and soft tissue infection, severe pneumonia and also during an outbreak. Where appropriate, MRSA isolates should be typed including testing for PVL-MRSA.

2.1.5 Community-associated MRSA

The emergence of CA-MRSA strains in healthcare settings and vice versa, the difficulty in distinguishing healthcare-associated and CA-MRSA based on case definitions and microbiological features, and the rapidly evolving molecular features of CA-MRSA, mean it is difficult to define CA-MRSA solely on demographic, clinical and epidemiological factors. However, for practical purposes a definition is required (1, 2). The committee believes that CA-MRSA has the following characteristics:

- The isolate must be confirmed as MRSA
- Patients with CA-MRSA usually reside in the community as opposed to the healthcare environment and have no risk factors for the acquisition of MRSA
- CA-MRSA isolates are usually resistant to ß-lactam antibiotics but are relatively susceptible to most other classes of antibiotics, compared to healthcare associated MRSA strains
- In many cases, a patient with CA-MRSA usually presents with skin and soft tissue infection. However, other clinical manifestations may present, e.g. pneumonia
- When typed, CA-MRSA is predominantly Staphylococcal Chromosomal Cassette (SCC) mec type IV or V.

Recommendation 20
Patients with CA-MRSA in the following categories should be reported to the Medical Officer of Health (MoH)/Director of Public Health (DPH):

- Clusters/outbreaks of SSTI
- Cases with severe invasive disease or cases resulting in death
- Cases in at-risk groups such as healthcare workers or those involved in a gym or close contact sports
- Cases in a closed community where there may be potential for onward transmission (e.g. prison, military camps, nursing home). **Grade D**

Recommendation 21
Screening to detect asymptomatic colonisation in household contacts is generally not recommended unless advised by a clinical microbiologist or public health specialist.

Post-decolonisation screening is not recommended routinely for all cases but is advisable if:

- The case is at high-risk of developing infection, e.g. in-dwelling device or immunocompromised
- There are ongoing infections occurring in a household or a well-defined closely associated cohort
- The case is a risk to others e.g. a healthcare worker, household contact of a healthcare worker or a carer of at-risk people. **Grade D**

Practical Guidance

Surveillance and screening

a) There is no clear evidence on the optimal sites to screen for CA-MRSA in community settings. A minimum swab set should include:
   - Nostrils - (both anterior nares)
   - Throat
   - Skin lesions - discharging wounds/lesions, dry lesions or broken skin
   - Additional sites, i.e. perineum, axillae (armpits) and the umbilicus for neonates may be included after discussion with the Director of Public Health or the consultant microbiologist/ infectious disease physician. **Grade D**

Prevention

a) Prevention of transmission of CA-MRSA requires the consistent application of good hygiene practices, i.e. standard precautions, with an emphasis on hand hygiene, not sharing

potentially contaminated personal articles (e.g. towels, razors, brushes, water bottles and clothing) and covering draining skin lesions to prevent direct or indirect contact with the infected secretions of another person. **Grade C**

Diagnosis of suspected CA-MRSA infection

a) CA-MRSA infection should be suspected in the following groups:
- Patients with SSTI such as furunculosis, impetigo and folliculitis (or other infections) that do not respond to empiric ß-lactam antibiotic therapy, e.g. flucloxacillin
- Patients presenting with recurrent SSTI (two or more in six months)
  - Clusters of SSTI within a household or social group
  - Patients with rapidly progressive pneumonia – haemoptysis should be an alerting sign
  - Patients with necrotising SSTI. **Grade B**

b) Microbiological culture of appropriate clinical specimens is the only way of detecting CA-MRSA cases and should be performed in the above patient groups. Appropriate specimens include:
- Fluid from a purulent lesion or abscess cavity
- Respiratory secretions (e.g. sputum, tracheal aspirations)
- Blood cultures from a moderately or severely ill patient with signs and symptoms of systemic infection
- Other specimens from a normally sterile site suspected to be a focus of infection (e.g. joint or bone). **Grade D**

c) The routine collection of nasal specimens in patients presenting with possible CA-MRSA infection is not recommended. This does not make a diagnosis of infection as a positive result merely indicates the patient is colonised. **Grade D**

Rationale

Surveillance and screening

In Ireland there is no formal surveillance system to monitor CA-MRSA cases or SSTI clusters. However, some countries have such systems, e.g. in Switzerland, and in Western Australia (2,3). In England, the focus is specifically on Panton-Valentine leukocidin (PVL)-positive *S. aureus* infection rather than CA-MRSA, especially in at-risk groups, i.e. healthcare worker, residential/care home staff, those involved in gyms or close contact sports such as wrestling and rugby, and cases in a closed community where there may be potential for onward transmission, e.g. prison, military camps, nursing home (4, 5).

Neither PVL nor SCC mec IV (clone associated with CA-MRSA in other countries) carriage can be used in Ireland as sole markers for CA-MRSA as a significant proportion of CA-MRSA strains are PVL negative (6, 7). A CA-MRSA carriage rate of 0.57% was reported in healthy Irish volunteers, all of whom were PVL negative and there was an association with sport (8). Although CA-MRSA is not currently endemic in Ireland, it is essential that cases are appropriately managed, the potential for ongoing spread is minimised, and that SSTI clusters, cases in high risk groups or cases in closed communities are reported to the Director of Public Health.

Screening after attempted decolonisation is not routinely indicated with the exception of the circumstances outlined above. If screening after decolonisation is indicated, if the case has no active infections and/or negative screening results are achieved one and three months after decolonisation, then no further action is recommended in a community setting unless further infections occur. If a person has recurrent infections following two consecutive decolonisation treatments, antibiotic management should be discussed in consultation with a clinical microbiologist.

Prevention

The aim of community control of CA-MRSA is to prevent spread from an infected/colonised individual to other persons in the family and in the community. Drainage from CA-MRSA infections, wound dressings and other materials contaminated with wound drainage are infectious and therefore should always be contained with clean dry dressings that completely cover lesions, i.e. adherence to standard precautions.

Diagnosis of suspected CA-MRSA infection

The diagnosis of CA-MRSA infection is frequently difficult as the infection often occurs sporadically in otherwise healthy people, including children or young adults, without identifiable risk factors. Exposure to one or more antibiotics in the past year and the use of quinolones or macrolides are potential treatment-related risk factors for CA-MRSA infection (9). As PVL-positive MSSA infection may present with a similar picture, microbiological culture is the only way of detecting CA-MRSA cases, and is particularly relevant in the patient groups described above.

Treatment of confirmed CA-MRSA Infection (Table 3, Figure 1) (Prescribers Notice, Table 3)

a) Incision and drainage should be considered and may be the only treatment required in mild SSTI. This is especially important for abscesses or necrotic infected tissue as antimicrobial agents poorly penetrate such sites. **Grade A**

b) Local antibiotic susceptibility data should be used to guide treatment. **Grade C**

c) Patients should be advised to seek prompt medical assessment if there is no improvement in the infection within 48 hours of treatment, the infection worsens, systemic symptoms develop, or the infection recurs after initial treatment. **Grade C**

d) Non-severe CA-MRSA SSTI should be treated with doxycycline or co-trimoxazole if susceptible except where such infections occur in pregnant women or children less than 12 years of age (Table 3). **Grade A**

e) A glycopeptide is recommended for severe SSTI. **Grade A**

f) Alternatives for severe SSTI include linezolid, daptomycin or clindamycin. **Grade B**

g) Severe CA-MRSA causing SSTI or pneumonia with toxic shock or necrotising disease should be treated intravenously with a combination of linezolid and clindamycin with the addition of rifampicin if necessary. **Grade D**

h) Early surgical debridement should be carried out where possible in more severe cases of CA-MRSA SSTI. **Grade D**

i) The use of adjunctive therapy such as intravenous immunoglobulin (IVIG) may be considered in severe disease on the recommendation of a microbiologist or infectious diseases consultant. **Grade D**

j) Patients with CA-MRSA infection should be excluded where possible from participation in activities involving close skin-to-skin contact until the infection has cleared and any wounds have healed. **Grade D**

The management of confirmed CA-MRSA infection involves treatment of infection (drainage of abscess and antibiotic therapy), decolonisation of the index case, increased individual and environmental hygiene, investigation of close contacts and notification of the case to the public health specialist if the case meets the criteria outlined earlier.

Patient education is a critical component of CA-MRSA case management. Patients and their carers/household members should be educated on methods to limit further spread within their household and among other close contacts with an emphasis on covering wounds at all times and hand washing.

(http://www.hpsc.ie/hpsc/A-Z/MicrobiologyAntimicrobialResistance/EuropeanAntimicrobialResistanceSurveillanceSystemEARSS/ReferenceandEducationalResourceMaterial/SaureusMRSA/Factsheets/).

Although there is no unequivocal evidence to support the combination of linezolid, clindamycin and rifampicin the high mortality (>60%) in necrotising pneumonia supports the use of this combination. Linezolid and clindamycin suppress PVL and alpha toxin production while rifampicin is added for *in-vitro* synergy to enhance the intracellular clearance of staphylococci. Serum levels of linezolid are reduced by rifampicin, therapeutic monitoring of linezolid levels should be considered to ensure effectiveness when this combination is used. Further details on the treatment of MRSA are outlined in section 2.2.1. Initial options for CA-MRSA are outlined in Table 3 and Figure 1.

There is a theoretical benefit in using IVIG in the management of severe CA-MRSA infection where toxins are involved. Clinical data is sparse and it is unlicensed for this indication but clinical improvement and a sustained fall in inflammatory markers have been noted in case reports. The UK Health Protection Agency (HPA) guidelines recommend that IVIG "should be considered" for patients with necrotising pneumonia as an addition to intensive-care support and high-dose antimicrobial therapy because it neutralises toxins and the expected benefits outweigh the risks in a condition with a mortality rate over 60%. The recommended dose is 2g/kg, repeated once after 48 hours if the patient has not responded (10). US guidelines on the treatment of MRSA infections do not routinely recommend IVIG as adjunctive therapy for the management of invasive MRSA disease. However, they do recognise that some experts may consider these agents in selected scenarios (11).

Table 3 Practical guidance on antibiotic choices for the management of moderate CA-MRSA SSTI*

(Adapted from Guidelines for the management of community-associated methicillin resistant *Staphylococcus aureus*, Government of Western Australia. Department of Health, WA Communicable Disease Control Directorate, Department of Health 2013. http://www.public.health.wa.gov.au/3/896/3/camrsa.pm)

Prescribers Notice

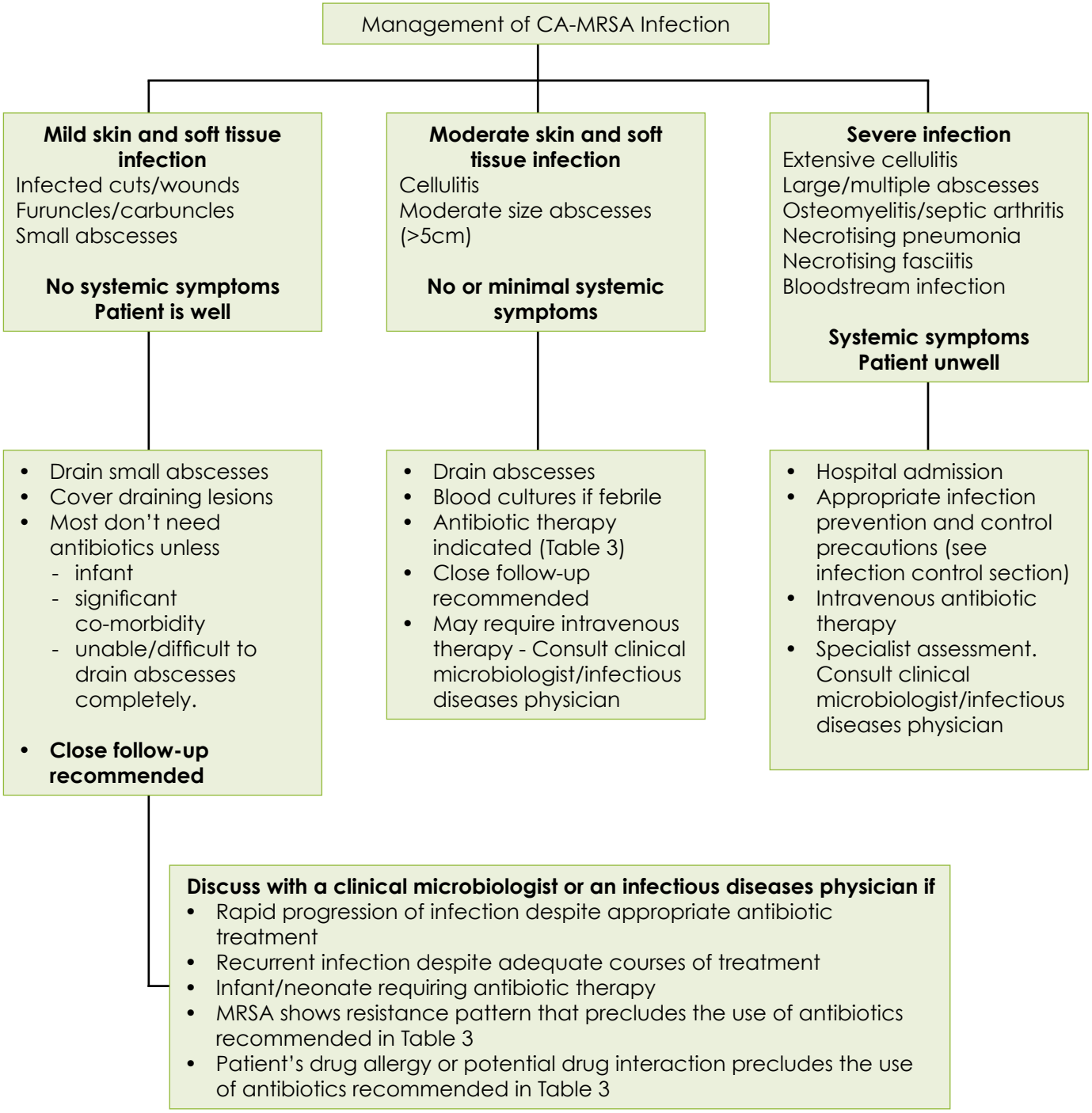
Antibiotic stewardship is the subject of on-going research and debate. Local antibiotic susceptibility data should be used to guide treatment having due regard to the clinical judgement of the prescriber and the individual circumstances of each patient. Therapeutic options should be discussed with a clinical microbiologist or infectious disease physician on a case-by-case basis as necessary.

Antibiotic (also confirm susceptibility)	Adult**	Pregnancy	Children	Infants & neonates
Clindamycin[1]	450mg orally, 4 times daily x 5 days	450mg orally 4 times daily x 7 days	Check BNF	Discuss with a paediatrician, clinical microbiologist or infectious diseases physician
Trimethoprim/ sulphamethoxazole[2]	160+800mg orally twice daily x 5 days	Discuss with clinical microbiologist or infectious diseases physician	Check BNF	
Doxycycline	100mg orally twice daily x 5 days	Not recommended	Child over 12 years ONLY: Check BNF	
Linezolid	Discuss with a clinical microbiologist or infectious diseases physician. Reserve for patients who are not able to take or tolerate the above regimens			
CA-MRSA RESISTANT to antibiotics above *Or* Patient's drug allergy or potential drug interaction precludes the use of antibiotics above	Discuss with a clinical microbiologist or infectious diseases physician			

BNF=British national Formulary
*If the patient requires treatment in hospital with intravenous therapy, please refer to Section 2.2.1 and Figure 1
** Doses refer to adults with normal renal and hepatic function
[1] Clindamycin should NOT be used for MRSA isolates RESISTANT to erythromycin.
[2] Trimethoprim-sulphamethoxazole is not recommended in infants and neonates under 6 weeks of age.

Note 1: Longer therapy may be required for carbuncles and those with associated cellulitis.
Note 2: Group A Streptococci (GAS) are another common cause of skin and soft tissue infection. If GAS infection is suspected, therapy should include an agent against this organism. Discuss with a clinical microbiologist or infectious diseases physician.

Figure 1 Practical guidance for the management of suspected CA-MRSA infection



Recommendation 22
Decolonisation for CA-MRSA should be considered when individuals or their household contacts:
- have recurrent CA-MRSA infections
- are a healthcare worker or carer
- are at high risk of developing CA-MRSA infection e.g. in-dwelling device or immunocompromised
- when there are ongoing MRSA infections occurring in a well defined closely-associated cohort (e.g. prison inmates, sports club).

Decolonisation of neonates (< 2 months) should not be commenced in the community unless specifically recommended by a clinical microbiologist or infectious diseases physician. **Grade D**

Decolonisation of cases of CA-MRSA

- Decolonisation is recommended for all index colonised/infected CA-MRSA cases once any infection has cleared and wounds are healed or almost healed. **Grade D**

- Decolonisation is unlikely to be successful and is not recommended where there are open wounds or permanent indwelling devices in-situ. Decolonisation should not be commenced in patients with active exfoliative skin conditions, until the underlying condition is treated first in consultation with a dermatologist. **Grade D**

Current North American guidelines do not recommend decolonisation of cases nor contact tracing of CA-MRSA cases (12,13). Decolonisation is recommended only in certain situations such as multiple (two or more cases within six months) recurrences of MRSA infection, ongoing transmission in a well-defined, closely-associated cohort such as a household, and only after documenting that reinforcement of standard preventative measures has been unsuccessful. In contrast many European countries and Australia have taken a different approach recommending decolonisation and contact tracing albeit with different strategies. The difference in prevalence of CA-MRSA between countries could support the differing approaches, i.e. CA-MRSA is very prevalent in North America. The evidence base to support decolonisation is poor. Decolonisation has been recently shown to be effective in settings with sporadic CA-MRSA infections (13). CA-MRSA is not endemic in Ireland at present and therefore a similar approach as taken in other European countries in terms of decolonisation is recommended (Figure 1).

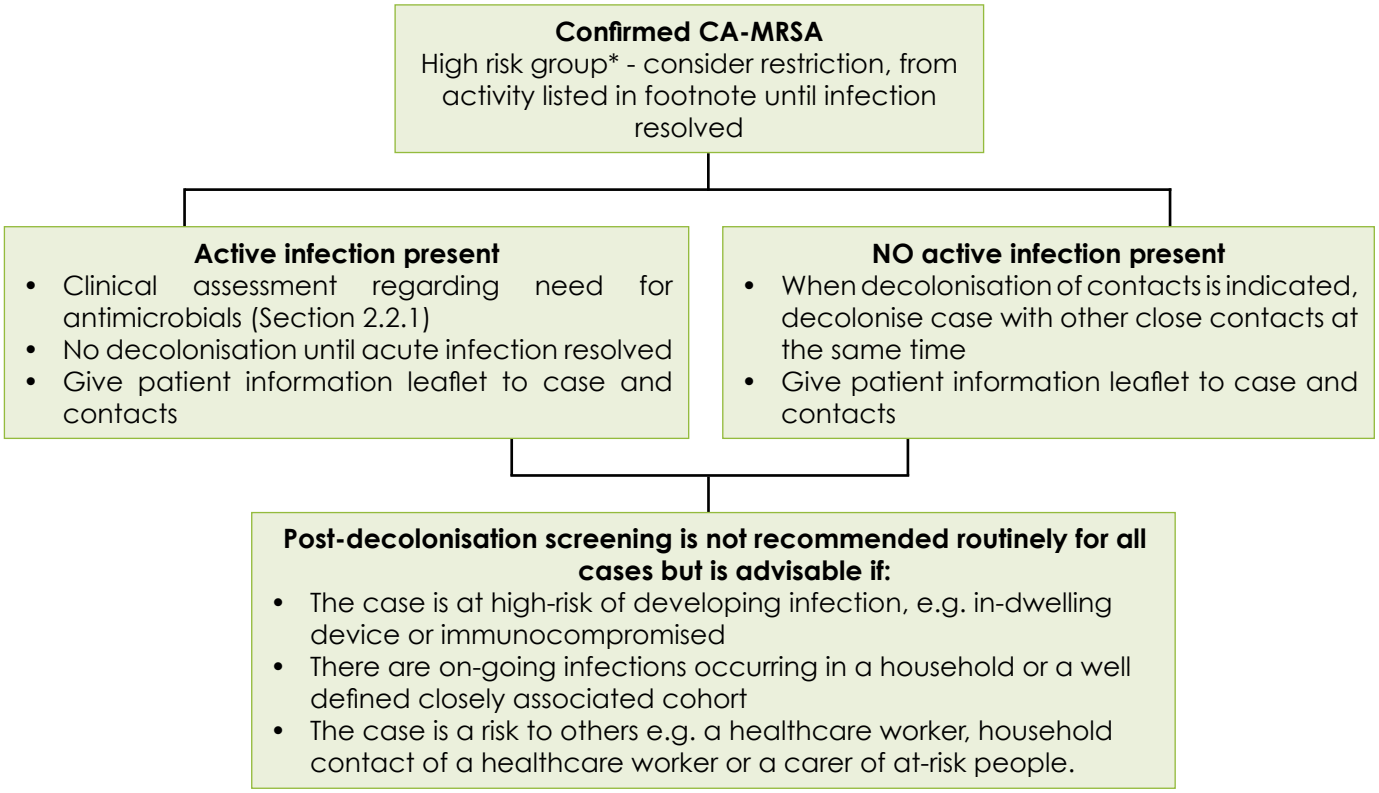
Follow-up after decolonisation of CA-MRSA

- Patients with CA-MRSA infection should be instructed to seek medical assessment if infections recur. **Grade D**

- Screening after decolonisation is not recommended unless:
  - The case is at high-risk from infection, e.g. on cancer chemotherapy
  - Infections are recurring in cases or close contacts following decolonisation.
  - The case is a risk to others e.g. healthcare worker, household contact of a healthcare worker, or a carer of high-risk people. **Grade D**

- The decolonisation regimen should be repeated if decolonisation fails after the first course of treatment and after assessing the patient and rectifying any obvious reasons for decolonisation failure, e.g. underlying skin condition. **Grade D**

Figure 2 Practical guidance - algorithm for decolonisation of confirmed CA-MRSA infection



* High risk group = Healthcare worker, residential/care home staff, those involved in close contact sports (rugby, wrestling etc.), gyms.

Decolonisation of contacts of CA-MRSA

The approach to management of contacts differs significantly from country to country in the absence of hard scientific data and or clinical trials. There is little information concerning the effectiveness of decolonisation in the community and an evidence-base to support recommendations is lacking. Practical guidance on defining contacts and their risk of CA-MRSA acquisition are outlined in Table 4.

Table 4: Definition of contacts of CA-MRSA index cases

	Definition
CA-MRSA contact	People with frequent close skin-skin contact with on MRSA index case and /or share items that come in close contact with the skin of the index case.
Higher-risk (household) contacts	Persons who regularly live in the some household as the index case and therefore have frequent close skin contact or are likely to share items that come in close contact with the skin of the index case. This includes dormitory room contacts, group homes etc. where people live together.
Lower-risk contacts	Closely-associated cohorts outside of a single household. These groups include day-care centres or contact sports teams (football, wrestling) where there is close skin-skin contact (especially with skin abrasions), sharing of personal hygiene items (e.g. towels) or shared surfaces or items that come into contact with skin (e.g. equipment).

(Adapted from Guidelines for the management of community-associated methicillin resistant *Staphylococcus aureus*, Government of Western Australia. Department of Health, WA Communicable Disease Control Directorate, Department of Health 2013. http://www.public.health.wa.gov.au/3/896/3/camrsa.pm)

Household transmission of CA-MRSA is commonly reported. Decolonisation is recommended when individuals fulfil a number of criteria as outlined in Table 4. As discussed above, decolonisation of cases should only commence once any infection has cleared and wounds are healed or almost healed. If decolonisation is indicated for cases and household contacts, the treatment for that household should commence simultaneously. If a contact requiring decolonisation has any pre-existing dermatological conditions this should be discussed with a dermatologist prior to starting the course of treatment. Contacts should be provided with information about measures to prevent the spread of CA-MRSA (http://www.hpsc.ie/hpsc/A-Z/MicrobiologyAntimicrobialResistance/EuropeanAntimicrobialResistanceSurveillanceSystemEARSS/ReferenceandEducationalResourceMaterial/SaureusMRSA/Factsheets/).

Lower-risk contact groups, e.g. those attending the same day-care centre, (Table 4), should be identified and provided with information. Screening and decolonisation is not routinely recommended for lower-risk contacts unless transmission is identified i.e. at least one other case is identified in that group of contacts. Key staff from a group (e.g. home) should be informed when a CA-MRSA carrier is identified in the group, maintaining confidentiality of the person's details, and providing information to prevent spread or dissemination to members. Enquiries should be made about any other cases of SSTIs that may have been noted. The group should be instructed to report any further infections arising to the local public health specialist. If there is suspicion of spread of CA-MRSA infections in a group, the public health specialist will assess potential risk, and the practicalities of screening and decolonisation, to determine action.

Follow-up after decolonisation of CA-MRSA

- Patients with CA-MRSA infection should be instructed to seek medical assessment if infections recur. **Grade D**
- The decolonisation regimen should be repeated if decolonisation fails after the first course of treatment and after assessing the patient and rectifying any obvious reasons for decolonisation failure, e.g. underlying skin condition. **Grade D**

Decolonisation should not be commenced in patients with active exfoliative skin conditions, such as psoriasis, as it is likely to fail and the skin treatments may exacerbate their condition. The underlying condition should be treated first in consultation with a dermatologist. In the case of failure following a second course of treatment, the advice of a microbiologist, infectious diseases physician and dermatologist (as indicated) should be sought.

Pets colonised with MRSA have been implicated in ongoing household transmission (35-39). Treatment of pets is not indicated and colonisation tends to be short-term. Therefore, investigations and interventions with pets should occur only in exceptional circumstances where the household is at risk and following reinforcement of hygiene measures. Consultation with a veterinarian, in addition to a clinical microbiologist/infectious disease physician and public health specialist, is recommended. Leaflets on the HPSC website provide:

- Information for people and their close contacts, who have been informed they have CA-MRSA
- Information for groups when there is a case of CA-MRSA e.g. sports teams, daycare
- Infection prevention and control recommendations for CA-MRSA in primary care settings – reducing the risk of transmission
- Information for day-care centres and schools.

2.1.6 Eradication of MRSA carriage (decolonisation)

Decolonisation of cases of CA-MRSA is described in Section 2.1.5

Recommendation 23
MRSA decolonisation is not sufficiently effective to warrant routine use in all colonised patients. **Grade A**

Recommendation 24
Excessive use of mupirocin should be avoided as this will select for resistance. **Grade B**

Recommendation 25
Decolonisation may be considered in certain cases but the likely success or impact of such therapy should be risk assessed to evaluate the aim, the required agents and whether it is likely to be successful. **Grade C**

Recommendation 26
An attempt at decolonisation may be considered in the following groups or situations:
- Patients colonised with MRSA who are due to undergo an elective operative procedure especially high risk surgery e.g. cardiothoracic surgery, orthopaedic implant
- Patients in a clinical area where there is a high risk of colonisation leading to invasive infection e.g. the ICU/NICU
- If the risk of infection is high and the consequences severe e.g. immunosuppressed patients
- As part of a strategy to address uncontrolled transmission despite the use of other measures. **Grade C**

Practical Guidance

Justification for decolonisation

a) In patients with colonisation at non-nasal sites there is a high possibility that decolonisation therapy will fail. Therefore use, in such populations, should be carefully considered and the aim and likely outcome taken into account before such therapy is initiated. **Grade C**

b) Attempts at decolonisation are unlikely to be successful in patients with chronic skin conditions, ulcers, in-dwelling urinary catheters and therefore use in such populations should be carefully considered and the aim and likely outcome taken into account before such therapy is initiated. **Grade C**

Decolonisation protocols

a) The following decolonisation protocol is recommended:
- Apply a small amount of 2% mupirocin in paraffin base (with cotton swab or gloved tip of little finger) to the inner surface of each nostril (anterior nares) three times daily for five days. Apply enough to cover the inner surface.
- Pinch the distal end of nose gently after application, the patient should be able to taste mupirocin at the back of the throat a minute or so later. Other agents that may be considered include naseptin (0.5% neomycin + 0.1% chlorhexidine), chlorhexidine cream, bacitracin, or povidone iodine ointment although data on their use is lacking and suggest that they are less effective than mupirocin.
- Patients should bathe daily for five days with an antiseptic detergent, if the patient's skin condition allows. Agents such as 4% chlorhexidine, 7.5% povidone-iodine, 2% triclosan or octenidine dihydrochloride (0.1%) can been used. There are also data demonstrating the effectiveness of tee tree oil for skin carriage.

- Antiseptic detergents should be used as per manufacturer's instruction with appropriate contact times. The skin should be moistened and the antiseptic-detergent applied thoroughly to all areas before rinsing in the bath or shower. Special attention should be paid to known possible carriage sites including axilla, groin, perineum and buttock area. The antiseptic detergent should also be used for all other washing procedures and for bed bathing.
- Daily application of 1% chlorhexidine powder to axillae and groins following body washing may be considered.
- Hair should be washed twice weekly with an antiseptic detergent.
- The value of local treatment for throat carriage such as antiseptic gargles or sprays is uncertain, but may reduce the organism load.
- During a course of treatment, clean clothing, bedding, towels and flannel should be provided, in addition to regular changes of clothing, bed linen etc. **Grade C**

b) Combined topical and oral antimicrobial therapy may be considered, under the supervision of a clinical microbiologist or an infectious disease physician, for the eradication of MRSA in certain patient groups e.g. extranasal sites of colonisation and patients about to undergo high risk surgery. If eradication of throat carriage is required, rifampicin and fusidic acid, or trimethoprim combined with either rifampicin or fusidic acid, according to susceptibility results, may be given for 5 to 7 days. The potential for drug interactions and drug toxicity should be considered. Liver function tests should be monitored. **Grade C**

Decolonisation in special groups

Decolonisation of patients in non-acute healthcare facilities

Non-acute healthcare facilities should seek expert advice before embarking on decolonisation for MRSA. **Grade C**

MRSA carriers will not normally require decolonisation following discharge from an acute hospital to a non-acute healthcare setting, the community or home. **Grade B**

If decolonisation treatment has been commenced prior to discharge it should be completed. **Grade B**

The need for decolonisation after discharge should be decided by the patients' consultant in conjunction with the hospital infection prevention and control team. Decolonisation may be required in certain circumstances e.g. pre-operatively on the advice of the admitting physician/ surgeon where a patient is to be readmitted for further treatment. **Grade D**

The need for decolonisation treatment must be communicated to the non-acute healthcare facility, and general practitioner on discharge. **Grade D**

MRSA decolonisation in neonates

- Decolonisation of infants outside of high risk units is not usually required, unless recommended by the infection prevention and control team. **Grade D**
- For infants in the NICU and other high risk units, nasal mupirocin is recommended for decolonisation if the MRSA isolate is susceptible. **Grade D**
- If the neonate is >26 weeks gestation strongly consider gentle skin bathing with octenidine dihydrochloride. **Grade D**
- 1% chlorhexidine powder may be used on the umbilical and nappy area. **Grade D**
- Chlorhexidine 4% disinfectant should not be used on the skin of premature infants, on account of the risk of burns and dermatitis. **Grade C**

Rationale

Justification for decolonisation

Decolonisation of MRSA refers to the use of either topical and or systemic agents for the purpose of eradicating carriage. Such a strategy may be used in an attempt to prevent the spread of the organism or to reduce the risk infection in the individual patient carrying MRSA. Decolonisation is also used in patients colonised with methicillin-susceptible *Staphylococcus aureus* (MSSA). However, the aim in such cases is to reduce the risk of infection in the colonised patient.

The optimal strategy for controlling MRSA infection remains unclear. A Cochrane systematic review in 2003 concluded that there was insufficient evidence to support use of topical or systemic antimicrobial therapy for eradicating nasal or extra-nasal MRSA (1). There was no demonstrated superiority of either topical or systemic therapy or of combinations of these agents and they also concluded that potentially serious adverse events with the development of antimicrobial resistance can result from therapy.

However, a Cochrane review in 2008 suggested a benefit to the screening and decolonisation of patients at high risk of MSSA infection e.g. cardiac surgery, implant surgery (2). A subgroup analysis showed a pronounced effect on surgical patients and patients undergoing dialysis, confirming previous findings in relation to dialysis patients. In a more recent study from the Netherlands a reduction in *S. aureus* hospital acquired surgical site infection was found by the use of rapid screening and decolonisation of *S. aureus* carriers on admission (3). The rate of *S. aureus* infection was 3.4% (17 of 504 patients) in the mupirocin-chlorhexidine group compared with 7.7% (32 of 413 patients) in the placebo group (relative risk of infection, 0.42; 95% confidence interval [CI], 0.23 to 0.75). The effect was most pronounced for deep surgical-site infections (relative risk, 0.21; 95% CI, 0.07 to 0.62). The length of hospital stay was also shortened. Although showing benefits for patients with MSSA, and not MRSA due to the relative absence of MRSA in that country, it is plausible that the same result would have occurred had MRSA been endemic.

Factors that appear to affect the efficacy of available strategies include whether MRSA is endemic in the institution, the presence of mupirocin resistance, the number of patient sites colonised with MRSA, in particular throat colonisation, the presence of wounds, extensive skin lesions, whether the gastrointestinal tract is colonised and the presence of foreign bodies such as urinary catheters, percutaneous endoscopic gastrostomy (PEG) tubes, haemodialysis lines, etc. In such cases the risk of failure is higher.

A number of studies have shown that short term decolonisation can be achieved and that this can be beneficial. An observational study of mupirocin and chlorhexidine baths in an intensive care unit by Sandri *et al* found a significant reduction in the incidence of MRSA nosocomial infection (4). Ridenour, after an intervention utilising nasal mupirocin and chlorhexidine baths, also found a significant 52% decrease in colonisation/infection; all MRSA isolates remained susceptible to chlorhexidine and the overall rate of mupirocin resistance was low (4.4%) (5).

Other studies however, despite achieving short term decolonisation, have not demonstrated an impact on infection rates. Robicsek *et al,* in a retrospective cohort study, found that the use of mupirocin did not affect the risk of infection although there was a trend towards delayed infection in the treated patients (6).

The possible role of decolonisation in the reduction of MRSA rates in both Scotland and the UK has recently been reviewed (7,8). The authors conclude that the evidence is incomplete but it is possible that the widespread use of decolonisation has contributed to the significant reductions in MRSA BSI observed in recent years. However, in high risk groups e.g. haemodialysis, although decolonisation may be effective in the short term, there are data to demonstrate that the risk of recolonisation is high and more recent data support that this is still the case and many questions remain unanswered (9,10).

Apart from the role of decolonisation in the endemic setting such as in most acute Irish hospitals, decolonisation has also been used as an adjunct to other control transmission in a medical surgical intensive care unit after the initiation of decolonisation therapy for all colonised patients (11).

Although questions regarding MRSA decolonisation still exist, it is now generally accepted that treatment of proven carriers reduces the risk of infection in patients undergoing surgical procedures and in other high risk groups. Most experts agree that MRSA decolonisation is not sufficiently effective to warrant routine use in all colonised patients and that excessive use of nasal decolonisation agents should be avoided as this will select for resistance (12, 13, 14). There is also a consensus that more studies are needed both in terms of the benefit to the patient from MRSA decolonisation and also the role that decolonising therapy might play in the control of MRSA transmission and outbreak control measures within institutions (15,16).

Decolonisation protocols

In the case of the decolonisation regimen, the optimal regimen remains unclear and the length of treatment has varied from 5 to 14 days and the agents used have also varied. In 2009, Ammerlaan *et al* reported a systematic review to determine the effectiveness of different approaches for eradicating MRSA carriage (17). Twenty-three clinical trials were selected. Seven evaluated oral antibiotics, 12 trials evaluated topically applied antibiotics and 4 trials both. Subgroup analysis of studies with similar study populations was performed because of the clinical heterogenicity of the trials selected. They found that short-term nasal application of mupirocin was the most effective treatment for eradicating methicillin-resistant *S. aureus* carriage, with an estimated success of rate of 90% one week after treatment and approximately 60% after a longer follow-up period. The development of drug resistance during treatment was reported in 1% and 9% of patients receiving mupirocin and oral antibiotics, respectively.

In terms of topical agents mupirocin is well established as the most effective topical agent for the removal of staphylococci from the anterior nares (18-20). Data have shown that initial clearance following mupirocin use is high but recolonisation after three months is also high. There are now data available on a number of other agents including povidone-iodine cream, tea tree oil, and extract of green tea but further studies are needed to determine the potential of these products. Topical 4% chlorhexidine bodywash/shampoo or 7.5% povidone iodine are equally efficacious for decolonisation of non-nasal sites. A review of the use of octenidine hydrochloride was also recently published (21).

Resistance has been associated with the increased use of mupirocin and high level mupirocin resistance has been associated with decolonisation failure (22). The clinical significance of low level resistance remains unclear. A recent review has recommended that laboratories should ensure that appropriate methods are in place to detect such resistance and to monitor the impact of mupirocin use (23, 24).

Full body decolonisation is recommended, irrespective of which site or sites are colonised to maximise prevention and control measures. Eradication of carriage of MRSA, from sites other than the nose, is associated with a higher failure rate (25, 26). In patients with MRSA in non-nasal sites, e.g. wounds, higher success rates have been achieved when topical decolonisation is either accompanied by or followed by the use of a systemic agent. Although such a strategy can be useful if appropriately used e.g. if one is trying to achieve short term decolonisation for a procedure or during hospitalisation, the risks of resistance and adverse events need to be considered.

Chlorhexidine is now being used in many centres for an increasing number of indications including MRSA decolonisation, universal patient bathing in ICU, oropharyngeal antisepsis in ventilated patients and as part of the routine care of vascular catheter sites. In two studies, one a multi-centre study in six ICUs and the other in four general medicine units, the use of chlorhexidine bathing compared with soap and water resulted in reduced infections and colonisation with MRSA and vancomycin-resistant enterococci (27,28). Further work is required to determine if the

widespread use of chlorhexidine to reduce HCAI and MRSA colonisation is indicated or should be confined to high risk areas such as ICU. Chlorhexidine resistant MRSA strains have been described but the significance and the likely clinical impact is poorly understood (29). The use of chlorhexidine baths in ICU may be a reasonable alternative to the use of mupirocin or systemic agents given the adverse events associated with their use.

