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Guidelines for the control and prevention of meticillin-resistant *Staphylococcus aureus* (MRSA) in healthcare facilities☆

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Summary Meticillin-resistant *Staphylococcus aureus* (MRSA) remains endemic in many UK hospitals. Specific guidelines for control and prevention are justified because MRSA causes serious illness and results in significant additional healthcare costs. Guidelines were drafted by a multi-disciplinary group and these have been finalised following extensive consultation. The recommendations have been graded according to the strength of evidence. Surveillance of MRSA should be undertaken in a systematic way and should be fed back routinely to healthcare staff. The inappropriate or unnecessary use of antibiotics should be avoided, and this will also reduce the likelihood of the emergence and spread of strains with reduced susceptibility to glycopeptides, i.e. vancomycin-intermediate *S. aureus*/glycopeptide-intermediate *S. aureus* (VISA/GISA) and vancomycin-resistant *S. aureus*

☆ In this document, 'meticillin' has been used in place of the established 'methicillin' in accordance with the new International Pharmacopoeia guidelines.

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(VRSA). Screening for MRSA carriage in selected patients and clinical areas should be performed according to locally agreed criteria based upon assessment of the risks and consequences of transmission and infection. Nasal and skin decolonization should be considered in certain categories of patients. The general principles of infection control should be adopted for patients with MRSA, including patient isolation and the appropriate cleaning and decontamination of clinical areas. Inadequate staffing, especially amongst nurses, contributes to the increased prevalence of MRSA. Laboratories should notify the relevant national authorities if VISA/GISA or VRSA isolates are identified.

1. Preamble

Guidelines for the control of meticillin-resistant *Staphylococcus aureus* (MRSA) infections in hospitals in the UK have been published previously by a Joint Working Party of the British Society for Antimicrobial Chemotherapy and the Hospital Infection Society in 1986[1] and 1990,[2] and together with the Infection Control Nurses Association in 1998.[3] With the increased media and public interest, the advent of glycopeptide-resistant *S. aureus* and new drugs, including linezolid and teicoplanin, the Department of Health's Specialist Advisory Committee on Antimicrobial Resistance (SACAR) asked the three societies to revise the guidelines. SACAR also requested an enhanced focus on: (i) prophylaxis and therapy of MRSA infections; (ii) the laboratory diagnosis and susceptibility testing of MRSA; and (iii) the prevention and control of MRSA infections in the UK. The last is the subject of this report. The first two will be published elsewhere. These guidelines exclude evidence and recommendations for MRSA in paediatric, neonatal and dental patients for whom insufficient evidence exists. Where possible, recommendations have been given based on the evidence available, even though the evidence base may be poor. Most of the evidence reviewed concerns acute care settings. Nonetheless, many of the recommendations and principles in the guidelines will apply in other healthcare settings.

A systematic review was conducted covering the literature from the beginning of 1996 to the end of June 2004, thus focusing on the period since the preparation of the last guidelines. This review has also been published in this supplement. Data sources included MEDLINE, EMBASE, the Cumulative Index of Nursing and Allied Health Literature, the Cochrane Clinical Trials Register, the National Health Service (NHS) Centre for Reviews and Dissemination Database of Reviews of Effectiveness, and the Health Management Information Consortium Database. The focus of the review centred on the following questions:

- To what extent does the screening of patients before or on admission to hospital reduce the incidence of MRSA transmission and what are the costs?
- To what extent does the use of MRSA surveillance data reduce the incidence of MRSA transmission and what are the costs?
- To what extent does the isolation or cohorting of patients prevent the spread of MRSA and what are the costs?
- To what extent does environmental cleaning with detergent or detergent plus disinfectant contribute to the control of MRSA infection and what are the costs?

2. Grades of evidence and recommendations

Each recommendation, as graded by the US Centers for Disease Control and Prevention (CDC), is categorized on the basis of existing scientific data, theoretical rationale, applicability and economic impact. These grades were chosen in preference to those published by the Scottish Intercollegiate Guidelines Network or the National Institute for Clinical Excellence as they include scientific evidence and are not exclusively clinical. The CDC/Hospital Infection Control Practices Advisory Committee (HICPAC) system for categorizing recommendations is as follows.

- Category 1a. Strongly recommended for implementation and strongly supported by well-designed experimental, clinical or epidemiological studies.

- Category 1b. Strongly recommended for implementation and strongly supported by certain experimental, clinical or epidemiological studies and a strong theoretical rationale.
- Category 1c. Required for implementation, as mandated by federal or state regulation or standard. The UK equivalent is to operate within European Union or UK Health & Safety Legislation.
- Category 2. Suggested for implementation and supported by suggestive clinical or epidemiological studies or a theoretical rationale.
- No recommendation. Unresolved issue. Practices for which insufficient evidence exists or for which there is no consensus regarding efficacy.

2.1. Surveillance

Surveillance must be undertaken routinely as part of the hospital's infection control programme and must be a recognized element of the clinical governance process. As such, there should be clear arrangements identifying those responsible for acting on the results in individual hospital directorates (Category 1b).

For benchmarking purposes, surveillance data should be collected and reported in a consistent way, to agreed case definitions and using agreed specialty activity denominators, with stratification according to case mix (Category 1b).

Surveillance data should be fed back to hospital staff routinely, readily intelligible to most hospital staff, considered regularly at hospital senior management committees, and used in local infection control training.

MRSA surveillance should include:

- any mandatory requirements (Category 1c);
- results of microbiological investigations for clinical purposes (Category 1b); and
- results of microbiological investigations undertaken for screening purposes (Category 1b).

The dataset should include:

- patient, laboratory, unit/ward and hospital identifiers;
- patient demographics (address, age, sex);
- date of admission;
- date of onset of infection (if appropriate);
- site of the primary infection, if appropriate (if bacteraemia, source of the bacteraemia);
- date specimen taken;
- site of specimen (blood culture, wound, etc.);
- where the MRSA was acquired (hospital, community, specialty, etc.);
- whether part of an outbreak; and
- antimicrobial susceptibilities.

Other desirable items include the primary diagnosis, an assessment of severity of underlying illnesses, prior antimicrobial therapy and possible risk factors for infection (Category 2).

2.2. Antibiotic stewardship

- Avoidance of inappropriate or excessive antibiotic therapy and prophylaxis in all healthcare settings (Category 1a).
- Ensuring that antibiotics are given at the correct dosage and for an appropriate duration (Category 1b).
- Limiting the use of glycopeptide antibiotics to situations where their use has been shown to be appropriate. If possible, prolonged courses of glycopeptide therapy should be avoided (Category 1a).
- Reducing the use of broad-spectrum antibiotics, particularly third-generation cephalosporins and fluoroquinolones, to what is clinically appropriate (Category 1b).
- Instituting antibiotic stewardship programmes in healthcare facilities, key components of which include the identification of key personnel who are responsible for this, surveillance of antibiotic resistance and antibiotic consumption, and prescriber education (Category 1c).

2.3. Screening

Active screening of patients for MRSA carriage should be performed and the results should be linked to a targeted approach to the use of isolation and cohorting facilities (Category 2).

Certain high-risk patients should be screened routinely, and certain high-risk units should be screened at least intermittently in all hospitals. The fine detail regarding which patients are screened should be determined locally by the infection control team and must be discussed with the appropriate clinical teams and endorsed by the relevant hospital management structure. They will be influenced by the local prevalence of MRSA in the hospital and unit concerned, the reason for admission of the patient, the risk status of the unit to which they are admitted, and the likelihood that the patient is carrying MRSA. Patients at high risk of carriage of MRSA include those who are:

- known to have been infected or colonized with MRSA in the past (Category 1b);

- frequent re-admissions to any healthcare facility (Category 1b);
- direct interhospital transfers (Category 1b);
- recent inpatients at hospitals abroad or hospitals in the UK which are known or likely to have a high prevalence of MRSA (Category 1b); and
- residents of residential care facilities where there is a known or likely high prevalence of MRSA carriage (Category 1b).

Other risk groups may be defined by local experience, based on screening initiatives or outbreak epidemiology. Published examples have included injecting drug users, patients infected with human immunodeficiency virus, and members of professional contact sport teams (Category 2).

Units caring for patients at high risk for suffering serious MRSA infections or with a high proportion of MRSA infections among colonized patients include: intensive care, neonatal intensive care, burns, transplantation, cardiothoracic, orthopaedic, trauma, vascular surgery, renal, regional, national and international referral centres (all Category 1b), and other specialist units as determined by the infection control team and as agreed with the senior clinical staff of the units and relevant hospital management structure.

Patients on elective surgical units (e.g. orthopaedic, vascular), usually with short inpatient stays, are at lower risk of MRSA acquisition than patients on trauma and emergency units, or mixed units. Due account of these differences should be taken when local screening policies are being established (Category 2).

All patients who are at high risk for carriage of MRSA should be screened at the time of admission unless they are being admitted directly to isolation facilities and it is not planned to attempt to clear them of MRSA carriage (Category 2).

Regular (e.g. weekly or monthly, according to local prevalence) screening of all patients on high-risk units should be performed routinely (Category 2).

In addition, screening all patients (regardless of their risk-group status) should be considered on admission to high-risk units (Category 2). The decision about whether or not to perform routine admission screening should be made explicitly by the infection control team in consultation with the senior clinical staff of the units, and should be agreed with the relevant hospital management structure. Such 'blanket' screening may be used intermittently, and may be especially worthwhile if the local prevalence of MRSA carriage in such patients is higher than usual for the UK, if there are sufficient local isolation/cohorting resources to manage carriers effectively, and if local policies for clearance of carriage and/or use of surgical prophylaxis with glycopeptides are in place.

The following sites should be sampled for patients (Category 1b): anterior nares, skin lesions and wounds and sites of catheters, catheter urine, groin/perineum, tracheostomy and other skin breaks in all patients, and sputum from patients with a productive cough. The umbilicus should be sampled in all neonates. One should also consider sampling the throat.

The decision whether to perform screening of patients on admission to other wards or regular screening of inpatients on other wards should be decided by the local infection control team in consultation with the senior clinical staff of the units, and as agreed with the relevant hospital management structure (Category 2). In principle, hospitals with significant problems with MRSA transmission or a high prevalence of MRSA carriage or infection should consider performing more widespread and regular screening than units with a low prevalence. However, this approach has resource implications and should first be used in areas where the clinical impact of high MRSA prevalence is highest (i.e. in the 'high-risk' clinical areas). The aim is to identify all positive patients within the hospital to allow targeting of isolation and cohorting facilities in order to minimize the risk of onward transmission to other patients.

When possible, patients awaiting elective admission who satisfy local requirements for screening should be screened before admission by their general practitioners or in pre-admission clinics (Category 2). Patients who are at high continuing risk of acquiring MRSA between the time of pre-admission screening and that of admission (e.g. they reside in a residential care facility which is known to have a high prevalence of MRSA) must be rescreened on admission, and should be isolated or cohorted according to policies in place on the admitting unit until both sets of screening results are known.

Action to be taken if screening results are positive

In general, detection of patients colonized or infected with MRSA on a ward should be an indication for increased screening (Category 2). Little evidence exists to guide the details of an appropriate response, but this should be influenced by the risk group of the affected unit, by the number of newly detected MRSA-positive

patients, by the adequacy of nurse numbers to staff the ward, and by the availability of isolation and cohorting facilities. There is always a delay between MRSA acquisition by a patient and its presence being detectable by screening samples, so it is recommended that at least three screens at weekly intervals should be performed before a patient can be considered to be at low risk of having acquired MRSA if they have been nursed in proximity to unknown and unisolated MRSA-positive patients or by the same staff (Category 2). The screening for MRSA in each unit within a hospital should be the subject of regular audit, with the results reviewed by the hospital's infection control committee. The results should also be made available to management.

Screening of staff is not recommended routinely, but if new MRSA carriers are found among the patients on a ward, staff should be asked about skin lesions. Staff with such lesions should be referred for screening and for consideration of dermatological treatment by the relevant occupational health department (Category 1b). Staff with persistent carriage at sites other than the nose should be considered for referral for appropriate specialist management (e.g. ear, nose and throat; dermatology) who should arrange follow-up screening according to local protocols (Category 1b).

Staff screening is indicated if transmission continues on a unit despite active control measures, if epidemiological aspects of an outbreak are unusual, or if they suggest persistent MRSA carriage by staff (Category 2).

Care is needed to distinguish between transient carriage (i.e. nasal carriage which is lost within a day or so of removal from contact with MRSA-positive patients and carries little risk of onward transmission) and prolonged carriage (especially associated with skin lesions) (Category 1b). This is usually best achieved by screening staff as they come on duty at the beginning of their shift and not as they leave at the end of their shift.

Nurses, doctors, physiotherapists, 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 on other wards should also be considered (Category 2).

The special difficulties and risks posed by agency and locum staff should be considered (Category 1b).

Appropriate sampling sites for staff screening include anterior nares, throat and any areas of abnormal or broken skin (Category 1b). As a guide to use of eradication measures, one should consider screening the hairline and groin/perineum of staff members found to be MRSA positive.

It is recommended that a minimum of three screens at weekly intervals, while not receiving antimicrobial therapy, should be performed before a previously positive staff member can be considered to be clear of MRSA (Category 2). Local policies should be developed to guide postclearance sampling of staff (Category 2), and due note should be taken of the individual's risk of transmission to patients when agreeing their continuation or return to work. In principle, only staff members with colonized or infected hand lesions should be off work while receiving courses of clearance therapy.

No recommendation is made about performance of 'discharge screening'.

Performance of active screening for MRSA in each unit within a hospital must be the subject of regular audit, with the results reviewed and minuted by the hospital's infection control committee and made available to the appropriate hospital management structure (Category 1b).

Units with highly prevalent, endemic MRSA should consider focusing screening, control measures and other resources on high-risk units at first, with the intention of rolling them out to lower-risk areas after the position has improved (Category 2). Screening should not be seen as an end in itself, but rather it should be linked to specific, locally determined packages of control measures.

Geographically adjacent healthcare facilities, and those exchanging large numbers of patients because of clinical links, should liaise to agree common and efficient screening measures that should be linked to common and efficient control measures (Category 2). Such links should capitalize on any developing networking relationships among clinical and laboratory units, such as those encouraged through the Pathology Modernization initiative.

Results of screening cultures should be made available promptly to the clinical and infection control teams of other healthcare facilities to whom a patient is to be, or has recently been, transferred (Category 1b). Refusal to accept transfer of a patient is not justifiable on the basis of the risk posed to other patients by an individual's carriage of or infection with MRSA. All units should have procedures in place and adequate facilities for containment of MRSA.

Trusts should develop local protocols for informing patients, carers, relatives and staff members of their MRSA status with due regard for confidentiality (Category 2).

2.4. Decolonization

Nasal decolonization
Patients receiving prophylaxis for an operative procedure and in an outbreak situation under the advice of the infection control team should undergo nasal decolonization. This should be achieved by applying mupirocin 2% in a paraffin base to the inner surface of each nostril (anterior nares) three times daily for five days. The patient should be able to taste mupirocin at the back of the throat after application (Category 1b).

Mupirocin should not be used for prolonged periods or used repeatedly (i.e. for more than two courses for five days) as resistance may be encouraged (Category 1a).

Nasal decolonization using topical nasal mupirocin should be used with other forms of intervention such as skin decolonization with 4% chlorhexidine gluconate aqueous solution (Category 2).

Throat decolonization
Systemic treatment should only be prescribed on the advice of the consultant microbiologist in the hospital, with appropriate monitoring [e.g. regular liver function tests (LFTs) to monitor effects of the drugs on the liver]. If treatment is required, this should be restricted to one course of treatment, the course should not be repeated and the possible side-effects should be explained to the patient (Category 1b).

Systemic treatment should be given in conjunction with nasal mupirocin and skin decolonization (Category 1b).

Local treatment for throat carriage such as antiseptic gargles or sprays may be used to reduce the organism load (no recommendation).

Skin decolonization
Skin decolonization using 4% chlorhexidine bodywash/shampoo, 7.5% povidone iodine or 2% triclosan is useful in eradicating or suppressing skin colonization for short times, particularly preoperatively to reduce the risk of surgical site infections (Category 1a).

Patients should bathe daily for five days with the chosen antiseptic detergent. The skin should be moistened and the antiseptic detergent should be applied thoroughly to all areas before rinsing in the bath or shower. Special attention should be paid to known carriage sites such as the axilla, groin and perineal area. The antiseptic should also be used for all other washing procedures and for bed bathing. Hair should be washed with an antiseptic detergent (Category 1a).

After satisfactory completion of a course of treatment, i.e. each bath and hairwash, clean clothing, bedding and towels should be provided (Category 2).

For patients with eczema, dermatitis or other skin conditions, attempts should be made to treat the underlying skin condition. Advice on suitable eradication protocols for these individuals should be sought from a consultant dermatologist. Oilatum bath additive or Oilatum plus (with added benzalkonium chloride 6% and triclosan 2%) may be used with these patients; these should only be prescribed on the advice of a dermatologist (Category 2).

2.5. Patient management

General principles
The general principles of infection control should be adopted for the management of patients with MRSA. Good infection control practice should be placed at the centre of clinical practice, and requires the explicit support of the organizational executive to ensure that it is seen as having an appropriate position within the organization and can be enforced as a matter of clinical governance (Category 1b).

Standard infection control principles
A standard approach to isolation precautions should be adopted in accordance with the general principles of infection control, rather than introducing specific guidance for the management of MRSA that may lead to differing standards (Category 1b).

Management of MRSA-infected or -colonized patients
Patients should be managed in accordance with the type of facility in which they receive care, the resources available, and the level of risk that is posed to them and to others. Patients (and the facilities that may house them) classified as being at high risk of contracting MRSA or for whom the consequence of infection may have a high impact will require a rigorous approach to screening, placement and treatment. Patients identified with MRSA infection or colonization should be informed of their condition, and local arrangements should be made to ensure ease of identification if re-admission to the facility occurs (Category 1b).

Patient isolation
Patient isolation for those infected or colonized with MRSA will be dependent on the facilities available and the associated level of risk. Where new buildings or refurbishment are planned, published guidelines should be adopted to provide the most appropriate facilities for patient care. Isolation should be in a designated closed area that should be clearly defined; in most facilities, this will be either single-room accommodation or cohort areas/bays with clinical handwashing facilities. Consideration should be given to the provision of isolation wards to contain MRSA spread. The procedures for isolation should be clearly stated, and where necessary explained, to staff, patients and visitors. Hospital staff entering isolation facilities should be required to adopt the prescribed isolation precautions rigorously and these should be audited regularly. Non-staff visitors should be requested to adopt the necessary level of precautions to minimize the risk of spread of MRSA to other areas of the facility (Category 1b).

Cleaning and decontamination
Management of the environment and equipment should be considered as central to decrease the spread of MRSA. Cleaning regimens for isolation facilities should focus on the minimization of dust and the removal of fomites from contact areas. This should be a two-fold approach; firstly, the management of the occupied facility, and then the terminal clean of the facility after discharge of the patient. Cleaning regimens and products should be in accordance with local policy, but should include the removal of organic material with a general-purpose detergent. Cleaning regimens and their performance should be audited regularly.

Patient equipment, e.g. wheelchairs, hoists, slings, sphygmomanometer cuffs, etc., should either be capable of being decontaminated and be decontaminated before use with other patients, or should be single-patient use and discarded as clinical waste at the end of a period of usage (Category 1b).

Patient movement
The movement of patients with MRSA within a facility should be kept to a minimum to reduce the risk of cross-infection and any potential embarrassment for the patient. Where patients need to attend departments for essential investigations, the receiving area should be notified of the patient's MRSA status in advance of the transfer, and arrangements should be put in place to minimize their contact with other patients, i.e. to be called forward when the department is ready for them and to ensure that they are not held in communal waiting areas. Staff should adopt isolation precautions whilst in contact with the patient.

Arrangements for transfer to other healthcare facilities, e.g. hospitals, residential care homes, etc., should include notification of the individual's MRSA status, as appropriate (Category 1b).

Surgical/invasive procedures
Prior to any planned invasive procedure, efforts should be made to minimize the level of risk of infection through topical and systemic decolonization, and prophylactic antimicrobial therapy, as appropriate.

It may be considered desirable to place the individual at the end of a procedure list. However, in mechanically filtered environments such as operating theatre suites, the number of air exchanges should render this unnecessary. Good infection control practices, which should be in place between all patients, should reduce the risk of cross-infection (Category 1b).

Transportation
The risk of cross-infection from an MRSA-colonized or -infected patient to other patients in an ambulance is minimal. Good infection control practices and routine cleaning should suffice to prevent cross-infection (Category 2).

Discharge
Generally, there is no requirement for patients colonized with MRSA to continue with extended eradication protocols after discharge. This may be varied in the event of anticipated re-admission to a hospital, especially for a planned invasive procedure. It is appropriate that individuals/groups involved in further care are informed of the individual's known MRSA status at discharge.

Patients and their appropriate contacts should be fully briefed and given relevant information on MRSA, its implications and significance prior to discharge in order to reduce unnecessary anxiety and concern when returning to the home environment (Category 2).

2.6. Nursing staff workload and MRSA transmission

The Working Party emphasizes that inadequate nurse staffing is incompatible with effective infection control. Infection control teams and hospital managements should bear nursing workload in mind (including staff numbers, grades and levels

of experience, and patient acuity) when planning local responses to MRSA and when reacting to outbreaks, and adequate staffing resources must be given a high priority for all patient care areas (Category 1a).

Improving nurse staffing levels on an affected ward may allow improved adherence to local infection control policies (Category 2), and should be considered as a component of a package of measures to control local outbreaks (Category 2).

2.7. Control of vancomycin-intermediate and -resistant *S. aureus* (VISA and VRSA)

In the absence of randomized controlled trial data and on the basis of the descriptive studies outlined above and a strong theoretical rationale, recommendations for the control of these organisms remain the province of existing best practice and professional opinion. These measures can be conveniently considered under the headings of prevention, surveillance and precautions.

Prevention

Antibiotic resistance flourishes when antimicrobial drugs are abused, misused and dispensed at levels lower than treatment guidelines dictate. Virtually all strains of *S. aureus* with reduced susceptibility to glycopeptide antibiotics described to date are thought to have arisen from pre-existing reservoirs of MRSA, usually in patients with chronic underlying disease who have received multiple and/or prolonged courses of glycopeptide treatment. It seems logical, therefore, to ensure that measures outlined elsewhere in this document for control of MRSA are implemented within the healthcare institution, and that careful antibiotic stewardship is employed to minimize the inappropriate use of glycopeptide agents (Category 1b).

Where the use of such agents is deemed appropriate, clinicians should ensure that adequate dosages are given to ensure that therapeutic levels are obtained at the site of infection and that duration of therapy is not unnecessarily prolonged. These measures will help to reduce the likelihood of resistant strains arising *de novo* (Category 1b).

Surveillance

It is vital that clinicians and microbiologists remain aware of the potential for emergence of strains of *S. aureus* with reduced susceptibility to glycopeptide antibiotics, and that this awareness is reflected in ongoing laboratory-based surveillance programmes. The detection of intermediate-level resistance is challenging for laboratories. This is especially true for strains that are heterogeneous in their expression of glycopeptide resistance. A high level of suspicion must be maintained, particularly in patients who have received multiple and/or prolonged courses of glycopeptide antibiotics or who are known to be colonized/infected with MRSA and vancomycin-resistant enterococci (VRE). Detailed recommendations and levels of evidence for the laboratory detection of these strains are given in the Guidelines for the Laboratory Diagnosis and Susceptibility Testing of MRSA [3a].

The laboratory must notify the relevant clinician and infection control personnel as soon as possible after the isolation of a presumptive *S. aureus* isolate with reduced glycopeptide sensitivity in order that control measures can be implemented with minimum delay. It is also important that the relevant national surveillance network is notified to ensure that accurate information about the epidemiology and spread of these organisms is gathered (Category 1b).

Control precautions (all Category 1b)

Action to be taken on identification of a case of VISA/glycopeptide-intermediate S. aureus (GISA) or VRSA

- The laboratory should immediately notify the relevant clinician and infection control personnel.
- The infection control team should immediately identify where the patient is and where the patient has been during all of the current admission, including transfers from other healthcare facilities.
- The relevant national surveillance organization, e.g. Health Protection Scotland, Health Protection Agency in England and Wales, and the Health Protection Agency (Communicable Disease Surveillance Centre) in Northern Ireland, should be notified.

If the patient is still an inpatient

- The number of healthcare workers caring for the patient should be reduced. This will cause problems for those who are allocated to care for the patient. These healthcare workers will need support.
- Healthcare workers with chronic skin conditions, e.g. eczema or psoriasis, should not be involved in direct care of the patient.
- All staff caring for the patient should be made aware of how the organism is transmitted and the precautions necessary to prevent this.

- The patient should be cared for in a single room with toilet facilities and a wash hand basin.
- The patient and visitors must understand the need for isolation.
- Fans should not be used to control the patient's temperature.
- Appropriate infection control procedures should be implemented:
  1. Standard precautions should be used. Gowns/disposable aprons and disposable gloves should be worn by all those entering the patient's room. Clean, non-sterile gloves and gowns/aprons are adequate. Consideration should be given to use of theatre-style greens in addition to protective clothing to ensure that healthcare workers do not take uniforms home to launder.
  2. Disposable masks and eye protection should be worn by carers for procedures likely to generate aerosols/splashing. Use of closed suction systems will help to reduce aerosols.
  3. Hand hygiene should be performed with an antibacterial preparation before and after patient contact. Visibly soiled hands should be washed with soap prior to disinfection.
  4. Non-disposable items that cannot be easily cleaned or disinfected (e.g. sphygmomanometer cuffs) should be dedicated for use only by the infected/colonized patient.
  5. Patient charts and records should be kept outside the isolation room.
  6. Linen should be treated as infected. It must be discarded into alginate bags within the patient's room and a secondary bag outside the room.
  7. All waste should be discarded into a clinical waste bag inside the room, and bags should subsequently be disposed of according to hospital policy.
  8. Transfers of colonized/infected patients within and between institutions should be avoided unless essential, and the receiving institution should be made aware of the patient's colonization/infection status prior to transfer.
  9. After discharge, the room in which the patient was cared for should be cleaned according to local disinfection policy, with special attention given to horizontal surfaces and dust-collecting areas. Hot water and detergent are usually satisfactory. Curtains should be changed.
  10. Compliance with infection control procedures should be monitored.

Screening (all Category 1b)
Patients

- Nose, axillae, perineum, skin lesions and manipulated sites of the index case and all other patients in the unit should be screened for carriage of VISA/GISA or VRSA.
- The infection control team should review the admission history of the patient and determine if screening needs to be extended to other areas and other units alerted.

Staff

- Agreement with staff on the need for screening should be sought.
- Nose, axillae and perineum of healthcare workers and others with close physical contact with the case should be screened for carriage of VISA/GISA or VRSA.
- Healthcare workers who maintain contact with the patient will require weekly screening. This may require significant support for these staff.
- Feedback of results and maintenance of confidentiality should be considered.