It is generally agreed that prolonged repeated courses of decolonisation regimens are not likely to be effective and may lead to the development of resistance to some topical disinfectants, antiseptics and antibiotics, or may result in side effects for the patient. A suggested approach on how to decide to decolonise or not is outlined in Figure 3.

Decolonisation of patients in non-acute healthcare facilities

The effectiveness of decolonisation with nasal mupirocin has not been demonstrated in the non-acute healthcare setting. A high rate of recolonisation has been reported in a study examining the use of mupirocin for decolonisation of *S. aureus* in residents of two long term care facilities. At 90 days post treatment, 39% of residents were recolonised with MSSA (28). Also prolonged use and multiple courses of mupirocin have been associated with the development of mupirocin resistance and prolonged or repeated courses are to be avoided in long stay patients (29).

MRSA decolonisation in neonates

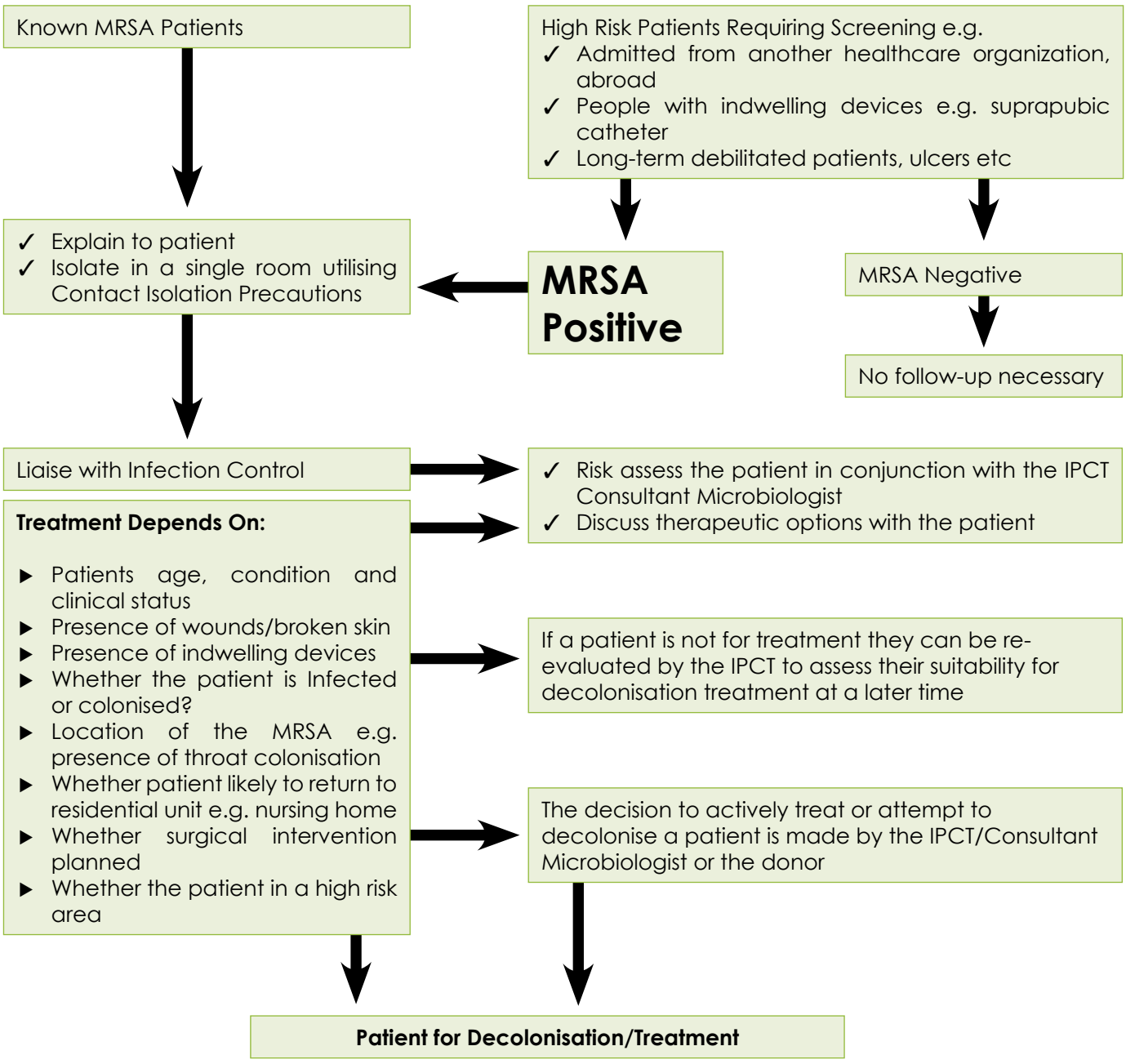
MRSA sepsis in the paediatric population is uncommon. The incidence of MRSA BSI in Irish children <16 years is 1.1 per 100,000 child population (30).

Neonates who are MRSA positive and in a high risk unit (e.g. NICU, special care baby unit, paediatric ICU, haematology-oncology unit, cardiothoracic surgery, neurosurgery, transplant) or pre-elective surgery, should be decolonised. Clinical MRSA isolates are indistinguishable from the colonising isolate in >90% of episodes in a NICU (31). Decolonisation may reduce the subsequent infection rate and may reduce transmission within the NICU.

There is evidence that mupiricin has been used for many years in neonatal units without cause for concern. In a US National survey of MRSA eradication in NICU's, 100% of respondents who attempted to decolonise MRSA carriers used topical mupiricin (32). The use of octenidine dihydrochloride baths (especially if >28 weeks corrected gestation) can be considered as well as the use of 1% chlorhexidine powder on the groin and umbilical area. Topical 4% chlorhexidine wash is not recommended for premature infants, as it may cause dermatitis or burns.

(Adapted from Guidelines for the management of community-associated methicillin resistant *Staphylococcus aureus*, Government of Western Australia. Department of Health, WA Communicable Disease Control Directorate, Department of Health 2013. http://www.public.health.wa.gov.au/3/896/3/camrsa.pm)

Figure 3 Practical guidance for the management of MRSA



Topical Treatment:

- Apply mupirocin 2% (Bactroban®) nasal ointment to both nostrils TDS for 5 days.
- Wash with chlorhexidine gluconate (CX) 4% (Hydrex®)daily for 5 days, washing the hair with this solution on day 2 and day 5.
- Depending on the location of colonisation CX powder may he recommended to be applied to the skin after washing e.g. axillaor groin area.
- Consider a mouth wash if throat colonisation.
- All treatment MUST be discontinued after the recommended period. Failure to do so can lead to excoriation of the skin, continued colonisation in excoriated areas and resistance.
- If treatment causes adverse reactions then it should be discontinued immediately and discussed with the IPCT.

(Adapted from Guidelines for the management of community-associated methicillin resistant *Staphylococcus aureus*, Government of Western Australia. Department of Health, WA Communicable Disease Control Directorate, Department of Health 2013. http://www.public.health.wa.gov.au/3/896/3/camrsa.pm)

2.1.7 Antimicrobial stewardship in the prevention and control of MRSA

Recommendation 27
Unnecessary or prolonged antibiotic use, particularly of broad-spectrum agents should be avoided. **Grade A**

Recommendation 28
Healthcare institutions should implement the recommendations included in the *Strategy for the Control of Antimicrobial Resistance in Ireland* (SARI 2009). **Grade B**

Recommendation 29
Antibiotic stewardship programmes should be implemented in all healthcare settings including long-term care facilities. **Grade B**

Practical Guidance

Antimicrobial use in long term care facilities

- Antibiotic stewardship programmes should be implemented for longterm care facilities. **Grade B**
- When antibiotics are prescribed to treat MRSA, local advice should be sought from the consultant microbiologist or infectious diseases physician. **Grade D**
- The use of antibiotics associated with MRSA selection or resistance should be avoided or minimised as much as possible. These include cephalosporins, macrolides and fluoroquinolones. **Grade B**
- Topical therapy for superficial MRSA skin infections should not be used without advice from a consultant microbiologist or an infectious diseases physician. **Grade D**

Rationale

Antimicrobial use in the acute hospital setting

Antibiotic use promotes the spread of existing strains of MRSA through reduction in colonisation resistance in individual patients and by negative ecological effects on MRSA acquisition, persistence and transmission, giving such resistant strains a survival advantage in the hospital environment (1, 2).

MRSA prevalence in hospitals has been linked to overall levels of antibiotic consumption and to consumption of specific antibiotic classes, most notably fluoroquinolones, cephalosporins, amoxicillin/clavulanate and macrolides (3-6). A systematic review and meta-analysis found that antibiotic exposure in individual patients was associated with a 1.8-fold increase in the risk of subsequent acquisition of MRSA, and that the relative risk was higher for specific antibiotic classes, i.e. fluoroquinolones 3; glycopeptides 2.9; cephalosporins 2.2; and other beta-lactams 1.9 (7). Antibiotic exposure has been identified as a risk factor for carriage of community-acquired CA-MRSA strains (8).

Antibiotic stewardship programmes are strongly associated with a reduction in MRSA colonisation and infection rates, particularly after reduction in beta-lactam and/or quinolone use (2,9-12). More emphasis needs to be put on antibiotic stewardship to control MRSA (9). Please refer to the 2009 SARI antibiotic stewardship guidelines for further details http://www.hpsc.ie/hpsc/A-Z/MicrobiologyAntimicrobialResistance/StrategyforthecontrolofAntimicrobialResistanceinIrelandSARI/KeyDocuments/File,1070,en.pdf.

There is also greater interest in the social and behavioural aspects of antibiotic resistance and antibiotic prescribing. Recent studies and reviews have highlighted the cultural, contextual and behavioural aspects that need to be explored further, i.e. differences within and between countries (13, 14).

Colonisation or infection with glycopeptide-intermediate and glycopeptide-resistant *Staphylococcus aureus* (GISA and GRSA) is strongly associated with prolonged exposure to glycopeptides and prior colonisation or infection with MRSA. Promotion of prudent glycopeptide use has been shown to reduce the prevalence of vancomycin-resistant enterococci (VRE) in intensive care units and it follows that prudent glycopeptide use should also be promoted to prevent glycopeptide resistance in staphylococci (15).

Antimicrobial use in long term care facilities

The development of antibiotic resistant organisms has been strongly associated with antibiotic use. Prudent antimicrobial use is important in the prevention and control of MRSA (16).

Infection prevention and control measures, antibiotic restrictions and appropriate therapy for infection were successful in controlling an outbreak of CA-MRSA in a residential setting for adults with developmental disabilities. No host risk factors were identified for the acquisition of MRSA. However, excessive antibiotic use was observed in the facility affected (17).

As in the acute hospital sector challenges remain in the successful implementation of antibiotic stewardship programmes. These include inadequate numbers of personnel with the necessary background and training and a belief amongst the public and some healthcare professionals that more antibiotics are being developed that will address antibiotic resistance. Also, there is the dilemma for the individual prescriber between doing what is best for the individual patient, e.g. using a broad-spectrum agent or using multiple antibiotics in patients who are sicker and acknowledging the need to contribute to reducing the pressure on antibiotic resistance in the wider health community. This can be partly addressed by public health campaigns explaining to the wider public the issues relating to antibiotic resistance and the feeding back of prescribing data to prescribers so that they can see how they compare with equivalent colleagues. In addition, the provision of greater financial details about costs associated with prescribing, especially when this is linked with accountability through clinical directorates in acute hospitals and community care units will drive changes in lower rates of antibiotic use.

2.1.8 Occupational health aspects of MRSA

Recommendation 30
Occupational health (OH) staff providing services to the healthcare sector should be familiar with the multifaceted approach required to manage MRSA in their workplace setting and of the need for a risk assessment approach in understanding the complex interplay between staff, patients and the environment. **Grade C**

Recommendation 31
The screening of staff on a routine basis is not indicated. Staff screening may be considered for institutions without endemic MRSA, or for specific high-risk units, as determined by the local IPCT. **Grade C**

Recommendation 32
Healthcare workers (HCW) should only be screened for MRSA infection or colonisation if they are epidemiologically linked to a cluster of MRSA infections. **Grade C**

Practical Guidance

Role of occupational health (OH)
Individual employees need to act responsibly with regard to their own health and seek advice from OH when appropriate. **Grade C**

Managers should facilitate OH when relevant issues of personal health or MRSA exposure arise. **Grade C**

OH practice and guidance should be informed by the hierarchy of risk controls incorporating knowledge of standard precautions as an administrative control. **Grade D**

Risk Control
Good management is required in the effective implementation of an MRSA control programme in any healthcare setting. **Grade D**

OH should identify healthcare workers with risk factors for MRSA as early as possible and should provide education on workplace risks in both formal and informal educational sessions. **Grade C**

OH should liaise closely with the IPCT during outbreaks and ensure that individual HCWs receive appropriate investigation, treatment and follow-up where colonisation or infection is suspected or confirmed. **Grade C**

Personal protective equipment should be readily available for use as a barrier in appropriate circumstances and includes gloves, masks etc. **Grade C**

OH should assist the IPCT in the education of HCWs on the prevention and management of exposure to or infection with MRSA where resources allow. **Grade D**

OH should implement on-going systematic evaluation to ensure that programmes achieve their stated objectives, that policies remain current, and are legally compliant. **Grade D**

Staff with persistent exfoliative skin lesions should be excluded from the care of patients colonised or infected with MRSA. **Grade C**

MRSA colonisation and infection in HCWs and the need for laboratory support
When investigating the involvement of HCW in outbreaks, or when HCWs themselves are colonised or infected, there should be ready access to appropriate laboratory facilities. **Grade B**

Molecular analyses to establish distinguishability of MRSA isolates are useful in determining the link between healthcare worker colonisation/infection and transmission to patients. **Grade C**

Screening of HCW for MRSA
If new MRSA cases are found among patients on a ward, staff should be asked about skin lesions. Those with lesions and other potential positive sites, e.g. ears, should be referred for screening and for consideration of treatment by the relevant occupational health department. Topical clearance will not eradicate MRSA in HCWs if there is an underlying focus of infection. **Grade C**

HCW screening should be taken before a shift. Taking specimens at the end of a shift will detect transient carriers who are rarely a cause of transmission. **Grade B**

A swab from the anterior nares and from any abnormal or broken skin is usually sufficient when initially screening HCW for MRSA. Full screening is necessary after an initial MRSA positive site including the perineum. **Grade B**

A minimum of three full screens at least 48 hours apart, while not undergoing decolonisation, should be performed before a previously positive HCW can be considered to be clear of MRSA. **Grade D**

Pre-employment health assessment (PEHA) and screening
Pre-employment MRSA screening of healthcare staff is not routinely recommended. It may be considered where MRSA is not endemic or for specific units on the basis of local risk assessment. **Grade C**

Pre-employment MRSA screening may be deemed necessary depending upon the location (unit, hospital, country) of prior workplace if relevant, if this location is recognised to have specific problems with high rates of MRSA, or if there are unusually pathogenic strains of MRSA (e.g. CA-MRSA). **Grade D**

Healthcare worker risk factors identified at PEHA should be used by OH professionals to determine whether clinical HCWs deployed in certain high risk areas should be screened. **Grade D**

HCWs should not be denied employment because of MRSA colonisation or infection though they may be restricted from working in certain roles. **Grade D**

Screening during outbreaks
Staff screening is indicated if transmission continues on a unit despite active control measures, if epidemiological aspects of an outbreak or strain are unusual, or if they suggest persistent MRSA carriage by staff. **Grade C**

Nurses, doctors, physiotherapists and other allied health professionals and non-clinical support staff (e.g. porters) should be considered for screening, and the implications for onward spread by staff working in other wards should also be considered. **Grade C**

Agency and locum staff should be screened if permanent staff are screened as part of outbreak management, for example. **Grade C**

Screening, surveillance and decolonisation where MRSA is endemic
Those involved in decisions regarding the decolonisation of HCWs must understand its limitations and all decisions should be based on a comprehensive risk assessment. **Grade D**

Clinicians (including GPs) involved in the treatment or decolonisation of healthcare workers should inform their local OH service to ensure that local protocols are adhered to and they should also seek advice on fitness for work. **Grade D**

The decolonisation protocol used for patients is also recommended for HCWs. However, particular care should be taken in prescribing any treatment which might compromise skin integrity. **Grade A**

Specialist advice from a consultant microbiologist or infection disease physician should be sought for HCW with MRSA infection depending on the site of infection. Decolonisation therapy will usually be required along with treatment. **Grade D**

Fitness for work

OH should recommend exclusion of clinical HCWs and food handlers from work (having obtained appropriate cultures) if they have dermatitis, a chronic skin condition, a draining lesion on hand(s), or other exposed site where MRSA colonisation is likely until the infection has been outruled or they have received adequate therapy and their infection has resolved. **Grade C**

OH may recommend exclusion of clinical HCWs with MRSA if they are found to be epidemiologically linked to patient transmission until antibiotic treatment and medical assessments are complete and appropriate control measures and/or work restrictions have been agreed. **Grade C**

In principle, only HCWs with colonised or infected lesions at exposed sites should be off work while receiving courses of clearance therapy, but decisions on fitness for work or the necessity for work adjustments should be based on local risk assessment. **Grade D**

Unless a HCW identified as carrying MRSA work in high-risk wards, i.e. intensive care units, neonatal, orthopaedic or haematology units, solid organ or bone marrow transplant unit, they should not be excluded from work. Staff working in these areas should be excluded from work, or reassigned to a low-risk area, for 24 hours only from the start of decolonisation therapy. **Grade D**

Decisions on fitness for work in complex or unusual cases of infected or colonised HCWs can only be arrived at by close collaboration between a specialist occupational physician and a consultant microbiologist/infectious disease physician using a risk assessment approach. **Grade D**

Rationale

Role of occupational health

There is an expanding literature on the role of the healthcare worker and MRSA (1). Many questions remain unanswered as there have been no controlled intervention studies specifically addressing the role of HCWs in MRSA transmission (1). These are needed as the issues of HCW colonisation and decolonisation are different to those that relate to patients and there is an on-going controversy as to how extensive HCW screening should be. In countries where MRSA rates are low, e.g. the Netherlands, there is a more proactive approach to HCW screening, compared to those countries such as Ireland when HCW screening tends to be more reactive such as during outbreaks.

For the purposes of this document the term HCW is used to include any individual who has the potential to acquire or transmit an infectious agent during the course of his or her work in healthcare. This includes the three categories of employee identified by the Association of National Health Occupational Physicians (ANHOPS) in their guidelines on immunisation of HCWs, i.e. clinical, laboratory staff and non-clinical ancillary (2). However, in Ireland, not every healthcare facility has access to an OH service and advice is often provided by IPCTs with clinical microbiologists and others in its absence.

Both asymptomatic carriers of MRSA and those with symptoms of infection have been causally associated with outbreaks in the healthcare setting (1). The more recent threat of community-associated MRSA (CA-MRSA) which affects young healthy people without traditional risk factors has additional implications for HCWs. Furthermore, there have been several reports of HCWs acquiring MRSA infection from colonised patients (3).

Though this guideline addresses MRSA, it is worth noting that Methicillin-Susceptible *Staphylococcus aureus* (MSSA) has similar characteristics and mechanisms of spread. It was established some time ago that nasal carriers of *S. aureus* who have concurrent respiratory tract infection can disperse bacteria into the air causing outbreaks (4,5). Known *S. aureus* shedders can reduce the risk of spread to patients by wearing a surgical mask while symptomatic from URTI (4). There is no reason to believe that staff colonised and/or infected with MRSA should present a transmission risk that is any different to the spread of MSSA. Risk factors for MRSA amongst HCWs are outlined in Table 5.

The role of OH is to protect, promote and maintain employee health in a healthy work environment. In the context of infection prevention and control the objective is to reduce the transmission of infection to or from the HCW in accordance with best practice and in a legally compliant manner. The employer's legal responsibility is defined in relevant workplace health and safety legislation and the Employment Equality Act (6-8). Close collaboration between OH and the IPCT is essential in achieving this objective as responsibilities can overlap especially in the area of education, during an outbreak situation, or when the HCW has duties in a high risk clinical area.

Professionals in OH should be familiar with the principles of good infection prevention and control practice as well as the relevant occupational safety concepts within the industrial hygiene hierarchy of risk controls (9, 10). The four components necessary for an effective OH programme targeting MRSA are risk assessment, risk control, education and evaluation (11). Risk assessment includes assessing the risk of transmission to HCWs as well as considering the risk of transmission to patients from infected or colonised HCWs. Risk factors for MRSA amongst HCWs are outlined in Table 5 (1).

All HCWs need to be aware of their responsibility to report relevant health conditions to their occupational health provider both at the PEHA stage and thereafter as conditions arise. All HCWs in managerial positions need to be aware of their responsibility to be alert to the possibility that staff with relevant health complaints may have MRSA infection and should refer them promptly for OH assessment. Furthermore, all health professionals (including OH professionals) who provide clinical care to HCWs as patients need to be aware of the particular implications of MRSA infection/ colonisation in HCWs. Poor infection control practices have been implicated in both acquisition and transmission of MRSA (and MSSA) by healthcare staff. However, good adherence to infection control practice does not entirely prevent transmission from heavily colonised staff to patients, since staff may unwittingly shed MRSA into the air, and/or contaminate surfaces, both of which may act as reservoirs within the healthcare environment (12).

Table 5: Risk Factors for MRSA in HCWs

MRSA carriage
• Co-morbidities o Cutaneous lesions or conditions (e.g. dermatitis, eczema, psoriasis, pemphigus) o Sinusitis, rhinitis (chronic, allergic, infectious) o Chronic otitis externa, earlobe dermatitis o Recent urinary tract infection o Cystic fibrosis • Other endogenous factors o Recent antibiotic use • Work related factors o Previous work abroad o Work experience (e.g. student HCW, longer duration of service) o Area of service (e.g. medicine, surgery, long-term care facilities, decreasing risk from ward to ICU to operating theatre) o Employment in areas of high patient MRSA prevalence (e.g. patients from high-prevalence countries) o Close contact with patients (e.g. dressing changes, wound contact) o Poor attention to infection control (e.g. poor hand hygiene) o High work load
MRSA persistence despite eradication
• Co-morbidities: cutaneous lesions/conditions • Sites of colonisation: pharynx, rectum, perineum, extensive skin • Household and environmental contamination • Mupirocin resistance
Relapse after eradication
• Sites of colonisation: pharynx, rectum, genitals (vagina, prepuce), skin, ear lobes • Infections: upper respiratory tract infection, chronic otitis externa • Mupirocin resistance

Risk Control

Measures to prevent HCW exposure to or acquisition of infection with MRSA can be categorised under the headings, e.g. engineering controls, administrative controls, work practices and PPE (11).

Engineering controls reduce the hazard at source e.g. hand washing facilities, antiseptic hand gel dispensers, facilities for decontaminating patient care equipment.

Administrative controls include the development and adoption of policies which support and provide resources for programmes aimed at defined objectives. Also included are the support of a confidential records management programme, the provision of appropriate advice where infection or colonisation is suspected or confirmed and the implementation of fitness for work recommendations in individual cases. Healthcare managers should also ensure that external service providers also comply with the workplace OH programmes and that this is outlined in contractual agreements.

Work practices include the support of the IPCT's endeavours to reduce the transmission of infection as outlined in its policies. Open and clear communication with the HCW is essential to minimise unnecessary anxiety. The role of the OH team is paramount here. In addition, communication with line managers in a way which facilitates good management decisions while protecting

HCW confidentiality is essential. The concept of work adjustment (rather than seeking to impose sickness absence) is recommended in cases where continuing in the current role is considered to pose a risk to the HCW or patient.

Personal protective equipment (PPE) is considered the final and least effective step in the hierarchy of risk controls as it requires user compliance to achieve its goal.

Should these controls fail, OH must assess the HCW exposed to MRSA following direct or indirect contact of skin or mucous membrane with colonised or infected body sites, wound exudates or respiratory secretions. OH should also, in collaboration with IPCT, undertake assessment of the source of HCW exposure in order to assess the potential for transmission. The number of healthcare staff who have direct contact with patients colonised or infected with MRSA should be kept to a minimum. Staff with persistent exfoliative skin lesions should be excluded from the care of patients colonised or infected with MRSA (13, 14).

MRSA colonisation and infection in HCWs and the need for laboratory support

MRSA-colonised and infected patients readily contaminate their environment and a HCW coming into contact with either will readily contaminate their hands, clothing and equipment. Colonisation in healthcare workers is usually found in the nose and on the hands with other body sites less frequently reported (perineum, pharynx). In a recent comprehensive review where over 30,000 HCWs were tested for MRSA, 4.6% were found to be positive (1).

Recent studies have shown that neckties, white coats and mobile phones may be contaminated with bacteria including MRSA but there is as yet no evidence that either has resulted in transmission to patients (15-17).

Three types of MRSA carriage by HCWs have been described: *non carriers, persistent carriers,* who are chronically colonised with the same strain and *intermittent or transient carriers* who are colonised with varying strains for short periods of time. Transient carriage (after a work shift but cleared before the next shift) was found in one small study to be mainly nasal (1). Persistent carriage is less common than for MSSA and usually involves extra-nasal carriage. Care is needed to distinguish between transient and persistent carriage (18, 19). Hand carriage is usually transient and is greatly influenced by hand hygiene compliance. The transient or persistent colonisation of HCWs with MRSA has been shown to be the source of several hospital outbreaks. Molecular analyses to establish distinguishability of MRSA isolates has been useful in such situations (18). Strains identified on contaminated hands usually match nasal strains (20). A recent review identified 27 studies where transmission occurred and another 52 where it was considered likely (1). One report described an outbreak in a newborn nursery where a healthy nasal carrier was implicated and another identified a HCW with nasal MRSA colonisation and upper respiratory infection which caused transmission to eight surgical ICU patients (21,4). Heretofore, MRSA has been regarded as a nosocomial pathogen but recent literature cites it as an occupational disease (22). The latter is particularly pertinent for patients colonised and/or infected with CA-MRSA, since HCW acquisition of these strains is more likely to be clinically significant.

Screening of HCW for MRSA

While both symptomatic and asymptomatic HCWs have been implicated in the transmission of MRSA in the healthcare setting, and decolonisation as part of a multi-faceted approach has contributed to successful termination of outbreaks, there is some debate about when HCW screening should be undertaken. A systematic review suggests that asymptomatic HCWs are only rarely the likely source in nosocomial outbreaks (1.6%) and recommends that a more effective approach in this context is to identify infected HCWs (23).

By contrast, another paper identified 44 studies with either proven or likely transmission to patients from HCWs who were not clinically infected with MRSA (1). They suggest that screening should not

be restricted to outbreaks because there is a trend for higher colonisation rates in settings with endemic MRSA.

Screening of staff on a routine basis is not indicated (20). It may be considered for institutions without endemic MRSA, or for specific high-risk units, as determined by the local IPCT. Ironically, though colonisation rates tend to be higher where MRSA is endemic, the benefit of more regular HCW screening is greater where MRSA prevalence is lower. Thus, it may be expected that if prevalence rates go down, more widespread staff screening may be advocated.

Regardless of whether units have endemic MRSA, the identification of new patient carriers on a ward should prompt local IPCTs and managers to remind staff of their responsibility to report skin lesions or indeed, any other low-grade infections. Such staff should be referred for evaluation and screening to the OH department (19). Staff with persistent carriage at sites other than the nose (e.g. pharynx, perineum, ear and/or skin) should be referred for appropriate specialist management and follow–up screening (13, 19).

Staff screening is indicated if transmission continues on a unit despite active control measures, i.e. if epidemiological aspects of an outbreak are unusual, if there is suspicion of persistent carriage of MRSA by staff, if one or more patients demonstrate severe infection, or if a particularly pathogenic or resistant strain is found from either one or more patients and staff in a specific clinical area (19). HCW screening should be taken before a shift or after at least 12 hours (ideally one day) after a period of duty (19). HCWs must be fully informed of the context in which screening is taking place and be reassured that regardless of the outcome, they are not culpable. For practical and logistical purposes, the anterior nares are considered the most appropriate sampling site for initial staff screening along with swabbing of any areas of abnormal or broken skin (13). Screening of other body sites (e.g. throat, groin/perineum) should be considered only in those found to be MRSA positive. The perineum is better than the groin, and perineal swabs in generally fit and mobile staff can be obtained by asking the HCW to take the swab themselves.

It is recommended that a minimum of three screens at least 48 hours apart, while not receiving antimicrobial therapy, should be performed before a previously positive staff member can be considered to be clear of MRSA (13).

Pre-employment health screening

Unlike screening and surveillance of existing staff, PEHA screening has the advantage of being a 'once off' assessment. When a colonised HCW (or those with risk factors, Table 5) is identified, decisions can be taken at the outset either to ensure that they are deployed in low risk units or to enhance their training and surveillance if deployed in higher risk areas. If screening is undertaken as part of the PEHA process, it should be clear that the outcome of the test does not determine the employability of the candidate.

While some units with low MRSA prevalence consider it useful to undertake PEHA screening, it is a costly exercise. When OH staff identify individual risk factors during a new recruit's PEHA they may consider whether clinical staff with such risk factors should be screened prior to their deployment in higher risk units.

Screening, surveillance and decolonisation where MRSA is endemic

The screening of healthcare workers is not routinely recommended in settings where MRSA is endemic unless they have been epidemiologically linked to new cases or there is on-going spread despite conventional control measures, e.g. patient screening and enhanced compliance with standard precautions. Furthermore, a recent review that assessed the case for routine healthcare worker screening concluded that further research is required before such a step is taken in NHS Scotland (24).

Decolonisation of HCWs is complex and must be handled with great sensitivity by all concerned. Screening itself has limitations. It is advised that those involved in making decisions to prescribe decolonisation therapy for HCWs familiarise themselves with Section 2.1.6. This emphasises the limitations of decolonisation which must also be borne in mind when treating colonised HCWs. While it may be appropriate at times to decide against decolonising patients in certain settings it is virtually always the case that decolonisation of colonised HCW will be attempted (25). Indeed, to do otherwise would undermine the effort of screening and question its legitimacy.

The decision to decolonise a HCW must be taken by a specialist occupational physician in consultation with a consultant microbiologist or infectious disease physician. The risk assessment on which treatment decisions are based should be recorded. This must consider the individual HCW (and their risk factors), their occupation/role and the patient care context. Awareness of HCW risk factors (both personal and occupational) may help to identify those at risk of failed decolonisation. Where HCWs are identified as being colonised (or infected) with MRSA by their general practitioner, they should notify their occupational health service to ensure that local decolonisation and treatment protocols are adhered to.

The decolonisation protocol for HCWs is identical to that used for patients although chlorhexidine bathing has not been well studied in the context of HCWs (see section 2.1.6). Healthcare workers who are infected with MRSA require particularly careful management and it is advised that specialist advice be sought (e.g. dermatological, ENT) depending on the infection site (13). Decolonisation therapy will usually be required along with treatment.

MRSA positive staff in clinical areas

Practical guidance

a) OH should recommend exclusion of clinical HCWs and food handlers from work (having obtained appropriate cultures) if they have dermatitis, chronic skin conditions, a draining lesion on hand(s), or other exposed site where MRSA colonisation is likely until the infection has been out ruled or they have received adequate therapy and their infection has resolved. **Grade C**

b) OH may recommend exclusion of clinical HCWs with MRSA if they are found to be epidemiologically linked to patient transmission until antibiotic treatment and medical assessments are complete and appropriate control measures and/or work restrictions have been agreed. **Grade C**

c) In principle, only HCWs with colonised or infected lesions at exposed sites should be off work while receiving courses of clearance therapy, but decisions on fitness for work or the necessity for work adjustments should be based on local risk assessment. **Grade D**

d) Unless a HCW identified as carrying MRSA work in high-risk wards, i.e. intensive care units, neonatal, orthopaedic or haematology units, solid organ or bone marrow transplant unit, they should not be excluded from work. Staff working in these areas should be excluded from work, or reassigned to a low-risk area, for 24 hours only from the start of decolonisation therapy. **Grade D**

e) Decisions on fitness for work in complex or unusual cases of infected or colonised HCWs can only be arrived at by close collaboration between a specialist occupational physician and a consultant microbiologist/infectious disease physician using a risk assessment approach. **Grade D**

Rationale

An assessment of fitness for work of a HCW colonised or infected with MRSA must be based on objective assessment and must consider the following:

1. Whether or not s/he feels 'ill'.
2. Individual risk factors for MRSA.
3. Site(s) of colonisation (or infection).
4. History of previous infection or association with transmission.
5. Job tasks required of them in their role or occupation.
6. Their understanding of and ability to comply with standard precautions.
7. Local epidemiology of MRSA and risk to patients (in consultation with the IPCT).

Informed decisions on fitness to work will have a positive impact on patient care and worker health and will facilitate efficiency and optimise productivity. Those with MRSA infections who are clinically unwell or who have draining lesions should be certified unfit for work by their GP and be reviewed by the OH team prior to returning to clinical or food handling duties. Appropriate cultures and susceptibility testing should inform treatment protocols.

Those with MRSA infections who are clinically well and able for work (e.g. skin infections, furuncles, otitis externa) should be excluded from all clinical work and food handling until they have been fully treated. Their resumption of clinical and food handling duties should be dictated by the OH team who will liaise closely with the IPCT. Every effort should be made to keep them at work undertaking alternative duties (e.g. non-clinical administrative duties) for the duration of their infectivity.

Decisions regarding fitness for work of HCWs colonised with MRSA are more challenging and can only be made following risk assessment by the OH team in consultation with the IPCT. Those with nasal carriage and normal skin are likely to decolonise easily while those with risk factors may take longer. Occasionally, a HCW may prove impossible to decolonise.

Unless staff identified as carrying MRSA work in high-risk wards, i.e. intensive care units, neonatal units, orthopaedic units, haematology units, solid organ or bone marrow transplant unit they should not be excluded from duty. Staff working in high-risk wards should be excluded from work unless this compromises patient care, or reassigned to a low-risk area, for 24 hours only from the start of decolonisation therapy (13). It may be prudent to delay their return to regular duties until the results of the first post treatment screening is available to obviate the need for further restrictions if the result does not confirm clearance.

The term 'exclude from duty' should be taken to mean exclusion from similar work in all healthcare settings, including relevant community settings (14). Many HCWs, particularly NCHDs, move readily between units in one healthcare setting and also move frequently to other enterprises. OH professionals should be aware of the need to communicate with the OH service of the next employer where an infected or colonised worker is due to rotate elsewhere. Other doctors, e.g. consultants, may work in other public hospitals or in the private sector.

While it is possible to provide general guidance on work restrictions in a range of scenarios of HCW/patient contact, a combination of issues should be considered (see Appendix X) but this should not be interpreted as prescriptive. Decisions on complex cases require close collaboration between OH, microbiology/infectious diseases and the IPCT, with the involvement of the individual HCW and responsible treating clinician, if there is one. The decisions and their rationale should be recorded carefully in the employee's OH file and reviewed as further information unfolds.

2.2 Management of MRSA (Recommendations 33-45)

The following are responsible for implementation of recommendations 33-45:
Clinical Teams, Senior Management and the Infection Prevention and Control Team (IPCT). Public health professionals and medical scientists have some specific roles as outlined in the relevant recommendations.

2.2.1 Treatment and prophylaxis

Please note in the section below that the guideline refers to the hospital management, including antibiotic treatment of HA- and CA-MRSA (please also refer to Section 2.1.5) but that no evaluation or assessment has been made of the pharmacoeconomic implications of the recommendations which are outside the scope of this guideline. In the case of complicated infections or of infections that fail to resolve with first line agents, expert advice from clinical microbiology, infectious diseases and antimicrobial pharmacists should be obtained.

Much of the advice that follows has been derived from other treatment guidelines, consensus among the working group and some clinical trials. While new agents have become available in the last decade, e.g. linezolid and daptomycin, the original trials, as required by regulatory agencies were designed to show non-inferiority with recognised agents such as vancomycin and not superiority. Consequently, there is a need for larger, multi-centre trials to determine if newer alternatives are superior in key areas, e.g. BSI. While there has been increased emphasis on improving prescribing in Ireland in the last decade the limited access to clinical microbiology, infectious diseases or antimicrobial pharmacist expertise is a significant barrier to the effective implementation of this section in some areas. The wider availability of advice from such sources together with education at local and national level can optimise the treatment of MRSA infections.

Initial approach before treatment

Recommendation 33
Healthcare associated MRSA (HA-MRSA) infection should be considered in any patient exhibiting signs and symptoms of infection and who is known to have been previously infected or colonised with MRSA or to have risk factors for same. **Grade A**

Recommendation 34
Serious consideration should be given to the removal where feasible of in-situ devices/prosthetic material such as intravascular catheters, infected pacemakers, shunts, prosthetic joints and valves. **Grade C**

Practical Guidance
In patients with MRSA BSI, a thorough history and examination is necessary with appropriate investigations, e.g. echocardiogram, to identify the underlying source of infection. **Grade C**

Patients with SSTI due to MRSA, and especially if severe or due to CA-MRSA may require surgical incision, drainage, and antibiotics. Patients with localised CA-MRSA SSTI infection may be cured with surgical drainage alone. **Grade B**

Pus should be drained surgically or under imaging control and where possible necrotic material should be removed and sent for culture and antibiotic susceptibility testing. **Grade B**

It is essential to involve the appropriate specialists, e.g. surgeon, particularly when deeper foci of infection are identified and where intervention is likely to be required such as drainage of a deep-seated abscess/removal of a prosthetic joint. **Grade C**

Rationale
MRSA is increasingly implicated as a cause of infection in hospital and the community and there is a high incidence of subsequent MRSA infection in patients currently or previously colonised or infected with MRSA (1). Risk factors for the acquisition of MRSA infection include previous hospitalisation, admission to an intensive care unit, prolonged hospital stay, proximity to another patient with MRSA, older age, invasive procedures, the presence of wounds or skin lesions, and prior antimicrobial therapy (2).