Eradication (all Category 1b)

- Eradication of colonization/carriage of patients and healthcare workers should be attempted (see section on eradication of MRSA carriage).
- Colonized staff should be excluded from work until eradication of carriage is achieved.

3. Background

MRSA was first reported in 1961;[4] it has since been regarded both as a rare condition and of doubtful clinical significance,[5] and as a major pathogen in many countries.[6] Control is necessary because of the recent emergence of VISA and VRSA.[7,8] In some countries, such as The Netherlands, the proportion of *S. aureus* bloodstream infections that are meticillin resistant is small[9] (under 1%) compared with Germany (19%), Belgium (28%), France (33%), the USA (50%) and the UK (40%).[9,10] The low rates in some northern European countries may reflect a more vigorous 'search and destroy' policy combined with lower bed occupancy rates, or may reflect exposure to different strains of MRSA with less propensity for spread.

3.1. Why is control and prevention still important?

MRSA remains common in the UK.[11] Nonetheless, up to the early 1990s, MRSA accounted for less than 5% of *S. aureus* blood culture isolates. However, there has been a dramatic change in the last 10 years. The prevalence of meticillin resistance amongst strains of *S. aureus* causing bloodstream infection in the UK between 1990 and the early 2000s increased from 2% to >40%, and the mean overall rates of MRSA bacteraemia per 1000 occupied beds ranged from 0.10 to 0.19.[12] In an all-island prospective study of MRSA in Ireland, the prevalence rate per 100 000 population was higher in the south (14.0) compared with the north (11.4), and the incidence of invasive infection ranged from 5% to 10%.[13] Throughout Europe, there is considerable variation in the prevalence of MRSA, varying from low in the Scandinavian countries to high in the UK, Ireland, Spain and Italy, with the proportion of MRSA of *S. aureus* isolates amongst blood cultures increasing significantly between 1999 and 2002 in both the UK and Ireland.[14]

The reasons for continuing efforts to control MRSA, i.e. to prevent its occurrence in clinical areas that are MRSA free and minimize the prevalence and clinical impact (see below) where MRSA is not uncommon or even endemic, remain valid in the opinion of the Working Party. Nevertheless, justification for not implementing specific measures has been argued by others.[15–17] Amongst the reasons offered for relative inactivity include the view that these bacteria do not spread easily, are not virulent, specific measures advocated to control MRSA are counter-productive and, furthermore, they divert energies from other important areas of infection prevention. Finally, it is argued that the clinical impact of MRSA is no greater than that of meticillin-sensitive *S. aureus* (MSSA). Others acknowledge the clinical impact of MRSA but have been obliged, due to other considerations, to relax control measures and have documented the consequences.[18]

It is mistaken to believe that specific measures to control MRSA are at the expense of measures to control and prevent infection with other pathogens such as Gram-negative bacteria, as suggested in one study from a burns unit.[19] The experience of some countries such as Finland, where two successive MRSA outbreaks in the early 1990s were managed successfully and where MRSA is largely confined to long-term facilities rather than acute hospitals, suggests that it is possible in the non-endemic situation to control the spread of MRSA and also to eradicate it.[20,21] Whether it is possible to eradicate MRSA in hospitals where MRSA is endemic is debatable, but it is possible to control spread and minimize the clinical impact.

MRSA control measures have additional advantages to those of controlling MRSA alone as they accentuate the awareness of the importance of healthcare-associated infection and assist in the containment of other multi-antibiotic-resistant bacteria.[22] One of the reasons for the relative lack of success in the control of MRSA may be inadequate resources and the failure of healthcare professionals to comply with good infection control practice. A recent report, which incorporated a literature review and surveillance cultures in a 500-bed hospital in North America, confirmed that, amongst other things, poor adherence to isolation precautions and handwashing accounted for the apparent ineffectiveness of control measures.[23] Furthermore, an investigation of contact transmission of MRSA in Australia showed that 17% of contacts between a healthcare worker and an MRSA-colonized patient resulted in transmission of MRSA from the patient to the healthcare worker's gloves.[24] However, compliance rates with glove use in the same study were 75% amongst the healthcare workers surveyed but only 27% amongst doctors.[24] In a study of risk factors for MRSA transmission in an adult intensive care unit (ICU), staff shortages were the only significant variable associated with clusters of cases, but a mean of only 59% of patient contacts were followed by recommended hand disinfection procedures.[25] Furthermore, the authors calculated that an increase of 12% in hand hygiene compliance would have decreased the potential for MRSA transmission significantly.

Recent North American guidelines for the control and prevention of both MRSA and multi-drug-resistant enterococci emphasize the importance of good infection control practice such as hand hygiene protocols, but also recommend specific measures to control MRSA such as decolonization, active surveillance cultures and barrier precautions.[26] The arrival of clinically significant strains of vancomycin-heteroresistant *S. aureus* and strains that are fully resistant to vancomycin may mean that there will be fewer effective therapeutic options available to treat *S. aureus*.[27,28] Consequently, specific measures to control MRSA as part of an overall strategy of hospital infection prevention will help to reduce the number of patients likely to acquire both MRSA and strains resistant to vancomycin.

3.2. What is the true impact of MRSA?

Clinical

Although the majority of patients who acquire MRSA are merely colonized, not ill and do not require antibiotic therapy, a proportion (about one-third, depending on the patient population) of patients develop infection, including invasive infection, which may result in death. The number of patients in whom infection with MRSA has been associated with death as recorded on death certificates increased from 8% in 1993 to 44% in 1998 in England and Wales.[29] In a retrospective comparison of 504 bacteraemia patients with either MSSA or MRSA bacteraemia, mortality was greater in the MRSA group (14% vs 8%, $P < 0.05$).[30] Many historical or retrospective studies are difficult to assess because of deficiencies in data capture and because due allowance has not been made for inadequate initial antibiotic therapy. In a prospective study carried out over a four-year period, 84 patients with MRSA bacteraemia were compared with 100 patients with MSSA bacteraemia.[31] Multi-variate analysis revealed that overall mortality was highest in the MRSA group and that meticillin resistance was independently associated with death. A meta-analysis of nine suitable studies revealed that all but one found an increased risk of death from MRSA bacteraemia, the relative risk compared with MSSA bacteraemia arising from all of these studies being 2.12.[32] A more recent publication that assessed studies published between 1980 and 2000 found no studies that showed a lower mortality in patients with MSSA bacteraemia compared with MRSA bacteraemia, seven studies that showed a higher mortality in patients with MRSA bacteraemia, and 24 studies where there was no difference in mortality.[33] However, when the studies were combined in a meta-analysis, the odds ratio for increased mortality from MRSA bacteraemia was statistically significant.[33]

There is also significant morbidity and mortality associated with other invasive MRSA infections. In a prospective study of patients with ventilator-associated pneumonia caused by MRSA or MSSA, the presence of bacteraemia and septic shock was more frequent in the MRSA group, and mortality directly due to pneumonia was significantly higher amongst patients with MRSA infection.[34] In a prospective study of patients with MRSA and MSSA surgical site infections, patients with MRSA had a longer mean duration of hospital stay with a higher mortality.[35] Meticillin resistance remained an independent factor influencing mortality on multi-variate analysis in this study.

Inadequate or inappropriate infection control measures, including those directed at controlling MRSA, may have an adverse impact on hospital-acquired infection. There was a significant increase in the overall rate of hospital-acquired infection in a US hospital from 4.5% to 5.9% at a time when MRSA spread in that particular institution.[36]

Financial

A variety of attempts have been made to document the increased costs associated with MRSA, but separating the true cost of MRSA infections compared with the cost of MSSA, and the cost of the actual interventions to control and prevent MRSA from the consequences of colonization and infection, are very difficult. In a prospective case-control study, the median hospital stay attributable to primary nosocomial MSSA bacteraemia was four days compared with 12 days for MRSA, and the overall costs were $9661 and $27 083, respectively.[37]

It is difficult to extrapolate from local data to national data when assessing the true costs of MRSA in the healthcare sector and in society generally, because the incidence and prevalence varies from hospital to hospital, and it is difficult to standardize costs between hospitals. Nonetheless, in a Canadian hospital in which 20 patients with MRSA infections were compared with 79 colonized patients between 1996 and 1998, the cost of isolation and management of colonized patients was 1363 Canadian dollars per admission; extrapolating that throughout Canada, the authors concluded that the annual costs associated with MRSA infection in Canadian hospitals were between 42 and 59 million Canadian dollars.[38] In The Netherlands, where MRSA is relatively uncommon, it has been calculated that the cost of keeping one medical centre in Utrecht free of MRSA over a 10-year period (1991–2000) by implementing a 'search and destroy' policy, i.e. vigorous screening of possible MRSA cases, isolation, decontamination with topical agents and effective follow-up, was €2.8m.[39] The implementation of this policy was associated with 2265 lost hospital bed-days and wards being closed on 48 occasions.[39] The financial consequences of MRSA, if it had spread and caused infection requiring treatment over the 10-year period, were not calculated but would probably have been well in excess of this.

MRSA isolated from superficial sites and in long-stay patients in the community may have little clinical or financial impact. In contrast, MRSA in the ICU often results in bloodstream infection,

ventilator-associated pneumonia, intravascular-device-associated infections and urinary tract infections, with significant financial implications. A carrier in the ICU may also act as a reservoir for MRSA acquisition by many very ill patients at risk of invasive infection over many days or even weeks.

In a case-control study of patients in a medical ICU in France between 1993 and 1997 with a prevalence of MRSA carriage of 4%, the mean attributable cost associated with MRSA infection was calculated as $9275, and the total cost of an MRSA control programme ranged from $340 to $1480 per patient.[40] The authors also made an effort to calculate the impact of control measures, depending upon the cost of those control measures and their success in reducing incidence. A study of two tertiary neonatal units where efforts to control spread and prevent infections were different revealed interesting findings. In the first hospital, where there were 18 colonized patients and four infections over a 10-month period, the costs ranged from $48 617 to $68 637. In the second hospital, where efforts at control were less successful, 75 bacteraemias and 14 deaths over 31 months were recorded, with costs totalling $1.3 million.[41] There are, of course, the additional costs to patients and their families (e.g. loss of income), and to society (e.g. absence from the workforce) that also need to be considered.

3.3. Do control measures work and are they worthwhile?

The objective of control measures should be to prevent the acquisition of MRSA and eradicate it when it does arise in centres where it is not currently prevalent. In hospitals where MRSA is endemic, the objective is to minimize spread and, in particular, avoid as far as possible the clinical impact in high-risk patients such as those in the ICU or in other key clinical areas. Harbarth *et al*. argued that the number of patients with MRSA bacteraemia correlates with the hospital-wide prevalence of MRSA, and that even where control measures are delayed, control measures have a substantial impact on both the reservoir of MRSA patients and the attack rate of MRSA bacteraemia.[42] This is also supported by the modelling studies in the Health Technology Assessment systematic review of isolation policies.[43] Furthermore, some recent studies have suggested that MRSA control measures as part of an infection control programme can also reduce the impact of other multi-resistant bacteria in ill patients.[44] After the institution of good infection control practice, the incidence of MRSA colonization decreased (from 7.7% to 2.6%) and the percentage of patients with antibiotic-resistant *Klebsiella pneumoniae* also declined (1.7% to 0%).[44] In one of the largest resource-limited hospitals in the world, targeted intervention programmes, in which staff and patients were screened for MRSA carriage, patient carriers were isolated, and mupirocin and chlorhexidine were administered to carriers, resulted in the percentage of patients with MRSA bacteraemia in the ICU declining from 1% to 0.5%; however, this increased one year after the study when the intervention measures were withdrawn.[45] Feedback of MRSA rates is also important; when this was undertaken for *Clostridium difficile* infections, there was a decrease in incidence but this increased again when the feedback was discontinued.[46]

In a French study assessing the efficacy of a control programme during the mid 1990s, the rate of MRSA infection decreased from 5.9 to 0.8/1000 patient-days as did the prevalence of MRSA carriage and the ratio of MRSA to all *S. aureus*.[47] In a Spanish study, three time periods were studied, i.e. pre-outbreak, during an outbreak of MRSA and when a control programme was instituted. The number of cases per 1000 patient-days was 3.2, 8.2 and 2.0 during the respective periods in the ICU.[48] The authors estimated that the programme prevented 76% of expected MRSA cases and 85% of expected fatalities due to MRSA in the ICU. Another study in an ICU on the effect of application of mupirocin ointment to the nose with whole-body washing using chlorhexidine in patients colonized with MRSA to prevent pneumonia showed that there was a significant reduction in infection.[49]

In contrast, in a recent UK study conducted in two ICUs to assess the effectiveness of patient isolation during two periods, one of which involved not moving positive patients to an isolation room, the authors found no difference in the MRSA acquisition or transmission rates, and concluded that isolation policies should be re-evaluated.[50] An accompanying commentary argued that their conclusions were premature because admission cultures were obtained in only 80—87% of patients (possibly insufficient to prevent dissemination) and because compliance with hand hygiene was only 21%.[51] Nonetheless, this study demonstrates the need for well-designed studies to be carried out on specific interventions, addressing confounding factors.