In suspected MRSA infection, appropriate samples e.g. pus, exudates and sputum should be obtained before starting treatment whenever possible. In particular, surgical intervention where required, reduces the bio burden and provides optimal specimens i.e. pus/tissue rather than swabs. Microbiological yield is improved substantially if specimens are taken prior to antibiotic therapy (3, 4). MRSA isolated from a normally sterile site should always be regarded as significant e.g. blood, cerebrospinal fluid, joint aspirate and intra-operative tissue specimens. In adults, to investigate a source, transoesophageal echocardiography (TOE) is preferred to transthoracic echocardiography (TTE) (3). When MRSA is isolated from blood, an underlying focus of infection should always be sought from other sources, e.g. intra-vascular device, vascular graft, heart valve, portal shunt etc. (5).

MRSA is difficult to eradicate with prosthetic devices in place and their retention may also encourage the selection of more resistant strains. If the focus is not removed or is irremovable, the chances of successful antimicrobial therapy are small. Surgical debridement may be required in some soft tissue infections (5).

A recent review of the clinical management of *S. aureus* BSI, the conclusion from which could apply to MRSA and other invasive infections, was that many issues remain unanswered but there is strong evidence that infective foci should be removed and prolonged treatment is required for persistent BSI or a deep, irremovable focus of infection (6).

Choice of antimicrobial agents

Recommendation 35
An intravenous glycopeptide is the recommended treatment for patients with suspected serious/ life-threatening MRSA infection (e.g. BSI) having due regard to the clinical judgement of the prescriber and the individual circumstances of each patient. Therapeutic options should be discussed with a clinical microbiologist or infectious disease physician on a case-by-case basis as necessary. **Grade C**

Practical Guidance
It is safer to commence treatment with an antibiotic with activity against MRSA, with subsequent step-down to a beta-lactam, if the isolate is methicillin-susceptible unless the proportion of hospital acquired and community acquired MRSA infection is low as established by local surveillance. **Grade C**

Intravenous therapy is required in the initial management of patients with BSI and in patients with serious MRSA infection requiring hospitalisation. **Grade A**

Vancomycin trough concentrations should be monitored and advice sought as required regarding dosing modification. Adequate doses of glycopeptides and other agents must be used when treating MRSA infections. **Grade D**

Teicoplanin, instead of vancomycin, may be considered in patients with significant renal impairment or in those at high risk of deterioration in renal function. Specialist advice should be sought regarding the indications for teicoplanin therapeutic drug monitoring. **Grade A**

For severe SSTIs, when patients are initially treated with IV antibiotics effective against MRSA, it may be possible to step down to oral treatment with doxycycline, clindamycin, linezolid or co-trimoxazole, after an initial clinical response, based on results of susceptibility tests, following discussion with a consultant microbiologist or infectious diseases physician. **Grade D**

Topical therapy for superficial MRSA infections should not be used without advice from a consultant microbiologist or an infectious diseases physician. **Grade D**

The use of antibiotics associated with MRSA selection or resistance should be avoided or minimised as much as possible. These include cephalosporins, macrolides and fluoroquinolones. **Grade A**

Rationale

There are few clinical trials to determine the optimal antimicrobial therapy for MRSA infections, and even fewer specifically for CA-MRSA. In many studies, vancomycin is the "gold standard" against which other agents are compared (7, 8). Alternative agents should be considered if a glycopeptide is not suitable e.g. due to adverse reactions, or if the infection is due to an organism with reduced susceptibility to vancomycin (4, 5, 7, 8). Delays in the administration of appropriate therapy are associated with poorer outcomes (9).

Co-trimoxazole is not licensed for staphylococcal infections, but it has become an important option as 95 to 100% of CA-MRSA strains are susceptible to this agent (3). Advice recommending restricted use of co-trimoxazole pre-dates the emergence of CA-MRSA (10). Table 6 summarises treatment recommendations for MRSA infection in adults in hospital.

Table 6: Treatment – practical guidance for MRSA infections in adults

Prescribers Notice

Antibiotic stewardship is the subject of on-going research and debate. Local antibiotic susceptibility data should be used to guide treatment having due regard to the clinical judgement of the prescriber and the individual circumstances of each patient. Therapeutic options should be discussed with a clinical microbiologist or infectious disease physician on a case-by-case basis as necessary.

Indication	First line agent	Alternative	Comments	Duration
Non-severe MRSA SSTI (boils and furuncles may only require drainage)	Doxycycline PO 100mg every 12 hours OR co-trimoxazole PO 960mg every 12 hours	Clindamycin[1] PO 450mg every 6 hours	May consider linezolid PO 600mg every 12 hours (expert advice required)	5 to 10 days
Severe or complicated MRSA SSTI	Glycopeptide IV (see text for dose)	Linezolid PO/ IV 600mg every 12 hours (expert advice required) OR daptomycin IV 4mg/kg every 24 hours	May consider clindamycin[1] PO 450mg every 6 hours OR IV 600mg to 1.2g every 6 to 8 hours	7 to 14 days

Indication	First line agent	Alternative	Comments	Duration
SSTI with toxic shock, necrotising fasciitis, purpura fulminans or suspected PVL positive isolate	Linezolid IV 600mg every 12 hours PLUS clindamycin1 IV 1.2g every 6 hours +/- rifampicin[2] PO/ IV 600mg every 12 hours		Consider IVIG	10 to 14 days
IV line related infection	Glycopeptide IV (see text for dose)	Daptomycin[3] IV 6mg/kg every 24 hours. Doses up to 10mg/kg used off-license.	The IV line should be removed if possible. Review empiric treatment at 48 hours once susceptibility data available.	See SARI IV catheter guidelines (Ref 10)
HA-MRSA pneumonia	Linezolid IV/PO 600mg every 12 hours (expert advice required) OR Glycopeptide IV (see text for dose)			7 to 21 days
CA-MRSA necrotising pneumonia	Linezolid IV 600mg every 12 hours PLUS clindamycin[1] IV 1.2g every 6 hours +/- rifampicin2 PO/ IV 600mg every 12 hours		Consider IVIG	10 to 14 days
Bronchiectasis	Linezolid IV/PO 600mg every 12 hours (expert advice required)		Optimal treatment is unresolved–seek advice	
Bloodstream infection	Glycopeptide IV (see text for dose)	Daptomycin3 IV 6mg/kg every 24 hours. Doses up to 10mg/kg used off-license.		Uncomplicated: minimum 2 weeks Complicated: 4 to 6 weeks

Indication	First line agent	Alternative	Comments	Duration
Persistent bloodstream infection or vancomycin treatment failure	Consider high dose daptomycin[3] IV 10mg/kg once daily PLUS gentamicin IV 5mg/kg every 24 hours OR rifampicin PO/IV 300mg to 450mg every 12 hours OR linezolid PO/IV 600mg every 12 hours OR a beta-lactam	If reduced susceptibility to vancomycin and daptomycin consider linezolid PO/IV 600mg every 12 hours OR co-trimoxazole IV 30mg/kg every 12 hours +/- other antibiotics	Expert advice required	4 to 6 weeks
Endocarditis, native valve	Vancomycin IV (see text for dose)	Daptomycin3 IV 6mg/kg every 24 hours. Doses up to 10mg/kg used off-license		Minimum 4 weeks
Endocarditis, prosthetic valve	Vancomycin IV (see text for dose) PLUS rifampicin PO/IV 300mg every 8 hours PLUS gentamicin IV 1mg/kg every 8 hours			Minimum 6 weeks vancomycin and rifampicin. Stop gentamicin after 2 weeks
Severe sepsis with toxic shock	Glycopeptide IV (see text for dose) PLUS clindamycin[1] IV 1.2g every 6 hours +/-rifampicin2 PO/ IV 600mg every 12 hours	Linezolid IV 600mg every 12 hours PLUS clindamycin[1] IV 1.2g every 6 hours +/-rifampicin2 PO/ IV 600mg every 12 hours	Consider IVIG	
Osteomyelitis and septic arthritis	Glycopeptide IV (see text for dose) +/- rifampicin PO/ IV 300mg to 450mg every 12 hours OR sodium fusidate PO 500mg every 8 hours Add rifampicin after clearance of bloodstream infection	Linezolid IV 600mg every 12 hours (limit to 4 weeks) OR daptomycin[3] IV 6mg/kg every 24 hours +/- rifampicin[2] PO/IV 300mg to 450mg every 12 hours	May consider combination of rifampicin PO/IV 300mg to 450mg every 12 hours PLUS co-trimoxazole IV 24mg/kg every 12 hours OR clindamycin[1] IV 600mg to 1.2g every 6 to 8 hours OR sodium fusidate PO 500mg every 8 hours Expert advice required	Osteomyelitis: minimum 8 weeks. Consider an additional 1 to 3 months, possibly longer, with oral rifampicin based combination therapy Septic arthritis: 3 to 4 weeks
Prosthetic joint/ spinal infection	See IDSA guidelines (Reference 3)			
CNS Infection	See Reference 3			

Indication	First line agent	Alternative	Comments	Duration
Uncomplicated MRSA UTI	Doxycycline PO 100mg every 12 hours OR nitrofurantoin PO 50mg to 100mg every 6 hours OR trimethoprim PO 200mg every 12 hours if susceptible	Co-trimoxazole PO 960mg every 12 hours		5 to 7 days
Complicated MRSA UTI	Glycopeptide IV (see text for dose)	Daptomycin[3] IV 4mg/kg every 24 hours		

SSTI, skin and soft tissue infection; **PVL**, panton valentine leucocidin, **IVIG**, intravenous immunoglobulin; **SARI**, Strategy for the control of Antimicrobial Resistance in Ireland. **HA**, healthcare-acquired; **CA**, community-acquired; **CNS**, central nervous system; **UTI**, urinary tract infection.

[1] Check clindamycin susceptibility and inducible resistance
[2] Rifampicin reduces serum levels of linezolid
[3] Check daptomycin susceptibility following vancomycin therapy

Please note the following:
- If the patient is being treated empirically they may also require antibiotic therapy for other potential causes of infection such as Gram negative bacteria, anaerobes, fungi.
- All doses quoted are for adults with normal renal function; modifications may need to be made for patients with impaired renal and hepatic function
- It is recommended to check the British National Formulary (BNF) for paediatric doses.

Further guidance on treatment can be obtained from other sources (References 3, 5, 7, 10-14)

The role of glycopeptides

Recommendation 36
An initial vancomycin dose of 15mg/kg (based on actual body weight), not to exceed 2g, every 12 hours is suggested for patients with normal renal function. A loading dose of 25mg/kg (based on actual body weight), should be considered for seriously ill patients. It is essential that patients are given a dose appropriate to their weight and not just 1g every 12 hours when using vancomycin having due regard to the clinical judgement of the prescriber and the individual circumstances of each patient. Therapeutic options should be discussed with a clinical microbiologist or infectious disease physician on a case-by-case basis as necessary. **Grade D**

Recommendation 37
Subsequent dose adjustment should be based on trough serum vancomycin concentrations in order to achieve effective targeted therapeutic concentrations of vancomycin. **Grade C**

Recommendation 38
Vancomycin or teicoplanin are equally effective for most MRSA infections. It is unclear whether the lower adverse event rate associated with teicoplanin, including nephrotoxicity, should influence the choice of glycopeptides. **Grade A**

Practical Guidance
Trough levels should always be maintained above 10mg/L in adults and children (no evidence for neonates) to avoid the development of resistance. **Grade D**

Trough serum vancomycin concentrations of 15 to 20mg/L are recommended to ensure improved clinical outcomes for serious infections, such as BSI, endocarditis, osteomyelitis, meningitis, pneumonia and severe SSTI caused by MRSA. **Grade C**

Check the first trough serum vancomycin level before the fourth dose, then once weekly in haemodynamically stable patients. More frequent monitoring is advisable in patients with serious infection, morbid obesity, renal dysfunction, who are haemodynamically unstable, or on concomitant nephrotoxins. Serum creatinine should also be monitored. **Grade D**

The patient's clinical and microbiological response, including the vancomycin minimum inhibitory concentration (MIC), will guide the continued use of vancomycin and expert advice should be sought in any patient not responding to treatment. **Grade D**

An initial teicoplanin dose of 10mg/kg every 12 hours for three doses, then 10mg/kg once daily is recommended for severe infections. The recommended target trough level is greater than 10 mg/L for the majority of severe infections and greater than 20mg/L for endocarditis and bone or prosthetic infection. Therapeutic monitoring is not recommended routinely but may be indicated for deep seated infections where higher maintenance doses of teicoplanin may be necessary to achieve appropriate tough levels. **Grade C**

Rationale

A glycopeptide is currently the treatment of choice for severe invasive MRSA infections and vancomycin remains the most commonly used glycopeptide. There is ongoing debate about the place of vancomycin in the management of serious MRSA infections (15, 16). The shortcomings of vancomycin include poor tissue and intracellular penetration, lack of activity against organisms growing in biofilm, slow bactericidal effect, lack of interference with toxin production, and poor activity against some *S. aureus* isolates, including heteroresistant and VISA strains (17). Therapeutic drug monitoring is required when prescribing vancomycin to ensure effective concentrations and to minimise the occurrence of toxicity (18).

The emergence of vancomycin-intermediate and vancomycin-resistant *S. aureus* is of ongoing concern (19). Recently, a number of studies have established a relationship between vancomycin treatment failures and infections caused by MRSA isolates displaying an MIC of 2mg/L (20). Increased mortality occurred in patients infected with MRSA strains having an MIC of 1.5 or 2mg/L compared with patients infected with low-MIC strains, despite achieving target trough vancomycin concentration of 15 to 20mg/L (21).

Guidelines on the therapeutic monitoring of vancomycin treatment for *S. aureus* infections in adults were published in 2009 by an expert panel of the Infectious Diseases Society of America (IDSA), the American Society of Health-System Pharmacists, and the Society of Infectious Diseases Pharmacists, recommending larger vancomycin doses and higher trough serum concentrations of vancomycin to achieve a target area under the curve (AUC/MIC) of 400. The potential benefit of increased dose for adults was felt to be worth the risk of mostly reversible adverse events, but they advise close monitoring of vancomycin trough levels (19).

Limited data suggest that there is a relationship between vancomycin in Ireland exposure and nephrotoxicity and that the vancomycin trough level best indicates this (21, 22). Alternatively, it has been suggested that the increased rates of nephrotoxicity observed with aggressive vancomycin dosing may be due to selection bias and confounding other factors. Clinicians unwilling to use vancomycin aggressively at higher doses in accordance with clinical practice guidelines should use an alternative agent (23).

Vancomycin-induced nephrotoxicity is defined as multiple (at least two or three consecutive) high serum creatinine concentrations, i.e. increase of 44 micromol/L or ≥ 50% increase from baseline,

whichever is greater after several days of vancomycin therapy, in the absence of an alternative explanation (20).

The appropriate dose of teicoplanin will depend on the clinical indication. Higher doses e.g. 10mg/kg have been suggested for septic arthritis and osteomyelitis. Therapeutic monitoring is not necessary to avoid toxicity but can be helpful to ensure that dose regimens are optimised to achieve target trough concentrations (24-28). Currently teicoplanin is significantly more expensive than vancomycin in Ireland. A pharmacoeconomic analysis is needed to evaluate the overall cost benefit of using teicoplanin or vancomycin.

Duration of therapy

Recommendation 39
The duration of therapy will depend on the type of infection and the clinical response and should be discussed with a consultant microbiologist or infectious diseases physician. **Grade D**

Rationale
There is an absence of high quality data on the optimum duration of therapy. Short course therapy may be associated with relapse and the seeding of distant foci particularly in cases of deep seated infection. However, unnecessarily long courses are associated with the development of resistance (5).

The duration of therapy should be individualised depending on the patient's clinical response (3). In general, primary uncomplicated MRSA BSI, i.e. no underlying focus, should be treated for at least two weeks and up to 4 to 6 weeks for complicated infection (3). Pneumonia should be treated for 7 to 21 days, depending on the extent of infection (3). Deep-seated infections with MRSA should be treated for longer (e.g. 3 to 12 weeks). In patients with a non-removable focus of infection long-term suppressive therapy with oral agents may be considered (3).

Treatment duration for less severe infections such as SSTI and UTI should be guided by clinical response and infection markers such as the C-reactive protein (CRP). Non-severe SSTI will require five to ten days of treatment (3). Uncomplicated UTI can be treated for 5 to 7 days (3).

Combination therapy

Recommendation 40
Despite other recent guidelines from North America that recommend the use of single agent therapy for the treatment of BSI infection or native valve endocarditis, combination therapy may be deemed necessary in certain clinical situations. Expert advice should be sought in these situations. **Grade D**

Practical Guidance
The adjunctive use of rifampicin is not recommended for the treatment of SSTI. **Grade A**

Some experts recommend the addition of rifampicin or sodium fusidate as adjunctive therapy for bone and joint infections. **Grade D**

Combination therapy with high dose daptomycin (10mg/kg) and a second agent may be considered for persistent MRSA BSI and vancomycin treatment failure, but susceptibility to daptomycin needs to be confirmed after prior vancomycin treatment. Combination therapy may be considered when isolates have reduced susceptibility to both vancomycin and daptomycin. **Grade D**

Rationale
There is no evidence that the adjunctive use of rifampicin for SSTI provides benefit (3,29). Studies of MRSA BSI and endocarditis have shown increased risk of nephrotoxicity with low dose gentamicin in combination with vancomycin and a longer duration of BSI with rifampicin in combination with vancomycin, compared to vancomycin monotherapy (30,31).

The use of a second antibiotic (e.g. gentamicin, rifampicin or sodium fusidate) is not recommended for the initial treatment of MRSA infection, in the absence of data to support use (32).

The favourable pharmacokinetics of rifampicin and sodium fusidate, with excellent penetration into bone and biofilm, support their use as adjunctive therapy in bone and joint infection (3,12). Data are very limited on combination therapy in the setting of persistent MRSA BSI and reduced susceptibility to vancomycin and daptomycin (3,15).

Surgical prophylaxis

Recommendation 41
A glycopeptide is indicated for surgical prophylaxis in adult patients undergoing implant surgery known to be MRSA positive or suspected/in a risk category for MRSA but have not being screened having due regard to the clinical judgement of the prescriber and the individual circumstances of each patient. Options should be discussed with a clinical microbiologist or infectious disease physician on a case-by-case basis as necessary. **Grade B**

Recommendation 42
Patients undergoing non-implant surgery where surgical prophylaxis is indicated should be prescribed a glycopeptide as part of their prophylaxis regimen if they are confirmed as being MRSA positive, having due regard to the clinical judgement of the prescriber and the individual circumstances of each patient. Options should be discussed with a clinical microbiologist or infectious disease physician on a case-by-case basis as necessary. **Grade A**

Practical Guidance
For elective procedures, either implant or non-implant surgery, every effort should be made to screen at-risk patients to determine if they are MRSA positive or negative prior to surgery. **Grade C**

Rationale
A meta-analysis of antibiotic prophylaxis showed that glycopeptides are no more effective than beta-lactams in preventing SSI caused by MRSA in cardiac surgery (33). However, glycopeptides remain the choice of prophylaxis in patients known to be or strongly suspected of being colonised with MRSA as this finding was in one category of surgical patients only.

Use of newer anti-MRSA agents

Recommendation 43
The prescribing of newer anti-MRSA agents should be firmly controlled by reserving their use for glycopeptide failure, resistance or intolerance, or on the recommendation of a consultant microbiologist or infectious diseases physician. **Grade D**

Rationale
Linezolid, daptomycin, quinopristin-dalfopristin (where available) and tigecycline are active against MRSA. They are licensed to treat infection due to Gram-positive bacteria, e.g. complicated skin and soft tissue infection. As with other MRSA agents these drugs require close monitoring for toxicity and efficacy. In the USA, the Food and Drug Administration (FDA) issued a warning in 2010

to consider alternatives to tigecycline in patients with severe infection following an increased risk of all-cause mortality in a pooled analysis of 13 clinical trials (34).

The use of all new anti-MRSA agents should be carefully restricted to (5):

a) minimise the emergence of further resistance amongst Gram-positive organisms
b) preserve activity for patients with difficult-to-treat infections and/or organisms
c) minimise escalating costs of antimicrobials in hospital.

Ceftaroline was approved in 2012 for the treatment of complicated SSTI, and community acquired pneumonia in adults, but patients with confirmed/suspected MRSA pneumonia at baseline were excluded from clinical trials. Phase III trials are underway for dalbavancin and oritavancin. Despite initial promise, three other antibiotics with activity against MRSA are not available for clinical use. Telavancin had its EU marketing authorization suspended in 2012, ceftobiprole was not granted marketing approval and the filing has been withdrawn for iclaprim (35).

Dalbavancin has a very long half-life, allowing for weekly dosing, which may prove useful for out-patient treatment (36). These new agents may prove valuable as resistance evolves to the currently available anti-MRSA drugs.

Reference laboratory facilities

Practical Guidance
The National MRSA Reference Laboratory (NMRSARL) currently provides the following services and these should continue:

- Communicating with users, e.g. referring laboratories, state agencies and the public, on the work of NMRSARL through annual reports scientific papers, symposia, etc.
- Assisting in the confirmation of *S. aureus* identification and methicillin resistance
- Epidemiological typing of MRSA strains, especially those from the bloodstream, in order to monitor different types of MRSA circulating in Ireland, and for the investigation of outbreaks
- Investigating and confirming antimicrobial resistance among MRSA.
- Detection of virulence factors of staphylococci, e.g. PVL
- Advising on the treatment of patients with MRSA infections
- Advising on infection prevention and control aspects
- Providing support on laboratory aspects of MRSA such as the use of selective media and other laboratory aspects of MRSA
- Providing education on aspects of MRSA
- Conducting research on aspects of MRSA with local, national and international partners
- Collaborating with international colleagues (e.g. European Centre for Disease Control) in the study of the epidemiology, virulence and antimicrobial resistance of MRSA, especially within the EU
- Developing and providing typing methodologies consistent with international best practice within a European context

- Introducing further services for users including the typing of MSSA consistent with clinical need and within the resources provided

- Introducing further assays for the detection of virulence factors as these become relevant and readily available. **Grade D**

Rationale
The NMRSARL was established in 2001 and is located at St. James's Hospital, Dublin. The laboratory was established to provide a resource for hospitals and microbiology laboratories around the country in their efforts to investigate and control MRSA. It is now internationally accepted that there is a requirement for a resource to provide specialist laboratory support (37, 38).

Reduced susceptibility to glycopeptides

Recommendation 44
An agar screening plate BHIV6 (i.e. brain heart infusion agar containing 6 mg/L of vancomycin) is recommended for the detection of reduced susceptibility to glycopeptides in addition to standard methods i.e. disc diffusion or an automated method. If possible, laboratories should incorporate the vancomycin agar screen plate for testing all *S. aureus* isolates. Alternatively, the screening may be limited to MRSA isolates, since nearly all vancomycin-intermediate or vancomycin-resistant isolates are MRSA. **Grade D**

Recommendation 45
If clinical failure is suspected with glycopeptide therapy a minimum inhibitory concentration (MIC) should be performed and any isolate with an MIC of >2 mg/L referred to the Reference Laboratory. A macro-method using both vancomycin and teicoplanin should be performed. **Grade D**

Glycopeptide resistance among *Staphylococcus aureus* is an area of potential concern and complexity. Isolates with reduced susceptibility to glycopeptides may be categorised as follows:

1. **Vancomycin resistant *S. aureus* (VRSA)**
   These isolates exhibit vancomycin MICs that are >8 mg/L and resistance is usually mediated by the van A gene from enterococci that codes for an altered binding site (39).

2. **Vancomycin-intermediate or glycopeptide-intermediate resistant *Staphylococcus aureus* (VISA or GISA)**
   These isolates exhibit lower MICs, usually between 4 and 8 mg/L, and reduced susceptibility is probably caused by vancomycin binding or trapping in the cell wall (40).

3. **Hetero-glycopeptide intermediate resistant *Staphylococcus aureus* (hGISA)**
   These isolates exhibit vancomycin MICs of 1-2 mg/L but have a resistant sub-population occurring at frequencies of 10^6 following selection with vancomycin (41). Detection of isolates with reduced susceptibility to glycopeptides may be problematic especially isolates exhibiting MICs of 4-8 mg/L.

Definitions
Both US (Clinical and Laboratory Standards Institute) and European (European Committee on Antimicrobial Susceptibility Testing) bodies define a strain as having reduced susceptibility to vancomycin if the MIC is >2 mg/L (42, 43). The USA has an intermediate category where the MIC is between 4 or 8 mg/L. European definitions do not include an intermediate category. Both organisations stress that reference broth microdilution is the most appropriate test to confirm an MIC as Etests® tend to produce MICs of about 0.5 to 1 mg/L higher than broth dilution.

Rationale
Disc diffusion and some of the automated systems do not reliably detect isolates with reduced susceptibility to vancomycin, i.e. MICs of 4-8 mg/L (44). Hence, it is prudent to include a screening plate if any of these methods are routinely used. In the USA, the use of BHIV6 is recommended. This screening plate may miss up to 30% of isolates with MICs of 4 mg/L and further work is being undertaken to determine the most appropriate screening methodology.

There is much discussion regarding the correct breakpoint for glycopeptides and *S. aureus*; a number of studies suggest that isolates with an MIC of >1 mg/L have a poorer outcome than isolates where the MIC is <1 mg/L (43,45,46). It is therefore prudent to check the MIC for all serious infections caused by *S. aureus* where glycopeptides are used as therapy. An Etest® is acceptable but all suspected VISA should be confirmed by reference broth microdilution methodology.

The clinical relevance of the hGISA phenotype is uncertain but there are studies that suggest that patients infected with these isolates have a poorer outcome compared to vancomycin susceptible isolates (47-50). Detection of hGISA is difficult. The reference method is to use population analysis profiling area under the curve (PAP-AUC) to determine the proportion of cells with reduced susceptibility compared to reference strains. This method is not suitable for the routine laboratory. A number of screening methods have been suggested but none are in routine use. The most established method is to perform an Etest® 'macro method' i.e. use a 2 McFarland turbidity standard and refer any isolate with a reading of ≥ 8 mg/L for vancomycin and or ≥ 12 mg/L for teicoplanin alone for further investigation.

Treatment of isolates with reduced susceptibility to glycopeptides
Please refer to the treatment section of the guidelines (Section 2.2).

Infection Control precautions of patients infected or colonised with S. aureus exhibiting reduced susceptibility to glycopeptides
Details can be found elsewhere (section 2.2) and http://www.cdc.gov/ncidod/dhqp/pdf/ar/visa_vrsa_guide.pdf (51).

2.3 Surveillance (Recommendations 46-50)

Recommendation 46
Staphylococcus aureus bloodstream infection (BSI) must be reported to the Health Protection Surveillance Centre (HPSC) on a quarterly basis, based on EARS-Net case definitions (statutory requirement).

Recommendation 47
All healthcare facilities should maintain a record of new cases of MRSA. Where possible, this should be maintained in an electronic format. The list should include the following details or core data:
- Patient identification
- Specimen site
- MRSA isolation site
- Date of first positive result
- Hospital/facility location at time of specimen collection (e.g. ward name)
- Date of admission. **Grade C**

Recommendation 48
All acute hospitals should participate in the *Staphylococcus aureus* component of the EARS-Net enhanced BSI surveillance system. **Grade D**

Recommendation 49
Outbreaks of infection caused by MRSA must be notified to the local Medical Officer of Health (MoH), Department of Public Health (DPH) (statutory requirement).

Recommendation 50
The local DPH should be informed of individual cases of CA-MRSA infection under the categories listed below:
- Severe invasive disease for definitions or cases resulting in death
- Cases in high risk groups e.g. healthcare workers working in the community or in hospitals, those involved in gyms or close contact sports and teachers
- Cases in a closed community where there may be potential for onward transmission e.g. prison, military camps, nursing home. **Grade C**

Rationale
Surveillance is often defined as "information for action". MRSA surveillance is required at local level to:

1. Inform and assess local MRSA policies for prevention and control
2. Identify potential clusters and outbreaks.

At national level MRSA surveillance is required to:

1. Inform and assess national strategies for the control and prevention of MRSA
2. Identify potential regional and national outbreaks
3. Identify emerging patterns of resistance and changes in MRSA epidemiology.

National surveillance of MRSA in Ireland is based on EARS-Net (formerly known as the European Antimicrobial Resistance Surveillance System (EARSS), which collects data on the first invasive isolate of a given pathogen per patient per quarter. EARS-Net provides reliable national-level data on MRSA BSI, but has limitations when applied to regional or individual hospital-level data. Notification of *S. aureus* BSI to EARS-Net, via HPSC, has been mandatory, under Infectious Diseases legislation, since 2004. A number of acute hospitals in Ireland also report additional demographic, clinical and outcome data on *S. aureus* BSI reported to EARS-Net, as part of a voluntary enhanced BSI surveillance system.

The simplest method of surveillance of MRSA in healthcare facilities is maintaining a line listing of new cases of MRSA colonisation/infection. A list of patients with a previous history of MRSA is also useful. The line list provides identification of patients with a history of infection or colonisation, for calculating prevalence or incidence rates, and can be used to trigger and follow outbreak investigations. An increase in the number of cases in a healthcare facility may signify a growing problem and may require the additional collection of data to confirm a rise in incidence or incidence density (1).

With the increasing shift towards outpatient management, the blurring of the distinction between acute and non-acute healthcare institutions and the emergence of CA-MRSA, the traditional division between hospital and community acquisition has become less valid. Nevertheless, it is important to be able to identify cases of MRSA colonisation/infection that may be related to care in a given institution, and therefore a potential target for local infection prevention and control interventions. Likewise, it is important to be able to identify cases of MRSA colonisation/ infection that are not related to healthcare exposure. For surveillance purposes, cases of MRSA

colonisation/infection may be classified using temporal (i.e. the timing of MRSA-positive samples relative to the hospital/institution admission date) or clinical definitions (i.e. combining the timing of specimen collection with an assessment of whether or not the patient has had recent significant healthcare exposure).

Temporal definitions
These classify MRSA cases as either hospital or community onset. These have the advantage that they are only dependent on data routinely available from diagnostic laboratories and do not require a detailed clinical or chart review of each case. They have the disadvantage that they may be less specific for identifying true nosocomial infections, because the assessment of recent healthcare exposures or of whether an infection may have been incubating at the time of admission is lacking (1).

Clinical definitions
These classify MRSA cases by likely acquisition source, i.e. hospital-acquired, community-acquired or healthcare-associated. They have the advantage of providing more detailed information on the likely source of MRSA colonisation/infection and, therefore, identifying potential targets for interventions (2). They have the disadvantage of being more labour-intensive than temporal definitions, as they require clinical or chart review of every case, and of being more prone to variations in case classification between different observers.

To ensure as many healthcare institutions as possible are able to carry out surveillance, using common surveillance definitions that minimise bias and are straight forward to apply temporal definitions should be used for routine MRSA surveillance. However, clinical definitions may still be used for targeted local surveillance, e.g. in specific high-risk units or during outbreak situations, and are also recommended for national enhanced surveillance of *S. aureus* bloodstream infection.

2.4 Evaluation and audit (Recommendations 51-53)

The following are responsible for implementation of recommendations 51-53:
Clinical Teams, Senior Management and the Infection Prevention and Control Team (IPCT). Public health professionals and medical scientists have some specific roles as outlined in the relevant recommendations.

Recommendation 51
All acute hospitals should report rates of new cases of hospital-onset and community-onset MRSA colonisation/infection at least twice per year to hospital management, clinical directors, clinicians and ward/unit managers. Rates should be expressed as new cases per 100 bed-days used. **Grade C**

Recommendation 52
All acute hospitals should carry out local surveillance of process indicators related to the control and prevention of MRSA. **Grade B**

Recommendation 53
Audit is recommended to support a continuous quality improvement process in relation to the implementation of the National Clinical Guideline - The Prevention and Control of Methicillin-resistant *Staphylococcus aureus* (MRSA). **Grade D**

Rationale
Key performance indicators (KPIs) are specific and measurable elements of health and social care that can be used to assess the quality of care (3). According to the Joint Commission on Accreditation of Healthcare Organizations (JCAHO) in the United States, KPIs are not intended to

be direct measures of quality but instead act as alerts to identify opportunities for improvements in the quality of patient care (4). The Health Information and Quality Authority have published guidance on developing KPIs for healthcare settings (5). KPIs are ideally based on standards determined through evidence-based academic literature or through the consensus of experts when evidence is unavailable. However, there is a paucity of high quality evidence for KPIs relating to MRSA and other multidrug-resistant organisms (1). Thus, the recommendations for surveillance and KPIs in this document are based on international experience and consensus guidelines.

The use of KPIs in Ireland is not currently widespread and deficiencies in IPCTs, especially in the non-acute health sector, are a factor. Furthermore, the arrival of other challenges such as carbapenem-resistant Enterobacteriaceae (CREs) has meant that IPCTs have had less time to focus on some aspects of MRSA prevention and control including the use of KPIs to improve patient care. However, the provision of improved information technology facilities and education at local and national level may help to improve this (1, 6-9).

Practical Guidance

The following are examples of audit criteria which are consistent with HIQA *National Standards for the Prevention and Control of Healthcare Associated Infections* (2009):

1. Adherence to environment management standards *(Standard 3)*
2. Written communication of MRSA status to patients, general practitioners and other healthcare professionals, e.g. on patient transfer *(Standard 5)*
3. Hand hygiene compliance *(Standard 6)*
4. Appropriate screening of at-risk groups *(Standard 7)*
5. Isolation or cohorting of known positives or high-risk groups of patients for MRSA *(Standard 7)*
6. Incorporation of an antibiotic with activity against MRSA for routine surgical prophylaxis in those patients known to be MRSA positive or at-risk of MRSA *(Standard 7)*
7. Optimal empiric antibiotics for patients with suspected MRSA infection *(Standard 12)*.

3.0 Background and methodology

Staphylococcus aureus (*S. aureus*) is a Gram-positive organism that commonly colonises the skin and nose. In the majority of cases this organism acts as a harmless commensal. However, in the right setting it can cause severe and at times fatal infections such as bloodstream infection (BSI), infective endocarditis, pneumonia, skin and soft tissue infections (SSTI) and bone and joint infection. *S. aureus* is one of the commonest causes of BSI, which may be fatal, and in many hospitals and in scientific studies it is only superseded in frequency by *Escherichia coli*. A full set of abbreviations and a glossary are provided in appendices I and II.

ß-lactam antibiotics, such as flucloxacillin are the antibiotics of choice in treating staphylococcal infection. Methicillin is an example of a ß-lactam antibiotic first used in the treatment of S. aureus infections in the 1950s and 1960s. In 1961 the first strain of methicillin-resistant *Staphylococcus aureus* (MRSA) was identified (1). This organism was also found to be resistant to all other ß-lactam antibiotics. Although methicillin is no longer in clinical use all ß-lactam resistant *S.aureus* isolates are referred to as MRSA. MRSA has been prevalent in Irish hospitals for over thirty years with significant accompanying mortality, e.g. from BSI, morbidity and additional healthcare costs, post-operative SSI. Much work was carried out in this country on MRSA in the 1970s and '80s which has enhanced our understanding of the virulence features, clinical effects and epidemiology of this pathogen (2-5). Much of this work continues to this day (6-10).

The prevention and control of MRSA is a global challenge and is important generally in the control of healthcare associated infection (HCAI). Whether it is possible to fully eradicate MRSA in hospitals, where it is endemic, is debatable. However, it is possible to control the spread of MRSA, minimise rates of superficial and deep infections and to contain healthcare costs. MRSA BSI rates have been shown to correlate with the hospital–wide prevalence of MRSA, and efforts to reduce the number of patients colonised with MRSA will also reduce BSI rates (11). MRSA control measures have additional merits to those of merely addressing MRSA as they increase the awareness of the importance of all HCAI and their implementation decreases the rates of other HCAIs (12).

Control of MRSA is a multidisciplinary task, involving surveillance, patient screening, decolonisation, isolation and cohorting of patients, environmental cleaning, antimicrobial stewardship, maintaining adequate staffing levels and hand hygiene. The prevention and control of MRSA is the responsibility of all those who work in the healthcare sector and not just those professionally involved in infection prevention and control.

3.1 Economic impact report

The Guideline Development Group examined the economic impact of the guideline which is outlined in this section. In addition a budget impact analysis was completed with the support of HIQA. This analysis supports the clinical guideline recommendations and is presented in full in Appendix XV.

Assessing the impact in terms of the true numbers of cases of MRSA, the morbidity and associated mortality, and the cost of MRSA infections is difficult in the absence of comprehensive national surveillance. Currently, the main focus of MRSA surveillance is on BSI but this excludes other infections such as SSTI, bone and joint infections and pneumonia. One of the most comprehensive studies of the prevalence of MRSA ever done was the North/South Study of MRSA in Ireland conducted in 1999, when 508 cases, (colonisation and infection) of MRSA were identified in the South of Ireland, representing a prevalence rate per 100,000 population of 14.0 (13-17). In a survey

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A varying proportion of cases die from MRSA BSI. This can be 30% or higher in debilitated patients such as those with one or more significant underlying chronic diseases, e.g. diabetes mellitus, and in patients requiring organ support in critical care units. Patients with other non-fatal infections are often left with lifelong suffering such as bone pain arising from chronic osteomyelitis and other infections such as SSTI that result in additional hospital stays and a delayed return to work and to other activities. Therefore the true clinical, financial and psychological impact of MRSA is not known.