When assessing the cost-effectiveness of MRSA control programmes, a number of variables have to be considered. These include the cost of the intervention and the cost of MRSA infection. Laboratory costs for MRSA screening are quite low; in one Canadian hospital, these were found to be $8.34 per specimen with a total cost of $30 632 during 1996 for a 980-bed hospital.[52]

A model has been proposed to explore the impact of MRSA acquisition and different MRSA screening tests; it was concluded that taking a sample from the nose alone and inoculating directly on to a ciprofloxacin Baird-Parker agar, without broth incubation, was the most cost-effective approach.[53] However, other aspects have to be costed and these include hospital-wide programmes of adequate cleaning and environmental decontamination. Interventions to improve hospital hygiene decreased the percentage of environmental sites positive for MRSA from 32% to 0.47% in one report.[54] Enhanced environmental decontamination is likely to assist in controlling the spread of MRSA as well as other bacteria such as *C. difficile*. It is also likely to improve the aesthetic appearance of the hospital, resulting in other beneficial health and psychological effects and demonstrating the values of the organization.

3.4. Conclusions

The data available to date strongly implicate MRSA as a significant hospital-acquired infection resulting in additional morbidity and mortality as well as contributing to healthcare costs. This applies to patients at particular risk, e.g. patients requiring intensive care and patients following major surgery, and the elderly, which comprise an increasing proportion of patients in acute hospitals and in other healthcare institutions. Furthermore, patients and the public are increasingly seeing MRSA and rates of MRSA infections as indicators of the quality of patient care. They require reassurance that all healthcare professionals are taking reasonable and sensible precautions to minimize spread. Although it is very difficult to carry out double-blind randomized controlled trials on specific aspects of recommended control programmes, because MRSA colonization and infection rates vary considerably from time to time and from centre to centre, control measures have been shown to be effective, resulting in reduced mortality as well as helping to contain healthcare costs. Consequently, the Working Party is of the strong opinion that an active MRSA control and prevention programme, as part of an overall infection control strategy within a hospital, continues to be the recommended approach.

4. Surveillance

'Epidemiologic surveillance is the ongoing systematic collection, analysis, and interpretation of health data essential to the planning, implementation, and evaluation of public health practice, closely integrated with the timely dissemination of these data to those who need to know. The final link in the surveillance chain is the application of these data to prevention and control.'

Thacker SB, Berkelman RL. Public health surveillance in the United States. *Epidemiol Rev* 1998;**10**: 164—190.

4.1. Background

Most reviews of interventions to prevent and control MRSA document the difficulty of establishing the effect of particular infection control interventions, as multiple interventions are usually used together. Surveillance, however, is a critical part of any infection control programme. It must not be an end in itself, but should be undertaken to improve the quality of care. It is the instrument for early recognition of changes in patterns of infection, identifying the size of the problem, monitoring trends and comparing rates, evaluating the effectiveness of interventions, identifying areas for further investigation or research, re-inforcing good practice, and influencing key hospital staff and decision makers. Robust surveillance cannot be undertaken on a 'shoestring' budget, but requires resourcing for the collection, collation, analysis and interpretation of data. Typically, this requires input from staff with information technology skills to the infection control team.

Seminal work in this area has demonstrated that hospitals with infection surveillance and control programmes reporting wound infection rates back to surgeons reduced rates of hospital-acquired infection by 20%, highlighting the importance of feeding back data to inform decision makers. These reductions were further augmented incrementally when surveillance had been in operation for at least one year and there were dedicated infection control practitioners (this study also demonstrated the cost-effectiveness of such programmes).[55] More recent work has also emphasized the importance of feedback of surveillance information. For instance, Stone *et al.* demonstrated that feedback of *C. difficile* rates with involvement of clinicians was associated with reductions in the incidence of *C. difficile* diarrhoea. When feedback was relaxed, rates rose, as did those for MRSA.[46] In addition, a descriptive study by Curran *et al.* investigated the hospital-wide feedback of MRSA acquisition data monthly to

clinical staff using statistical process control charts for each unit and its effect on rates of MRSA.[56] Twenty-five months of retrospective data and 21 months of prospective data were collected, and there were monthly reductions in MRSA acquisition from two months into the feedback process. During the prospective period, acquisition rates fell by approximately 50%, suggesting that regular feedback of surveillance data to healthcare staff had a positive effect on staff behaviour. In other studies, the surveillance usually formed part of a wider aggressive control programme.[57,58]

4.2. Sources of surveillance information

The most commonly utilized sources of surveillance information are microbiological reports, usually collected as part of 'alert organism' surveillance. However, most hospital control plans for MRSA also include interventions that are a source of surveillance data. Thus, many aggressive control strategies are based on screening patients to identify those colonized or infected with MRSA in order to segregate them from unaffected patients.[59,60] Many hospitals employ admission screening to keep units at high risk for serious MRSA infections free of MRSA, and routine patient screening on a regular basis may also be undertaken. Occasionally, discharge screening may be used to identify acquisitions during the admission. Staff may be screened in certain circumstances (see below). Prevalence surveys may be undertaken periodically across part of or the whole hospital to identify its infection status. These actions all result in information that may be useful for surveillance purposes.

4.3. Surveillance: information for action

The key steps in surveillance are the systematic collection of data, and its analysis, interpretation and dissemination for action. As noted earlier, feeding back the surveillance data to the staff in the hospital units surveyed is, in itself, an important infection control intervention. Moreover, for the benefits of surveillance to be maximized, surveillance needs to be tied in actively to system improvements. This is the basis of the quality improvement model, where the infection control practitioner must be able to identify the difference between natural and unnatural variation in real time, as well as all the possible causes and the most important causes, so that actions to improve the system can be recognized and implemented. This requires knowledge of the important elements in the system that are not performed or are not performed sufficiently well, e.g. hand hygiene or information about isolation precautions. There are various methods for displaying root causes of particular problems, such as the Fishbone cause-and-effect chart (Figure 1). This can be useful in identifying and addressing all factors contributing to acquisition and transmission of infection in a hierarchical way.[61] The numbers of MRSA acquisitions can be tracked clearly using a statistical process control (SPC) chart (Figure 2). This is a chronological chart of past events used to predict, with some degree of certainty, where future results should fall if the system remains stable and in control. SPCs distinguish between natural variation (part of the system) and unnatural variation (outwith the system). They are becoming increasingly used to present the data and to identify when numbers of cases are exceeding normal expectations for that unit. They can also identify significant reductions in variation that would occur if system improvements were implemented and sustained. An SPC chart must be updated regularly, preferably at monthly intervals. The initial objective is for results to stay within control limits. However, in the longer term, the objective is to reduce variation through sustained system improvements in infection control. An SPC chart will identify if the system has changed but not identify the cause of the change. CuSums and other statistical methods of depicting data may also be used.

Consequently, the information from the SPC chart or other statistical method being used to identify changes away from expected levels of acquisition needs to be linked to the causes of new acquisitions, with a focus on those that have the biggest impact. This approach is designed to reduce MRSA, but does not indicate the level at which it should be applied. National and organizational data are essential for trend analysis, but action to reduce MRSA acquisition should be taken at the ward or unit level as individual units vary in the patient risks, procedures, environment, facilities and staff. Actions must be tailored to each clinical unit's needs.

For surveillance to operate fully as a tool for quality improvement, it is important that it is recognized as being an inherent part of the hospital's clinical governance process, with clear arrangements in place that identify those responsible for taking action on the results in individual hospital departments. The results should be considered by the relevant senior management committee on a regular basis. They should also be used to inform local infection control training. Thus, the data should be disseminated in a timely manner and should be readily intelligible to a wide variety of hospital practitioners, from cleaners to

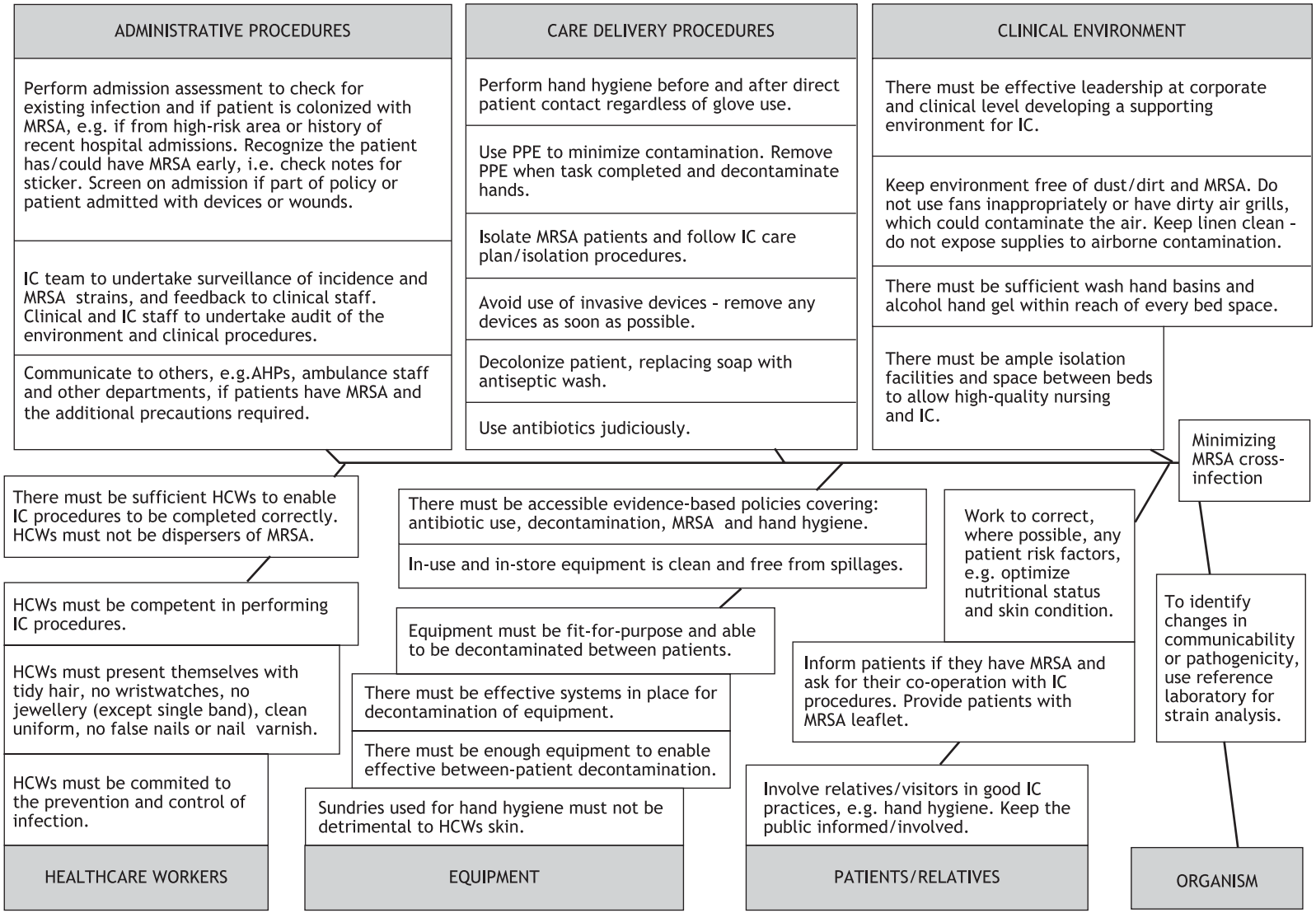

Figure 1 Fishbone cause and effect diagram displaying factors that impact upon the transmission of MRSA. The main branches represent the main factors. AHPs, allied health professionals; PPE, personal protective equipment; HCWs, healthcare workers; IC, infection control. Source: E. Curran.

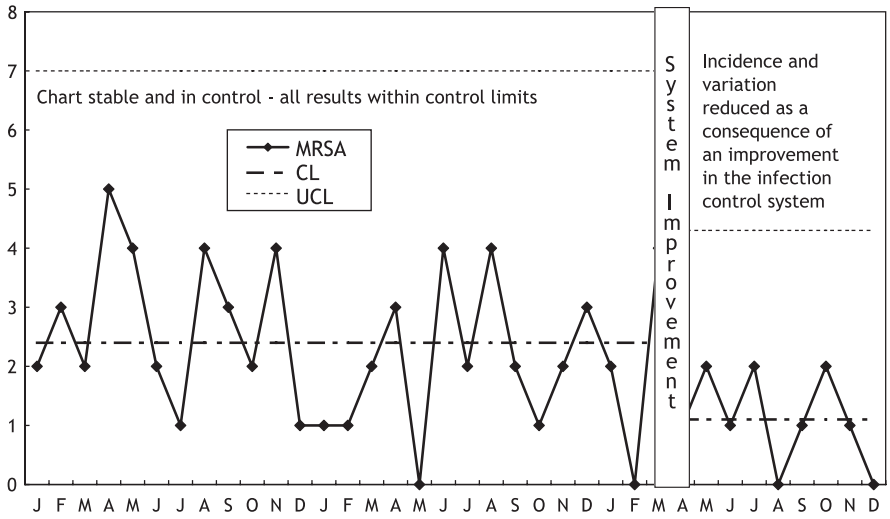

Figure 2 Statistical process control chart showing new meticillin-resistant *Staphylococcus aureus* acquisitions on a ward by month, before and after the introduction of system improvements. The centre line (CL) shows the mean number of acquisitions, whilst the upper (UCL) and lower (LCL) control limits show the range in which the data are expected if infection control systems in the ward remain stable. If new results fall within this range, the system is stable or 'in control'. If new acquisitions rise above the UCL, the system is out of control and infection control staff should identify likely cause(s) and intervene to bring the situation back to the 'in control' range. Apart from remaining 'in control', it is also important to put in training improvements to reduce the mean and control limits over time. Sources: E. Curran and Health Protection Agency.

clinicians, so that they can be utilized in training or update sessions.