Regarding the healthcare costs of MRSA, the Health Service Executive (HSE) has calculated that over 25,000 patients may acquire a HCAI annually at a cost of €118 million (Table 7). If 10% of all HCAI are due to MRSA this represents a figure of €23 million per annum spent on MRSA alone. If one third of HCAI in Ireland could be prevented then approximately €7.6 million per year would be saved from those due to MRSA. Similarly, an expert group in 2010 reviewed the above and other data and calculated that the costs in Ireland of MRSA in the hospital setting alone were also €23 million annually and that a pro rata figure of the impact at national level resulting in costs to careers and to the general economy for Ireland could be calculated from those estimated to apply to the UK, which are £3-8 billion annually (20).

Table 7 Estimation of the costs of HCAI in Ireland for 2011 extrapolated from national and international sources

2011	Hospital admissions	Patients with HCAI[1]	Extra hospital days[2, 3]	Estimated cost for all HCAIs[3]	Deaths expected if 3.68%[2] or 13% mortality rate[3*]	If 10% of HCAI were prevented there would have been a cost saving of:
Overall	587,753	29,388	117,552 or 411,432	€118,257,312	1,081 or 3,820	€ 11,825,731
West	147,547	7,377	29,508 or 103,278	€29,685,048	271 or 959	€2,968,505
South	150,345	7,517	30,068 or 105,238	€30,248,408	277 or 977	€3,024,841
Dublin Mid-Leinster	173,285	8,664	34,656 or 121,296	€34,863,936	319 or 1,126	€3,486,394
Dublin North-East	116,576	5,829	23,316 or 81,606	€23,455,896	215 or 757	€2,345,590

1 Data sourced from the National Point Prevalence Study in Ireland 2006, reference 18.
2 European Centre for Disease Prevention & Control, Annual Epidemiological Report 2008, reference 21
3 Plowman Report 1999: 'The Socio-economic Burden of Hospital Acquired Infection', reference 22

* for comparison purposes 552 deaths due to suicide; 238 due to road traffic accidents; 59 due to murder/manslaughter. Data from the 2009 Garda Síochana Annual Report, reference 23.

Data from the European Centre for Disease Prevention & Control (ECDC), Annual Epidemiological Report 2008 have been used to calculate length of stay and the number of deaths (21). Although the Plowman report was published 14 years ago (22), it is very comprehensive and is based on the UK health system which is similar in many respects to the Irish health system. The ECDC report is based on all of Europe. The cost estimate includes longer term and wider societal costs (e.g. ongoing healthcare needs, disability costs, litigation, loss of productivity etc.). The Plowman report (22) also calculated that patients in the UK, who acquire an infection in hospital, when compared with uninfected patients, were estimated to take an additional 8.7 million days to resume normal daily activities. Savings have been calculated based on a preventable reduction in HCAIs of 10% but this may be an underestimate as most device-related infections, e.g. catheter-related BSI and catheter-associated urinary tract infection including those caused by MRSA, are very preventable, and for these, the potential preventable proportion may be 50-70% .

3.2 Need for a revised guideline

Since the publication of the last set of guidelines in 2005, there have been a number of changes necessitating a review of what was recommended then. For example, over the past four years the number of invasive infections caused by MRSA has decreased: the 2011 annual report from the National MRSA Reference Laboratory reported 225, cases of BSI due to MRSA, compared with 280, 325, 407 and 467 in 2010, 2009, 2008 and 2007, respectively (24). This decrease in the number of MRSA BSI most likely represents a decrease in the total number of cases of MRSA. The reason for this decline is unclear but it does follow international trends. For example, in the UK the rate of MRSA BSI between 2003 and 2008 halved (25). In addition, increasing rates of resistance, not only to glycopeptides, (e.g. vancomycin) but to older antimicrobials such as fusidic acid and rifampicin are a concern. The prevalence of community acquired MRSA (CA-MRSA) is increasing in some countries, e.g. the emergence of livestock-associated MRSA (ST398-MRSA-V) among farmers in some European countries has highlighted the versatility of this pathogen (26, 27).

However, there is some progress in the battle against MRSA. A number of drugs have been introduced in recent years for the treatment of MRSA infections such as daptomycin and tigecycline and more recently ceftaroline. The previous set of guidelines did not include recommendations on the treatment of infection or the use of antibiotic prophylaxis in MRSA patients undergoing surgery, which are both important components in the management of MRSA. Finally, the governance relating to the prevention and control of HCAI has changed with the establishment of the Health Information and Quality Authority (HIQA). This has resulted in the production of important documents that are changing the healthcare landscape, including national standards for safer better healthcare and infection prevention and control. In the case of the latter, i.e. relating specifically to HCAI, this has been followed up by institutional audits of local governance arrangements and practice.

3.3 Methodology

3.3.1 Guideline development group

This guideline was developed by the Royal College of Physicians Ireland (RCPI) Clinical Advisory Group on healthcare associated infections (HCAI) - Subgroup MRSA Guideline Committee. The MRSA guideline development group was a multi-disciplinary (Appendix III) team with wide geographic and professional spread and hence felt it was not unreasonable to formulate a view on some issues where there was no scientific evidence and to recommend accordingly. It met on a number of occasions over three years, with teleconferencing facilities being available to assist those contributing from outside Dublin. However, much of the work was carried out by email with the exchange of draft documents, comments and opinions on issues as they arose. Efforts were made to ensure that all the relevant professional groups were represented and that the background of those involved included the acute hospital and community care settings.

Membership of the guideline development group was voluntary, no member was paid a fee for his/her contribution, and the input of working group members was usually done out-of hours, e.g. during evenings/weekends and at their own expense, e.g. using their own personal computer. The work was not funded by any public or private agency but did receive clerical and administrative support from the Health Protection Surveillance Centre (HPSC), the RCPI and the Royal College of Surgeons in Ireland. The guideline development group members' names and any potential conflicts of interest are outlined at the end of this document in Appendix III.

When reviewing the evidence and coming to decisions on what should be recommended, this was done through a process that initially reviewed the literature (see section 3.3.2) and the previous 2005 guidelines. The preparation of a draft was carried out after achieving consensus amongst the guideline development group members. All the recommendations and also for those areas where no recommendations were made, were agreed to by all members of the guideline development group. Potential conflicts of interest, as outlined in Appendix III, did not impact on agreeing what was or was not appropriate to recommend.

The draft guideline was actively distributed and made available for a wide consultation exercise which involved the active soliciting of feedback from a variety of groups (i.e. Colleges, professional societies, etc.) and from patients (Appendix IV) and was designed to be comprehensive to ensure that any gaps in representation on the guideline development group were compensated for. This consultation exercise included health service managers and two external reviewers, one from the UK and the other from Australia with expertise in MRSA prevention and control. All ensuing feedback was considered and if deemed appropriate incorporated in to the final draft document.

3.3.2 Literature review

The best available evidence was used in drafting and agreeing the final recommendations. The methodology and approach to developing these guidelines included reviewing the scientific evidence in the form of published scientific papers, concentrating on the literature since the last set of guidelines was published in 2005. Due to restrictions in time and expertise a meta-analysis was not possible. Computerised literature searches of PubMed were performed. Human studies in the English language literature were searched from 1st January 2005 to 30th December 2011 and a subsequent search was performed for the calendar year 2012 after the initial National Clinical Effectiveness Committee (NCEC) review to ensure that all relevant literature was captured before the final version was agreed in early 2013. Individual terms and combinations, such as MRSA, *Staphylococcus aureus*, antibiotic resistance, multidrug resistant bacteria, screening, infection prevention and control, occupational MRSA in healthcare workers, MRSA and pregnancy, decolonization, treatment, mupirocin, vancomycin, linezolid, daptomycin antibiotic stewardship, healthcare-acquired, community-acquired, hygiene and decontamination, were used. Each reference cited as supporting the guidelines has been categorised, e.g. outbreak report, guideline document, etc.

The guideline development group also reviewed the last set of national guidelines which arose from the *Strategy for the Control of Antimicrobial Resistance in Ireland* (SARI), Infection Control Subcommittee, in 2005 (28). A number of other international guidelines have been produced since then, which were reviewed and these include guidelines by the Infectious Diseases Society of America (IDSA) on the treatment of adults and children with infections caused by MRSA (2011) and guidelines produced in the UK by the Healthcare Infection Society, British Society for Antimicrobial Chemotherapy (BSAC) and the Infection Control Nurses Association (now the Infection Prevention Society) on the control and prevention of MRSA in healthcare facilities (2006) and on the prophylaxis and treatment of MRSA infections (2009) (29-31).

A new development since 2005 has been the publication of guidelines on the management of community acquired MRSA which recently appeared in Australia, America, Canada and the UK, and guidelines have also been developed for the management of Panton-Valentine Leucocidin (PVL) toxin positive MRSA infections (32-37). The groups that have published these guidelines have made their recommendations, largely on the basis of expert opinion and observation, rather than on the basis of randomised controlled trials (RCTs), which are relatively rare in this area.

It should be noted that the scientific literature on healthcare infection prevention and control including on MRSA is largely based upon descriptions of outbreaks, observational and *in vitro* studies and retrospective analyses rather than on RCTs. Furthermore, few studies, reviews or other guidelines provide much evidence or data on the economic aspects of the various recommended measures or interventions. Hence, the data already outlined is extrapolated from available documents and studies but not from studies primarily designed to assess the economic impact of MRSA.

A review of various different international guidelines for the prevention and control of MRSA published in 2007 found that similar measures were recommended in all the guidelines, even if the aim of the individual set of guidelines differed depending on the country's ability to fully implement them and on the local prevalence of MRSA (38). Countries in which MRSA rates are low, e.g. the Netherlands, aim to keep their healthcare institutions free of MRSA while countries where MRSA is endemic, e.g. the UK, aim to minimise its spread. Consequently, there is still research required on key components of MRSA prevention and control in Ireland and in other countries where MRSA is endemic, e.g. should screening be targeted or universal and clinical trials of alternatives to mupirocin for nasal decolonisation.

Therefore the guideline that follows expands on and updates the Irish guidelines published in 2005 where relevant, and incorporates other international guidelines such as those listed above,

relevant published literature and the consensus expert opinion of the guideline development group itself. In addition, the comprehensive consultation exercise (Appendix IV) that included a wide range of professional groups (e.g. Academy of Medical Laboratory Science), healthcare agencies (e.g. the Health Service Executive), patient groups (e.g. (Irish Patients Association) and experts from abroad has improved the final draft.

3.3.3 Grading of recommendations

The recommendations are followed by a grade which indicates the strength of the evidence supporting the recommendation as in the previous guidelines (28). The recommendations are followed by a grade. This is a consensus grade agreed by the MRSA guideline development group reflecting the strength of the evidence supporting the recommendation, and discussion of the evidence amongst the MRSA guideline development group.

There are a number of grading systems used in the literature but that below was felt to best meet the needs of the guideline and the guideline development group, given the absence of RCTs in many of the areas covered.

Therefore the grades used throughout the guideline document are as follows;

- **Grade A -** Evidence from a meta-analysis of RCT or from at least one RCT.
- **Grade B -** Evidence based on one controlled trial without randomisation, a quasi-experimental study, or extrapolated from RCT.
- **Grade C -** Evidence from comparative studies, correlation studies, case control studies or extrapolated from category A or B.
- **Grade D -** Evidence from expert committees, reports or opinions, the clinical experience of respected authorities, and the conclusions of the guideline development group.

3.3.4 Review date

The last set of guidelines were published in 2005, a seven year interval between this current set of guidelines. This guideline will be reviewed in 2016 and this will be overseen by the RCPI Clinical Advisory Group on the Prevention of Healthcare-Associated Infection and Antimicrobial Resistance. This will be done in accordance with the specifications set out by the NCEC regarding clinical guideline development.

3.4 Target population

The National Clinical Guideline is relevant and has been developed for all healthcare staff involved in the care of patients, residents or clients who may be at risk of or have MRSA in acute hospitals, nursing homes/long stay residential units, other institutions and general practices. Such members of staff include medical doctors, nurses, midwives, healthcare assistants, pharmacists, biomedical scientists and allied healthcare professionals. This new guideline also acknowledges changes in the epidemiology, i.e. the emergence of CA-MRSA. The public and patients will find this guideline of interest as it outlines the general and specific measures required to prevent and control MRSA and how these can and should be incorporated into quality measures to safeguard the quality of patient care.

3.5 Implementation of the National Clinical Guideline

The National Clinical Guideline will be circulated and disseminated through the professional networks that assisted in the drafting and in the review of an earlier version of this document. The document will also be upload on to relevant websites, e.g. HPSC. This will help ensure professional buy-in from healthcare professionals, including from the experts in the field, e.g. infection prevention

and control nurses. Educational sessions will take place at local and at national level to update all healthcare professionals on the implications of this revised guideline, especially the changes from those issued in 2005. Short summaries of the recommendations will be prepared for specific groups, e.g. general practitioners, nursing home staff and critical care units to highlight those aspects that are especially important in their particular setting. Audits of important components will be promoted and encouraged, with feedback of the results, to highlight successes as well as challenges in their full implementation. The National Clinical Guideline will be circulated to patient groups, including those that participated in the consultation exercise, and it will also be made available on public websites. Issues that arise from the perspective of patients or healthcare professionals can be communicated to the RCPI.

3.6 Barriers and facilitators to implementation

There are some barriers that will impact on the full implementation of the guideline. Most measures are cost neutral as they represent a re-iteration of previous guidelines with some minor additional measures, e.g. throat samples as part of a set of MRSA screening samples. While many of the measures recommended are generic, e.g. hand hygiene, and will also contribute to the prevention of other HCAIs such as norovirus infection, some are specific and have some resource implications.

Many acute hospitals have insufficient isolation rooms, access to microbiology laboratories and antimicrobial pharmacists may be limited in some areas and expertise in HCAI prevention and control is not always readily available to all healthcare professionals at all times, especially in the non-acute sector. Also, many healthcare professionals still do not see themselves as having a key role in infection prevention and control, believing that this is an issue that should be addressed by experts in the field and by the health authorities. Consequently, while there has been some progress in recent years, e.g. the fall in MRSA BSI, a culture change is required to ensure that every healthcare professional understands his/her responsibility and ensures that his or her practice is optimal in not contributing to HCAI, including MRSA. In this manner preventable HCAIs should be reduced to a minimum.

The implementation of the guideline can be facilitated by ensuring that all healthcare professionals understand and appreciate that the guideline contributes to the quality and safety of patient care. The increasing awareness of patients themselves of the importance of infection prevention has helped drive improvements in practice and their demands for the highest standards of healthcare has a positive impact on guideline implementation.

Those professionals involved in the drafting of this guideline will promote its implementation locally and nationally and they will engage with opinion leaders to facilitate that. Highlighting associated barriers, will facilitate the implementation of the changes necessary to ensure full guideline implementation. Anticipated barriers to the implementation of particular recommendations are discussed in the relevant sections.

3.7 Guiding principles for the National Clinical Guideline

The following are guiding principles identified as part of the National Clinical Guideline:

- Every effort should be made by all healthcare professionals to minimise HCAI, including MRSA, in every healthcare setting through best professional practice.
- Recognising patients at-risk of MRSA colonisation and infection is an important component of safe patient care.
- Communication with patients and between healthcare practitioners in all healthcare settings is essential in the implementation of this guideline.

- Collaboration between clinical teams and experts in infection, i.e. clinical microbiologists and infectious disease physicians, is strongly recommended in the management of MRSA infections requiring antibiotic treatment.
- On-going surveillance of MRSA rates and any changing patterns of infection or antibiotic resistance remains important.

3.8 Roles and responsibilities

Each healthcare professional has a role to play in minimising HCAI through adherence to best practice, e.g. optimal hand hygiene compliance. The guideline should be reviewed by key healthcare professionals in the clinical programmes to ensure that the prevention and control of MRSA is included as a patient safety issue and to help contribute to the quality of patient care.

3.8.1 Organisational responsibility

Within each organisation corporate responsibility is required for the implementation of the National Clinical Guideline to ensure that there is a system of care in place for the prevention and control of MRSA.

3.8.2 Clinical staff

All clinical staff should comply with this National Clinical Guideline and related policies, procedures and protocols. Clinical staff should adhere to their professional scope of practice and maintain their competency, in the prevention and control of MRSA. In using this guideline professional healthcare staff must be aware of the role of appropriate delegation.

3.9 Key audit criteria

To ensure that this guideline positively impacts on patient care, it is important that it is audited. Audit is recommended to support continuous quality improvement in relation to the implementation of the National Clinical Guideline - The Prevention and Control of Methicillin-resistant *Staphylococcus aureus* (MRSA).

The following are examples of audit criteria which are consistent with HIQA *National Standards for the Prevention and Control of Healthcare Associated Infections* (2009):

- Adherence to environment management standards *(Standard 3)*
- Written communication of MRSA status to patients, general practitioners and other healthcare professionals, e.g. on patient transfer *(Standard 5)*
- Hand hygiene compliance *(Standard 6)*
- Appropriate screening of at-risk groups *(Standard 7)*
- Isolation or cohorting of known positives or high-risk groups of patients for MRSA *(Standard 7)*
- Incorporation of an antibiotic with activity against MRSA for routine surgical prophylaxis in those patients known to be MRSA positive or at-risk of MRSA *(Standard 7)*
- Optimal empiric antibiotics for patients with suspected MRSA infection *(Standard 12)*.

4.0 Appendices

Appendix I
Abbreviations

This abbreviation list is within the context of this document.

ANHOPS	Association of National Health Occupational Physicians
BHIV6	Brain Heart Infusion with Vancomycin at 6 mg/l
BNF	British National Formulary
BSAC	British Society for Antimicrobial Chemotherapy
BSI	Bloodstream Infection
CA-MRSA	Community-Acquired MRSA
CDC	Centre for Disease Prevention & Control (USA)
CEA	Cost-effectiveness Analysis
CP	Contact Precautions
CRP	C-Reactive Protein
CURB Score	Severity score for community-acquired pneumonia, i.e. based on Confusion, Urea, Respiratory rate and Blood pressure.
CVC	Central Vascular Catheter
EARS-Net	European Antimicrobial Resistance Surveillance Network
EARSS	European Antimicrobial Resistance Surveillance System
ECDC	European Centre for Disease Control
ED	Emergency Department
EMEA	European Medicines Agency
ENT	Ear, Nose and Throat
EU	European Union
FDA	Food and Drug Administration (USA)
GISA	Glycopeptide-Intermediate Resistant *Staphylococcus aureus*
GRSA	Glycopeptide-Resistant *Staphylococcus aureus*
HA-MRSA	Healthcare-Associated MRSA
HCAI	Healthcare-Associated Infection
HCW	Healthcare Worker
hGISA	Hetero-Glycopeptide- Intermediate resistant *Staphylococcus aureus*
HICPAC	Healthcare Infection Control Practices Advisory Committee (USA)
HIQA	Health Information and Quality Authority
HIS	Healthcare (Hospital) Infection Society (UK)

HPA	Health Protection Agency (UK)
HPSC	Health Protection Surveillance Centre
HSE	Health Service Executive
ICU	Intensive Care Unit
IPCT	Infection Prevention and Control Team
IV	Intra-Vascular
IDSA	Infectious Diseases Society of America
IVIG	Intravenous Immunoglobulin
JCAHO	Joint Commission on Accreditation of Healthcare Organisations (USA)
KPI	Key Performance Indicators
LTCFs	Long Term Care Facilities
MIC	Minimum Inhibitory Concentration
MRSA	Methicillin-Resistant *Staphylococcus aureus*
MSSA	Methicillin-Susceptible *Staphylococcus aureus*
NICU	Neonatal Intensive Care Unit
NMRSARL	National MRSA Reference Laboratory
OH	Occupational Health
PAP-AUC	Population Analysis Profiling the Area Under the Curve
PVL	Panton-Valentine Leukocidin
PEG	Percutaneous Endoscopic Gastrostomy
PEHA	Pre-Employment Health Assessment
PO	Per Oralis (oral administration of a drug)
PPE	Personal Protective Equipment
RCPI	Royal College of Physicians of Ireland
RCSI	Royal College of Surgeons in Ireland
RCT	Randomised Controlled Trials
RoI	Republic of Ireland
SARI	Strategy for the control of Antimicrobial Resistance in Ireland
SCBU	Special Care Baby Unit
SCC	Staphylococcal Chromosome Cassette
SSTI	Skin and Soft Tissue Infection
TOE	Transoesophageal Echocardiography
TTE	Trans Thoracic Echocardiography
URTI	Upper Respiratory Tract Infection
UTI	Urinary Tract Infection
VISA	Vancomycin Intermediate Resistant *Staphylococcus aureus*
VRE	Vancomycin-Resistant Enterococci
VRSA	Vancomycin-Resistant *Staphylococcus aureus*
WHO	World Health Organisation

Appendix II
Glossary

This glossary details key terms within the context of this document.

Antibiotic stewardship: A programme to ensure the effective use of antibiotics such that patients are treated appropriately but antibiotics are not abused resulting in resistance.

ß-lactam antibiotics: A group of antibiotics that includes penicillin, cephalosporins, monobactams and carbapenems, that all have the ß-lactam ring, which is important for their antimicrobial activity.

Bloodstream infection: The presence of bacteria in the blood with clinical significance, i.e. the patient has a raised temperature, rigors, low blood pressure, etc.

Carrier: An individual who has MRSA on their skin or in their nose, but is not infected or ill due to MRSA. The term may be synonymous with being colonised.

Chlorhexidine: A topical antibiotic used to remove MRSA from the skin. This is also used in hand hygiene.

Chorioamnionitis: This is an infection that occurs late in pregnancy when the amniotic fluid, which surrounds the foetus, becomes infected and results in infection of the mother and the child.

Cohorting: In the absence of sufficient single rooms, patients with MRSA are grouped together and physically separated from patients without MRSA such as in a bay of a ward.

Colonisation: Carriage of MRSA without evidence of infection, i.e. the absence of fever, inflammation, etc. See also 'Carrier'.

Combination treatment: The use of two or more antibiotics to treat an infection, e.g. vancomycin and rifampicin, to treat some MRSA bloodstream infections.

Contact precautions: Contact precautions are intended to prevent transmission of infectious agents i.e. MRSA, which are spread by direct or indirect contact with a patients or the patients' environment

Critical care areas: This includes intensive care units, special care baby units, neonatal intensive care units, and other areas with patients especially vulnerable to infection, e.g. specialist ICUs.

Decolonisation: A process by which efforts are made to remove MRSA from the patient who is colonised or is carrying MRSA through the use of topical antibiotics to the nose (e.g. mupirocin) and body washes (e.g. chlorhexidine).

Endocarditis: Infection of the inside lining of the heart, specifically the heart valves.

Glycopeptides: Antibiotics, i.e. vancomycin and teicoplanin, currently the agents of choice used to treat MRSA infections.

Hand hygiene: Decontamination of the hands either with soap or a liquid antiseptic with water or through the use of alcohol hand rubs.

Hand-touch sites: There are areas in the hospital that are commonly touched by the hands of healthcare workers, e.g. lockers, drip stands, beds.

Healthcare-associated Infection: Infections acquired in hospitals, i.e. 48 hours or more after admission, and also infections acquired following contact with other aspects of the health service, e.g. nursing homes, residential care units, day centres, renal dialysis, etc.

High risk surgery: This refers to major surgery where life threatening infection can occur if caused by MRSA, e.g. bloodstream infection. This would include cardiothoracic, vascular, orthopaedic implant surgery and neurosurgery.

Infection: The presence of MRSA with associated symptoms and signs of infection, e.g. pyrexia, rigors, productive sputum (e.g. pneumonia), pain and discharge (e.g. osteomyelitis)

Isolation: This refers to the physical separation of patients with MRSA from others who don't have MRSA, typically in a single room.

Key performance indicators: Specific and measurable elements of health that can be used to assess the quality of care, e.g. maintaining a record of all new cases of MRSA.

Long-term care facility: This includes residential units, nursing homes and other units where the elderly or others reside permanently and is their home.

Mastitis: Infection of the breast. This is most commonly seen during breast feeding.

Methicillin (meticillin): The ß-lactam antibiotic first used for the treatment of *S. aureus* in the 1950s. It is no longer used clinically, but a related antibiotic, i.e. flucloxacillin, is the agent of choice to treat methicillin-susceptible *S. aureus*. MRSA implies resistance to flucloxacillin and other ß-lactam antibiotics.

Mupirocin: A topical antibiotic used to remove/decolonise MRSA from the nose.

Occupational health: Services provided for healthcare workers, e.g. pre-employment screening, vaccination, etc. by medical, nursing and other staff.

Osteomyelitis: Infection involving the bone.

Outbreak: Where there are more cases of MRSA than would be expected e.g. four cases on a ward where there would normally be at most 1-2.

PCR: The polymerase chain reaction is a molecular technique that can detect the presence of genetic components of microbes without the necessity for culture. It can also do so in hours rather than days.

Personal protective equipment: This includes gloves, plastic aprons or gowns and eye or face protection to protect healthcare workers and to prevent cross-infection.

Reference laboratory: A specialised laboratory that provides additional support and expertise to routine laboratories, e.g. molecular typing of MRSA isolates.

Screening samples: These are samples, usually swabs, taken from a patient to detect carriage of MRSA. A standard set would include nose, perineum/groin, throat, areas of broken skin and urine if a urinary catheter is present.

Septic arthritis: Infection involving the joints.

Skin and soft tissue infection: A range of infections affecting skin and associated structures, e.g. surgical site infection, cellulitis, etc.

Standard precautions: This is the most basic series of measures used to prevent infection and includes hand hygiene, use of personal protective equipment, environmental decontamination, safe disposal of waste, etc. It is required when in contact with every patient, irrespective of whether he/she is suspected of having infection.

Staphylococcus aureus (S. aureus): This is a Gram positive bacterium that normally resides in the nose in about one third of healthy individuals and on moist areas of skin, e.g. perineum. In most individuals, the bacterium acts as a harmless commensal, i.e. it does not cause disease. MRSA is the antibiotic resistant derivative of this bacterium.

Surgical prophylaxis: The use of antibiotics, given within an hour of surgery, to minimise infective complications arising from the surgery, specifically surgical site (wound) infection.

Targeted screening: The screening of all patients known to be at risk for MRSA, e.g. patients previously MRSA positive or patients transferred from other hospitals.

Teicoplanin: A glycopeptides antibiotic (like vancomycin), used to treat MRSA infection

Universal screening: The screening of all patients on admission to hospital irrespective of risk.

Vancomycin: A glycopeptide antibiotic, currently the drug of choice to treat MRSA infections.

Appendix III
Guideline development group membership and conflicts of interest

The following is a list of active members who contributed to the drafting and amendments of the guidelines.

- **Ms Patricia Coughlan**, Infection Prevention and Control Nurse, HSE South - Disability Services, St. Finbarr's Hospital, Cork

  Conflicts of interest – Nothing to declare

- **Dr Robert Cunney**, Consultant Microbiologist, Health Protection Surveillance Centre (HPSC) and the Children's University Hospital, Temple Street, Dublin

  Conflicts of interest – Nothing to declare

- **Dr Fidelma Fitzpatrick**, Consultant Microbiologist, Health Protection Surveillance Centre (HPSC) and Beaumont Hospital, Dublin, and National Clinical Lead in Healthcare-Associated Infection and Antimicrobial Resistance

  Conflicts of interest – Nothing to declare

- **Dr Blánaid Hayes**, Consultant Occupational Physician, Beaumont Hospital, Dublin

  Conflicts of interest – Clinical Director of Partner Health which provides occupational health services to Pfizer, Newbridge, Co. Kildare

- **Prof Hilary Humphreys**, Professor of Clinical Microbiology, Royal College of Surgeons in Ireland and Consultant Microbiologist, Beaumont Hospital, Dublin (Chair)

  Conflicts of interest - Research funding from Steris Corporation, 3M, Inov8 Science, Pfizer & Cepheid in the last four years. Lecture or consulting fees from 3M, Novartis, AstraZeneca & Astellas

- **Dr Phil Jennings**, Director of Public Health - Midland Area HSE Area Office, Co. Offaly

  Conflicts of interest – Nothing to declare

- **Dr Susan Knowles**, Consultant Microbiologist, The National Maternity and The Royal Eye and Ear Hospitals, Dublin

  Conflicts of interest - Received sponsorship to attend medical meetings from Abbott Laboratories, GlaxoSmithKline and Pfizer

- **Ms Lenora Leonard**, Infection Prevention & Control Nurse Specialist, UPMC Beacon Hospital, Dublin

  Conflicts of interest – Nothing to declare

- **Dr Olive Murphy**, Consultant Microbiologist, Bon Secours Hospital, Cork

  Conflicts of interest – Nothing to declare

- **Dr Sinéad McNicholas**, Lecturer in Clinical Microbiology, Royal College of Surgeons in Ireland, Dublin

  Conflicts of interest - Received research funding from Pfizer in the last two years. Received sponsorship to attend medical meetings from Novartis and Pfizer

- **Dr Brian O'Connell,** Medical Director, National MRSA Reference Laboratory and Consultant Microbiologist, St James Hospital, Dublin

  Conflicts of interest - Received research funding from Wyeth in the last three years. Received sponsorship to attend medical meetings from Novartis, Pfizer, Astellas and Wyeth

- **Ms Marie Tierney**, Antimicrobial Pharmacist, Galway University Hospital, Galway (representing Irish Antimicrobial Pharmacists Group)

  Conflicts of interest - Received sponsorship to attend medical meetings from Novartis and Pfizer

Others:

Mr. Sean Egan, Antimicrobial Pharmacist, Adelaide and Meath Hospital Dublin incorporating the National Children's Hospital

Dr Patrick Gavin, Consultant Infectious Diseases Physician, The Children's University Hospital, Temple Street and Our Lady's Children's Hospital, Crumlin

Ms Mary Kelleher, Surveillance Scientist, St James Hospital, Dublin

Dr Karina O'Connell, Specialist Registrar, The Children's University Hospital, Dublin

Ms. Laura Smith, Midlands Area HSE Office, Co. Offaly

Appendix IV
Consultation process

The draft document was placed on the HSE and HPSC websites for general consultation in June 2011 with a six week period allowed for individuals and groups to feedback comments and suggested amendments. In addition, a draft of this document was sent to the following groups with a covering letter actively seeking feedback and comment:

Academy of Medical Laboratory Science
Cystic Fibrosis Registry of Ireland
HSE HCAI Governance Group
HSE Directors of Nursing
Haematology Association of Ireland
Irish Antimicrobial Pharmacists Group
Irish Association of Critical Care Nurses
Irish Association for Emergency Medicine
Irish Association for Nurses in Oncology
Irish Association for Paediatric Nursing
Intensive Care Society of Ireland
Irish College of General Practitioners
Infectious Diseases Society of Ireland
Irish Nephrology Nurses Association
Irish Society of Clinical Microbiologists
Irish Patients Association
Infection Prevention Society
Occupational Health Nurses Association of Ireland
Public Health Medicine Communicable Disease Group
Royal College of Physicians of Ireland (RCPI)
RCPI Faculty of Occupational Health
RCPI Faculty of Pathology
RCPI Faculty of Paediatrics
RCPI Faculty of Public Health Medicine
Royal College of Surgeons in Ireland (RCSI)
RCSI Faculty of Radiologists
SARI National Committee
SARI Regional Committees
Surveillance Scientists Association of Ireland

Feedback was received from the following: -

	Individual	Group
Bernie McArdle, CNS in Infection Control, Cavan General Hospital	√	
Richard Drew, Research Fellow in Clinical Microbiology, St. Patrick Dun's Laboratory, Trinity College, Dublin 2.	√	
Teresa Farrell, ADoN, Infection Prevention and Control, Sligo General Hospital	√	
Peter Jenks, Plymouth Hospitals, NHS Trust, UK	√	
Michelle Bergin, ADoN Infection Prevention/Control, HSE, Midlands Regional Hospital, Tullamore	√	
Caroline Marshall, Infectious Disease Physician, Victorian Infectious Diseases Service, Royal Melbourne Hospital, Grattan St, Parkville, Victoria, Australia	√	
Teresa Graham, Stop Infection Now Campaign, Co. Waterford		√
Carmel Fallon, Infection Control Nurse, Public Health, HSE West, Merlin, Galway		√
Anne Marie Howard, A/CNM3, Occupational Health Dept, Waterford Regional Hospital	√	√
Elaine Brabazen, Surveillance Scientist, HSE North East	√	
Deirdre Lenehan, Antimicrobial Pharmacist, Mater Misercordiae University Hospital, Dublin Irish Antimicrobial Pharmacists Group (IAPG) Special Interest Group of the Hospital Pharmacists Association of Ireland (HPAI)		√
Dympna McDonnell, Infection Prevention and Control Specialist, AMNCH, Dublin 24	√	
Tracey Doherty, CNS, Infection Prevention and Control, Drogheda, Co. Louth	√	
Sheena Notley, Inspector, Health and Safety Authority, Dublin		√
Eileen Hickey, Infection Control Nurse, Kerry General Hospital	√	
Sheila Donlon, Infection Control Nurse Manager, HPSC, Dublin	√	
Noreen Quinn, Pharmacist, Dept of Health, Dublin 2	√	√
Cathal O'Sullivan, Consultant Microbiologist	√	
Karen Burns, Consultant Microbiologist, Beaumont Hospital, Dublin	√	√
CUH, CUMH, St. Finbarr's, St. Mary's Orthopaedic Hospital, Cork Community Services, Cork/Kerry Disability Services – Infection Control team members and other healthcare professionals		√
Marena Burd, IPCN (retired)	√	
Grainne McHale and Rose Cafferky – Infection Prevention and Control Clinical Nurse Specialist, Antimicrobial Pharmacist	√	
Margaret O'Riordan, Head of Quality and Standards, Irish College of General Practitioners, Dublin 2.		√
Lelia Thornton, Specialist in Public Health, HPSC, Dublin		√

	Individual	Group
Colm Power, Senior Scientist, Microbiology, Kerry General Hospital, Tralee, Co. Kerry	√	
James Powell, Surveillance Scientist, Microbiology, MWRHL, Limerick	√	
Ruth Hobson, Centre of Nurse and Midwifery Education, Mayo/ Roscommon		√
Aisling Purcell, Clinical Nurse Specialist, Occupational Health Dept, St. Vincent's University Hospital , Elm Park, Dublin 4.		√
Helen Lamass & Berna Walshe, CNS Infection Prevention and Control, Portiuncula Hospital, Ballinasloe, Galway		√
Health Service Executive Hospital Group, South/South East Network Infection Prevention and Control Team for Waterford, Carlow, Kilkenny and South Tipperary		√
Helen Murphy, Infection Control/Communicable Diseases Nurse Manager, Public Health, HSE East, Dr. Steeven's Hospital, Dublin	√	
Niamh O'Sullivan, Consultant Microbiologist, Our Lady's Hospital for Sick Children	√	
Martin Cormican, Consultant and Professor of Bacteriology, HSE, Galway	√	√
Deirbhile Keady, Consultant Microbiologist, Lead for Infection Control team, Microbiology Departments, Galway University Hospitals, Galway		√
Eilish Creamer, Infection Prevention and Control Nurse	√	
Susan McGovern, Infection Control, Clinical Nurse Manager 2, Clontarf Hospital (Rehabilitation), Dublin	√	√
Breida Boyle, Clinical Microbiologist, St. James's Hospital, Dublin		√

The feedback was initially collated by two members of the working group (Professor Hilary Humphreys and Dr Sinead McNicholas, HH & SMcN) and those suggestions that were non-contentious and easy to address, were incorporated in to the next draft of the document. Where it was not clear whether a suggestion could or should be addressed, this was highlighted for consideration by all members of the guideline development group. Subsequent to this initial re-drafting, a full meeting of the guideline development group took place where the revised guideline with the queries were tabled together with a full set of the feedback documents from the above organisations and groups, as well as another document highlighting what other generic issues need to be addressed, e.g. a review date. At that meeting decisions were taken on what further changes could and should be made, e.g. clarifying points or re-organising the order of the document and what issues could not be addressed, e.g. providing recommendations for very precise clinical settings. After that final meeting of the guideline development group, certain members agreed to revise and review fully a limited number of sections or components, e.g. decolonisation regimens. When these changes had been made and received by HH and SMcN, the penultimate document was sent to all members of the guideline development group for final review and approval. Given the extensive feedback from many individuals and groups, it was not felt feasible to include in this document all the feedback and how the guideline development group responded to each issue. A further draft of the document was prepared after feedback was received from the National Clinical Effectiveness Committee (NCEC).

Appendix V
How to obtain a nasal swab

Gather together the equipment needed to obtain a nasal swab:

- Gloves
- Apron*
- Swab/specimen collection device
- Appropriate documentation

**The need for an apron should be risk assessed*

The procedure

- Obtain informed consent (oral suffices) from the patient. Answer any questions and allay any anxieties that the patient may have
- Clean hands thoroughly. Use appropriate PPE
- Open swab packaging, checking expiry date
- Remove swab from packaging, moisten with sterile water if required (to prevent any discomfort to the patient)
- Insert the swab into the anterior nostril by about 2 cm
- Rotate for about three seconds
- Repeat the procedure with the same swab in the other nostril
- Without contaminating swab, place in the culture medium provided
- Remove and dispose of PPE appropriately and clean hands

Appendix VI
Template letter to general practitioner and copied to consultant

Hospital Name & Address:

Date:

GP name:

GP address:

Patient name:

DOB:

Address:

Dear Dr (name),

The above named patient was an in-patient in this hospital on (date)…….

MRSA was isolated from the (state location) ……...

The patient was discharge home on (date) …….

A copy of this letter is being forwarded to the consultant under whom the patient was an in-patient.

	Tick as appropriate
The patient was prescribed a 5 day regimen of chlorhexidine washes and Bactroban (mupirocin) nasal ointment. MRSA was not isolated from 3 consecutive swabs post treatment.	❑
The patient was prescribed a 5 day regimen of chlorhexidine washes and Bactroban (mupirocin) nasal ointment. MRSA was not isolated from the 1st repeat swab post treatment. The patient was discharged home prior to repeat swabs after treatment.	❑
The patient was prescribed a 5 day regimen of chlorhexidine washes and Bactroban (mupirocin) nasal ointment. No repeat swabs after treatment were taken as the patient was discharged home before the recommended follow up period.	❑
No treatment was commenced as we received these positive results after the patient's discharge. No action is required unless the patient is scheduled soon (within 3 months) for surgery	❑

This information will be important for screening in the event of any future hospital admissions.

Please contact me if you have any queries.

Regards,

…….

cc Consultant's name, department and address

Appendix VII
Risk stratification tool for the isolation and cohorting of MRSA patients

The following tool for risk stratification of patients with MRSA for isolation and cohorting is based on the Lewisham Isolation Prioritisation System (LIPS).[1] The LIPS was developed in 1999 as a scoring system based on factors likely to influence transmission. It was modified by one of the original authors in 2009, following extensive feedback from users.

Table 2. Score card

Patient name ..... Date ..... Name and designation of person scoring .....

Significant details, e.g. microorganism(s) .....

Criteria	Classification	Score	Comments
ACDP	2	5	
	3	10	
	4	40	
Route	Airborne	15	
	Droplet	10	
	Contact/faeco-oral	5	
	Blood-borne	0	
Evidence of transmission	Strong (published)	10	
	Moderate (consensus)	5	
	Poor	0	
	Nil	−10	
Significant resistance	Yes	5	Such as MRSA, VRE, ESBL, Gent resistance.
	No	0	
High susceptibility of other patients with serious consequences	Yes	10	Specific for various infections and patient populations.
	No	0	
Prevalence in hospital	Sporadic	0	
	Endemic	−5	This reflects the burden of infection in the hospital and cohort measures may be more applicable.
	Epidemic	−5	See above.
Dispersal	High risk	10	This includes diarrhoea, projectile vomiting, coughing, confused wandering, infected patients etc.
	Medium risk	5	
	Low risk	0	

TOTAL SCORE (document score in patient's notes):

Using the score to determine the priority for isolation:

Score	Priority for isolation
0–20	Low
25–35	Med
35+	High

ACDP–Advisory Committee on Dangerous Pathogens; ESBL–Extended-spectrum beta-lactamases; MRSA–Meticillin-resistant Staphylococcus aureus; VRE–Vancomycin-resistant Enterococcus.

Example for a patient with MRSA:

Patient colonised with MRSA identified on a nasal swab in the ICU of a hospital with endemic MRSA	**Score**
ACDP=2	5
Route=contact	5
Evidence of transmission=published	10
Significant resistance=yes	5
High susceptibility of other patients with serious consequences of infection=yes	10
Prevalence=endemic	-5
Dispersal=high risk	5
Total score	35 =category of priority for isolation=high

Reference

1. Jeanes A, Macrae B, Ashby J. Isolation prioritization tool: revision, adaptation and application. *Br J Nurs* 2011; 20(9):540-544

Appendix VIII

Infection prevention and control measures advised when caring for residents colonised or infected with MRSA in residential care facilities.

Standard Precautions have been designed to reduce the risk of cross infection from both recognised and unrecognised sources of infection. It is not always possible to identify people who may be a source of infection thus Standard Precautions are advocated for the care of all patients/clients at all times. Standard Precautions are the foundation for preventing transmission of infection during patient/client care in all healthcare settings.

Standard Precautions are work practices required for a basic level of infection control and prevention. They can be applied as Standard principles by

- **ALL** healthcare practitioners to the care of
- **ALL** clients
- **ALL** the time

Standard Precautions include

1. Hand hygiene
2. Personal protective clothing
3. Respiratory hygiene/cough etiquette
4. Safe use and disposal of sharps
5. Blood and body fluid spills management
6. Management of blood and body fluid exposures.
7. Management of laundry and linen
8. Environmental hygiene
9. Client-care equipment/medical devices
10. Resident/client placement, movement and transfer
11. Safe injection practices
12. Infection control practices for lumbar punctures

Standard Precautions should be used for the care of all residents who are colonised or infected with MRSA.

Isolation of residents with MRSA is not generally recommended. Within long-term care facilities residents are encouraged to take part in-group activities and eat in a common dining/day room. It would be contrary to the philosophy and policy of these facilities to isolate ambulatory residents with MRSA. Therefore, the routine use of isolation/single room placement is not encouraged. The exceptions might be a resident with wounds heavily colonised with MRSA, or a resident with a tracheostomy who is unable to control their secretions.

The decision to isolate a resident must be considered carefully and should take into account the risk to the individual, other residents and staff. The psychological effects of isolation must be considered carefully. Where available advice should be sought from the local infection control team/nurse.

When published, national guidance on Standard Precautions and Transmission based Precautions will be available at www.hpsc.ie and will supersede this appendix.

Hand Hygiene as per Standard Precautions

- Hand hygiene is the single most important element of preventing the transmission of MRSA and must be performed appropriately by all staff according to the WHO 5 Moments for Hand Hygiene.

- Hand hygiene should be carried out using an alcohol based hand rub - on visibly clean hands only - plain soap and water is required when hands are visibly soiled.

- Encourage and assist residents to carry out hand hygiene.

Patient Placement as per Standard Precautions

- Consider the potential for transmission of infection in resident placement decisions. Local risk assessment of the individual and the environment will be required prior to placement.

- Visitors should be encouraged to clean their hands before and after visiting all residents.

Placement of Residents known to be colonised or infected with MRSA

- Residents known to be colonised with MRSA should be allowed to participate in group activities provided wounds are covered and good hand hygiene is adhered to.

- Residents known to be colonised with MRSA may share a room with another resident who is at low risk of acquiring MRSA. Hand hygiene facilities should be available.

- Residents known to be colonised with MRSA, where facilities are available, should not share bedrooms with or in a shared room be placed adjacent to residents who are at increased risk of acquiring MRSA e.g. residents with open wounds, invasive devices.

- It is preferable that residents colonised or infected with MRSA should receive physical care in their own room, for example:
  - wound dressing changes for residents with colonised wounds
  - chest physiotherapy, suctioning for residents colonised in their respiratory tract.

- Residents known to be colonised with MRSA in a wound which cannot be covered by dressings or clothing should be in a single room if available and if this will not adversely affect the resident or their rehabilitation.

- Visitors of residents colonised or infected with MRSA do not need to wear PPE and should be encouraged to wash their hands before and after visiting.

Personal Protective Equipment (PPE) as per Standard Precautions

- Disposable gloves (nitrile or suitable alternative) should be worn for all contact with blood or body fluids, non-intact skin, mucus membranes and items contaminated with blood or body fluids.

- Disposable aprons should be worn where there is a risk of splashing of clothing with blood or body fluids or direct contact of clothing with non-intact skin or items contaminated with blood or body fluids.

- Hand hygiene should be performed after removing PPE.

Decontamination of Medical/Care Equipment as per Standard Precautions

- Medical equipment should be dedicated to the resident e.g. hoist slings or must be decontaminated between each resident e.g. stethoscope.

- Reusable equipment must not be used for the care of other residents until it has been decontaminated and reprocessed appropriately.

- Single use items must not be reused and must be discarded appropriately.

- Chemical disinfection is not required for routine decontamination of low risk items i.e. items which only come in contact with intact skin and are not soiled with body fluids (bathing aids, mattresses).

- All items for personal hygiene must be dedicated for the residents own use.

Decontamination of the Environment as per Standard Precautions

- Cleaning of the environment should be carried out using warm water and detergent with attention to hand contact surfaces (bed rails, hand rails, bed tables, door handles etc.).

- Baths and showers should be cleaned between uses by all residents.

- Chemical disinfection is not required for routine decontamination of the environment.

- Where the environment is soiled with blood or body fluid, following cleaning, chemical disinfection is recommended.

- Cutlery and crockery should be washed in a dishwasher. Separate or disposable cutlery or crockery is not required.

Management of Laundry as per Standard Precautions

- Clean linen should be stored in a clean dry area.

- All linen soiled with bodily fluids should be treated as contaminated by placing in a water-soluble or alginate stitched bag prior to placing in a laundry bag which is designated for contaminated linen by label or colour.

- There must be no manual washing of soiled clothing.

- Personal clothes should be machine-washed.

- Hand washing after handling all used linen is essential.

Management of healthcare waste -as per Standard precautions

- Waste unless soiled with blood or with body fluids assessed as infectious should be discarded as healthcare non-risk waste, including PPE.

Appendix IX
MRSA- Information for schools and day care facilities for children

What is MRSA?

- MRSA stands for **m**ethicillin-**r**esistant *Staphylococcus aureus*.
- *Staphylococcus aureus* (pronounced staf-ill-okok- us -aur-ee-us), or "*Staph aureus*" for short, is a common bacterium (germ) that lives harmlessly on the skin or in the nose of about one in three people.
- MRSA is a type of *Staph aureus* that has become resistant to a number of different antibiotics. 'Resistant' means it is not killed by antibiotics.
- Most people who carry MRSA on their bodies or in their noses don't suffer any ill effects. Carrying the germ harmlessly like this is called "colonisation".
- However MRSA sometimes causes infections if it enters the body.

What is the difference between "colonisation" and "infection"?

- MRSA colonisation means that the germ is simply "sitting on the skin" (in any site) but is causing no harm to the person.
- In a MRSA infection, the germs cause signs of infection, for example, fever and/or pus discharging from a wound and the person will feel unwell. This is more likely to happen to people who are already unwell, particularly those who are in hospital with a serious illness.

What are the symptoms of an infection caused by *Staph aureus* or MRSA?

- *Staph aureus* bacteria, including MRSA, can cause skin infections that may look like a pimple or boil and can be red, swollen, painful or discharge pus.
- People with infection may also have a temperature or fever and feel generally unwell.
- More serious infections may cause pneumonia, bloodstream infections or surgical wound infections.
- MRSA should be considered in someone with repeated skin infections or with a wound that is taking longer to heal than normal.
- A laboratory test is the only way to tell if someone is carrying MRSA.

Who is at risk of infection?

- The following reasons make people vulnerable to any infection, including infection caused by MRSA:
  - Their underlying condition
  - How frequently they have used antibiotics
  - The number of operations they have had
  - The presence of open wounds

- Those who have been in hospital/long-term care facility for a long time
- People with a long-term illness.

How do people get MRSA?

- MRSA is usually spread by direct skin-to-skin contact.
- The people most at risk of becoming colonised with MRSA are those who have been in hospital for a long time, have a lot of contact with hospitals, have a long-term illness, or have had a lot of antibiotics.
- Where healthcare is provided, MRSA may be passed from one person to another on the unclean hands of staff or visitors, through the use of care equipment which is inadequately cleaned, or by contamination of the healthcare environment.
- MRSA is most likely to spread in healthcare settings where there is overcrowding and where a lot of antibiotics are used.
- Outside of healthcare settings, there is little risk of transmitting MRSA to healthy people who are at low risk of becoming infected.

What precautions should all schools take to prevent transmission of MRSA?

- To prevent MRSA infections and the transmission of other germs such as those which can cause colds, flu, vomiting or diarrhoea, the following general precautions should be followed:
- **Wash your hands regularly**
- Encourage **all children to wash their hands** after using the bathroom and before meals – assist children to do this where necessary
- **Care for all wounds properly**, ensuring wounds are covered at all times.
- Inform the family if there is any concern about the clinical status of any child (e.g. potential skin infection that needs antibiotic treatment). The family can then consult their general practitioner for advice.

What precautions can special school/classroom settings take to prevent transmission of MRSA?

For settings such as special schools or classrooms where children require physical care (such as assistance with toileting or feeding) the following is recommended for all children regardless of whether or not a child is known have MRSA:

Hand Hygiene

- Caregivers should wash their hands with soap and water before and after providing physical care to **all** children.
- Disposable gloves should be worn only if contact with body fluids, areas of broken skin or dressings are expected and hands must be washed after removing the gloves.
- Cuts or breaks in the skin of care givers should be covered with a waterproof dressing.

Cleaning of the Environment

- Routinely clean the environment using detergent and water and clean immediately if soiled (dirtied) with body fluids. Pay attention to frequently used and touched surfaces.

- The routine use of disinfectants for environmental cleaning is unnecessary unless there is a higher risk of infection, such as where surfaces become soiled with body fluids.

- Routinely clean equipment, such as sensory equipment and toys, and clean immediately if soiled with body fluids.

- Where disinfection is required a bleach based disinfectant* is advised.

Equipment/products used in providing personal care

- Equipment used in providing personal care (changing mats, beds, toilet aids etc.) should be cleaned with detergent and water between uses for different children.

- Do not share personal care items e.g. face cloths, towels creams, lotions.

- Chemical disinfection is not routinely required unless equipment is soiled with body fluids.

- Where disinfection is required a bleach based disinfectant* is advised.

Linens (bedding, blankets etc.)

- Change and wash linens between uses by different children.

Preventing and controlling infection where additional care activities are necessary in the school setting:

Where children require additional care such as enteral feeding, respiratory care e.g. suctioning, care of urinary catheters or other devices, it is recommended that:

- care givers have infection prevention and control education relevant to the care they provide,

- hand hygiene facilities, including hand washing sinks, liquid soap and paper towels and alcohol hand rubs, are available and

- personal protective equipment (disposable gloves and aprons) is available.

Who needs to know when a child has MRSA?

- In general, only staff involved in the child's healthcare need to know that he/she has MRSA. These include public health nursing, GP and the nursing and medical staff who are responsible for care during a hospital stay.

- If a person had MRSA in the past it is helpful to tell the doctors and nurses looking after them as it will assist in planning care.

Can a child who is known to have MRSA attend school?

- Children known to be colonised with MRSA in the nose or skin or other sites do not need to be excluded from school or activities within the school.

- Children who have wounds or skin sores which can be covered (by a dressing or by clothing) do not need to be excluded from school.

- Exclude children who have wounds or skin sores which are wet or producing pus and which cannot be covered or contained by a dressing and/or the dressing cannot be kept dry and intact. Exclude children until the wounds can be covered sufficiently or are healed.

** Manufacturers' instruction should be followed (safety of use, dilution, and rinsing if required, suitability for the use on equipment/surface)*

Further information on infection control for school settings available in:

Management of Infectious Diseases in Childcare Facilities and other Childcare Settings (HPSC 2012) Preschool and Childcare Facility Subcommittee available at http://www.hpsc.ie/hpsc/A-Z/LifeStages/Childcare/

Further information on

MRSA available at http://www.hpsc.ie/hpsc/A-Z/MicrobiologyAntimicrobialResistance/EuropeanAntimicrobialResistanceSurveillanceSystemEARSS/ReferenceandEducationalResourceMaterial/SaureusMRSA/

Hand Hygiene at http://www.hpsc.ie/hpsc/A-Z/Gastroenteric/Handwashing/

Appendix X
Matrix for work restrictions in colonised healthcare workers

This is provided as general guidance and may be useful initially, where expert opinion is not immediately available. Expert opinion based on local risk assessment may justify deviation from this.

HCW Patient	Level 1 Nasal colonisation	Level 2 Nasal and skin colonisation	Level 3 Nasal and throat colonisation	Level 4 Multiple sites of colonisation (>2)	Level 5 Multiple sites of colonisation (>2) with individual HCW risk factors
Level 1 Casual contact with low risk patients					
Level 2 Clinical contact with short stay patients (e.g. elective surgical)					
Level 3 Clinical contact with long stay patients					
Level 4 Clinical contact with immuno-compromised patients					
Level 5 Repeated clinical contact with dependent patients in high risk units					

Key to table:

Blank: Low risk of transmission from HCW to patient

Horizontal lines: moderate risk of transmission from HCW to patient

Trellis lines: high risk of transmission from HCW to patient

Appendix XI

MRSA surveillance definitions

(Please see Section 2.3 for original sources and references)

An outbreak of infection

This is defined as two or more cases where the observed number of cases exceeds the normally expected number for that unit or clinical area.

Severe invasive disease

This includes:

- infection at a normally sterile site, e.g. blood, cerebrospinal fluid, joint fluid etc.
- necrotising pneumonia
- community-acquired pneumonia with a CURB-65 score of 4 or 5
- skin or soft tissue infection requiring ICU care or extensive surgical debridement.

Local surveillance of invasive infections

These should include any infection at a normally sterile site (e.g. bloodstream infection, meningitis, septic arthritis). Other invasive infections (e.g. deep surgical site infections) may also be included, but this should be determined by local risk assessment.

Temporal surveillance definitions

Hospital-onset

The first MRSA-positive specimen was collected from the patient three or more days after admission to the hospital, where the first day is the date of admission (the "three midnight rule"). For example, if a patient is admitted to the hospital at any time on a Monday, only specimens taken after midnight Wednesday night would be considered to represent hospital-onset infection. All hospital-onset infections are considered healthcare-associated.

Community onset

The MRSA-positive specimen was collected within three days of hospital admission. However, a subset of community-onset infections may be healthcare-associated, i.e. MRSA was acquired in another healthcare facility such as a nursing home.

Clinical surveillance definitions

The following are adapted from surveillance definitions currently in use in Australia, Canada and USA. Clinical case definitions should be applied in addition to temporal case definitions for the purposes of targeted local surveillance, e.g. surveillance in high-risk units or during outbreak situations. Clinical case definitions must be applied to cases of *S. aureus* BSI reported to the enhanced EARS-Net surveillance programme.

Healthcare-associated MRSA

This is a newly identified MRSA infection or colonisation with MRSA that satisfies at least one of the following criteria:

- Acquired during hospitalisation and not documented as present or incubating on admission: i.e. occurring three or more days after admission. For patients admitted to hospital via the emergency department (ED), the date of attendance at the ED should be counted as the date of admission, even if this includes one or more overnight stays in the ED.

- MRSA-positive specimens taken within three days of hospital admission or admitted via the ED (see first bullet point) in a patient who was admitted from a long term care facility, e.g. nursing home, hospice or non-acute hospital, or from another acute hospital.

- A complication of the presence of an indwelling medical device, e.g. intravascular catheter, urinary catheter.

- A surgical site infection, or related BSI, within 30 days of a surgical procedure.

- Instrumentation or incision related to the infection was performed within 48 hours before onset of the infection. If the time interval was longer than 48 hours, there must be compelling evidence that the infection was related to the invasive device or procedure.

- Associated with neutropenia (<1000 neutrophils x 106/L) contributed to by cytotoxic therapy.

Healthcare-associated MRSA infection or colonisation should be subdivided into:
a. Associated with care at this hospital/healthcare facility.
b. Associated with care at another hospital/healthcare facility, e.g. nursing home, dialysis unit, other hospital.

Community-associated MRSA (CA-MRSA) infection
For the purposes of epidemiological investigation and public health interventions, CA-MRSA infections are defined as MRSA infections occurring in persons where all of the following apply:

- Diagnosis of MRSA was made in the outpatient setting or by an MRSA-positive specimen taken within three days of admission to the hospital/ED (see above)

- No medical history of MRSA infection or colonisation.

- No medical history in the past year of:
  - Hospitalisation
  - Admission to a nursing home, skilled nursing facility, or hospice
  - Dialysis
  - Surgery

- No permanent indwelling catheters or medical devices that pass through the skin into the body

Undetermined source
Cases of MRSA infection or colonisation that do not fit the above criteria, or where the relevant clinical data is unavailable, should be classified as "undetermined source of MRSA".

Appendix XII
MRSA - Related process indicators

The following process indicators for control and prevention of MRSA have been adapted from recommendations produced by the US Society for Healthcare Epidemiology.

Compliance with hand-hygiene guidelines
Monitor healthcare personnel compliance with hand hygiene guidelines both before and after contact with the patient or environment, using a standardised hand hygiene observation tool. A standardised hand hygiene observation tool has been developed by the HPSC and may be downloaded from www.hpsc.ie. Note that HSE-funded acute hospitals are now required to use this tool for six-monthly national reporting of hand hygiene compliance. Compliance is calculated by:

- Numerator, number of observed adequate hand hygiene episodes performed by healthcare personnel
- Denominator, number of observed opportunities for hand hygiene
- Multiply by 100 so that the measure is expressed as a percentage.

Compliance with contact precautions (CP)
This assessment should be performed only as an internal measure within acute hospitals, as this measure has not been validated for, and should not be used for, inter-hospital comparisons. This is calculated by

- Numerator, number of observed patient care episodes in which CP are appropriately implemented
- Denominator, number of observed patient care episodes in which CP are indicated
- Multiply by 100 so that the measure is expressed as a percentage.

Compliance with MRSA active surveillance screening
This assessment should be performed only as an internal measure within acute hospitals, as this measure has not been validated for, and should not be used for, inter-hospital comparisons. This is calculated by:

- Numerator, number of persons from whom surveillance specimens were appropriately collected
- Denominator, number of persons meeting the selected criteria for surveillance testing
- Multiply by 100 so that the measure is expressed as a percentage.

Appendix XIII
Areas for Further Research

Does universal admission screening for MRSA result in fewer new acquisitions of MRSA? Is it cost-effective, particularly at a time of falling MRSA rates?

Does inclusion of patients with non-intact skin (e.g. wounds, ulcers), exfoliative skin conditions, PEG tubes or urinary catheters, and patients who are healthcare workers, in admission screening for MRSA result in fewer new acquisitions of MRSA?

What is the cost-effectiveness of culture versus molecular-based detection methods for screening patients for MRSA carriage?

Are control of infection wards a cost-effective means of reducing the rate of new MRSA colonisation or infection?

What is the minimum time period between screening swabs, after MRSA decolonisation therapy, that will effectively demonstrate that a patient is no longer carrying MRSA (for purposes of discontinuing isolation precautions)?

Do healthcare workers, who are found to be colonised with MRSA but not epidemiologically linked to acquisition of MRSA by patients, need to avoid patient contact in high risk units and, if so, for how long after starting decolonisation therapy?

How many repeated attempts at decolonisation should be made for patients or healthcare workers persistently colonised with MRSA?

What is the effectiveness of alternative approaches to decolonisation, for patients or healthcare workers persistently colonised with MRSA?

What is the effectiveness of adding an antiseptic mouthwash, to reduce or eliminate throat carriage of MRSA, to decolonisation regimens?

Are healthcare workers with exfoliative skin lesions at increased risk of acquiring and transmitting MRSA and, if so, should their contact with patients be restricted?

Does the wearing of face masks by healthcare workers reduce the transmission of MRSA, if worn for (1) every contact with an MRSA-colonised patient or (2) only for contact with MRSA-colonised patients with an intercurrent respiratory tract infection?

Does promoting hand hygiene compliance by patients reduce the incidence of new MRSA acquisition, or the incidence of MRSA infection?

What level of additional environmental cleaning/decontamination is required in operating theatres, after a procedure on an MRSA-colonised patient, to prevent transmission to subsequent patients?

What is the risk of transmission of MRSA via laundry, and does the risk justify designating all laundry associated with a patient colonised with MRSA as potentially infectious?

Does routine MRSA screening in non-acute healthcare settings result in fewer new acquisitions of MRSA and, if so, under what circumstances is it indicated?

What is the most effective choice of antibiotic therapy for MRSA SSTI or pneumonia?

Do adjunctive therapies, such as intravenous immunoglobulin, result in improved outcomes for MRSA SSTI or pneumonia?

Does decolonisation of index cases of CA-MRSA in non-hospital settings result in fewer new acquisitions of CA-MRSA?

Does routine monitoring of vancomycin or teicoplanin trough levels result in improved outcome for patients with invasive MRSA infections?

What duration of therapy is required for specific MRSA infections to maximise therapeutic efficacy while minimising unnecessary drug exposure?

Is exclusion of healthcare workers, found to be carriers of MRSA, from patient contact in high risk areas required (in the absence of an epidemiological link to MRSA transmission) and, if so, for how long should they be excluded following the initiation of decolonisation therapy?

Appendix XIV
Ambulance transportation of patients colonised/infected with MRSA

There is no evidence that ambulance staff/hospital drivers or their families are put at risk by transporting patients with MRSA. The risk of cross-infection from a MRSA colonised or infected patient to other patients in an ambulance is minimal. Good infection control practices and routine cleaning (i.e., Standard Precautions) are sufficient to prevent cross-infection. No additional cleaning of the ambulance is required after transporting a MRSA positive patient.

- The ambulance service should be notified in advance by the ward staff of the patient's MRSA status.
- To minimise the risk of cross infection with any infectious agent, ambulance staff should use an alcohol based hand rub after contact with all patients, as part of Standard Precautions.
- Every effort should be made to minimise the need to handle wounds and invasive devices by the transporting staff.

Patients colonised/infected with MRSA can be classified into two categories for transportation by the ambulance services

1. **Can be transported with other patients:** In general, most patients may travel with other patients without additional precautions other than changing the bedding of the carrier. If the patient has skin lesions these should be covered with an impermeable dressing. Hands of ambulance staff should be decontaminated with alcohol gel/rub but aprons and gloves should only be worn for direct care.

2. **Need to be transported individually – there are two reasons why this will occur**

   a. **The patient is deemed at high risk of transmission of MRSA** (e.g., discharging lesions which cannot be covered with an impermeable dressing, patients with extensive psoriasis or eczema etc.)

   In these cases staff should wear a disposable apron and gloves, decontaminate their hands with alcohol hand rub following removal of apron/gloves and wipe down surfaces in contact with the patient with detergent wipes.

   Or

   b. **If the patient or other patients requiring transport are especially vulnerable**, e.g., immunocompromised

Appendix XV
Economic impact report

Key message
This review of the literature on the economic evaluation of the screening, prevention, treatment and detection of MRSA and the budget impact analysis support the clinical guideline recommendations.

The report was completed by Dr. Mary O'Riordan, specialist registrar in public health medicine in collaboration with Dr Patricia Harrington and Dr. Máirin Ryan, Health Technology Assessment Directorate, Health Information and Quality Authority and Mr. Gethin White, Health Service Executive library services.

Literature search of cost implications of MRSA guideline

Economic literature review
A systematic review was conducted to identify existing literature on the economic evaluation of MRSA screening, prevention, treatment and detection. The search strategy is based on the one used in the clinical literature review with the addition of an economic filter (1) for the Medline and EMBASE search. The full methodolgy is outlined in the next section of this appendix.

The impact of MRSA in Ireland
Assessing the impact in terms of the true numbers of cases of MRSA, the morbidity and associated mortality, and the cost of MRSA infections is difficult in the absence of comprehensive national surveillance. Currently, the main focus of MRSA surveillance is on BSI but this excludes other infections such as SSTI, bone and joint infections and pneumonia. One of the most comprehensive studies of the prevalence of MRSA ever done was the North/South Study of MRSA in Ireland conducted in 1999, when 508 cases, (colonisation and infection) of MRSA were identified in the South of Ireland, representing a prevalence rate per 100,000 population of 14.0 (2-6). In a survey of HCAI in the UK and Ireland in 2006, the prevalence in the Republic of Ireland (ROI) was 4.9% and of these 0.49% i.e. approximately 10% of all HCAI, were due to MRSA (7). In a more recent survey carried out in 2012 in Ireland and in other European countries, the prevalence of HCAI in ROI was 5.2%, varying from 16.5% in critical care units to 1.1% in obstetrical and gynaecology units. S. aureus accounted for 15% of the causative microbes of which 37% were MRSA (8).

A varying proportion of cases die from MRSA BSI. This can be 30% or higher in debilitated patients such as those with one or more significant underlying chronic disease, e.g. diabetes mellitus, and in patients requiring organ support in critical care units. Patients with other non-fatal infections are often left with lifelong suffering such as bone pain arising from chronic osteomyelitis and other infections such as SSTI that result in additional hospital stay and a delayed return to work and to other activities. Therefore the true clinical, financial and psychological impact of MRSA is not known.

Screening
MRSA screening is advocated as part of control measures, but an important consideration is the cost-effectiveness of the type of screening method. Seven studies (US: n=4; Germany: n=1; UK: n=1; Ireland; n=1) were retrieved that compared the cost of universal screening to targeted screening of at-risk patients admitted to the acute hospital setting. Costs were limited to direct medical costs and were evaluated from the perspective of the health care provider (hospital). Four studies were cost comparisons (9,10,13,14); two reported cost-effectiveness of the strategies compared to a base case of no screening and relative to each other (10,11); while one study provided a cost-benefit analysis of universal versus targeted screening (12). In hosptials where MRSA is

endemic, screening (targeted or universal) was shown to reduce infection rates and to be cost saving compared to a policy of no screening (9,10). The evidence showed that universal MRSA screening strategies were more effective, but also more cost-intensive than targeted screening (10,11,12). In a UK study by Collins et al., a retrospective review of a three year MSA screening programme from 2006-2009 showed that the seven extra MRSA cases that were detected using universal screening over targeted screening incurred £20,000 total laboratory costs and generated 4,200 associated negative screens in a one month period.(13) Similarly, in a prospective study by Creamer et al., it was found that extending screening to patients without risk factors (i.e., universal screening) increased the number of screenings and the costs, but did not result in the detection of a significant number of additional cases (14).

In a 2011 US study (costs in 2009 US$) targeted screening was associated with lower costs and better outcomes) than a policy of no screening, while universal screening was associated with an average cost-effectiveness ratio of $14,955 per MRSA HAI (11). In a second cost-effectiveness analysis (costs in 2007 US$), targeted screening strategies were found to be more cost-effective than universal screening, with incremental cost-effectiveness ratios (ICERs) of $4,100 to $36,200 (depending on the prevalence rate and testing used) compared to $131,000 to $232,700 per additional infection averted for universal screening (10). Finally, a US prospective study comparing the clinical effectiveness and cost benefit (costs in 2009 US$) of universal versus targeted screening reported a benefit-to-cost ratio of 0.50, indicating that for every additional dollar spend on universal versus targeted screening, only $0.50 could be recovered in avoided costs due to a reduction in MRSA HAI (12).

Although differences in the study settings and cost data limit the transferability of the results to all acute hospitals within the Irish healthcare system, the methods, costs and results in the studies were generally clearly described, and valid approaches were used in the determination of cost-effectiveness and to deal with the issue of uncertainty. The study conclusions appear robust and are likely generalisable to the Irish healthcare setting. That is, that screening (universal or targeted) results in fewer MRSA HAIs and is cost saving compared to a policy of no screening; that universal screening is the most costly and the most effective screening strategy, but that it is not cost-effective as it is resource intensive, detects few additional cases and results in a large number of additional negative screens compared to targeted screening. This finding is consistent with the guideline recommendations in which a continued policy of targeted screening is advocated.

Prevention

The cost implications of MRSA infection prevention and control interventions were also assessed. Five studies were retrieved using the search terms outlined. The evidence supported MRSA infection control interventions as a cost-beneficial measure to prevent the spread of MRSA (15,16,17). Farbman et al., undertook a systematic review of infection control interventions aimed at preventing spread of MRSA in hospitals. Strategies included surveillance, screening with or without decolonisation, contact isolation, droplet isolation, environmental control and antibiotic stewardship. Fifteen of eighteen studies reported a save/cost ratio >1 (values >1 indicate savings larger than costs); the median interquartile range was 7.16(IQR 1.37-16). Median intervention cost across all studies (n=31) was US$8,648 (IQR US$ 2,025-19,170) per month while the median savings were US$38,751(IQR US$14,206-75,842) per month. All costs were reported in 2011 US$. Higher save/cost ratios were observed in settings with intermediate to high endemicity compared with hospitals with low endemicity, interventions of greater than 6 months duration and in hospitals with fewer than 500 beds. Save/cost ratios were noted to be lower for 'search and destroy' policies compared to more restrictive interventions and for screening with decolonisation compared to screening without decolinisation (17).

In another study by Robotham et al examining screening, isolation, decolonisation strategies in intensive care units, all decolonisation strategies were shown to improve health outcomes and reduce costs and thus were highly likely to be cost-effective in an ICU setting. Although it was noted that universal decolonisation (regardless of MRSA status) using daily patient washing with

chlorhexidine for five days was the most effective in the short term, such a policy may hasten the emergence of resistance and was unlikely to be considered a viable option. Among the targeted strategies, decolonisation using nasal mupirocin was found to be the most cost-effective strategy. All strategies using isolation (contact precautions only rather than physical separation), but not decolonisation were associated with improved health outcomes, but higher costs. The use of targeted screening and isolation in high risk groups was likely to be a more efficient use of resources than universal screening with isolation or universal pre-emptive isolation (18).

The use of a Dutch 'Search and Destroy' policy for MRSA prevention that included various treatment of carriers, contact tracing and isolation interventions was estimated to prevent 36 cases of MRSA BSI per year, with annual savings of €211,559 for the study hospital (cost year 2001-2006) and ten lives per year (95% [CI] 8-14). The authors concluded that the programme saved money and lives from the perspective of the hospital; however, several assumptions were made and the results were not based on an explicit comparison between the programme and the control strategy. This limits the generalisability of this study to other jurisdictions (19).

Contact precautions alone were also examined in a prospective US study by Spence et al. between 2007 and 2010. Over a three year period they identified seven MRSA HAIs and determined that the costs incurred for contact precautions for the study population (screened n=6,712, positive n=633) averaged $8,055 for each year. They concluded that placing patients who were asymptomatically harbouring MRSA in contact precautions did not decrease the rate of HAI and was expensive (20).

In summary, there is general evidence in the literature that MRSA prevention and control methods are associated with significant cost savings. However, prevention and control methods encompass a wide range of interventions, the efficacy and cost of some of which are dependent on MRSA prevalence rates, local resistance patterns, the characteristics of the patient population and of the hospital facilities. This evidence is therefore not inconsistent with the guideline where a series of recommendations are made in relation to the prevention and control of MRSA, but these are graded based on clinical evidence with selective approaches suggested for different scenarios.

Treatment

Four studies (US: n=2; France: n=1; Germany: n=1) were retrieved that examined the clinical and cost outcomes or cost-effectiveness of three agents daptomycin, linezolid and vancomycin in the management of MRSA complicated skin and skin structure infections (SSTI) and pneumonia (23,24). Costs were limited to direct medical costs and were evaluated from the perspective of the healthcare provider. Linezolid was found to be the most cost-effective strategy in the management of hospital acquired MRSA pneumonia. This was consistent with the guideline recommendations where linezolid or a glycopeptide is recommended as a possible first line agent for hospital-acquired MRSA pneumonia (23).

Linezolid was the most cost-effective strategy for the treatment of complicated SSTI in both of the retrieved economic studies, while daptomycin was found to be financially the most advantageous in the cost-consequence study (22). Results were noted to be sensitive to assumptions regarding the general ward stay, the price of linezolid, and resistance patterns. (21,22,23). Differences in treatment practices and cost data may limit the generalisability of the results to acute hospitals within the Irish healthcare system The 2013 clinical guideline recommends that glycopeptides (vancomycin or teicoplanin) should be used as first line therapy for MRSA SSTI, with the newer agents reserved for glycopeptide failure, resistance or intolerance so as to minimise emergence of further resistance amongst Gram-positive infections and to ensure that activity can be preserved for patients with difficult-to-treat infections. This strategy of using the existing gold standard (vancomycin) as first line therapy appears plausible in the absence of a specific CEA using Irish epidemiology, resistance patters and cost data. The clinical guideline highlights the need for an evaluation of the cost-effectiveness of teicoplanin compared to vancomycin given its significantly

higher acquisition costs. Such an assessment would help to inform decisions regarding the most appropriate first line glycopeptide agent in the Irish healthcare setting.

Detection
Bacteriological culture (broth-enriched culture test) remains the most common way of detecting MRSA. However, polymerase-chain-reaction (PCR)-based MRSA assay testing has also been shown to be highly sensitive and specific with fast turnaround times (25,26). Information concerning the cost-effectiveness of rapid MRSA PCR testing is still sparse and conflicting.

A 2010 Norwegian study published by Anderson et al. showed that a rapid MRSA Xpert test would save at least €925 per exposed healthcare worker and €550 per MRSA-negative patient , compared with culture testing alone (25). In a study by Buhlmann et al, the use of PCR instead of culture for 258 screening episodes added costs of €84,598 and saved €31,242. They concluded that although PCR tests were valuable in terms of rapid detection of MRSA carriers, the high costs required for PCR rapid testing would require careful evaluation of use particularly in patient populations with low MRSA endemicity (27,28).

In contrast, a 2012 Norwegian study by Li et al compared the cost-effectiveness of PCR testing with broth-enriched culture. They found that the broth enriched strategy was more expensive (€2055 per patient) than daytime or 24h Xpert PCR tests (€890 and €446, respectively). The new PCR tests reduced length of pre-emptive isolation (by 43.9h daytime Xpert and 57.5h 24h Xpert) and also the number of unavailable room hours per patient. However, the improvement of patient quality adjusted life year was nominal (2.4* 10(-4) and 3.0*10(-4) QALYs per patient for the daytime Xpert strategy and 24h Xpert test, respectively.)(29)

A US cost comparison study reported that same-day PCR testing of high risk patients resulted in fewer infection compared to different culture-based tests and the lowest total costs, however test characteristics (particularly turnaround time), transmission rates, prevalence rates and hospital size were highly influential (9). In contrast, the cost of targeted screening and isolation per averted MRSA infection was found to lower with chromogenic-based screening in high and medium prevalence settings compared to PCR-based tests (10). The use of culture confirmation of positive PCR results in combination with pre-emptive isolation was found to generate the lowest costs for a hospital in a German cost comparison study (10).

In summary, the available evidence of the cost-effectiveness of PCR-based testing compared to traditional culture based testing is conflicting. Differences in local prevalence rates, resistance patterns and organisational issues (e.g. laboratory processing) limit the generalisability of the international studies to the Irish healthcare setting. This is consistent with the recommendation in the clinical guideline where it is noted that PCR-based testing may be considered as an alternative to the current gold standard (culture-based testing) in certain facilities, but given the higher cost of testing, its introduction should be informed by an economic evaluation to determine the optimal testing approach.

Budget impact of the proposed guideline for MRSA prevention

Scope of the budget-impact analysis
Rather than cost each recommendation statement, the cost-impact analysis focuses on two main areas as determined by discussions with the MRSA guideline development group:

1. Overall cost implications of MRSA prevention

2. Additional cost implications that may arise from changes in the updated guideline. The specific areas for consideration include:
   a. Recommendation of a throat swab
   b. Laboratory resource limitations and future PCR testing possibilities
   c. Work exclusion of HCW and food handlers who carry MRSA

d. Any variability or gap in terms of the recommendations and current practice and what costs might accrue to address this variability.