Many different methods may be used for collecting and collating surveillance information and feeding it back to clinical teams.[62,63] Infection control software packages are available that can assist with the collation and analysis of surveillance information [Health Protection Agency Infection Control IT Implementation and Evaluation Project. Report prepared for the Department of Health, August 2005. Available at: http://hpa.org.uk/infections/topics_az/hai/ICITIAE_report_Dec_2005.pdf. Last accessed 26 January 2006].

Although the primary focus of surveillance should be as a tool for use at local level, surveillance at regional and national level is important to identify differing trends and for benchmarking. When comparing units within a hospital, it is often sufficient to measure numbers of infections. However, for data to be comparable between hospitals, specialty activity denominators become necessary and active case finding in a consistent fashion to agreed case definitions is paramount. National surveillance data may be used to drive action, as has been the case with the mandatory *S. aureus* bacteraemia surveillance system established in England in 2001 (Figure 3).[64–66] This, allied to the setting of targets and performance indicators, has been used by the UK Government to highlight unacceptably high rates of serious MRSA infections and to drive hospital management to take action.[67]

4.4. Recommendations

Surveillance must be undertaken routinely as part of the hospital's infection control programme, and should be a recognized element of the clinical governance process. As such, there should be clear arrangements identifying those responsible for acting on the results in individual hospital directorates (Category 1b).

For benchmarking purposes, surveillance data should be collected and reported in a consistent way, to agreed case definitions and using agreed specialty activity denominators, with stratification according to case mix (Category 1b).

Surveillance data should be fed back to hospital staff routinely, readily intelligible to most hospital staff, considered regularly by hospital senior management committees, and used in local infection control training.

MRSA surveillance should include:

- any mandatory requirements (Category 1c);
- results of microbiological investigations for clinical purposes (Category 1b); and
- results of microbiological investigations undertaken for screening purposes (Category 1b).

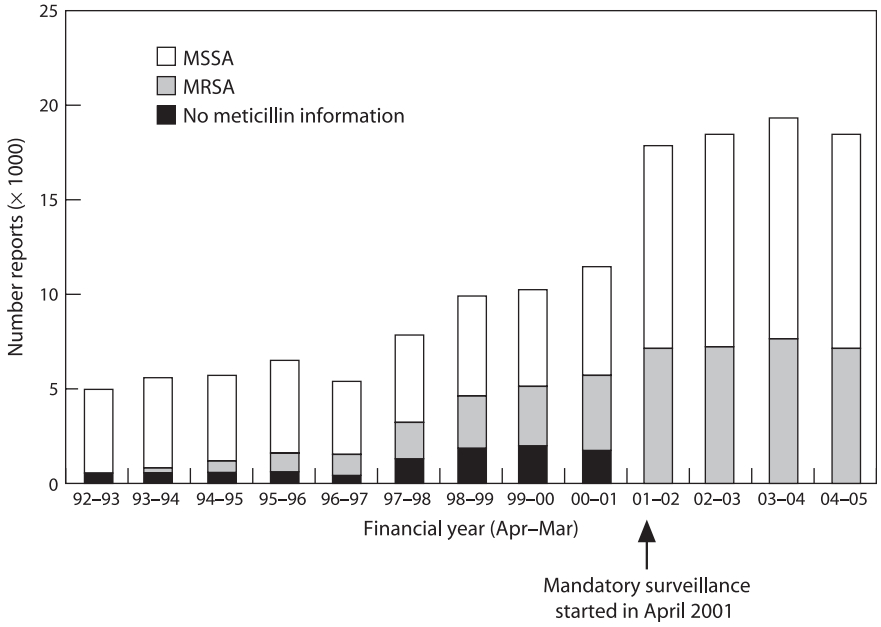

Figure 3 *Staphylococcus aureus* bacteraemias in England, 1992—2005. Mandatory surveillance of *S. aureus* bacteraemias started in April 2001. The data prior to this are from the routine laboratory reporting system (voluntary) to the Public Health Laboratory Service and, latterly, the Health Protection Agency. Numbers of reported bacteraemias increased following the start of mandatory surveillance, reflecting improved laboratory reporting of bacteraemias. MSSA, meticillin-sensitive *S. aureus*; MRSA, meticillin-resistant *S. aureus*.

The dataset should include:

- patient, laboratory, unit/ward and hospital identifiers;
- patient demographics (address, age, sex);
- date of admission;
- date of onset of infection (if appropriate);
- site of the primary infection, if appropriate (if bacteraemia, source of the bacteraemia);
- date specimen taken;
- site of specimen (blood culture, wound, etc.);
- where the MRSA was acquired (hospital, community, speciality, etc.);
- whether part of an outbreak; and
- antimicrobial susceptibilities.

Other desirable items include the primary diagnosis, an assessment of the severity of underlying illnesses, prior antimicrobial therapy and possible risk factors for infection (Category 2).

5. Prevention and control of MRSA infections

5.1. Antibiotic stewardship

Inappropriate antibiotic use promotes the emergence and spread of antibiotic resistance. The emergence of meticillin resistance in previously sensitive strains of *S. aureus* appears to be relatively rare. Excessive use of antibiotics, however, promotes the spread of existing strains of MRSA through reduction in colonization resistance in patients and by giving resistant strains a survival advantage in the hospital environment.[68]

Antibiotic use and compliance with local guidelines needs to be audited. Inappropriate antibiotic use, e.g. underdosing, multiple or excessive duration of courses, and the use of broad-spectrum agents are major factors in the spread of antibiotic resistance in healthcare settings. Numerous antibiotic classes have been associated with MRSA colonization and infection in different studies.[69—73] Exposure to broad-spectrum antibiotics, particularly third-generation cephalosporins and fluoroquinolones, is an independent risk factor for MRSA colonization and infection in numerous studies.[72,74—77] Furthermore, antibiotic stewardship programmes have been shown to result in significant reductions in MRSA colonization and infection rates.[78,79]

Colonization or infection with glycopeptide-resistant and intermediately-resistant *S. aureus* is strongly associated with prolonged exposure to glycopeptides and prior colonization or infection with MRSA.[27,80,81] Promotion of prudent glycopeptide use has been shown to reduce the prevalence of VRE in ICUs,[82] and it follows that prudent

glycopeptide use should also be promoted to prevent glycopeptide resistance in staphylococci.[83]

In addition to general (e.g. compliance with hand hygiene measures) and specific (e.g. screening for carriage) measures to control MRSA, attention must be given to the appropriate use of antibiotics. This includes the following.

- Avoidance of inappropriate or excessive antibiotic therapy and prophylaxis in all healthcare settings (Category 1a).
- Ensuring that antibiotics are given at the correct dosage and for an appropriate duration (Category 1b).
- Limiting the use of glycopeptide antibiotics to situations where their use has been shown to be appropriate. If possible, prolonged courses of glycopeptide therapy should be avoided (Category 1a).
- Reducing the use of broad-spectrum antibiotics, particularly third-generation cephalosporins and floroquinolones, to what is clinically appropriate (Category 1b).
- Instituting antibiotic stewardship programmes in healthcare facilities, key components of which include the identification of key personnel who are responsible for this, surveillance of antibiotic resistance and antibiotic consumption, and prescriber education (Category 1c).

5.2. Screening for MRSA

Introduction

Screening for MRSA should be directed at the common sites of carriage and infection. In *S. aureus* carriers of both meticillin-susceptible and -resistant strains, the anterior nares are persistently or intermittently colonized, whereas carriage at other normal body sites is generally less frequent and persistent.[84] Carriage is commonly persistent at sites of damaged or diseased skin (e.g. wounds, eczema) and at sites of insertion of foreign bodies such as intravenous catheters. Colonization of the throat may be a marker of persistent carriage in otherwise healthy staff members, and oropharyngeal carriage may persist in those with poor dental care, inadequately cleaned dentures or unhealthy tonsils. All studies of the value of screening patients and staff may inevitably be criticized methodologically. Screening is not a control measure in itself, and the clinical efficacy of any screening programme can only be measured by its ability to direct interventions such as isolation, cohorting and decolonization of a subset of patients. Implementation of these interventions varies widely among reported studies. Additional influential variables, such as the use of epidemiological factors to guide isolation of newly admitted patients before screening results are available, also differ among published reports. The authors of the recent Health Technical Assessment systematic review endorsed screening as a component of control policies, but did not find sufficient data to assess its individual contribution.[43]

Nevertheless, the Working Group agree with the conclusions of other MRSA guideline development groups who, while acknowledging the imprecision of the published evidence, were convinced by its consistency, which strongly suggests a causal relationship between programmes incorporating active surveillance cultures and isolation precautions and successful control of MRSA.[26,85] This approach is scientifically and managerially logical because colonized and infected patients are the primary reservoir of MRSA infection for others, and their identification by active screening allows focusing of effective but limited infection control resources on positive patients.[86] Fifteen full publications between 1982 and 2002 were adduced by the Society of Healthcare Epidemiology of America (SHEA) Working Party [26,40,42,87–98] in support of the value of active surveillance.[85–91] Several of these reports provided particularly significant additional information. Jernigan *et al.* demonstrated a 15.6-fold reduced rate of transmission (95% confidence interval 5.3–45.6, $P < 0.0001$) from patients who were known to be MRSA carriers by surveillance cultures compared with those whose screening results were not available.[87] Later re-analysis of the data showed that the effect was similar if patients who were only colonized with MRSA were studied (relative risk 11.9, 95% confidence interval 3.25–47.5, $P = 0.00014$).[99] Patients known to be positive were isolated with additional droplet or infection control precautions, while those not known to be positive were managed with standard or universal precautions. In a further study by the same group, these additional precautions were shown to be cost-effective.[41] Secondly, on a Dutch ICU, Vriens *et al.* found a 38-fold greater rate of transmission from unisolated unknown positive patients nursed with universal precautions compared with identified isolated positive patients cared for with gown, mask and gloves.[100]

Forceville *et al.* introduced active surveillance with other measures in a stepwise fashion to an ICU, and demonstrated a reduction in MRSA acquisition on the unit from 8.6% to 0% ($P < 0.001$) over a six-year period.[101] The methodology of this study may be criticized because the baseline rate was

only established over a one-month period, and the lowest rate was only seen in the final year, which may weaken the directness of the link between intervention and outcome. Surveillance screening data were used to produce control charts for regular feedback on MRSA local acquisition to ward clinical staff.[56] Twenty-five months of retrospective data and 21 months of prospective data were collected and, during the prospective intervention period, acquisition rates fell by about 50%.

A recent study in an 850-bedded community hospital in Italy with endemic MRSA (>50% of the *S. aureus* infections being meticillin resistant) reported the effects on MRSA bloodstream infections of introducing patient screening, targeted enhanced contact precautions, feedback of MRSA rates to ward staff, and mupirocin clearance of MRSA carriage.[102] A sustained fall in the incidence of MRSA bacteraemia was observed from 0.64 to 0.30 per 1000 admissions. Historical controls were used, but the baseline was established over 18 months, screening and interventions were progressively introduced over 30 months, and this was followed by a 24-month observation period. This reduction occurred despite rising usage of central venous catheters. Interestingly, a rise in the rate of MSSA central venous catheter infection was noted (0.81 to 1.59 per 1000 admissions, relative risk 1.96, 95% confidence interval 1.32−2.93, $P = 0.001$), which suggests that the change in MRSA rate was independent of any change in catheter management.

There is no good-quality, comprehensive guidance from the literature on which patients and body sites should be screened, and a variety of strategies have been adopted in published studies and are currently in use in UK healthcare facilities. Recommendations have been made based on consensus within the Working Party relating to screening of patients on admission to hospital and of inpatients on particular wards and units, and also relating to screening of staff members.

On the grounds of lack of evidence of clinical and cost-effectiveness, routine screening of all admissions to hospital is not advocated. However, local conditions may justify such a policy, perhaps temporarily, and such decisions should be made locally by the infection control team and be agreed with the relevant hospital managers and directors. This remains an unresolved issue. The decision to perform surveillance cultures before or at admission to a unit must be considered in relation to whether isolation or cohorting of patients on admission is to be used; whether details of patient management are to be influenced, such as attempts at decolonization or prophylaxis with glycopeptides for surgical procedures; and the availability of rapid methods for detection of MRSA carriage methods[3a].

'Discharge screening' as advocated in the 1998 guidelines may be useful as an epidemiological measure of the prevalence of MRSA colonization and acquisition on a unit, but it cannot guide the targeting of contact and isolation precautions at individual patients. There is no other valid reason for screening patients before discharge to the community, and carriage of MRSA is not a valid reason for exclusion from residential care homes.

There is evidently wide variation in practice among UK hospitals over screening patients who were known MRSA carriers in the past and may have received clearance therapy, and patients who have been exposed to MRSA. Some units specify two and others specify three sets of screens, between 48 h and seven days apart, and a variety of screening sites and screening methodologies have been used. Very few publications have addressed this issue. Bannister recommended five screens (with direct inoculation of a solid selective medium) for screening of previously positive patients before they were transferred to 'susceptible' hospital units.[103] The Working Party are not aware of any high-quality evidence to guide the choice among these alternatives, and it is recommended that this should be the subject of future study. On the grounds of practicability, the Working Party recommend that three screens should normally be performed one week apart, beginning at least 48 h after antibiotic and antiseptic therapy has stopped. Nevertheless, a total of five screens may be prudent in high-risk situations, and both relapse and re-infection may occur.

To guide the definition of risk groups, there is little good-quality published evidence on the prevalence and duration of MRSA carriage after attempted clearance of carriage and discharge of patients from hospital. A recent study from The Netherlands reported 95% clearance rates and prolonged clearance in patients with negative post-treatment screens and without conventional risk factors for MRSA persistence (e.g. abnormal respiratory tract, skin lesions or foreign bodies such as percutaneous gastroenterostomy tubes).[104] The authors recommended that patients could only be considered as risk free for subsequent MRSA carriage after remaining screen negative and free from risk factors for 12 months. This is a stringent requirement and the Working Party doubt that its application would be useful or practicable in the current UK healthcare system.

Recommendations

Active screening of patients for MRSA carriage should be performed and the results should be linked to a targeted approach to use of isolation and cohorting facilities (Category 2). The Working Party advocate that certain high-risk patients should be screened routinely, and certain high-risk units should be screened at least intermittently, in all hospitals. The fine details of which patients are screened should be determined locally by the infection control team and must be discussed with the appropriate clinical teams and endorsed by the relevant hospital managers and directors. These details will be influenced by the local prevalence of MRSA in the hospital and unit concerned, the reason for admission of the patient, the risk status of the unit to which they are admitted, and the likelihood that the patient is carrying MRSA. Patients regularly move among risk areas, and consideration should be given to extending screening measures to low-risk units if numerous patients are transferred from them to high-risk areas. Patients at high risk of carriage of MRSA include those who are:

- known to have been infected or colonized with MRSA in the past (Category 1b);
- frequent re-admissions to any healthcare facilities (Category 1b);
- direct interhospital transfers (Category 1b);
- recent inpatients at hospitals abroad or hospitals in the UK which are known or likely to have a high prevalence of MRSA (Category 1b); and
- residents of residential care facilities where there is a known or likely high prevalence of MRSA carriage (Category 1b).

Other risk groups may be defined by local experience, based on screening initiatives or outbreak epidemiology. Published examples have included injecting drug users, patients infected with human immunodeficiency virus, individuals with eczema, dermatitis and psoriasis, and members of professional contact sport teams (Category 2).

Units caring for patients at high risk for suffering serious MRSA infections or with a high proportion of MRSA infections among colonized patients include: intensive care, neonatal intensive care, burns, transplantation, cardiothoracic, orthopaedic, trauma, vascular surgery, renal, international referral centres (all Category 1b), and other specialist units (e.g. bone marrow transplant units) as determined by the infection control team and as agreed with the senior clinical staff of the units and relevant hospital management structure.

Patients on elective surgical units (e.g. orthopaedic, vascular), usually with short inpatient stays, are at lower risk of MRSA acquisition than patients on trauma and emergency units, or mixed units, and due account of these differences should be taken when local screening policies are being established (Category 2).

All patients who are at high risk for carriage of MRSA should be screened at the time of admission unless they are being admitted directly to isolation facilities and it is not planned to attempt to clear them of MRSA carriage (Category 2).

In addition, all inpatients on high-risk units should be screened regularly (e.g. weekly or monthly, according to local prevalence) (Category 2).

In addition, screening all patients (regardless of their risk-group status) should be considered on admission to high-risk units and to those units, especially elective surgical wards, designated as being 'MRSA free' (Category 2). The decision about whether or not to perform routine admission screening should be made explicitly by the infection control team in consultation with the senior clinical staff of the units, and should be agreed with the relevant hospital management structure. Such 'blanket' screening may be used intermittently, and may be especially worthwhile if the local prevalence of MRSA carriage in such patients is higher than usual for the UK, if there are sufficient local isolation/cohorting resources to manage carriers effectively, and if local policies for clearance of carriage and/or use of surgical prophylaxis with glycopeptides are in place.

For patients, the following sites should be sampled (Category 1b): anterior nares, skin lesions and wounds and sites of catheters, catheter urine, groin/perineum (specimens should be taken with sensitivity), tracheostomy and other skin breaks in all patients, and sputum from patients with a productive cough. The umbilicus should be sampled in all neonates. One should also consider sampling the throat as a marker of persistent colonization that may require more intensive clearance therapy.

The decision to perform screening of patients on admission to other wards or to screen inpatients on other wards regularly should be made by the local infection control team in consultation with the senior clinical staff of the units and as agreed with the relevant hospital managers and directors (Category 2). In principle, hospitals with significant problems with MRSA transmission or a high prevalence of MRSA carriage or infection should consider performing more widespread and regular screening than units with a low prevalence. However, this approach has resource implications and should first

be used in areas where the clinical impact of high MRSA prevalence is highest (i.e. in the 'high-risk' clinical areas). The aim is to identify all positive patients within the hospital to allow targeting of isolation and cohorting facilities to minimize the risk of onward transmission to other patients.

When possible, patients awaiting elective admission who satisfy local requirements for screening should be screened before admission by their general practitioners or in pre-admission clinics (Category 2). Patients who are at high continuing risk of acquiring MRSA between the time of pre-admission screening and that of admission (e.g. they reside in a residential care facility which is known to have a high prevalence of MRSA) must be rescreened on admission and should be isolated or cohorted according to policies in place on the admitting unit until both sets of screening results are known.

Action to be taken if screening results are positive
In general, detection of patients colonized or infected with MRSA on a ward should be an indication for increased screening (Category 2). Little evidence exists to guide the details of an appropriate response, but this should be influenced by the risk group of the affected unit, by the number of newly detected MRSA-positive patients, by the adequacy of nurse numbers to staff the ward, and by the availability of isolation and cohorting facilities. There is always a delay between MRSA acquisition by a patient and its presence being detectable by screening samples, and so it is recommended that at least three screens should be performed at weekly intervals before a patient can be considered to be at low risk of having acquired MRSA if they have been nursed in proximity to unknown and unisolated MRSA-positive patients or by the same staff (Category 2). The screening for MRSA in each unit within a hospital should be the subject of regular audit, with the results reviewed by the hospital's infection control committee. The results should also be made available to management.

Screening of staff is not recommended routinely, but the Working Party considers it to be valuable under certain circumstances. It is a controversial area and therefore guidance is provided. If new MRSA carriers are found among the patients on a ward, staff should be asked about skin lesions. Staff with such lesions should be referred for screening and for consideration of dermatological treatment by the relevant occupational health department (Category 1b). Staff with persistent carriage at sites other than the nose should be considered for referral for appropriate specialist management (e.g. ear, nose and throat; dermatology) who should arrange follow-up screening according to local protocols (Category 1b).

- Staff screening is indicated if transmission continues on a unit despite active control measures, if epidemiological aspects of an outbreak are unusual, or if they suggest persistent MRSA carriage by staff (Category 2).
- Care is needed to distinguish between transient carriage (i.e. nasal carriage which is lost within a day or so of removal from contact with MRSA-positive patients and carries little risk of onward transmission) and prolonged carriage (especially associated with skin lesions and throat colonization) (Category 1b). This distinction is usually best achieved by screening staff as they come on duty at the beginning of their shift and not as they leave at the end of their shift.
- Nurses, doctors, physiotherapists, 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 on other wards should also be considered (Category 2).
- The special difficulties and risks posed by agency and locum staff should be considered. It may be appropriate to consider the MRSA prevalence in units where staff of this type have recently worked when allocating work areas and tasks among agency and locum staff; this task is easier if agency and locum staff working on high-risk units can be drawn from a known pool of staff (Category 1b).
- Appropriate sampling sites for staff screening include anterior nares and any areas of abnormal or broken skin (Category 1b). As a guide to use of eradication measures and as markers of staff who may be at high risk of shedding MRSA to the environment, one should also consider screening throat, hairline and groin/perineum (specimens should be taken with sensitivity) of staff members found positive on initial screens.
- It is recommended that a minimum of three screens at weekly intervals (while not receiving antimicrobial therapy) should be performed before a previously positive staff member can be considered to be clear of MRSA (Category 2). Local policies should be developed to guide postclearance sampling of staff (Category 2), and due note should be taken of the individual's risk of transmission to patients when agreeing their continuation or return to work. For example, a staff member colonized with

MRSA working in an ICU or neonatal unit represents a greater potential risk to patients than a staff member with MRSA working in an outpatients department. In principle, it is recommended that only staff members with colonized or infected hand lesions should be off work while receiving courses of clearance therapy, but this decision should be based on local risk assessments. To aid staffing resources, it may be possible to re-allocate staff carriers temporarily to low-risk tasks or units.

The Working Party makes no recommendation about performance of 'discharge screening'.

Performance of active screening for MRSA in each unit within a hospital must be the subject of regular audit, with the results reviewed and minuted by the hospital's infection control committee and made available to the appropriate hospital managers and directors, and reported via the appropriate clinical governance structures (Category 1b).

Hospitals with highly prevalent, endemic MRSA should consider focusing screening, control measures and other resources on high-risk units initially, with the intention of rolling them out to lower-risk areas after the position has improved (Category 2). Screening should not be seen as an end in itself, but rather it should be linked to specific, locally determined packages of control measures.

Geographically adjacent healthcare facilities and those exchanging large numbers of patients because of clinical links should liaise to agree common and efficient screening measures that should be linked to common and efficient control measures (Category 2). Such links should capitalize on any developing networking relationships among clinical and laboratory units, such as those encouraged through the Pathology Modernization initiative.

Results of screening cultures should be made available promptly to the clinical and infection control teams of other healthcare facilities to whom a patient is to be, or has recently been, transferred (Category 1b). Refusal to accept transfer of a patient is not justifiable on the basis of the risk posed to other patients by an individual's carriage of or infection with MRSA. All units should have procedures in place and adequate facilities for containment of MRSA.

5.3. Decolonization

MRSA decolonization refers mainly to the use of topical agents such as nasal ointment and bodywash/shampoo to eradicate/reduce nasal and skin carriage.

Systemic antibiotics may be used to clear persistent carriage (e.g. persistent throat carriage). Complete eradication is not always possible but a decrease of carriage can reduce the risk of transmission in healthcare settings. Decolonization will also reduce the risk of inoculation to the patient's own surgical wound during the operation.

The efficacy of any decolonization regimen will depend on the presence of wounds, skin lesions and foreign bodies such as urinary catheters, nasogastric tubes, haemodialysis lines, etc. Any decolonization regimen should be carried out under the advice and supervision of the hospital infection control team.

The following section provides evidence for recommendations concerning the use of decolonization strategies in patients and staff to reduce the spread and incidence of MRSA. Suppression of carriage, eradication of carriage or both have been used at times to help control the spread of MRSA. Previous guidance suggests treatment of carriers of MRSA in certain circumstances, with evidence suggesting that patients and staff carriers are important sources of MRSA for subsequent spread.[3] The studies that have addressed the use of topical decolonization strategies in the eradication of MRSA include a recent Cochrane review of randomized controlled trials.[105] The remaining studies are observational, plus one controlled trial and a controlled before and after study. In addition to these studies, the most recent guidelines for the prevention of MRSA published by SHEA were appraised using the Appraisal of Guidelines for Research and Evaluation tool.[26] In these guidelines, it was shown that treating colonized or infected healthcare workers who were epidemiologically implicated in outbreaks has helped to control outbreaks.[106] For healthy healthcare workers, topical treatment with intranasal mupirocin ointment twice daily for five days was associated with a 91% reduction in the prevalence of *S. aureus* carriage, but recolonization was noted in 26% of decolonized healthcare workers within four weeks, with relapse or reinfection being the possible causes.[107] Higher success rates were reported for eradicating MRSA from hospitalized patients using a protocol that included mupirocin intranasal ointment, daily chlorhexidine baths, systemic therapy, removal and replacement of foreign bodies (e.g. catheters) and routine cleaning of the environment. Any studies using a combination of interventions together gave better success rates of decolonization, but only for a restricted time before recolonization. Therefore, it is difficult to evaluate the

effectiveness of one intervention alone, such as nasal mupirocin or chlorhexidine 4% for skinwashing.[108]

Nasal carriage

A Cochrane systematic review of randomized controlled trials involving patients colonized with MRSA tested the efficacy of intranasal mupirocin ointment compared with placebo in reducing colonization and preventing infection among persistent carriers of *S. aureus*. Reviewers concluded that there is insufficient evidence to support the widespread use of topical or systemic antimicrobial therapy for eradicating nasal or extranasal MRSA. Nevertheless, selective, short-term use of mupirocin for specific patient groups may be useful, e.g. patients about to undergo major surgery.[105]

The effect of a five-day course of mupirocin in reducing nasal colonization in both mupirocin-susceptible (MS) and mupirocin-resistant (MR) patients with MRSA (colonized, infected or both) in one hospital demonstrated that mupirocin was effective in eradicating MS MRSA, but strains of MR MRSA persisted after treatment suggesting treatment failure rather than recolonization.[109] Another study assessed the effectiveness of a programme of intranasal mupirocin throughout a neonatal unit during an outbreak of MRSA. The programme was effective in removing MRSA from the unit for three months and it therefore has a role when conventional methods have failed.[110] A prospective study considered the incidence of MRSA carriage at the time of admission and the rate of acquisition during hospitalization in patients with liver disease.[111] All nasal carriers of MRSA were treated with mupirocin for five days and underwent daily bodywashing using 4% chlorhexidine alternating with liquid soap. Nasal screening of all patients continued weekly. Although 98.8% were culture negative after one week of treatment, subsequent recolonization was common, particularly in long-term patients, and subsequent treatment failure was due to MR strains. As mupirocin did not reduce the risk of MRSA and high-level MR strains emerged, they recommended that mupirocin should only be used once.

In another study, patients were screened on admission and staff were screened for nasal carriage of MRSA on an ICU. Those positive for MRSA were treated with a five-day course of mupirocin.[112] Patients were placed in cohort isolation until discharge and a staff education programme of handwashing was introduced with monitoring for compliance. Although MRSA rates fell from 1.23 per 1000 to 0.53, follow-up was only for six months and it is not clear which of the interventions (i.e. isolation, mupirocin, handwashing education programme or monitoring of adherence) was the most effective in reducing MRSA.