The updated guideline is not expected to result in a significant cost to healthcare providers at a national level because it is close to current practice or is likely to be cost neutral. In addition, there has already been a significant investment by the Health Service Executive to prevent HCAIs and MRSA since the implementation of the MRSA prevention guidelines of 2005.

Overall cost implications

Regarding the healthcare costs of MRSA, the Health Service Executive has calculated that over 25,000 patients may acquire a HCAI annually at a cost of €118 million (Table 1). If 10% of all HCAI are due to MRSA this represents a figure of €23 million per annum spent on MRSA alone. If one third of HCAI in Ireland could be prevented then approximately €7.6 million per year would be saved from those due to MRSA. Similarly, an expert group in 2010 reviewed the above and other data and calculated that the costs in Ireland of MRSA in the hospital setting alone were also €23 million annually. A pro rata figure of the impact at national level resulting in costs to careers and to the general economy for Ireland could be calculated from those estimated to apply to the UK, which are £3-8 billion annually (30).

Table 1. Estimation of the costs of HCAI in Ireland for 2011 extrapolated from national and international sources

2011	Hospital admissions	Patients with HCAI[1]	Extra hospital days[2, 3]	Estimated cost for all HCAIs[3]	Deaths expected if 3.68%[2] or 13% mortality rate[3*]	If 10% of HCAI were prevented there would have been a cost saving of:
Overall	587,753	29,388	117,552 or 411,432	€118,257,312	1,081 or 3,820	€11,825,731
West	147,547	7,377	29,508 or 103,278	€29,685,048	271 or 959	€2,968,505
South	150,345	7,517	30,068 or 105,238	€30,248,408	277 or 977	€3,024,841
Dublin Mid-Leinster	173,285	8,664	34,656 or 121,296	€34,863,936	319 or 1,126	€3,486,394
Dublin North-East	116,576	5,829	23,316 or 81,606	€23,455,896	215 or 757	€2,345,590

1 Data sourced from the National Point Prevalence Study in Ireland 2006, reference 18.
2 European Centre for Disease Prevention & Control, Annual Epidemiological Report 2008, reference 21
3 Plowman Report 1999: 'The Socio-economic Burden of Hospital Acquired Infection', reference 22

* for comparison purposes 552 deaths due to suicide; 238 due to road traffic accidents; 59 due to murder/manslaughter. Data from the 2009 Garda Síochana Annual Report, reference 23.

Data from the European Centre for Disease Prevention & Control (ECDC), Annual Epidemiological Report 2008 have been used to calculate length of stay and the number of deaths (31). Although the Plowman report was published 14 years ago (32), it is very comprehensive and is based on the UK health system which is similar in many respects to the Irish health system. The ECDC report is based on all of Europe. The cost estimate includes longer term and wider societal costs (e.g. ongoing healthcare needs, disability costs, litigation, loss of productivity etc.). The Plowman report also calculated that patients in the UK, who acquire an infection in hospital, when compared with uninfected patients, were estimated to take an additional 8.7 million days to resume normal daily activities. Savings have been calculated based on a preventable reduction in HCAIs of

10% but this may be an underestimate as most device-related infections, e.g. catheter-related BSI and catheter-associated urinary tract infection including those caused by MRSA, are very preventable, and for these, the potential preventable proportion may be 50-70% .

Possible additional cost implications of 2013 guideline update

a) ***Recommendation of an additional throat swab –*** The addition of a throat swab to the testing sites was considered to be a negligible cost by the guideline development group. In many laboratories, specimens are pooled for processing and the implication of the additional swab was not thought to add significantly to the financial or personnel resources required for processing. By detecting throat carriage and eradicating MRSA from that site, decolonisation strategies were thought to be enhanced and may result in fewer follow-up specimens.

b) ***The use of PCR testing in certain hospitals or patient groups –*** Although PCR testing is widely used in the United States, it is not routinely used in Ireland due to the higher test costs compared to traditional chromogenic media-based tests. As noted in the review of the international economic literature, PCR testing is noted to be more costly, although it may be cost-effective in certain circumstances. The guideline development group concurred with the guideline recommendations that while it may be appropriate to introduce PCR testing in certain circumstances, its use should be evaluated. A limited Health Technology Assessment that assesses the cost-effectiveness and budget impact of the intervention in that hospital (or hospital group) would help inform the decision by providing advice in relation to the optimal testing strategy (e.g. patient group, laboratory logistics etc).

c) ***Work exclusion for HCW/food-handlers –*** The recommendation states that: '*Occupational Health (OH) should recommend the exclusion of clinical HCWs and food handlers from work (having obtained appropriate cultures) if they have dermatitis, chronic skin conditions, a draining lesion on hand(s), or other exposed site where MRSA colonisation is likely until the infection has been ruled out or they have received adequate therapy and their infection has resolved.*' The guideline development group concluded that this was in line with best practice, applies to a small number of individuals and thus is likely to have a very limited budget impact. Were these recommendations not implemented, further cases and outbreaks would result in increased requirement for investigation and treatment of affected healthcare workers, food handlers and patients, thereby increasing cases and costs.

d) ***Any variability or gap in terms of the recommendations and current practice and what costs might accrue to address this variability –*** It was noted that the 2013 guideline is an update of previous national guidelines published in 2005. These include only a limited number of changes or new recommendations that might result in an increase in resource consumption (points a-c above). The recommendations in the guideline should therefore be close to current practice or budget neutral. However, it was noted that a 2007 survey by the Strategy for the Control of Antimicrobial Resistance in Ireland (SARI) sub-committee identified a number of significant challenges that have impeded full implementation of the 2005 national guidelines. Of 49 acute care hospitals surveyed, 49% and 69% respectively reported that their infrastructure and laboratory resources were adequate to support only partial implementation of the guideline. Specific deficiencies included inadequate staffing levels, high bed occupancy rates, and the limited availability of single rooms (33). The absence of written policies on antibiotic use, antibiotic stewardship programmes and educational programmes on hand hygiene were also highlighted. While it is reported that there is no more recent national information on the compliance with implementation of the 2005 national guidelines, as part of the national clinical programme for the prevention and control of healthcare-associated infections and antimicrobial resistance, there have been improvements in hand hygiene and antimicrobial stewardship, education and monitoring. Furthermore, HPSC data indicate that there has been a significant decline in the proportion of MRSA bloodstream infections reported in Ireland from 42% in 2006 to 20.6% in 2013 (34). In the absence of updated compliance data, it is not possible to determine if full implementation of the 2013 guideline will result in significant

additional resource implications. The available international evidence suggest that the full implementation of updated MRSA guideline should have a positive impact on the control and prevention of health care associated infections in general, including a reduction in the number of patients acquiring MRSA in our healthcare facilities. This would include reduced healthcare facility stay, avoid the need for additional investigations and treatments and potentially have a wider benefit to society with respect to patients being able to return to work. Costs incurred would therefore likely be offset by savings and result in more efficient use of existing healthcare resources and facilities.

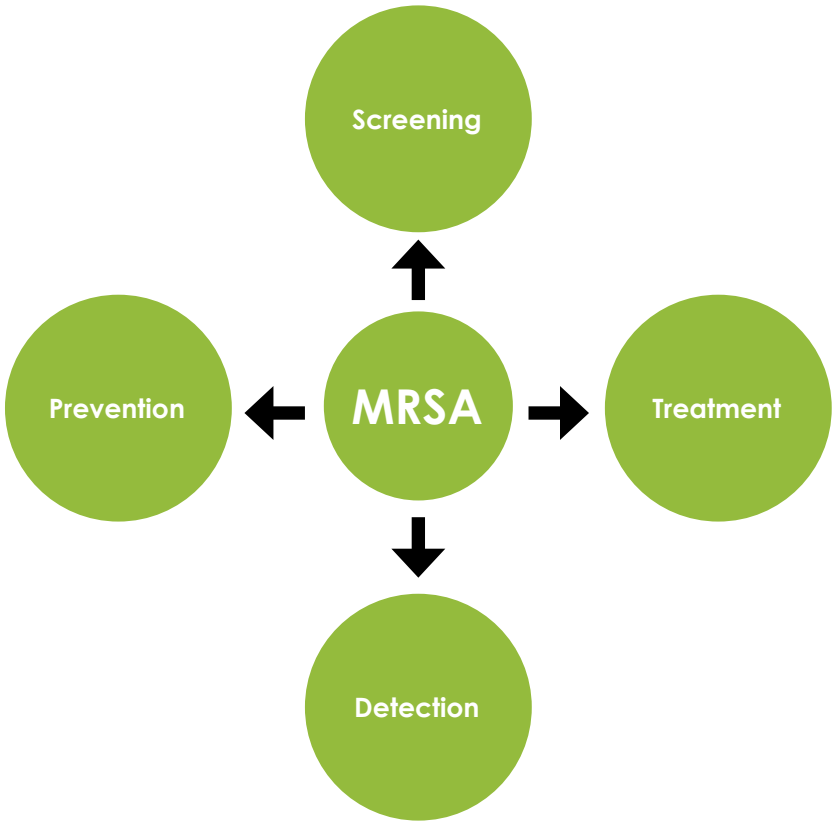
Methods

The search strategy is based on the one used in the clinical literature review with the addition of an economic filter (1) for the Medline and EMBASE search. The parameters, i.e. population, interventions, comparisons, and outcomes (PICOS) were provided along with the search strategy and the detailed search terms used in OVID Medline and EMBASE) and the Database of Abstracts of Reviews of Effects, NHS Economic Evaluation Database, Health Technology Assessment Database, Cochrane Central Register of Controlled Trials and Cochrane Database of Systematic Reviews.

Schema of topic search

The systematic review was divided in to four broad concepts as outlined in Figure 1.

Figure 1 Concepts for systematic review of economic impact report of MRSA prevention



PICOs and search terms

Intervention 1: MRSA Screening

Population: All patients, residents or clients who may be at risk of or may have MRSA in acute hosptials, obstetrics and neonates, nursing homes/long stay residential units and the community

Intervention: Targeted screening for MRSA for those deemed at risk of MRSA

Comparison: Targeted screening for MRSA, universal screening (i.e. all patients on admission to acute hospitals) – comparison against each other or with no intervention

Outcomes: Resources and costs

Concepts and key words

- MRSA
  - Methicillin-resistant *Staphylococcus aureus*

- Targeted Screening
  - At risk screening
  - Limited screening
  - Priority screening

- Universal Screening
  - Inpatient screening
  - All patient screening
  - New admission screening

ID	Search	Hits	
		Pubmed	Embase
1	"methicillin-resistant staphylococcus aureus"[MeSH Terms] OR ("methicillin-resistant"[All Fields] AND "staphylococcus"[All Fields] AND "aureus"[All Fields]) OR "methicillin-resistant staphylococcus aureus"[All Fields] OR "mrsa"[All Fields]	20811	30489
2	"diagnosis"[Subheading] OR "diagnosis"[All Fields] OR "screening"[All Fields] OR "mass screening"[MeSH Terms] OR ("mass"[All Fields] AND "screening"[All Fields]) OR "mass screening"[All Fields] OR "screening"[All Fields] OR "early detection of cancer"[MeSH Terms] OR ("early"[All Fields] AND "detection"[All Fields] AND "cancer"[All Fields]) OR "early detection of cancer"[All Fields]	4847847	483472
3	1 AND 2 AND economic filter	245	358

Table 1 Economic Filter

ID	Search	Hits
6	*Economics/	21479
7	*Economics, Medical/	21559
8	*Economics, Pharmaceutical/	5872
9	exp "Costs and Cost Analysis"/	400064
10	exp Health Care Costs/	224939

ID	Search	Hits
11	exp decision support techniques/	64779
12	exp models, economic/	102782
13	markov chains.sh.	8346
14	montecarlo method.sh.	35519
15	uncertainty.sh.	10158
16	quality of life.sh.	308452
17	quality-adjusted life years.sh.	5950
18	exp health economics/	564180
19	exp economic evaluation/	190553
20	exppharmacoeconomics/	160770
21	exp economic aspect/	1047120
22	quality adjusted life year/	15615
23	quality of life/	308452
24	exp "costs and cost analyses"/	168352
25	(economic impact or economic value or pharmaco-economics or health care cost or economic factors or cost analysis or economic analysis or cost or cost-effectiveness or cost effectiveness or costs or health care cost or cost savings or cost-benefit analysis or hospital costs or medical costs or quality-of-life).sh.	592852
26	(econom$ or cost or costly or costing or costed or price or prices or pricing or priced or discount or discounts or discounted or discounting or expenditure or expenditures or budget$ or afford$ or pharmacoeconomic or pharmaco-economic$).ti,ab.	1046158
27	(cost$ adj1 (util$ or effective$ or efficac$ or benefit$ or consequence$ or analy$ or minimi$ or saving$ or breakdown or lowering or estimate$ or variable$ or allocation or control or illness or sharing or life or lives or affordabl$ or instrument$ or technolog$ or day$ or fee or fees or charge or charges).ti,ab.	212069
28	(decision adj1 (tree$ or analy$ or model$)).ti,ab.	20279
29	((value or values or valuation) adj2 (money or monetary or life or lives or costs or cost)).ti,ab.	8947
30	(qol or qoly or qolys or hrqol or qaly or qalys or qale or qales).ti,ab.	63557
31	(sensitivity analys$s or quality-adjusted life year$ or quality adjusted life year$ or quality-adjusted life expectanc$ or quality adjusted life expectanc$).ti,ab.	11826
32	(unit cost or unit-cost or unit-costs or unit costs or drug cost or drug costs or hospital costs or health-care costs or health care cost or medical cost or medical costs).ti,ab.	45098
33	(decision adj1 (tree$ or analy$ or model$)).ti,ab.	20279
34	or/6-33	2377303

Intervention 2: MRSA prevention

Population: All patients, residents or clients who may be at risk of or may have MRSA in acute hosptials, obstetrics and neonates, nursing homes/long stay residential units and the community.

Intervention: MRSA prevention

Comparison: MRSA prevention interventions applied to target population compared with no prevention intervention applied

Outcomes: Resources and costs

Concepts and key words

- MRSA
  - Methicillin-resistant *Staphylococcus aureus*
- Prevention
- Community acquired
- Hospital acquired
- Hygiene
  - Decontamination
  - Decolonisation

ID	Search	Hits	
		Pubmed	Embase
1	"methicillin-resistant staphylococcus aureus"[MeSH Terms] OR ("methicillin-resistant"[All Fields] AND "staphylococcus"[All Fields] AND "aureus"[All Fields]) OR "methicillin-resistant staphylococcus aureus"[All Fields] OR "mrsa"[All Fields]	20811	30489
2	("prevention and control"[Subheading] OR ("prevention"[All Fields] AND "control"[All Fields]) OR "prevention and control"[All Fields] OR "prevention"[All Fields]) OR (("residence characteristics"[MeSH Terms] OR ("residence"[All Fields] AND "characteristics"[All Fields]) OR "residence characteristics"[All Fields] OR "community"[All Fields]) AND acquired[All Fields]) OR (("hospitals"[MeSH Terms] OR "hospitals"[All Fields] OR "hospital"[All Fields]) AND acquired[All Fields]) OR ("hygiene"[MeSH Terms] OR "hygiene"[All Fields]) OR ("decontamination"[MeSH Terms] OR "decontamination"[All Fields]) OR decolonisation[All Fields] OR ("decontamination"[MeSH Terms] OR "decontamination"[All Fields]) OR ("infection"[MeSH Terms] OR "infection"[All Fields] OR "communicable diseases"[MeSH Terms] OR ("communicable"[All Fields] AND "diseases"[All Fields]) OR "communicable diseases"[All Fields])	2354223	1896174
3	1AND 2 AND Economic Filter	619	168

Intervention 3: MRSA prevention

Population: All patients, residents or clients who may be at risk of or may have MRSA in acute hosptials, obstetrics and neonates, nursing homes/long stay residential units and the community.

Intervention: Treatment options for MRSA

Comparison: Between treatment and no treatment; between different treatment options

Outcomes: Resources and costs

Concepts and key words

- MRSA
  - Methicillin-resistant *Staphylococcus aureus*

- Hygiene
  - Antibiotics
  - Mupiricin
  - Vancomycin
  - Linezolid
  - Daptomycin

ID	Search	Hits	
		Pubmed	Embase
1	"methicillin-resistant staphylococcus aureus"[MeSH Terms] OR ("methicillin-resistant"[All Fields] AND "staphylococcus"[All Fields] AND "aureus"[All Fields]) OR "methicillin-resistant staphylococcus aureus"[All Fields] OR "mrsa"[All Fields]	20811	30489
2	("anti-bacterial agents"[Pharmacological Action] OR "anti-bacterial agents"[MeSH Terms] OR ("anti-bacterial"[All Fields] AND "agents"[All Fields]) OR "anti-bacterial agents"[All Fields] OR "antibiotics"[All Fields]) OR ("mupirocin"[MeSH Terms] OR "mupirocin"[All Fields]) OR ("vancomycin"[MeSH Terms] OR "vancomycin"[All Fields]) OR ("linezolid"[Supplementary Concept] OR "linezolid"[All Fields]) OR ("daptomycin"[MeSH Terms] OR "daptomycin"[All Fields])	592738	185
3	1 AND 2 AND Economic filter	395	23

Intervention 4: MRSA detection

Population: All patients, residents or clients who may be at risk of or may have MRSA in acute hosptials, obstetrics and neonates, nursing homes/long stay residential units and the community.

Intervention: MRSA detection options with PCR or Culture

Comparison: Between treatment and no treatment; between different treatment options

Outcomes: Resources and costs

Concepts and key words

- MRSA
  - Methicillin-resistant *Staphylococcus aureus*
- Polymerase chain reaction (PCR)
  - Polymerase Chain Reaction
- Broth Enrichment
  - Culture

ID	Search	Hits	
		Pubmed	Embase
1	(PCR[All Fields] OR ("polymerase chain reaction"[MeSH Terms] OR ("polymerase"[All Fields] AND "chain"[All Fields] AND "reaction"[All Fields]) OR "polymerase chain reaction"[All Fields]) OR broth[All Fields] OR enrichment[All Fields] OR ("ethnology"[Subheading] OR "ethnology"[All Fields] OR "culture"[All Fields] OR "culture"[MeSH Terms])) AND ("methicillin-resistant staphylococcus aureus"[MeSH Terms] OR ("methicillin-resistant"[All Fields] AND "staphylococcus"[All Fields] AND "aureus"[All Fields]) OR "methicillin-resistant staphylococcus aureus"[All Fields] OR "mrsa"[All Fields])	4200	52486
3	1 AND 2 AND Economic filter	159	557

Citations retrieved per topic area

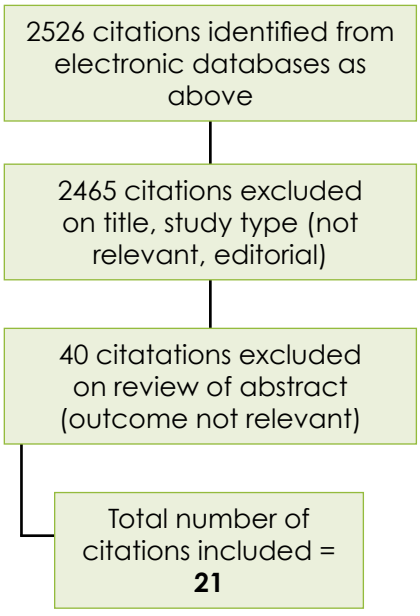
Topic area	*Pubmed, Embase, Web of Science, Up TO Date, Dynamed, Google Scholar, Cinahl, Trip, Guidleines.Gov, NICE, Cochrane/DARE/CCR
Screening	603
Prevention	789
Treatment	418
Detection	716

* A keyword search was employed alongside Mesh search as it could pick up the more recent e-pub ahead of print material. A keyword search also drew the closest mesh term meaning so that both options were covered. An economic filter was not used as a limit in the databases. Although this meant that there were irrelevant studies retrieved, given the paucity of economic studies in general, a broad initial database search was deemed the most appropriate approach.

Topic Area	Included studies after title review
Screening	27
Prevention	12
Treatment	6
Detection	16

Topic Area	Included studies after full publication review
Screening	7
Prevention	5
Treatment	4
Detection	5
Total	21

Flow Chart of Excluded Studies



References

1. Glanville J, Fleetwood K., Yellowlees A et al., (2009) Development and testing of search filters to identify economic evaluations in MEDLINE and EMBASE. Ottowa: Canadian Agency for Drugs and Technologies in Health. *(Modelling study)*

2. Department of Health and Children North/South study of MRSA in Ireland 1999, 2000. Dublin. *(Observational Study)*

3. McDonald P, Mitchell E, Johnson H et al. Epidemiology of MRSA: the North/South study of MRSA in Ireland 1999. *J Hosp Infect* 2003; 54:130-134. *(Observational Study)*

4. Rossney AS, McDonald P, Humphreys H, Glynn GM, Keane CT. Antimicrobial resistance and epidemiological typing of methicillin-resistant *Staphylococcus aureus* in Ireland (North and South), 1999. *Eur J Clin Microbiol Infect Dis* 2003; 22:379-381. *(Observational Study)*

5. Burd M, Humphreys H, Glynn G et al. Control and the prevention of methicillin-resistant *Staphylococcus aureus* in hospitals in Ireland: North/South Study of MRSA in Ireland 1999. *J Hosp Infect* 2003; 53:297-303. (Observational Study)

6. McDonald P, Mitchell E, Johnson H et al. MRSA bacteraemia: North/South Study of MRSA in Ireland 1999. *J Hosp Infect* 2002; 52:288-291. *(Observational Study)*

7. Smyth ETM, McIlvenny G, Enstone JE *et al.* Four country healthcare associated infection prevalence survey 2006: overview of the results. *J Hosp Infect* 2008; 69:230-248. *(Observational Study)*

8. Burns K, Foley M, Donlon S. Point prevalence survey of healthcare-associated infection and antimicrobial use in European acute care hospitals, May 2012. Republic of Ireland: national report, May 2012. *(Observational Study)*

9. Olchanski N, Mathews C, Fusfield L, Jarvis W. Assessment of the influence of test characteristics on the clinical and cost impacts of methicillin-resistant *Staphylococcus aureus* screening programs in US hospitals. *Infect Control Hosp Epidemiol* 2011; 32:250-7 *(Observational Study)*

10. Tubbicke A, Hubner C, Flessa S. Cost comparison of MRSA screening and management – decision tree. *BMC Health Serv Res* 2012; 12:438. *(Observational study)*

11. Kang J, Mandsager P, Biddle A, Weber D. Cost-effectiveness analysis of active surveillance screening for methicillin-resistant *Staphylococcus aureus* in an academic hospital setting. *Infect Control Hosp Epidemiol*; 33:477-86. *(Observational study)*

12. Leonhardt K, Yakusheva O, Costello M. Clinical effectiveness and cost benefit of universal versus targeted methicillin-resistant *Staphylococcus aureus* screening upon admission in hospitals. *Infect Control Hosp Epidemiol* 2011; 32:797-803. *(Observational study)*

13. Collins J, Raza M, Ford M, Gould FK. Review of a three-year methicillin-resistant *Staphylococcus aureus* screening programme. *J Hosp Infect* 2011; 78:81-5. *(Observational study)*

14. Creamer E, Galvin S, Dolan A, Humphreys H et al. Evaluation of screening risk and nonrisk patients for methicillin-resistant *Staphylococcus aureus* on admission in an acute care hospital. *Am J Infect Control* 2012; 40:411-5. *(Observational study)*

15. Gould IM, Reilly J, Bunyan D, Walker A. Costs of healthcare-associated methicillin-resistant *Staphylococcus aureus* and its control. *Clin Microbiol Infect* 2010; 16:1721-8. (*Observational study*)

16. You JH, Chan CY, Wong MY, Ip M. Active surveillance and decolonization of methicillin-resistant *Staphylococcus aureus* on admission to neonatal intensive care units in Hong Kong. *Infect Control Hosp Epidemiol* 2012; 33:1024-30. (*Observational study*)

17. Farbman L, Avni T, Paul M. Cost-benefit of infection control interventions targeting methicillin-resistant *Staphylococcus aureus* in hospitals: systematic review. *Clin Microbiol Infect*. 2013. (*Systematic review*)

18. Robotham JV, Deeny SR, Cooper BS. Targeted versus universal screening and decolonization to reduce healthcare-associated methicillin-resistant *Staphylococcus aureus* infection. *J Hosp Infect* 2013; 85:33-44 (*Observational study*)

19. Van Rijen MM, Kluytmans JA. Costs and benefits of the MRSA search and destroy policy in a Dutch hospital. *Eur J Clin Microbiol Infect Dis* 2009; 28:1245-52. (*Observational study*)

20. Spence MR, Dammel T, Courser S. Contact precautions for methicillin-resistant Staphylococcus aureus colonization: costly and unnecessary? *Am J Infect Control*; 2012 40:535-8. (*Observational study*)

21. Bounthavong M, Hsu DI, Vanness Dj. Cost effectiveness analysis aurens of linezolid, daptomycin and vancomycin in methicillin-resistant Staphylococcus aureus: complicated skin and skin structure infection using Bayesian methods for evidence synthesis. *Value Health*. 2011; 14(5): 631-639. (*Observational study*)

22. Wright BM, Eiland EH. Retrospective analysis of clinical and cost outcomes associated with methicillin-resistant *Staphylococcus aureus* complicated skin and skin structure infections treated with daptomycin, vancomycin or linezolid. *J Pathog*. 2011:347969 (*Observational study*)

23. De Cock E, Sorensen S, Levrat F et al. Cost-effectiveness of linezolid versus vancomycin for hospitalised patients with complicated skin and soft-tissue infections in France. *Med Mal Infect*. 2009;39(5):330-340. (*Observational study*)

24. De Cock E, Krueger WA, Sorensen S et al. Cost-effectiveness of linezolid vs vancomycin in suspected methicillin-resistant *Staphylococcus aureus* nosocomial pneumonia in Germany. Infection. 2009; 7(2):123-132. (*Observational study*)

25. Andersen BM, Tollefsen T, Sandvik L et al. Rapid MRSA test in exposed persons: costs and savings in hospitals. J Infect 2010; 60:293-9. (*Observational study*)

26. Chan WS, Tang BS, Leung PH et al. Detection of methicillin-resistant *Staphylococcus aureus* using a gold nanoparticle-based coulourimetric polymerase chain reaction assay. *Biosens Bioelectron* 2013; 53c:105-111. (*Observational study*)

27. Buhlmann M, Droz S, Muhlemann K et al. Rapid screening for carriage of methicillin-resistant *Staphylococcus aureus* by PCR and associated costs. *J Clin Microbiol* 2008; 46:2151-4. (*Observational study*)

28. Fiolic Z, Budimir A et al. The screening of methicillin-resistant *Staphylococcus aureus* in vascular surgery patients: a comparison of molecular testing and broth-enriched culture. *Chemotherapy* 2012; 58:330-6. (*Observational study*)

29. Li J, Ulvin K, Kristiansen IS, et al. Cost-effectiveness of supplementing a broth-enriched culture test with the Xpert methicillin-resistant *Staphylococcus aureus* (MRSA) assay for screening inpatients at high risk of MRSA. *J Hosp Infect* 2012; 82:227-33. (*Observational study*)

30. Smyth E, Cormican M, Hannan M, McMahon S, Philbin MP. Methicillin-resistant *Staphylococcus aureus* (MRSA) in Ireland: addressing the issues. Dublin 2010. (*Discussion Document*)

31. Annual Epidemiological *Report*. European Centre for Disease Prevention and Control, Stockholm, Sweden, 2008. (*International Report*)

32. Plowmann R. The socio-economic burden of hospital acquired infection. Public Health Laboratory Service, London, UK, 1999. (*Review*)

33. SARI Infection Control Subcommittee. Results from a Survey of Acute Hospitals on the Implementation of the 2005 Updated National Guidelines on the Control and Prevention of MRSA. December 2007. (*Report*)

34. Health Protection Surveillance Centre. Trends in *Staphylococcus aureus*/MRSA bacteraemia in Ireland, 2004 to the end of Q2 2013. October 2013. (*Report*)

5.0 References

Section 2: Recommendations

2.1.1 Screening

1. Clancy M, Graepler MT, Wilson M, Douglas I, Johnson J, Price CS. Active screening in high-risk units is an effective and cost-avoidant method to reduce the rate of methicillin-resistant *Staphylococcus aureus* infection in the hospital. *Infect Control Hosp Epidemiol* 2006; 27: 1009-1017. (*Observational Study*)

2. Shitrit P, Gottesman BS, Katzir N, Kilman A, Ben-Nissan Y, Chowers M. Active surveillance for methicillin-resistant *Staphylococcus aureus* (MRSA) decreases the incidence of MRSA bacteremia. *Infect Control Hosp Epidemiol* 2006; 27: 10004-10008. (*Observational Study*)

3. Jernigan JA, Titus MG, Gröschel DH, Getchell-White S, Farr BM. Effectiveness of contact isolation during a hospital outbreak of methicillin-resistant *Staphylococcus aureus*. Am J Epi 1996; 143: 496-504. (*Observational Study*)

4. Siegel JD, Rhinehart E, Jackson M, Chiarello L, Healthcare Infection Control Practices Advisory Committee. 2007 Guideline for isolation precautions: preventing transmission of infectious agents in healthcare settings. *Am J Infect Control* 2007; 35: 10 (Suppl 2) S65-164. (*Guideline*)

5. Cepeda JA, Whitehouse T, Cooper B, Hails J, *et al.* Isolation of patients in single rooms or cohorts to reduce spread of MRSA in intensive-care units: prospective two-centre study. *Lancet*. 2005 Jan 22-28;365(9456):295-304. (*Prospective Intervention Study*)

6. http://www.cdc.gov/ncidod/dhqp/pdf/isolation2007.pdf. The NHS Scotland MRSA Screening Pathfinder Programme. www.documents.hps.scot.nhs.uk/hai/mrsa-screening/mrsa-screening-interim-summary.pdf (*Clinical Guidelines*)

7. Ritchie K, Bradbury I *et al.* Health Technology Assessment 9: The clinical and cost effectiveness of screening for methicillin-resistant *Staphylococcus aureus* (MRSA). NHS Quality Improvement Scotland 2007. (*Clinical Guidelines*)

8. Screening for MRSA colonisation – a strategy for NHS Trusts: a summary of best practice. Health service guideline. Department of Health. 15 November 2006. http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_063188. (*Clinical Guidelines*)

9. Gilligan P, Quirke M, Winder S, Humphreys H. Impact of admission screening for methicillin-resistant *Staphylococcus aureus* on the length of stay in an emergency department. *J Hosp Infect* 2010; 75: 99-102. (*Observational Study*)

10. Creamer E, Galvin S, Dolan A *et al.* Evaluation of screening risk and non-risk patients for methicillin-resistant Staphylococcal aureus on admission in an acute hospital. *Am J Infect Control* 2012; 40: 411-5 (*Observational Study*)

11. Collins J, Raza M, Ford M, Hall L, Brydon J, Gould FK. Review of a three-year methicillin-resistant *Staphylococcus aureus* screening programme. *J Hosp Infect* 2011; 78: 81-85. (*Observational Study*)

12. Tübbicke A, Hübner C, Hübner NO, Wegner C, Kramer A, Fleßa S. Cost comparison of MRSA screening and management - a decision tree analysis. *BMC Health Serv Res.*2012 Dec 1;12:438. doi: 10.1186/1472-6963-12-438. (*Decision Modelling*)

13. Kang J, Mandsager P, Biddle AK, Weber DJ. Cost-effectiveness analysis of active surveillance screening for methicillin-resistant *Staphylococcus aureus* in an academic hospital setting. *Infect Control Hosp Epidemiol*. 2012;33:477-86. (*Decision Modelling*)

15. Leonhardt KK, Yakusheva O, Phelan D, Reeths A, Hosterman T, Bonin D, Costello M. Clinical effectiveness and cost benefit of universal versus targeted methicillin-resistant *Staphylococcus aureus* screening upon admission in hospitals. *Infect Control Hosp Epidemiol*. 2011; 32: 797-803 (*Observational Study*)

16. McKinnell JA, Huang SS, Eells SJ, Cui E, Miller LG. Quantifying the impact of extranasal testing of body sites for methicillin-resistant *Staphylococcus aureus* colonization at the time of hospital or intensive care unit admission. *Infect Control Hosp Epidemiol* 2013;34:161-70. (*Systematic Review*)

17. Matheson A, Christie P, Stari T, Kavanagh K, Gould IM, Masterton R, Reilly JS.Nasal swab screening for methicillin-resistant *Staphylococcus aureus*-how well does it perform? A cross-sectional study. *Infect Control Hosp Epidemiol* 2012; 33: 803-8. (*Observational Study*)

18. McKinnell JA, Huang SS, Eells SJ, Cui E, Miller LG. Quantifying the impact of extranasal testing of body sites for methicillin-resistant *Staphylococcus aureus* colonization at the time of hospital or intensive care unit admission. *Infect Control Hosp Epidemiol*. 2013;34:161-70. (*Systematic Review*)

19. Mertz, D, Frei R, Jaussi B *et al.* Throat swabs are necessary to reliably detect carriers of *Staphylococcus aureus*. *Clin Infect Dis* 2007; 45: 475-477. (*Observational Study*)

20. Nilsson P, Ripa T. *Staphylococcus aureus* throat colonisation is more frequent than colonisation in the anterior nares. *J Clin. Microbiol* 2006; 44: 3334-3339. (*Observational Study*)

21. Marshall C, Spelman D. Is throat screening necessary to detect methicillin-resistant *Staphylococcus aureus* colonisation in patients upon admission to an intensive care unit? *J Clin Microbiol* 2007; 45: 3855. (*Observational Study*)

22. Harbarth S, Schrenzel J, Renzi G, Akakpo C, Ricou B. Is throat screening necessary to detect methicillin-resistant *Staphylococcus aureus* colonisation in patients upon admission to an intensive care unit? *J Clin Microbiol* 2007; 45: 1048–1073. (*Observational Study*)

23. Salgado CS, Farr B. What proportion of hospital patients colonised with methicillin-resistant *Staphylococcus aureus* are identified by clinical microbiological cultures? *Infect Control Hosp Epidemiol* 2006; 27:116-121. (*Observational Study*)

24. Rossney AS, Herra CM, Brennan GI, Morgan PM, O'Connell B. Evaluation of the Xpert methicillin-resistant *Staphylococcus aureus* (MRSA) assay using the GeneXpert Real-Time PCR platform for rapid detection of MRSA from screening specimens *J Clin Microbiol*. 2008 ;46: 3285-90. (*In-vitro Study*)

25. Hardy K, Price C, Szczepura A *et al.* Reduction in the rate of methicillin-resistant *Staphylococcus aureus* acquisition in surgical wards by rapid screening for colonisation: a prospective, cross-over study. *Clin Microbiol Infect* 2010; 16: 333-339. (*Interventional Study*)

26. Creamer E, Dolan A, Sherlock O *et al.* The effect of rapid screening for methicillin-resistant *Staphylococcus aureus* (MRSA) on the identification and earlier isolation of MRSA-positive patients. *Infect Control Hosp Epidemiol* 2010; 31: 374-381. (*Observational Study*)

27. Rossney AS, Herra CM, Fitzgibbon MM, Morgan PM, Lawrence MJ, O'Connell B. Evaluation of the IDI-MRSA assay on the SmartCycler real-time PCR platform for rapid detection of MRSA from screening specimens. *Eur J Clin Microbiol Infect* Dis 2007; 26: 459-66. (*In-vitro Study*)

28. Polisena J, Chen S, Cimon K, McGill S, Forward K, Gardam M. Clinical effectiveness of rapid tests for methicillin resistant *Staphylococcus aureus* (MRSA) in hospitalized patients: a systematic review. BMC Infect Dis. 2011 Dec 12;11:336. doi: 10.1186/1471-2334-11-336 (*Literature Review*)

29. Policy Group on Healthcare-Associated Infection (HCAI). How to advise patients with a HCAI – Guidance for healthcare workers in dealing with patients and members of the public. The Royal College of Physicians of Ireland, 2010. (*Discussion document*)

2.1.2 Infection prevention and control measures in the acute hospital setting

1. Apisarnthanarak A, Khawcharoenpron T & Mundy L Practices to prevent multidrug-resistant Acinetobacter baumannii and methicillin-resistant *Staphylococcus aureus* in Thailand: A national survey. *American Journal of Infection Control* 2012; 1-6. (*National Survey*)

2. Pittet D, Mourouga P, Perneger TV. Compliance with hand washing in a teaching hospital. Infection Control Program. *Ann Intern Med* 1999; 130: 126-130. (*Observational Study*)

3. Clements A, Halton K, Graves N *et al.* Overcrowding and understaffing in modern health-care systems: key determinants in methicillin-resistant *Staphylococcus aureus* transmission. *The Lancet* 2008; 8: 427-434. (*Review*)

4. Haley RW, Cushion NB, Tenover FC *et al.* Eradication of endemic methicillin-resistant *Staphylococcus aureus* infections from a neonatal intensive care unit. *J Infect Dis* 1995; 171:614-624. (*Observational Study*)

5. Fridkin SK, Pear SM, Williamson TH, Galgiani JN, Jarvis WR. The role of understaffing in central venous catheter-associated bloodstream infections. *Infect Control Hosp Epidemiol* 1996; 17: 150-158. (*Case-Control & Cohort Study*)

6. Arnow P, Allyn PA, Nichols EM, Hill DL, Pezzlo M, Bartlett RH. Control of methicillin-resistant *Staphylococcus aureus* in a burn unit: role of nurse staffing. *J Trauma* 1982; 22:954-959. (*Retrospective Study*)

7. Kong F, Cook D, Paterson DL, Whitby M, Clements ACA. Do staff and workload levels influence the risk of new acquisition of methicillin-resistant Staphlococcus aureus in a well resourced intensive care unit. *J Hosp Infect* 2012; 80: 831-339. (*Observational Study*)

8. Health Information and Quality Authority. National Standards for the Prevention and Control of Healthcare Associated Infections 2009. (*National Standards*)

9. Department of Health (2003). Winning ways. Working together to reduce healthcare associated infections in England. Report from the chief Medical Officer, UK. (*National Report*)

10. NHS Estates (2002). Infection control in the built environment, UK. (*National Guidelines*)

11. Hignett S. Determining the space needed to operate a mobile and an overhead patient hoist. *Nursing Times* 2005; Nursing times.net. (*Survey*)

12. Strategy for the control of Antimicrobial Resistance in Ireland (SARI). Infection prevention and control building guidelines for acute hospitals in Ireland, Health Protection Surveillance Centre 2008. (*National Guidelines*)

13. HBN1. Buildings for health service. London: HMSO, 1998. (*National Guidelines*)

14. Manual Handling. Guidance on regulations. London: HMSO, 1992. (*National Guidelines*)

15. Williams RE, Jevons MP, Shooter RA, Thom BT, Noble WC, Lidwell OM. Isolation for the control of staphylococcal infection in surgical wards. *Br Med J* 1962; 2(5300); 275-282. (*Observational Study*)

16. Turner GC, Watson DC, Abbott JD. An isolation ward for patients with staphylococcal sepsis. *Lancet* 1965; 40: 426-429. (*Review*)

17. Eveillard M, Eb F, Tramier B *et al.* Evaluation of the contribution of isolation precautions in prevention and control of multi-resistant bacteria in a teaching hospital. *J Hosp Infect* 2001; 47:116-124. (*Evaluation and Control Programme*)

18. Jernigan JA, Titus MG, Groschel DH, Getchell-White S, Farr BM. Effectiveness of contact isolation during a hospital outbreak of methicillin-resistant *Staphylococcus aureus*. Am J Epidemiol 1996;143:496-504. (*Prospective Study*)

19. Pogorzelska M., Stone P.W. & Larson E.L. Wide variation in adoption of screening and infection control interventions for multidrug-resistant organism: *American Journal of Infection Control* 2012; 40:696-700. (*National Study*).