Throat carriage

Treatment of throat carriage should only be considered in exceptional circumstances, e.g. when there is evidence that there is transmission from a throat carrier in a continuing outbreak or when the patient carrying MRSA in the throat has experienced episodes of invasive infection. Advice on choice of treatment and duration should be sought from the consultant microbiologist. Throat carriage may be associated with the presence of foreign bodies such as dentures and nasogastric tubes. Underlying conditions such as chronic tonsillitis may also contribute to persistent throat carriage.

In a study to assess the efficacy and safety of a short course of oral vancomycin combined with intranasal mupirocin in the eradication of MRSA in patients and staff, 69% ($N = 24$) were MRSA free after one course.[113] Eleven required further treatment and 80% ($N = 28$) reported side-effects. Consequently, great caution should be exercised when considering this option. While the combination of oral vancomycin and mupirocin is effective in the elimination of MRSA colonization, the safety of vancomycin requires further study.

Skin carriage

In a controlled study to eradicate skin carriage as part of peri-operative prophylaxis to reduce MRSA surgical site infections in patients undergoing orthopaedic prosthetic surgery, intranasal mupirocin was commenced one day pre-operatively and continued for five days.[114] In addition, patients had a pre-operative shower or bath using 2% triclosan, and patients were followed-up for 12 months. The study investigators concluded that this regimen could reduce the incidence of MRSA surgical site infection after orthopaedic surgery, probably by reducing nasal MRSA carriage in the endemic setting without selecting for mupirocin resistance.

A randomized controlled trial in two long-term-care facilities involved patients colonized with MRSA and compared single or combination, topical or systemic antimicrobials with placebo.[115] Investigators concluded that mupirocin was effective in decolonizing MRSA in persistent carriers, but the efficacy had decreased by day 90 after study entry. They suggested that pulse therapy with 14-day treatment every two to three months may be useful.

It has never been proven that, once colonized, any group of patients remain permanently MRSA free after a decolonization regimen. There is also the possibility of confounding by re-acquisition of the same strain, especially for patients housed in hospital and in contact with other MRSA carriers. The evidence from the above study shows that an individual can remain decolonized for up to 90 days in a community healthcare facility.

Recommendations

Nasal decolonization

Patients receiving prophylaxis for an operative procedure and in an outbreak situation under the advice of the infection control team should undergo nasal decolonization. This should be undertaken by applying mupirocin 2% in a paraffin base to the inner surface of each nostril (anterior nares) three times daily for five days. The patient should be able to taste mupirocin at the back of the throat after application (Category 1b).

Mupirocin should not be used for prolonged periods or used repeatedly (i.e. for more than two courses for five days), as resistance may be encouraged (Category 1a). The presence of a foreign body such as nasogastric tube may reduce the efficacy of treatment with nasal mupirocin (Category 2).

Nasal decolonization using topical nasal mupirocin should be used with other forms of intervention such as skin decolonization with 4% chlorhexidine gluconate aqueous solution (Category 2).

Throat decolonization

Systemic treatment should only be prescribed on the advice of the consultant microbiologist in the hospital, with appropriate monitoring (e.g. LFTs). If treatment is required, this should be restricted to one course of treatment. The course should not be repeated and the possible side-effects should be explained to the patient (Category 1b).

Systemic treatment should be given in conjunction with nasal mupirocin and skin decolonization (Category 1b).

The value of local treatment for throat carriage such as antiseptic gargles or sprays is uncertain, but may reduce the organism load (no recommendation).

Skin decolonization

Skin decolonization using 4% chlorhexidine bodywash/shampoo, 7.5% povidone iodine or 2% triclosan is useful in eradicating or suppressing skin colonization for short times, particularly preoperatively to reduce the risk of surgical site infections (Category 1a).

Patients should bathe daily for five days with the chosen antiseptic detergent. The skin should be moistened and the antiseptic detergent should be applied thoroughly to all areas before rinsing in the bath or shower. Special attention should be paid to known carriage sites such as the axilla, groin and perineal area. The antiseptic should also be used for all other washing procedures and for bed bathing. Hair should be washed with an antiseptic detergent (Category 1a).

After satisfactory completion of a course of treatment, clean clothing, bedding and towels should be provided after each bath and hairwash (Category 2).

For patients with eczema, dermatitis or other skin conditions, attempts should be made to treat the underlying skin condition. Advice on suitable eradication protocols for these individuals should be sought from a consultant dermatologist. Oilatum bath additive or Oilatum plus (with added benzalkonium chloride 6% and triclosan 2%) may be used with these patients; these should only be prescribed on the advice of a dermatologist (Category 2).

Careful consideration should be given in neonates regarding the appropriate use of agents used for decolonization. This should be discussed with the infection control team and the paediatrician/neonatologist (Category 2).

5.4. Patient management

Introduction

The proper management and placement of patients with infectious conditions is one of the fundamentals of infection control in minimizing the impact and potential transmission of any infectious condition, including MRSA. Evidence to support specific interventions is lacking due to many studies employing multiple interventions in the management of these patient groups, without demonstrating the value of individual measures. However, there is good evidence that these interventions can substantially reduce the incidence of MRSA, even in settings with a high level of endemic MRSA.[43] Accordingly, this section focuses on the principles of infection control and their application to the management of MRSA patients. Standard principles for isolation are detailed in the appendices. This section is based on a review of the 1998 guidelines, encompassing current recommendations as appropriate.[3]

General principles

The primary objectives of infection control are the prevention of acquisition and spread of infection by patients and staff. The priorities for targeted

control procedures are high-risk areas such as ICUs, elective surgery (e.g. orthopaedic, cardiac, etc.) and patients who are identifiable as particularly susceptible to infection.[116]

Infection control is the responsibility of all staff associated with patient care. A high standard of infection control is required in all wards and units, although the level of risk may vary, and is an important part of total patient care.[117] Contractors of health services should add their weight to these requirements by specifically including infection control in contract specifications,[118] and requiring the active participation of senior clinical and management staff in the control of hospital infection.[117] Provision for good infection control will be an expectation of agencies, e.g. Healthcare Commission, Clinical Negligence Scheme for Trusts.

It is essential that infection control is seen as an organizational responsibility and priority, that adequate facilities and resources are provided, and that appropriate infection control staff and support services are available.[116] The infection control team should agree a long-term strategy for control with hospital senior management, which should include provision for adequate isolation and handwashing facilities in new or upgraded units or hospitals.[118,119]

To ensure a high standard of practice, it is essential that a strong emphasis is placed on infection control being included as a core element of induction programmes for all new staff. It should be included within undergraduate and postgraduate training,[117] and in continuing education programmes for all staff groups.[120]

The general principles of infection control apply to all healthcare facilities, and are applicable to the control of MRSA. Infection control practice and facilities should be monitored and audited regularly by infection control and/or clinical staff, as appropriate, against published standards.[121] Current evidence-based written policies and guidelines should be available in all wards and units. The establishment of a link nurse/practitioner scheme should be considered to support infection control teams.[116]

It is the view of the Working Party that there is a lack of robust studies on the effectiveness of the use of isolation wards for containing the spread of MRSA. However, a series of studies appear to demonstrate that the employment of isolation wards is of benefit but that the numerical burden of MRSA cases may overwhelm the facilities available, and the individual's underlying condition may be compromised if patients are removed from specialist care.[122] The majority of cases will be isolated in single rooms or isolation wards. Where multiple cases are present, it may be considered prudent to cohort patients in closed bays to maximize resources, including staffing, within the speciality of their underlying condition.

Management of MRSA-infected or -colonized patients

Given that MRSA is considered to be widespread within the NHS, the course of action taken for the management of patients colonized and/or infected with MRSA will depend on a variety of factors that will be influenced locally by the level of MRSA within the organization.[43] Factors determining isolation practices include:

- type of hospital or facility (tertiary referral, district general, single speciality, intermediate care);
- type of ward (non-acute, acute, admission, intensive care or other high-risk unit);
- facilities available for patient isolation;
- ward design (availability of single-room accommodation; 'Nightingale', i.e. open-plan with no bays; wards with bays or cubicles);
- whether affected patients are likely to be heavy shedders of MRSA (e.g. those with burns or infected eczema);
- resistance pattern, virulence and potential transmissibility of the organism (e.g. E-MRSA 16, VISA, VRSA, etc.).

Risk of cross-infection can be categorized according to the risk or vulnerability of other patients on the ward or unit. The introduction of different categories of infection risk and infection control responses depends on the susceptibility of patients and available resources. Categories of risk and the appropriate control procedures are outlined below but these may overlap. It is not possible to be prescriptive for all circumstances as decisions need to be based on the local situation. Local risk assessment together with these guidelines should indicate the appropriate course of action of the infection control team. The trust's infection control policy should identify which clinical areas are included in each clinical risk category (see below), i.e. local priorities need to be specifically discussed, agreed and minuted as part of a specific policy. Depending on local clinical practice and ward case mix, it may be more practical for some hospitals to merge clinical risk categories.

Patients who are colonized or infected with MRSA should be informed of their condition and its implications, and should be clearly identified for infection control purposes.[3]

Recommended methods for improving identification of MRSA patients include:

- labelling medical records, in a manner agreed locally to preserve patient confidentiality, so that they are recognized immediately on admission;
- electronic labelling of patient database;
- ready access to a database of known affected patients in the admissions and accident and emergency departments.

Patients may also be given cards indicating that they have been infected or colonized with MRSA in the past (this has the benefit of informing staff if the patient is admitted to a different hospital or healthcare centre for treatment other than that where the original diagnosis was made).

General principles for MRSA management

Active and timely intervention can be effective in reducing the overall numbers of colonized and infected patients.[122] The infection control team should continue to assess the MRSA incidence, and whether most cases are new acquisitions within the hospital, or admissions and transfers of already infected/colonized patients. Where an increased incidence occurs, the general principles should be reviewed and re-inforced, with emphasis on monitoring compliance with infection control policies; cleaning in affected wards should be increased, including a schedule for thorough cleaning of all wards in rotation; antibiotic policies should be reviewed, particularly antibiotics used for prophylaxis and empirical therapy; and movement of patients between wards should be reduced.[26] Units containing vulnerable patients at high risk of developing invasive infection (e.g. patients with multiple trauma, patients following major life-saving surgery, patients on immunosuppressive therapy) should be given priority for maximal precautions.

Approach in high-risk areas of a hospital

High-risk areas, including specialist wards or units (as defined below), are those where the consequence of uncontrolled MRSA is serious because of the risk of invasive infection and difficulties in treatment.[3] These include: intensive care, neonatal intensive care, burns, transplantation, cardiothoracic, orthopaedic, trauma, vascular surgery, renal, regional, national or international referral centres, and other specialist areas as determined by the infection control team, and as agreed with the senior clinical staff of the units and the relevant trust management structure.

Approach in medium-risk areas

The level of risk within other areas of a hospital, e.g. admission wards, general surgical, urological, paediatric, general medical, elderly medicine, etc., and the measures that need to be applied will be determined locally by risk assessment and in accordance with the MRSA burden and the facilities available.

Approach in low-risk areas

The level of intervention where there is a low risk of invasive infection, but a high risk of colonization in low-risk areas, e.g. psychiatric, psycho-geriatric and long-term-care facility, including residential homes, should be determined by risk assessment, e.g. if it is a regular feeder to high-risk areas.

Category of isolation

Standard source isolation procedures should be instituted for affected patients. The patient's medical and psychological welfare should not be compromised by unnecessarily restrictive infection control practices. The infection control team should be contacted in case of doubt.

Individual single rooms or isolation wards (with en-suite facilities, if available) should be employed as the preferred standard of accommodation.[26]

Although the value of cohorting patients in areas such as ICUs is disputed, nursing MRSA patients in a defined area of a ward and using designated staff may be a necessary alternative to using single rooms where there are a number of affected cases.[50] Consideration will need to be given to the need to protect the privacy and dignity of the individual. Such areas should be capable of physical separation from other ward areas.[122]

The implications of MRSA colonization, infection and treatment should be explained to the patient and close relatives at the time of diagnosis and ideally prior to transfer to a side-room, isolation unit or designated area.[123] Information leaflets should be available giving general information on MRSA in the language appropriate to the recipient. Patients and visitors should be encouraged to play their part by complying with local recommendations for hand hygiene. Leaflets on MRSA may be obtained from either local resources, the Health Protection Agency (www.hpa.org.uk), the Association of Medical Microbiologists (www.amm.co.uk/newamm/html/public.htm), the Infection Control Nurses' Association (www.icna.co.uk), or national resources such as the National Resource for Infection Control (www.nric.org.uk) or the Department of Health's simple guide to MRSA (www.dh.gov.uk/PolicyAndGuidance/HealthAndSocialCareTopics/HealthcareAcquiredInfection/HealthcareAcquired

GeneralInformation/HealthcareAcquiredGeneralArticle/fs/en?CONTENT_ID=4093113&chk=7/XgcQ).

Isolation procedures

High standards of hand decontamination are required to minimize the risk of cross-infection. Hands should be adequately decontaminated before and after patient contact, and on leaving an isolation facility. Hands should be decontaminated by thorough washing and/or the application of a 70% alcohol hand rub preparation.[124]

Disposable aprons or gowns should be worn by all staff handling the patient or having contact with their immediate environment. This also applies to visitors who assist with the patient's bodily care. Visitors who only have social contact with the patient, such as shaking hands, do not need to wear protective clothing but do need to decontaminate their hands after leaving the room.