20. Cookson BD, Phillips I. Epidemic methicillin-resistant *Staphylococcus aureus*. *J Antimicrob Chemother* 1988; 21 Suppl C:57-65. (*In-vitro Study*)

21. Fitzpatrick F, Murphy OM, Brady A, Prout S, Fenelon LE. A purpose built MRSA cohort unit. *J Hosp Infect* 2000; 46:271-279. (*Observational Study*).

22. Selkon JB, Stokes ER, Ingham HR. The role of an isolation unit in the control of hospital infection with methicillin-resistant staphylococci. *J Hosp Infect* 1980; 1: 41-46. (*Observational Study*)

23. Shanson DC, McSwiggan DA. Operating theatre acquired infection with a gentamicin-resistant strain of *Staphylococcus aureus*: outbreaks in two hospitals attributable to one surgeon. *J Hosp Infect* 1980;1:171-148. (*Outbreak Report*)

24. Bradley JM, Noone P, Townsend DE, Grubb WB. Methicillin-resistant *Staphylococcus aureus* in a London hospital. *Lancet* 1985; 1(8444):1493-1495. (*Review*)

25. Duckworth GJ, Lothian JL, Williams JD. Methicillin-resistant *Staphylococcus aureus*: report of an outbreak in a London teaching hospital. *J Hosp Infect* 1988; 11: 1-15. (*Outbreak Report*)

26. Association of Medical Microbiologists. Review of hospital isolation and infection control related precautions 2002. (*Review*)

27. SHEA/IDSA practice recommendations "Strategies to prevent transmission of methicillin-resistant Staphylococcus aureus in acute care hospitals". Infect Control Hosp Epidemiol, 2008; 29:Supplement 1. (*Guidelines*)

28. Strategy for the Control of Antimicrobial Resistance in Ireland. Guidelines for hand hygiene in Irish healthcare settings. HSE, Health Protection Surveillance unit: Dublin. 2005. (*National Guidelines*)

29. *MMWR* (2002). Guideline for Hand Hygiene in Health-Care Settings Recommendations of the Healthcare Infection Control Practices" Advisory Committee and the HICPAC/SHEA/APIC/ IDSA. Hand Hygiene Task Force. CDC. (*National Guidelines*)

30. Muto CA, Jernigan JA, Ostrowsky BE et al. SHEA guidelines for preventing nosocomial transmission of multidrug-resistant strains of *Staphylococcus aureus* and enterococcus. *Infect Control Hosp Epidemiol* 2003; 362-386. (*Guidelines*)

31. Guidelines for the Control of Methicillin-resistant *Staphylococcus aureus* in New Zealand. (2002). Wellington, New Zealand, Ministry of Health. (*National Guidelines*)

32. Pittet D, Hugonnet S, Harbarth S *et al.* Effectiveness of a hospital-wide programme to improve compliance with hand hygiene. *Lancet* 2000; 356: 1307-1312. (*Intervention Study*)

33. Dutch working party on infection prevention & control (2006). MRSA policy in the Netherlands. Health Council of the Netherlands. (*National Guidelines*)

34. Creamer E, Dorrian S, Dolan A *et al.* When are the hands of healthcare workers positive for methicillin-resistant *Staphylococcus aureus*? *J Hosp Infect* 2010; 75: 107-111. (*Observational Study*)

35. WHO. Guidelines on Hand Hygiene in Healthcare. Patient Safety challenge clean Care is Safer Care (2009). (*Guidelines*)

36. Gagne D, Bédard G and Maziade PJ. Systematic patients' hand disinfection: impact on methicillin-resistant *Staphylococcus aureus* infection rates in a community hospital. *J Hosp Infect* 2010; 75:269-248. (*Intervention Study*)

37. Siegel JD, Rhinehart E, Jackson M, Chiarello L, Healthcare Infection Control Practices Advisory Committee. 2007 Guideline for isolation precautions: preventing transmission of infectious agents in healthcare settings. *Am J Infect Control* 2007; 35: 10 (Suppl 2) S65-164. (*Guidelines*)

38. Moore G., Dunnill C.W. & Wilson P.R. The effect of glove material upon the transfer of methicillin-resistant *Staphylococcus aureus* to and from a gloved hand. *American Journal of Infection Control* 2013; 19-23. (*In-vitro Study*)

39. Gaspard P, Eschach E, Gunther D, Gayet, Bertrand X & Talon D. Meticillin-resistant *Staphylococcus aureus* contamination of healthcare workers' uniforms in long-term care facilities. *Journal of Hospital Infection* 2009; 71: 170-175. (*Descriptive Study*)

40. Routine practices and additional precautions for preventing the transmission of infection in healthcare. *Can Commun Dis Rep* 1999; 25 Suppl 4:1-142. (*Guidelines*)

41. Gagné D, Bédard G, Maziade PJ. Systematic patients' hand disinfection: impact on methicillin-resistant *Staphylococcus aureus* infection rates in a community hospital. *J Hosp Infect* 2010 75:269-48. (*Observational Study*)

42. Coia JE, Duckworth G, Edwards DI *et al.* Guidelines for the control and prevention of methicillin-resistant *Staphylococcus aureus* (MRSA) in healthcare facilities. Joint Working Party of the British Society of Antimicrobial Chemotherapy, the Hospital Infection Society, and the Infection Control Nurses Association. *J Hosp Infect* 2006; 63: S1-44. (*National Guidelines*)

43. Woodhead K, Taylor EW, Bannistir G, Chesworth T, Hoffman P, Humphreys H. A report from the Hospital Infection Society Working Party on Infection Control in operating theatre. Behaviour and rituals in the operating theatre. *J Hosp Infect* 2002; 51: 241-55. (*Report*)

44. Commission for the hospital hygiene and infection prevention at the Robert Koch-Institute. Recommendations for the prevention and control of methicillin-resistant *Staphylococcus aureus* isolates (MRSA) in hospitals and other healthcare facilities. *GMS Krankenhaushyg Interdiszip* 2009;4(1):doc01. (*National Guidelines*)

45. Ayliffe GAJ, Fraise AP, Geddes AM, Mitchel K. Control of hospital infection, a practical handbook. 4th ed. London: Arnold, 2000. (*Book*)

46. Sanchini A., Spitoni M.G., Monaco M., Raglio A., Grigis A., Petró W., Menchini M., Pesenti A., Goglio & Pantosti A. Outbreak of skin and soft tissue infections in a hospital newborn nursery in Italy due to community-acquired meticillin-resistant *Staphylococcus aureus* USA300 clone. *J Hosp Infect* 2013; 83: 36-40. (*Outbreak Report*)

47. National Hospitals Office (2006). Quality, Risk & Customer Care. Cleaning Manual. Acute Hospitals, HSE, Ireland. (*National Guidelines*)

48. Ndawula EM, Brown L. Mattresses as reservoirs of epidemic methicillin-resistant *Staphylococcus aureus*. *Lancet* 1991; 337(8739):488. (*Observational Study*)

49. Dancer S. Importance of the environment in methicillin-resistant *Staphylococcus aureus* acquisition: the case for hospital cleaning. *Lancet* 2008; 8:101-113. (*Review*)

50. Dancer S, White L, Roberston C. Monitoring environmental cleanliness on two surgical wards. *In J Environ Health Res* 2008;18:357-364. (*Environment Audit*)

51. Waghorn D, Wan WY, Greaves C, Whittome N, Bosley HC, Cantrill S. Contamination of computer keyboards in clinical areas: potential reservoir for nosocomial spread of organisms. *Br J Infection Control* 2005; 6:22. (*Observational Study*)

52. Devine J, Cook RP, Wright EP. Is methicillin-resistant *Staphylococcus aureus* (MRSA) contamination of ward-based computer terminals a surrogate marker for nosocomial MRSA transmission and hand washing compliance? *J Hosp Infect* 2001; 48:48-5. (*Survey*)

53. Faires M.C., Pearl D.L., Ciccotelli W.A., Straus K., Zinken G., Berke O., Reid-Smith R.J. & Weese J.S. A prospective study to examine the epidemiology of methicillin-resistant *Staphylococcus aureus* and *Clostridium difficile* contaminated in the general environment of three community hospital in southern Ontario, Canada. *Biomed Central Infectious Diseases* 2012; http://www.biomedcentral.com/1471-2334/12/290 Description: Research article. (*Prospective study*)

54. Society of Linen Services & Laundry Managers (2006). National guidelines: Hospital Laundry Arrangements for Used, Foul and Infected Linen, Ireland. (*National Guidelines*)

55. Department of Health & Children (2010). Segregation packaging and storage guidelines for healthcare risk waste, 3rd Edition. Ireland. 2.5. (*National Guidelines*)

56. Morgan DJ, Pineles L, Shardell M, Graham MM, Mohammadi S, Forrest GN, Reisinger HS, Schweizer ML & Perencevich EN. The effect of contact precautions on healthcare workers activity in acute care hospitals. Infection Control Hospital Epidemiology 2013; 34: 69-73. (*Prospective Cohort Study*)

2.1.3 MRSA in the non-acute healthcare setting

1. Manzur A, Gudiol F. Methicillin-resistant *Staphylococcus aureus* in long term care facilities *ClinMicrobiol Infect* 2009; 15: Suppl 7, 26-30. (*Review*)

2. Baldwin N, Gilpin D, Hughes C *et al.* Prevalence of methicillin-resistant *Staphylococcus aureus* colonisation in residents and staff in nursing homes in Northern Ireland. J Am Geriatr Soc 2009; 57:620-629. (*Point Prevalence Study*)

3. O'Sullivan NP, Keane CT. The prevalence of methicillin-resistant *Staphylococcus aureus* among the residents of six nursing homes for the elderly. *J Hosp Infect* 2000; 45: 322-329. (*Prevalence Study*)

4. Barr B, Wilcox M, Brady A, Parnell P, Darby B, Tomkins D. Prevalence of methicillin-resistant *Staphylococcus aureus* colonisation among older residents of care homes in the United Kingdom. *Infect Control Hosp Epidemiol* 2007; 28: 853-859. (*Observational Study*)

5. O'Sullivan NP, Keane CT. Risk factors for colonisation with methicillin-resistant *Staphylococcus aureus* among nursing home residents. *J Hosp Infect* 2000; 45: 206-210. (*Observational Study*)

6. Mody L, Kauffman C, Donabedian S, Zervos M, Bradley S, Epidemiology of *Staphylococcus aureus* colonisation in nursing home residents. *Clin Infect Dis* 2008; 46: 1368-1373. (*Observational Study*)

7. Manzur A, Gavalda L, ruiz de Gopegui E *et al.* Prevalence of methicillin-resistant *Staphylococcus aureus* and factors associated with colonisation among residents in community long-term care facilities in Spain. *Clin Microbiol Infect* 2008; 14: 867-848. (*Prevalence Study*)

8. Manzur A, Dominguez MA, Ruiz de Gopegui E and the Spanish Network for Research in Infectious Disease. Natural history of methicillin-resistant *Staphylococcus aureus* colonisation among residents in community long term care facilities in Spain. *J Hosp Infect* 2010; 334-335. (*Observational Study*)

9. Suetens C, Niclaes L, Jans B et al. Methicillin-resistant *Staphylococcus aureus* colonization associated with higher mortality in nursing homes residents with impaired cognitive function. *J Am Geriatric Soc* 2006: 54: 1854-1860. (*Observational Study*)

10. Manzur A., Ruiz De Gopegui E., Dominguez M., *et al* Clinical significance of methicillin –resistant *Staphylococcus aureus* colonization in residents in community long term care facilities in Spain Epidemiol Infect 2012:140, 400-406. (*Observational Study*)

11. Horner C., Wilcox M., Barr B.,et al The longitudinal prevalence of MRSA in care home residents and the effectiveness of improving infection prevention knowledge and practice on colonisation using a stepped wedge study design. *BMJ Open* 2012;2:E000423.DOI:1136/ BMJOpen-2011-000423 (*Controlled Intervention Study*)

12. Hughes C, Smith M, Tunney M. Infection control strategies for preventing the transmission of methicillin-resistant *Staphylococcus aureus* in nursing homes for older person. *Cochrane Database of Systematic Review* 2008 Issue 1Art.No:CD006354. (*Cochrane Review*)

13. Siegel JD, Rhinehart E, Jackson M, Chiarello L, and the Healthcare Infection Control Practices Advisory Committee, 2007 Guideline for Isolation Precautions: Preventing Transmission of Infectious Agents in Healthcare Settings. (*Guidelines*)

14. Farley JE., Ross T., Hayat M., *et al.* Prevalence, risk factors and molecular epidemiology of methicillin –resistant *Staphylococcus aureus* nasal and axillary colonization among psychiatric patients on admission to an academic medical center. *Am J Infect Control* 2013; 41: 199-203. (*Observational Study*)

15. Ebner W, Schlachetzki J, Schneider C, Dettenkofer M, Langosch J.M. Hand Hygiene seems to be sufficient for prevention of MRSA transmission in a closed psychiatric ward. *J Hosp Infect* 2010; 75: 334-335. (*Outbreak Report*)

16. Smith P, Bennett G, Bradley S *et al.* SHEA/APIC Guidelines: Infection prevention and control in long term care facility. *Infect Control Hosp Epidemiol* 2008; 29:785-814. (*Guidelines*)

17. Baldwin N, Gilpin D, Tunney M *et al.* Cluster randomised controlled trial of an infection control education and training intervention programme focusing on methicillin-resistant *Staphylococcus aureus* in nursing homes for older people. *J Hosp Infect* 2010; 76: 36-41. (*Clustered Randomised Control Trial*)

18. Gagne D, Bedard C, Maziade PJ. Systematic patients hand disinfection; impact on methicillin-resistant *Staphylococcus aureus* infection rates in a community hospital. *J Hosp Infect* 2010; 269-27. (*Observational Study*)

19. Ho ML, Seto WH., Lam TS, Wong LC and Wong TY. Hand hygiene promotion in long term care facilities (LTCF)- a cluster randomized controlled trial *Infect Control Hosp Epidemiol* 2012; 33(8);761-767 (*Cluster Randomised Control Trial*)

20. Yeung WK., Tam WSW., Wong TW., Clustered randomized control trial of a hand hygiene intervention involving pocket-sized containers of alcohol-based hand rub for the control of infections in long term care facilities. *Infect Control Hosp Epidemiol* 2011;32(1):67-76. (*Cluster Randomised Controlled Trial*)

21. Schweon SJ., Edmonds SL., Kirk J., Rowland DY., Acosta C., Effectiveness of a comprehensive hand hygiene program for reduction of infection rates in a long term care facility *Am J Infect Control* 2013;41:39-44. (*Observational Study*)

22. Lakdawla N, Pham J, Shah M, Holton J. Effectiveness of low–temperature domestic laundry on the decontamination of healthcare workers uniforms'. *Infect Control Hosp Epidemiol* 2011;32(11):1103-1108. (*Observational Study*)

23. Strategy for the control of Antimicrobial Resistance in Ireland (SARI). Infection prevention and control building guidelines for acute hospitals in Ireland, Health Protection Surveillance Centre 2008. (*National Guidelines*)

24. Strategy for the control of antimicrobial resistance in Ireland (SARI) Infection Control Subcommittee. Guidelines for hand hygiene in Irish healthcare settings. Health Protection Surveillance Centre (HPSC) 2005, Dublin. (*National Guidelines*)

25. World Health Organization. Guidelines on hand hygiene in healthcare. First global patient safety challenge, 2009 Switzerland. (*Clinical Guidelines*)

26. World Health Organisation Hand Hygiene in Outpatient and Long –term Care Facilities A Guide to the application of the WHO Multimodal Hand Hygiene Improvement Strategy and the "My Five Moments for Hand Hygiene" Approach. 2012 Geneva. (*Guidelines*)

27. Bloomfield SF, Cookson BD, Falkiner FR, C Griffith C, Cleary V. Methicillin resistant *Staphylococcus aureus* (MRSA), *Clostridium difficile* and ESBL producing *Escherichia coli* in the home and

community; assessing the problem, controlling the spread. International Scientific Forum on Home Hygiene. 2006 (*Report*)
http://www.ifh-homehygiene.org/best-practice-review/methicillin-resistant-staphylococcus-aureus-mrsa-clostridium-difficile-and-esbl accessed November 2013. (*Report*)

28. Policy Group on Healthcare-Associated Infection (HCAI). How to advise patients with a HCAI – Guidance for healthcare workers in dealing with patients and members of the public. The Royal College of Physicians of Ireland, 2010. (*Policy Document*)

Section 2.1.4 MRSA in obstetrics and neonates

1. Gray JW, Suviste J. Three years' experience of screening for methicillin-resistant *Staphylococcus aureus* in obstetrics. *J Hosp Infect* 2013; 83: 61-3. (*Observational Study*).

2. Top KA, Huard RC, Fox Z, Wu F, Whittier S, Della-Latta P, Saiman L and Ratner AJ. Trends in methicillin-resistant *Staphylococcus aureus* anovaginal colonization in pregnant women in 2005 versus 2009. *J Clin Microbiol* 2010;48:3675-80. (*In Vitro Study*)

3. Andrews WW, Schelonka R, Waites K, Stamm A, Cliver SP, Moser S. Genital tract methicillin-resistant *Staphylococcus aureus*; risk of vertical transmission in pregnant women. *Obstet Gynecol* 2008; 111:113-8. (*In Vitro Study*)

4. Beigi R, Hanrahan J. *Staphylococcus aureus* and MRSA colonisation rates among gravidas admitted to labor and delivery: a pilot study. *Infect Dis Obstet Gynecol* 2007:70876. (*In Vitro Study*)

5. Andrews JI, Fleener DK, Messer SA, Kroeger JS, Diekema DJ. Screening for *Staphylococcus aureus* carriage in pregnancy: usefulness of novel sampling and culture strategies. Am J *Obstet Gynecol* 2009;396:e1-5. (*In Vitro Study*)

6. Reusch M, Ghosh P, Ham C, Klotchko A, Singapuri S, Everett G. Prevalence of MRSA colonisation in peripartum mothers and their newborn infants. Scand *J Infect Dis* 2008;40:667-71. (*In Vitro Study*)

7. Pinter DM, Mandel J, Hulten KG, Minkoff H, Tosi MF. Maternal-infant perinatal transmission of methicillin-sensitive and methicillin-resistant *Staphylococcus aureus*. *Am J Perinatol* 2009;26:145-51. (*In Vitro Study*)

8. James L, Gorwitz RJ, Jones RC *et al.* Methicillin-resistant *Staphylococcus aureus* infections among healthy full-term newborns. Arch Dis Child Fetal Neonatal Ed 2008;93:F40-44. (*Outbreak Report*)

9. Creech CB, Litzner B, Talbot TR, Schaffner W. Frequency of detection of methicillin-resistant *Staphylococcus aureus* from recto-vaginal swabs in pregnant women. *Am J Infect Control* 2010:38:48-4. (*In Vitro Study*)

10. Beigi RH. Clinical implications of methicillin-resistant *Staphylococcus aureus* in pregnancy. Curr Opin Obstet Gynecol 2011;23:82-6. (*Review*)

11. Thurman AR, Anca Y, White CA, Soper DE. Post-cesarean delivery infectious morbidity: focus on preoperative antibiotics and methicillin-resistant *Staphylococcus aureus*. *Am J Infect Control* 2010;38:612-6. (*Observational Study*)

12. Berens P, Swaim L, Peterson B. Incidence of methicillin-resistant *Staphylococcus aureus* in postpartum breast abscesses. *Breastfeed Med* 2010;5:113-5. (*Observational Study*)

13. Johnson AP, Sharland M, Goodall CM et al. Enhanced surveillance of methicillin-resistant *Staphylococcus aureus* (MRSA) bacteraemia in children in the UK and Ireland. *Arch Dis Childhood* 2010; 95; 781-5. (*International Surveillance Study*)

14. Gerber SI, Jones RC, Scott MV et al. Management of outbreaks of methicillin-resistant *Staphylococcus aureus* infection in the neonatal intensive care unit: a consensus statement. *Infect Control Hosp Epidemiol* 2006;27:139-145. (*Clinical Guidelines*)

15. Huang Y-C, Chou Y-H, Su L-H, Lian R-I, Lin T-Y. Methicillin-resistant *Staphylococcus aureus* colonisation and its association with infection among infants hospitalised in neonatal intensive care units. *Pediatrics* 2006;118:469-474. (*Observational Study*)

16. Beigi RH, Bunge K, Song Y, Lee BY. Epidemiologic and economic effect of methicillin-resistant *Staphylococcus aureus* in obstetrics. Obstet Gynecol 2009;113:983-91. (*Cost-effectiveness Study*)

17. Gray J, Patwardhan SC, Martin W. Methicillin-resistant *Staphylococcus aureus* screening in obstetrics: a review. *J Hosp Infect* 2010:75:89-92. (*Review*)

18. Shane AL, Hansen NI, Stoll BJ *et al.* Methicillin-resistant and susceptible *Staphylococcus aureus* bacteremia and meningitis in preterm infants. *Pediatrics* 2012;129:e914-22. (*Observational Study*)

19. Pimentel JD, Meier FA, Samuel LP. Chorioamnionitis and neonatal sepsis from community-associated MRSA. *Emerg Infect Dis* 2009;15:2069-71. (*Case Report*)

20. Spencer JP. Management of mastitis in breastfeeding women. Am Fam Physician 2008;78:727-732. (*Review*)

21. Kawada M, Okuzumi K, Hitomi S, Sugishita C. Transmission of *Staphylococcus aureus* between healthy, lactating mothers and their infants by breastfeeding. J Hum Lact 2003;19:411-7. (*In Vitro Study*)

22. Mitrano JA, Spooner LM, Belliveau P. Excretion of antimicrobials used to treat methicillin-resistant *Staphylococcus aureus* infections during lactation: safety in breastfeeding infants. *Pharmacotherapy* 2009;29:1103-9. (*Review*)

23. Gastelum DT, Dassey D, Mascola L, Yasuda LM. Transmission of community associated methicillin-resistant *Staphylococcus aureus* from breast milk in the neonatal intensive care unit. *Pediatr Infect Dis J* 2005:24:1122-1124. (*Case Report*)

24. Behari P, Englund J, Alcasid G, Garcia-Houchins S, Weber SG. Transmission of methicillin-resistant *Staphylococcus aureus* to preterm infants through breast milk. *Infect Control Hosp Epidemiol* 2004;25: 778-780. (*Outbreak Report*)

25. Bratcher D. Methicillin-resistant *Staphylococcus aureus* in nurseries. *NeoReviews* 2005;6:424-429. (*Review*)

26. Vergnano S, Menson E, Smith Z *et al.* Characteristics of invasive *Staphylococcus aureus* in United kingdom neonatal units. *Pediatr Infect Dis J* 2011;30:850-4. (National Surveillance Study)

27. Geva A, Wright SB, Baldini LM, Smallcomb JA, Safran C, Gray JE. Spread of methicillin-resistant *Staphylococcus aureus* in a large tertiary NICU: network analysis. *Pediatrics* 2011;128:e1173-80. (*Observational Study*)

28. Rosenthal A, White D, Churilla S et al. Optimal surveillance culture sites for detection of methicillin-resistant *Staphylococcus aureus* in newborns. *J Clin Microbiol* 2006;44:4234-4236. (*Outbreak Report*)

29. Milstone AM, Song X, Coffin S and Elward A for the Society for Healthcare Epidemiology of America's Pediatric Special Interest Group. Identification and eradication of methicillin-resistant *Staphylococcus aureus* colonisation in the neonatal intensive care unit: Results of a national survey. *Infect Control Hosp Epidemiol* 2010;31:766-768. (*National Survey*)

30. Brennan GI, Shore AC, Corcoran S, Tecklenborg S, Coleman DC and O'Connell B. Emergence of hospital and community-associated Panton-Valentime Leukocidin-positive methicillin-resistant *Staphylococcus aureus* genotype ST772-MRSA-V in Ireland and detailed investigation of an ST772-MRSA-V cluster in a neonatal intensive care unit. *J Clin Micro* 2012;50:841-7. (*Outbreak Report*)

31. Ali H, Nash JQ, Kearns AM *et al.* Outbreak of a South West Pacific clone Panton-Valentime Leukocidin-positive methicillin-resistant *Staphylococcus aureus* infection in a UK neonatal intensive care unit. *J Hosp Infect* 2012;80:293-8. (*Outbreak Report*)

Section 2.1.5 Community-associated MRSA

1. Millar BC, Loughrey A, Elborn JS, Moore J.E. Proposed definitions of community-associated methicillin-resistant *Staphylococcus aureus* (CA-MRSA) *J Hosp Infect* 2007: 67; 109-113. (*Review*)

2. Amburu C, Harbarth S, Liassine N *et al* Community-acquired methicillin-resistant *Staphylococcus aureus* in Switzerland; first surveillance report. *Euro Surveill* 2006;11:42-45. (*Survey*)

3. Guidelines for the management of community-associated methicillin-resistant *Staphylococcus aureus* clones in Western Australia. For community settings Government of Western Australia. Department of Health, WA Communicable Disease Control Directorate© Department of Health 2008. (http://www.public.health.wa.gov.au/3/896/3/camrsa.pm) (*Guidelines*)

4. Health Protection Agency. Guidance on the diagnosis and management of PVL-associated *Staphylococcus aureus* infections (PVL-SA) in England, 2nd Edition. (*Guidelines*)

5. Shallcross LJ, Fragaszy E, Johnson AM, Hayward AC. The role of the Panton-Valentine leucocidin toxin in staphylococcal disease: a systematic review and meta-analysis. *Lancet Infect Dis*. 2013 Jan;13:43-54. (*Review*)

6. Rossney A, Shore A, Morgan P *et al.* The emergence and importation of diverse genotypes of methicillin-resistant *Staphylococcus aureus* (MRSA) harbouring the Panton-Valentine leukocidin gene (pvl) reveal that pvl is a poor marker for community-acquired MRSA strains in Ireland. *J Clin Micro* 2007; 45: 2554–2563. (*In-vitro Study*)

7. Amir NH, Rossney AS, Veale J, O'Connor M, Fitzpatrick F, Humphreys H. Spread of community-acquired methicillin-resistant *Staphylococcus aureus* skin and soft-tissue infection within a family: implications for antibiotic therapy and prevention. J Med Microbiol 2010; 59:489-92. (*Case Report*)

8. Mollaghan AM, Lucey B, Coffey A, Cotter L. Emergence of MRSA clone ST22 in healthy young adults in the community in the absence of risk factors. Epidemiol Infect 2010: 138; 673–676. (*Survey*)

9. Schneider-Lindner V, Delaney J, A, Dial S *et al.* Antimicrobial drugs and community acquired methicillin-resistant *Staphylococcus aureus*, United Kingdom. *Emerg Infect Dis* 2007; 13: 994-1000. (*Case Control Study*)

10. Paranthaman K, Maguire H, Haworth E, Lewis D. HPA – Local and Regional Services Management of PVL-*Staphylococcus aureus* Recommendations for Practice. January 2010 (http://www.hpa.org.uk/web/HPAwebFile/HPAweb_C/1267551719486) (*Guidelines*)

11. Gorwitz RJ, Jernigan DB, Powers JH, Jernigan JA, and Participants in the CDC Convened Experts' Meeting on management of MRSA in the community. Strategies for clinical management of MRSA in the community: Summary of an experts' meeting convened by the Centers for Disease Control and Prevention. 2006. (http://www.cdc.gov/ncidod/dhqp/ar_mrsa_ca.html) (*Guidelines*)

12. Gorwitz RJ, Jernigan DB, Powers JH, Jernigan JA, and Participants in the CDC Convened Experts' Meeting on management of MRSA in the community. Strategies for clinical management of MRSA in the community: Summary of an experts' meeting convened by the Centers for Disease Control and Prevention. 2006. (http://www.cdc.gov/ncidod/dhqp/ar_mrsa_ca.html) (*Guideline*)

13. Barton M, Hawkes M, Moore D *et al.* Guidelines for the prevention and management of community-associated methicillin-resistant *Staphylococcus aureus*: A perspective for Canadian healthcare practitioners. *Can J Infect Dis Med Microbiol* 2006; 17; Suppl C 4C-24C. (*Guideline*)

Section 2.1.6 Eradication of MRSA carriage (decolonisation)

1. Loeb MB, Main C, Eady A, Walkers-Dilks C. Antimicrobial drugs for treating methicillin-resistant *Staphylococcus aureus* colonization. *Cochrane Database Syst Rev* 2003, Issue 4. Art. No. CD003340. DOI: 10.1002/14651858.CD003340 (*Systematic Review*)

2. Van Rijen M, Bonten M, Wenel R, Klutymans J. Mupirocin ointment for preventing *Staphylococcus aureus* infections in nasal carriers. *Cochrane Database Sys Rev* 2008; (4): CD006216 (*Systematic Review*)

3. Bode LG, Klutymans JA, Wertheim HF *et al.* Preventing surgical site infections in nasal carriers of *Staphylococcus aureus*. *N Eng J Med* 2010; 362: 9-17 (*Randomised Controlled Trial*)

4. Sandri AM, Dalarose MG, de Alcantara IR *et al.* Reduction in incidence of nosocomial methicillin-resistant *Staphylococcus aureus* infection in an intensive care unit: role of treatment of intranasal mupirocin ointment and chlorhexidine baths for nasal carriers of MRSA. *Infect Control Hosp Epidemiol* 2006;27:185-7. (*Prospective Cohort Study*)

5. Ridenour G, Lampen R, Federspiel J *et al.* Selective use of intranasal mupirocin and chlorhexidine bathing and the incidence of methicillin-resistant *Staphylococcus aureus* colonization and infection among intensive care unit patients. *Infect Control Hosp Epidemiol*. 2007; 28:1155-61. (*Prospective Cohort Study*)

6. Robicsek A, Beaumont JL, Thompson RB *et al.* Topical therapy for methicillin-resistant *Staphylococcus aureus* colonization: impact on infection risk. *Infect Control Hosp Epidemiol* 2009 Jul;30(7):623-32. (Retrospective cohort study)

7. Edgeworth JD. Has decolonization played a critical role in the decline of UK methicillin-resistant *Staphylococcus aureus* transmission? A focus on evidence from intensive care. *J Antimicrob Chemother* 2011; 66 Suppl 2:ii41-7. (*Review*)

8. Lawes T, Edwards B, Lo´pez-Lozano J-M, *et al.* Trends in *Staphylococcus aureus* bacteraemia and impacts of infection control practices including universal MRSA admission screening in a hospital in Scotland, 2006-2010: retrospective cohort study and time-series intervention analysis. *BMJ Open* 2012;2:-000797.doi:10.1136/ bmjopen-2011-000797 (*Cohort Study & Intervention Analysis*)

9. Boelaert JR, Van Landuyt HW, Godard CA, *et al.* Nasal mupirocin ointment decreases the incidence of *Staphylococcus aureus* bacteraemias in haemodialysis patients. *Nephrol Dial Transplant* 1993; 8:235-239 (*Prospective Cohort Study*)

10. Simor AE. Staphylococcal decolonisation: an effective strategy for prevention of infection? *Lancet Infect Dis*. 2011; 11: 952-62. (*Review*)

11. Khan A, Lampitoc M, Salaripour M *et al* Rapid control of a methicillin resistant *Staphylococcus aureus* outbreak in a medical-surgical intensive care unit. *Can J Infect Control* 2009;24:98 (*Outbreak/Interventional study*)

12. Coia JE, Dukworth GJ, Edwards DI, *et al.* for the Joint Working Party of the British Society of Antimicrobial Chemotherapy, the Hospital Infection Society and the Infection Control Nurse Association. (2006) Guidelines for the control and prevention of methicillin-resistant *Staphylococcus aureus* (MRSA) in healthcare facilities. *J Hosp Infect*; 63S:S1-S44. (*Guideline*)

13. Bradley SF. Eradication or decolonization of methicillin-resistant *Staphylococcus aureus* carriage: What are we doing and why are we doing it? *Clin Infect Dis* 2007; 44:178 (*Editorial*)

14. Simor AE, Loeb M, CIDS/CAMM Guidelines Committee. The management of infection and colonisation due to methicillin resistant *Staphylococcus aureus*: A Canadian Infectious Disease Society and Canadian Association of Medical Microbiology Position Paper. 2004 (*Guideline*)

15. Klutymans, JA Harbath S. Methicillin-resistant *Staphylococcus aureus* Decolonisation: "Yes we can", but will it help? *Infect Control and Hosp Epidemiol* 2010; 30:633-635. (*Editorial*)

16. Cookson B, Bonten MJ, Mackenzie FM, Skov RL, Verbrugh HA, Tacconelli E; European Society of Clinical Microbiology and Infectious Diseases (ESCMID); International Society of Chemotherapy (ISC). Methicillin-resistant *Staphylococcus aureus* (MRSA): screening and decolonisation. *Int J Antimicrob Agents*. 2011; 37:195-201. (*Conclusions of European Consensus Conference*).

17. Ammerlaan HS, Kluytmans JA, Wertheim HF, *et al.* Eradication of methicillin-resistant *Staphylococcus aureus* carriage: a systematic review. *Clin Infect Dis* 2009; 48:922–930. (*Systematic Review*)

18. Reagan DR, Doebbeling BN, Pfaller MA, *et al.* Elimination of coincident *Staphylococcus aureus* nasal and hand carriage with intranasal application of mupirocin calcium ointment. *Ann Intern Med* 1991; 114:101-106. (*Randomised Controlled Trial*)

19. Doebbeling BN, Reagan DR, Pfaller MA *et al,* Long term efficacy of intranasal mupirocin ointment: A prospective cohort study of *Staphylococcus aureus* carriage. *Arch Int Med* 1994:154:1505-8 (*Prospective Cohort Study*)

20. Harbarth S, Dharan S, Liassine N, Herrault P, Auckenthaler R, Pittet D. Randomized, placebo-controlled, double-blind trial to evaluate the efficacy of mupirocin for eradicating carriage of methicillin-resistant *Staphylococcus aureus*. *Antimicrob Agents Chemother* 1999; 43:1412-1416. (*Randomised Controlled Trial*)

21. Krishna BV, Gibb AP. Use of octenidine dihydrochloride in methicillin-resistant *Staphylococcus aureus* decolonizing regimens: a literature review. *J Hosp Infect* 2010 Mar;74(3):199-203 (*Systematic Review*)

22. Patel JB, Gorwitz RJ, Jernigan JA. Mupirocin Resistance. *Clin Inf Dis* 2009; 49: 935-41 (*Review*)

23. Vasquez JE, Walker ES, Franzus BW, Overbay BK, Reagan DR, Sarubbi FA. The epidemiology of mupirocin resistance among methicillin-resistant *Staphylococcus aureus* at a Veterans' Affairs hospital. *Infect Control Hosp Epidemiol* 2000; 21:459-464. (*Retrospective Case Control Study*)

24. Caffrey AR, Quilliam BJ, LaPlante KL. Risk factors associated with mupirocin resistance in methicillin-resistant *Staphylococcus aureus*. *J Hosp Infect* 2010;76:206-10 (*Retrospective Case Control Study*)

25. Buelmann M, Frei R, Fenner L *et al.* Highly effective regimen for the decolonization of methicillin-resistant *Staphylococcus aureus* carriers. *Infect Control Hosp Epidemiol* 2008; 29: 510–516. (*Prospective Cohort Study*)

26. Simor AE, Philp I, McGeer A *et al.* Randomized controlled trial of chlorhexidine gluconate for washing, intranasal mupirocin, and rifampicin and doxycycline versus no treatment for the eradication of methicillin-resistant *Staphylococcus aureus* colonization *Clin Infect Dis* 2007; 44: 178-185. (Randomized Controlled Trial)

27. Climo MW, Sepkowitz KA, Zuccotti G *et al.* The effect of daily bathing with chlorhexidine on the acquisition of methicillin-resistant *Staphylococcus aureus*, vancomycin-resistant Enterococcus, and healthcare-associated bloodstream infections: results of a quasi-experimental multicenter trial. Crit Care Med 2009; 6: 1858-65. (*Observational Study*)

28. Kassakian SZ, Mermel LA, Jefferson JA, Parenteau SL, Machan JT. Impact of chlorhexidine bathing on hospital-acquired infections among general medical patients. *Infect Control Hosp Epidemiol* 2011; 32; 238-243. (*Prospective Intervention Study*)

29. Weber DJ, Rutala WA. Use of germicides in the home and the healthcare setting: is there a relationship between germicide use and antibiotic resistance? *Infect Control Hosp Epidemiol* 2006; 27:1107–19. (*Review*)

30. Johnson AP, Sharland M, Goodall CM et al. Enhanced surveillance of methicillin- resistant *Staphylococcus aureus* (MRSA) bacteraemia in children in the UK and Ireland. *Arch Dis Childhood* 2010; 95; 781-5. (*Observational Study*)

31. Huang Y-C, Chou Y-H, Su L-H, Lian R-I, Lin T-Y. Methicillin-resistant *Staphylococcus aureus* colonisation and its association with infection among infants hospitalised in neonatal intensive care units. *Pediatrics* 2006;118:469-474. (*Observational Study*)

32. Milstone AM, Song X, Coffin S, Elward A, for the Society for Healthcare Epidemiology of America's Pediatric Special Interest Group. Identification and eradication of methicillin-resistant *Staphylococcus aureus* colonisation in the neonatal intensive care unit: Results of a national survey. *Infect Control Hosp Epidemiol* 2010;31:766-768. (*Survey*)

33. Longtin Y, Sudre P, Francois P *et al.* Community-associated methicillin-resistant *Staphylococcus aureus*: risk factors for infection, and long-term follow-up. *Clin Microbiol Infect* 2009; 15: 552–559. (*Retrospective Case Control Study*)

34. Weese JS, Rousseau J, Traub-Dargatz JL, Willey BM, McGeer AJ, Low DE. Community-associated methicillin-resistant *Staphylococcus aureus* in horses and humans who work with horses. *J Am Vet Med Assoc* 2005;226:580-3. (*Observational Study*)

35. O'Mahony R, Abbott Y, Leonard FC *et al.* Methicillin-resistant *Staphylococcus aureus* (MRSA) isolated from animals and veterinary personnel in Ireland. *Vet Microbiol* 2005;109:285-96. (*Observational and In vitro Study*)

36. Weese JS, Dick H, Willey BM *et al.* Suspected transmission of methicillin-resistant *Staphylococcus aureus* between domestic pets and humans in veterinary clinics and in the household. *Vet Microbiol* 2006;115:148-55. (*Observational and In vitro Study*)

37. Weese JS, Caldwell F, Willey BM *et al.* An outbreak of methicillin-resistant *Staphylococcus aureus* skin infections resulting from horse to human transmission in a veterinary hospital. *Vet Microbiol* 2006;114:160-4. (*Outbreak Report*)

Section 2.1.7 Antimicrobial stewardship in the prevention and control of MRSA

1. Enright MC, Robinson DA, Randle G, Feil EJ, Grundmann H, Spratt BG. The evolutionary history of methicillin-resistant *Staphylococcus aureus* (MRSA). Proc Natl Acad Sci 2002;99:7687-92. (*In-vitro Study*)

2. Harbarth S, Samore MH. Interventions to control MRSA: high time for time-series analysis? *J Antimicrob Chemother*. 2008; 62:431-3. (*Editorial*)

3. Rogues AM, Dumartin C, Amadéo B *et al.* Relationship between rates of antimicrobial consumption and the incidence of antimicrobial resistance in *Staphylococcus aureus* and *Pseudomonas aeruginosa* isolates from 47 French hospitals. *Infect Control Hosp Epidemiol* 2007; 28: 1389-95. (*Observational Study*)

4. Aldeyab MA, Monnet DL, López-Lozano JM *et al.* Modelling the impact of antibiotic use and infection control practices on the incidence of hospital-acquired methicillin-resistant *Staphylococcus aureus*: a time-series analysis. *J Antimicrob Chemother* 2008; 62: 593-600. (*Retrospective Analysis & Modelling*)

5. MacKenzie FM, Bruce J, Struelens MJ, Goossens H, Mollison J, Gould IM; ARPAC Steering Group. Antimicrobial drug use and infection control practices associated with the prevalence of methicillin-resistant *Staphylococcus aureus* in European hospitals. *Clin Microbiol Infect* 2007; 13:269-76. (*Observational Study*)

6. Borg MA, Zarb P, Scicluna EA. Antibiotic consumption as a driver for resistance in *Staphylococcus aureus* and *Escherichia coli* within a developing region. *Am J Infect Control* 2010; 38: 212-6. (*Observational Study*)

7. Tacconelli E, De Angelis G, Cataldo MA, Pozzi E, Cauda R. Does antibiotic exposure increase the risk of methicillin-resistant *Staphylococcus aureus* (MRSA) isolation? A systematic review and meta-analysis. *J Antimicrob Chemother* 2008; 61:26-38. (*Review*)

8. Lo WT, Lin WJ, Tseng MH, Wang SR, Chu ML, Wang CC. Risk factors and molecular analysis of Panton-Valentine leukocidin-positive methicillin-resistant *Staphylococcus aureus* colonisation in healthy children. *Pediatr Infect Dis J* 2008;27;713-8. (*Case Control Study*)

9. Gould IM. Controversies in infection: infection control or antibiotic stewardship to control healthcare-acquired infection? *J Hosp Infect* 2009; 73:386-91. (*Review*)

10. Dancer SJ, Kirkpatrick P, Corcoran DS, Christison F, Farmer D, Robertson C. Approaching zero: temporal effects of a restrictive antibiotic policy on hospital-acquired *Clostridium difficile*, extended-spectrum ß-lactamase-producing coliforms and methicillin-resistant *Staphylococcus aureus*. *Int J Antimicrob Agents*. 2013; 41: 137-142. (*Observational Study*)

11. Nowak MA, Nelson RE, Breidenbach JL, Thompson PA, Carson PJ. Clinical and economic outcomes of a prospective antimicrobial stewardship program. *Am J Health Syst Pharm*. 2012;69:1500-8. (*Observational Intervention Study*)

12. Niwa T, Shinoda Y, Suzuki A, Ohmori *et al.* Outcome measurement of extensive implementation of antimicrobial stewardship in patients receiving intravenous antibiotics in a Japanese university hospital. *Int J Clin Pract*. 2012;66:999-1008. (Observation Study)

13. Hulscher MEJL, Grol RPTM, van der Merk JWM. Antibiotic prescribing in hospitals: a social and behavioural scientific approach. *Lancet Infect Dis* 2012; 10: 167-175. (*Review*)

14. Borg MA, Camilleri L, Waisfisz B. Understanding the epidemiology of MRSA in Europe: do we need to think outside the box? *J Hosp Infect* 2012; 81: 251-256. (*Observational Study*)

15. Recommendations of the Hospital Infection Control Practices Advisory Committee (HICPAC). Recommendations for preventing the spread of vancomycin resistance *MMWR* 1995; 44: 1-13. (*Guidelines*)

16. MacKenzie FM, Struelens M, Towner KJ, Gould IM; ARPAC Steering Group; ARPAC Consensus Conference Participants. Report of the consensus conference on antibiotic resistance; prevention and control (ARPAC). *Clin Microbiol Infect* 2005; 11:938-945. (*Consensus Review*)

17. Borer A, Gilad J, Yagupsky P, Peled N, Porat N, Trefler R, Shprecher-Levy H, Riesenberg K,Shipman M, Schlaeffer F. Community-acquired methicillin-resistant *Staphylococcus aureus* in institutionalised adults with developmental disabilities. *Emerg Infect Dis* 2002;8:966-970. (*Observational Intervention Study*)

Section 2.1.8 Occupational health aspects of MRSA

1. Albrich WC, Harbarth S. Healthcare workers: source, vector or victim of MRSA? *Lancet Infect Dis* 2008;8:289-301. (*Review*)

2. Immunisation of Healthcare Workers: Association of National Health Occupation Physicians Guidelines 2001 http://www.anhops.com/docs/29_9_immuninisation.pdf (*Guidelines*)

3. Muder RR, Brennen C, Goetz AM. Infection with methicillin–resistant *Staphylococcus aureus* among hospital employees. *Infect Control Hosp Epidemiol* 1993;14:576-78. (*Observational Study*)

4. Sherertz RJ, Reagan DR, Hampton KD *et al.* A cloud adult: the *Staphylococcus aureus* – virus interaction revisited. *Ann Intern Med* 1996;124:539-47. (*Observational Study*)

5. Belani A, Sherertz RJ, Sullivan ML *et al.* Outbreak of staphylococcal infection in two hospital nurseries traced to a single nasal carrier. *Infection Control* 1986;7:487-90. (*Observational Study*)

6. Safety, Health and Welfare at Work (Biological Agents) Regulations (SI No. 146 of 1994) amended in 1998 (SI No. 248 of 1998) http://www.irishstatutebook.ie/1994/en/si/0146.html http://www.irishstatutebook.ie/1998/en/si/0248.html (*National Regulations*)

7. Safety, Health and Welfare at Work Act 2005 (No. 10 of 2005) http://www.oireachtas.ie/viewdoc.asp?DocID=4305 (*National Regulations*)

8. Employment Equality Act 1998 http://www.irishstatutebook.ie/1998/en/act/pub/0021/index.html (*National Regulations*)

9. Siegel JD, Rhinehart E, Jackson M, Chiarello L, Healthcare Infection Control Practices Advisory Committee. 2007 Guideline for isolation precautions: preventing transmission of infectious agents in healthcare settings. *Am J Infect Control* 2007; 35: 10 (Suppl 2) S65-164. (*Guidelines*)

10. Hierarchy of risk controls. Canadian Centre for Occupational Health and Safety http://www.ccohs.ca/oshanswers/hsprograms/hazard_control.html (*Guidelines*)

11. Health Canada. Prevention and Control of Occupational Infections in Healthcare. An Infection Control Guideline. *CCDR* 2002;28S1:1-264. (*Guidelines*)

12. Dancer SJ. Importance of the environment in methicillin-resistant *Staphylococcus aureus* acquisition:the case for hospital cleaning. *Lancet Infect Dis* 2008; 8:101–113. (*Review*)

13. The control and prevention of MRSA in hospitals and in the community. Published on behalf of SARI by HSE, Health Protection Surveillance Centre, 2005. (*Guidelines*)

14. Bolyard EA, Tablan OC, Williams WW, Pearson ML, Shapiro CN, Deitchman SD, and The Hospital Infection Control Practices Advisory Committee. Guidelines for Infection Control in Healthcare Personnel 1998. *Infect Control Hosp Epidemiol* 1998;19:407-63. (*Guidelines*)

15. Koh KC, Husni S, Tan CW, *et al.* High prevalence of methicillin-resistant *Staphylococcus aureus* (MRSA) on doctors' neckties. *Med J Malaysia* 2009; 64:233-5. (*Observational Study*)

16. Treakle AM, Thom KA, Furuno JP, Strauss SM, Harris AD, Perencevich EN. Bacterial contamination of healthcare workers' white coats. *Am J Infect Control* 2009;37: 101-5. (*Observational Study*)

17. Ulger F, Esen S, Dilek A, Keramettin Y, Murat G, Hakan L. Are we aware how contaminated our mobile phones are with nosocomial pathogens? Ann Clin Microbiol Antimicrob 2009;8:7. (*Observational Study*)

18. SHEA / IDSA practice recommendation. Strategies to prevent transmission of methicillin – resistant *Staphylococcus aureus* in acute care hospitals. *Infect Control Hosp Epidemiol* 2008;29: S62-80. (*Guidelines*)

19. Coia JE, Duckworth GJ, Edwards DI *et al* for the Joint Working Party of the British Association of Antimicrobial Chemotherapy, the Hospital Infection Society, and the Infection Control Nurses Association. Guidelines for the control and prevention of methicillin- resistant *Staphylococcus aureus* (MRSA) in healthcare facilities. *J Hosp Infect* 2006 63S S1 – S44. (*Guidelines*)

20. Cookson B, Bonten MJM, MacKenzie FM, Scov RL, Verbrugh HA, Tacconelli E. Methicillin-resistant *Staphylococcus aureus* (MRSA): screening and decolonisation. *Int J Antimicrobial Ag* 2011;37:195-201. (*Review*)

21. Richardson JF, Quoraishi AH, Francis BJ, Marples RR. Beta-lactamase-negative, methicillin-resistant *Staphylococcus aureus* in a newborn nursery: report of an outbreak and laboratory investigations. *J Hosp Infect* 1990;16:109-21. (*Observational Study*)

22. Haamann F, Dulon M, Nienhaus A. MRSA as an occupational disease: a case series. Int Arch Occup Environ Health 2011 Jan; 84: 259-266. (*Observational Study*)

23. Vonberg RP, Stamm-Balderjahn S, Hansen S *et al.* How often do asymptomatic HCWs cause methicillin–resistant *Staphylococcus aureus* outbreaks? A systematic evaluation. *Infect Control Hosp Epidemiol* 2006;27:1123-1127. (*Systematic Review*)

24. Hawkins G, Stewart S, Blatchford O, Reilly J. Should healthcare workers be screened routinely for methicillin-resistant *Staphylococcus aureus*? A review of the evidence. *J Hosp Infect* 2011; 77: 285-289. (*Review*)

25. Wenzel RP. Healthcare workers and the incidence of nosocomial infection: Can treatment of one influence the other? A brief review. *J Chemother* 1994;6:33-7, 39. (*Review*)

Section 2.2 Management of MRSA – Acute Hospitals

1. Huang SS, Platt R. Risk of methicillin-resistant *Staphylococcus aureus* infection after previous infection or colonisation. *Clin Infect Dis* 2003; 36:281-5. (*Observational Study*)

2. Rotstein C. Hospital-acquired methicillin-resistant *Staphylococcus aureus*: epidemiology, treatment and control. *Can J Infect Dis Med Microbiol* 2006; 17 (Suppl B):13B-8B. (*Review*)

3. Liu C, Bayer A, Cosgrove SE *et al.* Clinical practice guidelines by the Infectious Diseases Society of America for the treatment of methicillin-resistant *Staphylococcus aureus* infections in adults and children. *Clin Infect Dis* 2011; 52(3):e18-e55. (*Guidelines*)

4. Management of community-associated MRSA. *Drug Ther Bull* 2010 Feb; 48:14-9. (*Review*)

5. Scottish Infection Standards and Strategy (SISS) Group of the Royal College of Physicians of Edinburgh and the Royal College of Physicians and Surgeons of Glasgow. Guidance for the hospital management of methicillin-resistant *Staphylococcus aureus*. RCPE 2006. http://www.hps.scot.nhs.uk/haiic/ic/wrdetail.aspx?id=30170&wrtype=2 (*Guidelines*)

6. Thwaites GE, Edgeworth JD, Gkrania-Klotsas E *et al.* Clinical management of *Staphylococcus aureus* bacteraemia. *Lancet Infect Dis* 2011; 11: 208-22. (*Review*)

7. Gorwitz RJ, Jernigan DB, Powers JH, Jernigan JA. Strategies for clinical management of MRSA in the community: Summary of an experts' meeting convened by the Centres for Disease Control and Prevention 2006 http://www.cdc.gov/ncidod/dhqp/pdf/ar/CAMRSA_ExpMtgStrategies.pdf (*Consensus Review*)

8. Barton M, Hawkes M, Moore D *et al.* Guidelines for the prevention and management of community-associated methicillin-resistant *Staphylococcus aureus* (CA-MRSA): A perspective for Canadian healthcare practitioners. *Can J Infect Dis Med Microbiol* 2006; 17 (Suppl C):4C-24C. (*Guidelines*)

9. Paul M, Kariv G, Goldberg E *et al.* Importance of appropriate empirical antibiotic therapy for methicillin-resistant *Staphylococcus aureus* bacteraemia. *J Antimicrob Chemother* 2010; 65:2658-65. (Retrospective cohort study)

10. Co-trimoxazole use restricted. *Drug Ther Bull* 1995 Dec; 33 (12):92-3. (*Review*)

11. Nathwani D, Morgan M, Masterton R *et al.* Guidelines for UK practice for the diagnosis and management of methicillin-resistant *Staphylococcus aureus* (MRSA) infections presenting in the community. *J Antimicrob Chemother* 2008; 61:976-94. (*Guidelines*)

12. HSE/HPSC Prevention of intravascular catheter-related infection in Ireland SARI Guidelines 2009, updated February 2010. http://www.ndsc.ie/hpsc/A-Z/Hepatitis/GuidanceforRenalUnits/File,4115,en.pdf (*Guidelines*)

13. Gould F, Brindle R, Chadwick P *et al.* Guidelines for the prophylaxis and treatment of methicillin-resistant *Staphylococcus aureus* (MRSA) infections in the United Kingdom. *J Antimicrob Chemother* 2009; 63:849-61. (*Guidelines*)

14. HPA Guidance on the diagnosis and management of PVL-associated *Staphylococcus aureus* infections (PVL-SA) in England 2nd Edition November 2008 http://www.hpa.org.uk/web/HPAwebFile/HPAweb_C/1226478464166 (*Guidelines*)

15. Stevens DL, Bisno AL, Chambers HF *et al.* Practice guidelines for the diagnosis and management of skin and soft-tissue infections. *Clin Infect Dis* 2005; 41:1373-406. (*Guidelines*)

16. Mohr JF, Murray BE. Point: Vancomycin is not obsolete for the treatment of infection caused by methicillin-resistant *Staphylococcus aureus*. *Clin Infect Dis* 2007; 44:1536-42. (*Review*)

17. Deresinski S. Vancomycin in combination with other antibiotics for the treatment of serious methicillin-resistant *Staphylococcus aureus* infections. *Clin Infect Dis* 2009; 49:1048-9. (*Review*)

18. Charles P, Ward P, Johnson P, Howden B, Grayson ML. Clinical features associated with bacteraemia due to heterogeneous vancomycin-intermediate *Staphylococcus aureus*. *Clin Infect Dis* 2004; 38:448-51. (*Observational Study*)

19. Rybak M, Lomaestro B, Rotschafer JC *et al.* Therapeutic monitoring of vancomycin in adult patients: a consensus review of the American Society of Health-System Pharmacists, the Infectious Diseases Society of America, and the Society of Infectious Diseases Pharmacists. *Am J Health Syst Pharm* 2009; 66:82-98. (*Consensus Review*)

20. Centers for Disease Control and Prevention (CDC). Brief Report: Vancomycin-resistant *Staphylococcus aureus*-New York, 2004. Morb Mortal Wkly Rep. 2004; 53:322-3. (*Case Report*)

21. Hidayat LK, Hsu DI, Quist R, Shriner KA, Wong-Beringer A. High-dose vancomycin therapy for methicillin-resistant *Staphylococcus aureus* infections: efficacy and toxicity. Arch Intern Med 2006; 166:2138-44. (*Observational Study*)

22. Lodise TP, Lomaestro B, Graves J, Drusano GL. Larger vancomycin doses (at least four grams per day) are associated with an increased incidence of nephrotoxicity. *Antimicrob Agents Chemother* 2008; 52:1330-6. (*Observational Study*)

23. Hazlewood KA, Brouse SD, Pitcher WD, Hall RG. Vancomycin-associated nephrotoxicity: grave concern or death by character assassination? *Am J Med* 2010; 123:182.e1-7. (*Review*)

24. Cavalcanti AB, Goncalves AR, Almeida CS, Bugano DD, Silva E. Teicoplanin versus vancomycin for proven or suspected infection. *Cochrane Database Syst Rev* 2010; Issue 6:CD007022. (*Review*)

25. Wilson AP. Clinical pharmacokinetics of teicoplanin. *Clin Pharmacokinet* 2000; 39:167-83. (*Review*)

26. Pea F, Viale P, Candoni A *et al.* Teicoplanin in patients with acute leukaemia and febrile neutropenia: a special population benefiting from higher dosages. *Clin Pharmacokinet* 2004; 43:405-15. (*Observational Study*)

27. Pea F, Brollo L, Viale P, Pavan F, Furlanut M. Teicoplanin therapeutic drug monitoring in critically ill patients: a retrospective study emphasizing the importance of a loading dose. *J Antimicrob Chemother* 2003; 51:971-5. (*Observational Study*)

28. Brink AJ, Richards GA, Cummins RR, Lambson J. Recommendations to achieve rapid therapeutic teicoplanin plasma concentrations in adult hospitalised patients treated for sepsis. *Int J Antimicrob Agents* 2008; 32:455-8. (*Observational Study*)

29. Perlroth J, Kuo M, Tan J, Bayer AS, Miller LG. Adjunctive use of rifampicin for the treatment of *Staphylococcus aureus* infections: a systematic review of the literature. Arch Intern Med 2008; 168:805-19. (*Review*)

30. Baxter K. Stockley's Drug Interactions. 9th Ed. London: Pharmaceutical Press; 2010. (*Book/ Monograph*)

31. Levine DP, Fromm BS, Reddy BR. Slow response to vancomycin or vancomycin plus rifampicin in methicillin-resistant *Staphylococcus aureus* endocarditis. *Ann Intern Med* 1991; 115:674-80. (*Randomised Controlled Trial*)

32. Cosgrove SE, Vigliani GA, Fowler VG Jr, Abrutyn E, Corey GR, Levine DP. Initial low-dose gentamicin for *Staphylococcus aureus* bacteremia and endocarditis is nephrotoxic. *Clin Infect Dis* 2009; 48:713-21. (*Meta-Analysis*)

33. Bolon MK, Morlote M, Weber SG, Koplan B, Carmeli Y, Wright SB. Glycopeptides are no more effective than beta-lactam agents for prevention of surgical site infection after cardiac surgery: a meta-analysis. *Clin Infect Dis* 2004; 38:1357-63. (*National Report*)

34. FDA Drug Safety Communication: Increased risk of death with Tygacil (tigecycline) compared to other antibiotics used to treat similar infections September 2010. http://www.fda.gov/Drugs/DrugSafety/ucm224370.htm (*Meta-Analysis*)

35. Barton E, MacGowan A. Future treatment options for Gram-positive infections--looking ahead. *Clin Microbiol Infect* 2009; 15 (Suppl 6):17-25. (*Review*)

36. Jauregui LE, Babazadeh S, Seltzer E, Goldberg L, Krievins D, Frederick M. Randomized, double-blind comparison of once-weekly dalbavancin versus twice-daily linezolid therapy for the treatment of complicated skin and skin structure infections. *Clin Infect Dis* 2005; 41:1407-15. (*Randomised Controlled Trial*)

37. National Methicillin-resistant *Staphylococcus aureus* reference Laboratory, Annual Report 2010. (*Report*)

38. European Centre for Disease Prevention and Control Updated Public Health Microbiology Strategy & Work Plan 2012-2016 http://www.ecdc.europa.eu/en/activities/microbiology/documents/1203_updated-ecdc-public-health-microbiology-strategy-work-plan-2012-2016.pdf (*Report*)

39. Chang S, Sievert D, Hageman JC *et al.* Infection with vancomycin-resistant *Staphylococcus aureus* containing the van A resistance gene. *N Engl J Med* 2003; 348: 1342-1347. (*Case Report*)

40. Hiramatsu K. Vancomycin-resistant *Staphylococcus aureus*: a new model of antibiotic resistance. *Lancet Infect Dis* 2001; 1: 147-155. (*Review*)

41. Hiramatsu K, Aritaka N, Hanaki H *et al.* Dissemination in Japanese hospitals of strains of *Staphylococcus aureus* heterogeneously resistant to vancomycin. *Lancet* 1997; 350:1670-1673. (*In-vitro Study*)

42. CLSI: Performance standards for antimicrobial susceptibility testing; twentieth informational supplement: M100-S20 Vol. 30 No.1 January 2010. (*Laboratory Standards*)

43. EUCAST Clinical Breakpoints: http://www.eucast.org/fileadmin/src/media/PDFs/EUCAST_files/Disk_test_documents/EUCAST_breakpoints_v1.3.xls (*Laboratory Standards*)

44. Tenover FC, Lancaster MV, Hill BC *et al.* Characterization of staphylococci with reduced susceptibilities to vancomycin and other glycopeptides. *J Clin Microbiol*. 1998; 36: 1020-7. (In-vitro stay)

45. Sakoulas G, Moise-Broder PA, Schentag J *et al.* Relationship of MIC and bactericidal activity to efficacy of vancomycin for treatment of methicillin-resistant *Staphylococcus aureus* bacteremia. *J Clin Microbiol* 2004; 42: 2398–2402. (*Observational Study*)

46. Moise-Broder PA, Sakoulas G, Eliopoulos GN *et al.* Accessory gene regulator group II polymorphism in methicillin-resistant *Staphylococcus aureus* is predictive of failure of vancomycin therapy. *Clin Infect Dis* 2004; 38: 1700-5. (*Observational Study*)

47. Ariza, J, Pujol M, Cabo J *et al.* Vancomycin in surgical infections due to methicillin-resistant *Staphylococcus aureus* with heterogeneous resistance to vancomycin. *Lancet* 1999; 353:1587-1588. (*Observational Study*)

48. Moore MR, Perdreau-Remington F, Chambers HF. Vancomycin treatment failure associated with heterogeneous vancomycin-intermediate *Staphylococcus aureus* in a patient with endocarditis and in the rabbit model of endocarditis. *Antimicrob Agents Chemother* 2003; 47: 1262 – 1266. (*In-vitro Study*)

49. Charles PG, Ward PB, Johnson PDR *et al.* Clinical features associated with bacteremia due to heterogeneous vancomycin-intermediate *Staphylococcus aureus*. *Clin Infect Dis* 2004; 38: 448-51. (*Observational Study*)

50. Maor Y, Hagin M, Belavsov N, Keller N, Brn-David B, Rahav G. Clinical features of heteroresistant vancomycin-intermediate *Staphylococcus aureus* bacteraemia versus those of methicillin-resistant *S. aureus* bacteraemia. *J Infect Dis* 2009 ; 199: 619-62. (*Observational Study*)

51. Hageman JC, Patel JB, Carey RC, Tenover FC, McDonald LC. Investigation and control of vancomycin-intermediate and-resistant *Staphylococcus aureus*: A guide for health departments and infection control personnel. Atlanta, GA, 2006. (*Guidelines*)

Section 2.3 Surveillance and Section 2.4 Evaluation and audit

1. Cohen AL, Calfee D, Fridkin SK *et al.* Society for Healthcare Epidemiology of America and the Healthcare Infection Control Practices Advisory Committee. Recommendations for metrics for multidrug-resistant organisms in healthcare settings: SHEA/HICPAC Position paper. *Infect Control Hosp Epidemiol* 2008; 29:901-13. (*Position Paper*)

2. Health Protection Surveillance Centre. Case Definitions for Notifiable Diseases (Infectious Diseases (Amendment) Regulations 2003 (SI No. 707 of 2003)). 2004. Available online from: http://www.hpsc.ie/hpsc/NotifiableDiseases/CaseDefinitions/File,823,en.pdf (*National Regulations*)

3. Marshall M, Campbell S. Introduction to quality indicators in general practice. Marshall M, Campbell Stephen, Hacker J, Roland M, (Eds) In: Quality indicators for general practice: A practical guide for health professionals and managers. The Royal Society of Medicine Press Ltd; 2002. (*Chapter*)

4. Turpin RS, Darcy LA, McMahill C *et al.* A model to assess the usefulness of performance indicators. *Int J Qual Healthcare* 1996; 8: 321-9. http://intqhc.oxfordjournals.org/cgi/reprint/8/4/321. (*Observational Study*)

5. Health Information and Quality Authority. Guidance on Developing Key Performance indicators and minimum data sets to monitor healthcare quality. Dublin, 2013. Available online from: http://www.hiqa.ie/publications/guidance-developing-key-performance-indicators-kpis-and-minimum-data-sets-monitor-healt (*National Regulations*)

6. Public Health Agency of Canada. Canadian Nosocomial Infection Surveillance Program, 2010 MRSA surveillance protocol: surveillance for methicillin-resistant *Staphylococcus aureus* (MRSA) in CNISP healthcare facilities. Available online from http://www.phac-aspc.gc.ca (*National Regulations*)

7. Australian Institute of Health and Welfare 2011. Australian hospital statistics 2010–11: *Staphylococcus aureus* bacteraemia (SAB) in Australian public hospitals. Health services series no. 42. Cat. no. HSE 116. Canberra: AIHW. (*National Regulations*)

8. Centre for Healthcare Related Infection Surveillance and Prevention (CHRISP). CHRISP surveillance manual (3rd Ed.). 2009, The State of Queensland, Queensland Health. Available online from http://www.health.qld.gov.au/chrisp/ (*National Regulations*)

9. Friedman ND, Kaye KS, Stout JE *et al.* Healthcare-associated bloodstream infections in adults: a reason to change the accepted definition of community-acquired infections. *Ann Intern Med* 2002;137:791-7. (*Observational Study*)

Section 3.0 Background and methodology

1. Jevons MP. Celbenin-resistant staphylococci. BMJ 1961;1:124-125. (*Observational Study*)

2. Cafferkey MT, Hone R, Coleman D. *et al.* Methicillin-resistant *Staphylococcus aureus* in Dublin 1971-84. *Lancet* 1985; 2(84570):705-708. (*Observational Study*)

3. Cafferkey MT (ed). Methicillin-resistant *Staphylococcus aureus*. Clinical management and laboratory aspects. New York: Marcel Dekkar, 1992. (Monograph/Book)

4. Cafferkey MT, Hone R, Falkiner FR, Keane CT, Pomeroy H. Gentamicin and methicillin-resistant *Staphylococcus aureus* in Dublin Hospitals: Clinical and laboratory studies. J Med Microbiol 1983; 16:117-127. (*Observational Study*)

5. Keane CT, Cafferkey MT. Severe infections caused by methicillin-resistant *Staphylococcus aureus*. *Eur J Clin Microbiol* 1983; 2:299-302. (*Review*)

6. Shore AC, Rossney AS, Kinnevey PM et al. Enhanced discrimination of highly clonal ST22-methicillin-resistant *Staphylococcus aureus* IV isolates achieved by combining spa, dru, and pulsed-field gel electrophoresis typing data. *J Clin Microbiol*. 2010;48:1839-52. (*In Vitro Study*)

7. Shore AC, Rossney AS, Brennan OM *et al.* Characterization of a novel arginine catabolic mobile element (ACME) and staphylococcal chromosomal cassette mec composite island with significant homology to *Staphylococcus epidermidis* ACME type II in methicillin-resistant

Staphylococcus aureus genotype ST22-MRSA-IV. *Antimicrob Agents Chemother* 2011 Feb 22. (*In Vitro Study*)

8. Shore A, Brennan OM, Ehricht R *et al.* Identification and characterization of the multidrug resistance eene *cfr* in a Panton-Valentine Leukocidin-positive sequence type 8 methicillin-resistant *Staphylococcus aureus* IVa (USA300) Isolate. *Antimicrob Agents Chemother* 2010;54:4978-84. (*In Vitro Study*)

9. Rossney A, Norgan P, O'Connell B. Community-acquired PVL+ MRSA in Ireland: a preliminary report. *Euro Surveill* 2005; 4: E050421.1 (*In Vitro Study*)

10. Rossney A, O'Connell B. Emerging high-level mupirocin resistance among MRSA isolates in Ireland. *Euro Surveill* 2008; 3-6. (*In Vitro Study*)

11. Harbarth S, Martin Y, Rohner P, Henry N, Auckenthaler R, Pittet D. Effect of delayed infection control measures on a hospital outbreak of methicillin-resistant *Staphylococcus aureus*. *J Hosp Infect* 2000;46:43-49. (Observational Interventional Study with Review)

12. Rubinovitch B, Pittet D. Screening for methicillin-resistant *Staphylococcus aureus* in the endemic hospital: what have we learned? *J Hosp Infect* 2001;47:9-18. (*Review*)

13. Department of Health and Children. North/South study of MRSA in Ireland 1999, 2000. Dublin. (*Observational Study*)

14. McDonald P, Mitchell E, Johnson H *et al.* Epidemiology of MRSA: the North/South study of MRSA in Ireland 1999. *J Hosp Infect* 2003; 54:130-134. (*Observational Study*)

15. Rossney AS, McDonald P, Humphreys H, Glynn GM, Keane CT. Antimicrobial resistance and epidemiological typing of methicillin-resistant *Staphylococcus aureus* in Ireland (North and South), 1999. *Eur J Clin Microbiol Infect* Dis 2003; 22:379-381. (*Observational Study*)

16. Burd M, Humphreys H, Glynn G et al. Control and the prevention of methicillin-resistant *Staphylococcus aureus* in hospitals in Ireland: North/South Study of MRSA in Ireland 1999. *J Hosp Infect* 2003; 53:297-303. (*Observational Study*)

17. McDonald P, Mitchell E, Johnson H *et al.* MRSA bacteraemia: North/South Study of MRSA in Ireland 1999. *J Hosp Infect* 2002; 52:288-291. (*Observational Study*)

18. Smyth ETM, McIlvenny G, Enstone JE et al. Four country healthcare associated infection prevalence survey 2006: overview of the results. *J Hosp Infect* 2008; 69:230-248. (*Observational Study*)

19. Burns K, Foley M, Donlon S. Point prevalence survey of healthcare-associated infection and antimicrobial use in European acute care hospitals, May 2012. Republic of Ireland: national report, May 2012. (*Observational Study*)

20. Smyth E, Cormican M, Hannan M, McMahon S, Philbin MP. Methicillin-resistant *Staphylococcus aureus* (MRSA) in Ireland: addressing the issues. Dublin 2010. (*Discussion Document*)

21. Annual Epidemiological Report. European Centre for Disease Prevention and Control, Stockholm, Sweden, 2008. (*International Report*)

22. Plowmann R. The socio-economic burden of hospital acquired infection. Public Health Laboratory Service, London, UK, 1999. (*Review*)

23. Annual Report. An Garda Síochana, Dublin, Ireland, 2009. (*National Report*)

24. Annual Report. National Methicillin-Resistant *Staphylococcus aureus* Reference Laboratory. St. James's Hospital, October 2011. (*National Report*)

25. Johnson AP, Davies J, Guy R, *et al.* Mandatory surveillance of methicillin-resistant *Staphylococcus aureus* (MRSA) bacteremia in England, the past 10 years. *J Antimicrob Chemother* 2012; 67: 802-809 (*Review*)

26. Van Cleef BA, Broens EM, Voss A *et al.* MRSA carriage in slaughterhouse workers in contact with live pigs in The Netherlands. *Epidemiol Infect* 2010; 138: 756-6321. (*Observational Study*)

27. Bootsma MC, Wassenberg MW, Trapman P, Bonten MJ. The nosocomial transmission rate of animal-associated ST398 methicillin-resistant *Staphylococcus aureus*. *J R Soc Interface* 2010; Sep 22. (*Observational Study*)

28. Strategy for the Control of Antimicrobial Resistance in Ireland Infection Control Sub-Committee. The control and prevention of MRSA in hospitals and in the community. Dublin, 2005. (*Clinical Guidelines*)

29. Liu, C, Bayer A, Cosgrove SE, *et al.* Clinical practice guidelines by the Infectious Diseases Society of America for the treatment of methicillin-resistant *Staphylococcus aureus* infections in adults and children. *Clin Infect Dis* 2011; 52: 1-38. (*Clinical Guidelines*)

30. Coia JE, Duckworth GJ, Edwards DI, *et al.* Guidelines for the control and prevention of methicillin-resistant *Staphylococcus aureus* (MRSA) in healthcare facilities by the joint BSAC/HIS/ICNA Working Party on MRSA. *J Hosp Infect* 2006; 63 (suppl): S1–S44. (*Clinical Guidelines*)

31. Gould FK, Brindle R, Chadwick PR et al. Guidelines for the prophylaxis and treatment of methicillin-resistant Staphylococcus aureus (MRSA) infections in the United Kingdom. J. Antimicrob Chemother 2009 63: 849-861.(*Clinical Guidelines*)

32. Guidelines for the management of community-associated methicillin-resistant *Staphylococcus aureus* clones in Western Australia. For community settings. Government of Western Australia. Department of Health, WA Communicable Disease Control Directorate© Department of Health 2008. http://www.public.health.wa.gov.au/3/896/3/camrsa.pm (*Clinical Guidelines*)

33. Gorwitz RJ, Jernigan DB, Powers JH, Jernigan JA, and Participants in the CDC Convened Experts' Meeting on Management of MRSA in the Community. Strategies for clinical management of MRSA in the community: Summary of an experts' meeting convened by the Centers for Disease Control and Prevention. 2006. http://www.cdc.gov/ncidod/dhqp/ar_mrsa_ca.html. (*Clinical Guidelines*)

34. Barton M, Hawkes M, Moore D *et al.* Guidelines for the prevention and management of community-associated methicillin-resistant Staphylococcus aureus: A perspective for Canadian healthcare practitioners. *Can J Infect Dis Med Microbiol* 2006; 17 (Suppl C): 4C-24C. (*Clinical Guidelines*)

35. Nathwani D, Morgan M, Masterton R *et al.* Guidelines for UK practice for the diagnosis and management of methicillin-resistant *Staphylococcus aureus* (MRSA) infections presenting in the community. *J Antimicrob Chemother* 2008; 61:976-94. (*Clinical Guidelines*)

36. Health Protection Agency 2007: HPA. Guidance on the diagnosis and management of PVL- associated *Staphylococcus aureus* infections (PVL-SA) in England, 2nd Edition. (*Clinical Guidelines*)

37. Health Protection Agency 2010: K Paranthaman, Maguire H, Haworth E, Lewis D. HPA – Local and Regional Services. Management of PVL-*Staphylococcus aureus*, Recommendations for Practice. January 2010. http://www.hpa.org.uk/web/HPAwebFile/HPAweb_C/1267551719486 (*Clinical Guidelines*)

38. Humphreys H. National guidelines for the control and prevention of methicillin-resistant *Staphylococcus aureus*-what do they tell us? *Clin Microbiol Infect* 2007; 13: 846-853. (*Review*)

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