Gloves do not obviate the need for hand decontamination and should be worn when there is contact with body fluids and handling of contaminated dressings or linen.

Masks are occasionally necessary for healthcare workers such as when procedures may generate staphylococcal aerosols, e.g. during sputum suction or chest physiotherapy.

The door should be kept closed to minimize spread to adjacent areas. If this is likely to compromise patient care, for instance in elderly confused patients, a risk assessment should be made regarding whether the door may be kept open. Such patients often benefit from being nursed together in a cohort with other MRSA patients. The side-room door must be kept shut during procedures that may generate staphylococcal aerosols, such as chest physiotherapy or bed-making, etc.

Visitors to the cubicle or ward and staff from other wards and departments, e.g. physiotherapists, radiographers, other medical teams, students, etc., should only enter after permission and instruction from the nurse in charge.

A card or information sheet detailing isolation precautions should be displayed prominently.

Cleaning and decontamination

There is little evidence of the role that the environment and equipment play in the transmission of MRSA in a facility,[26,125,126] although in one extended outbreak of MRSA, a strong association was demonstrated when enhanced cleaning was introduced and the outbreak ended.[54] Accordingly, general principles should be adopted to minimize the bacterial burden within a facility. The ability of MRSA to survive in dust demonstrates the need for dust minimization, the removal of fomites from contact surfaces, and the appropriate disposal of contaminated waste and linen.[127] Local policies for environmental cleaning and equipment decontamination, and waste and linen management should state the necessary standards, and should be applied rigorously.[128] This guidance should be based on agreed national standards which should be subjected to monitoring.[129]

Adequate handwashing facilities and antibacterial hand rub/gel should be available for staff and visitor hand decontamination before and after contact with the patient or their immediate environment.

Instruments or equipment should preferably be single-patient use. Multiple-patient-use items should be decontaminated appropriately before use on another patient in accordance with local policy or the manufacturer's instructions.

There is some evidence that standard cleaning regimens are ineffective in eliminating MRSA contamination.[126] There is a requirement for protocols to be agreed for enhanced levels of cleaning, to include additional time to enable the removal of all reservoirs of dust, e.g. ventilation ducts, radiators, equipment, etc. MRSA-contaminated patient areas should be cleaned after the patient's discharge with hot water and detergent in accordance with local environmental decontamination protocol. Curtains should be removed and laundered if not single-use disposable curtains. Pillows and mattress covers should be checked for damage. Therapy beds may need specialist cleaning in accordance with the manufacturer's/hirer's instructions.

Additional general measures that may reduce spread include installing antibacterial hand rub dispensers at the ward entrance and the individual bedsides, and using individual staff dispensers. All staff, patients and visitors entering and leaving the ward should be required to decontaminate their hands with the antibacterial hand rub.[124]

Finally, there should be planned, periodic and thorough cleaning of the whole ward, including bedding and curtains.[126,129]

Clinical waste

All waste should be categorized as clinical waste, and disposed according to local policy.[130]

Linen

All linen from patients infected or colonized with MRSA should be considered to be contaminated/infected, including bedding and adjacent curtains, and should be managed in accordance with local policy and national guidance.[131]

Ward closure
Ward closure to new admissions may need to be considered in certain circumstances on the basis of risk assessment. Factors influencing consideration of ward closure to admissions include:

- risk status of patients to be admitted, e.g. elective orthopaedics, coronary artery bypass surgery;
- number of cases;
- MRSA strain, e.g. virulence, resistance, etc.;
- availability of alternative facilities;
- staffing levels.

Before re-opening to new admissions, effective environmental decontamination is required.

Transfer and discharge of MRSA-colonized or -infected patients
Within the hospital

- Transfer of MRSA-affected patients to other wards should be minimized to reduce the risk of spread, but this should not compromise other aspects of care, such as rehabilitation.
- Transport of the infected/colonized patient should be supervised carefully;
- Lesions should be occluded whenever possible with an impermeable dressing;
- Attendants who may be in contact with the patient should wear disposable plastic aprons to protect their clothing whilst in contact with the patient. Aprons should be removed when contact with the patient has finished and disposed of as clinical waste;
- Gloves need only be worn if staff transporting the patient have skin abrasions;
- The trolley or chair should be decontaminated in accordance with local policy after use by the patient and before being used for another patient. All linen should be dealt with as infected, in accordance with local policy;
- Staff should decontaminate their hands thoroughly after dealing with the patient and cleaning the trolley or chair.

Visits to outpatients and specialist departments
Visits by MRSA patients to other departments should be kept to a minimum. If this is necessary, either for investigation or treatment, prior arrangements should be made with staff of the receiving department, so that control of infection measures for that department can be implemented. These should include:

- dealing with these patients at the end of the working session if at all possible;
- the patient should spend the minimum time in the department, being sent for when the department is ready and not left in a waiting area with other patients;
- staff coming into close contact with the patient should wear disposable aprons. Staff should avoid direct contact with other patients whilst dealing with an MRSA-positive patient;
- equipment and the number of staff attending should be kept to a minimum;
- surfaces with which the patient has had direct contact should be decontaminated with hot water and detergent;
- linen should be treated as infected;
- staff should decontaminate their hands after contact with the patient.

Surgical intervention
Every effort should be made to eliminate or suppress colonization or infection with MRSA before surgery.[132] Decolonization of patients is addressed in Section 5.3. If not possible, the following should be performed to minimize the numbers of bacteria colonizing the patient and reduce the risk of introduction of the organism into an open wound. As part of pre-operative preparation:

- bathe/shower the patient with an antiseptic detergent, applied direct to the skin as a wash, and rinsed off;
- cover affected lesions with an impermeable dressing;
- clean the area adjacent to the lesion with alcoholic chlorhexidine;
- apply mupirocin to the nose before the operation if the patient is a nasal carrier;
- prophylactic antibiotic cover for surgical procedures in colonized or infected patients, following discussion with a medical microbiologist (see CG Gemmell, DI Edwards, AP Fraise *et al*. Guidelines for the prophylaxis and treatment of methicillin-resistant *Staphylococcus aureus* (MRSA) infections in the UK. J Antimicrob Chemother. Advanced access February 27, 2006);
- consideration may be given to placing patients at the end of the operating session. However, with effective theatre ventilation systems, there should be an adequate number of air exchanges to provide a safe environment within 15 min of removal of the MRSA patient from the operating theatre;[133,136]
- theatre surfaces in close contact or near the patient, such as the operating table or

instrument trolley, should be decontaminated with hot water and detergent followed by alcohol before being used for the next patient;
- patients may be allowed to recover after surgery in the operating theatre or an area not occupied by other patients to avoid possible contamination of the usual recovery area. If this is not possible, the patients should be segregated as far as possible within the recovery area, and nursed by staff dedicated to their care, employing standard isolation precautions.

Ambulance transportation

- Most MRSA carriers may be transported with other patients in the same ambulance without any special precautions, other than changing the bedding used by the carrier. High-risk categories of susceptible patients should not be transported in the same ambulance as a known MRSA-positive patient. Lesions should be covered;
- The ambulance service should be notified in advance by the responsible ward staff, if considered necessary by the infection control team;
- There is no evidence that ambulance staff or their families are put at risk by transporting patients with MRSA;
- To minimize the risk of cross-infection with any infectious agent, ambulance staff should use an antibacterial hand rub after contact with all patients as part of good, basic infection control practice;
- If further measures are required in special circumstances, the infection control team should inform the ambulance service;
- No additional cleaning of the ambulance is required after transporting an MRSA-positive patient. Further information can be found in 'National Guidance and Procedures for Infection Prevention and Control' by the Ambulance Association (June 2004).

Transfer to another hospital

MRSA infection or colonization should not be a barrier to good clinical care. Consequently, inter-hospital transfers should not be prevented or delayed, although unnecessary movement should be avoided.

Identification of infected or colonized patients is the responsibility of the transferring hospital. Before transfer, a member of the clinical team for the patient, or a member of the infection control team, at the transferring hospital should inform either the receiving ward staff or the infection control team at the receiving hospital of the patient's status.

Discharge of patients

MRSA patients should be discharged promptly from hospital when their clinical condition allows. The general practitioner and others involved in the patient's care should be informed.

MRSA carriers will not normally require special treatment after discharge from hospital. If a treatment course needs to be completed in particular circumstances, the infection control team should advise the general practitioner about this.

If the patient is discharged to a residential care facility, the medical and/or nursing staff should be informed in advance. Colonization or infection with MRSA is not a contra-indication to the transfer of a patient to a nursing or convalescent home.

It is essential that patients, their relatives and carers should be fully briefed on MRSA, informed that there is no risk of infection to healthy relatives and contacts outside the hospital, and that normal social interaction should not be compromised.

Patients should be advised that if they are hospitalized in future, they should advise admitting staff that they have been identified as carriers of MRSA in the past to ensure that they are managed appropriately.

There is no indication for routine screening before discharge to the community, including discharge to residential or care homes.

Deceased patients

The infection control precautions for handling deceased patients are the same as those used in life. Any lesions should be covered with impermeable dressings. Plastic body bags are not necessary, but may be employed as part of general practice in accordance with standard precautions for all patients. There is negligible risk to mortuary staff or undertakers provided that standard infection control precautions are employed.

Recommendations

General principles

The general principles of infection control should be adopted for the management of patients with MRSA. Good infection control practice should be placed at the centre of clinical practice, and requires the explicit support of the organizational executive to ensure that it is seen as having an appropriate position within the organization and can be enforced as a matter of clinical governance (Category 1b).

Standard infection control principles
A standard approach to isolation precautions should be adopted in accordance with the general principles of infection control, rather than introducing specific guidance for the management of MRSA that may lead to differing standards (Category 1b).

Management of MRSA-infected or -colonized patients
Patients should be managed in accordance with the type of facility in which they are cared for, the resources available, and the level of risk that is posed to them and to others. Patients (and the facilities that may house them) classified as being at high risk of either contracting MRSA or for whom the consequence of infection may have a high impact will require a rigorous approach to screening, placement and treatment. Patients identified with MRSA infection or colonization should be informed of their condition, and local arrangements should be made to ensure ease of identification if re-admission to the facility occurs (Category 1b).

Patient isolation
Patient isolation for those infected or colonized with MRSA will be dependent on the facilities available and the associated level of risk. Where new builds or refurbishment are planned, published guidelines should be adopted to provide the most appropriate facilities for patient care. Isolation should be in a designated closed area, which should be clearly defined; in most facilities, this will be either single-room accommodation or cohort areas/bays with clinical handwashing facilities. Consideration should be given to the provision of isolation wards to contain MRSA spread. The procedures for isolation should be stated clearly, and where necessary explained, to staff, patients and visitors. Hospital staff entering isolation facilities should be required to adopt rigorously the prescribed isolation precautions, which should be audited regularly. Non-staff visitors should be requested to adopt the necessary level of precautions to minimize the risk of spread of MRSA to other areas of the facility (Category 1b).

Cleaning and decontamination
Management of the environment and equipment is important in reducing the spread of MRSA. Cleaning regimens for isolation facilities should focus on the minimizing of dust and the removal of fomites from contact areas. This should be a two-fold approach; firstly, the management of the occupied facility, and then the terminal clean of the facility after discharge of the patient. Cleaning regimens and products should be in accordance with local policy, but should include the removal of organic material with a general-purpose detergent. Cleaning regimens should be audited regularly

Patient equipment, e.g. wheelchairs, hoists, slings, sphygmomanometer cuffs, etc., should either be capable of being decontaminated (and be decontaminated before use with other patients), or should be single-patient use and discarded as clinical waste at the end of a period of use (Category 1b).

Patient movement
The movement of patients with MRSA within a facility should be minimized to reduce the risk of cross-infection and any potential embarrassment for the patient. Where patients need to attend departments for essential investigations, the receiving area should be notified of the patient's MRSA status in advance of the transfer, and arrangements should be put in place to minimize their contact with other patients, i.e. to be called forward when the department is ready for them and to ensure that they are not held in communal waiting areas. Staff should adopt standard precautions whilst in contact with the patient.

Arrangements for transfer to other healthcare facilities, e.g. hospitals, residential care homes, etc., should include notification of the individual's MRSA status, as appropriate (Category 1b).

Surgical/invasive procedures
Prior to any planned invasive procedure, efforts should be made to minimize the risk of infection through topical and systemic decolonization, and prophylactic antimicrobial therapy, as appropriate.

It may be considered desirable to place the individual at the end of a procedure list, although in environments with mechanically filtered ventilation, such as operating theatre suites, the number of air exchanges should render this unnecessary. Good infection control practices, which should be in place between all patients, should reduce the risk of cross-infection (Category 1b).

Transportation
The risk of cross-infection from an MRSA-colonized or -infected patient to other patients in an ambulance environment is minimal. Good infection control practices and routine cleaning (see also Ambulance Service Association guidelines) should suffice to prevent cross-infection (Category 2).

Discharge
Generally, there is no requirement for patients colonized with MRSA to continue with extended eradication protocols after discharge. This may be varied in the event of anticipated re-admission to a hospital, especially for a planned invasive procedure. It is appropriate that individuals/groups involved in further care are informed of the individual's known MRSA status at discharge.

Patients and their appropriate contacts should be fully briefed and given relevant information on MRSA, its implications and significance prior to discharge to reduce unnecessary anxiety and concern when returning to the home environment (Category 2).

5.5. Nursing staff workload and MRSA transmission

Many studies have identified peaks in ward nursing staff workload with increased rates of nosocomial infection,[18,25,90,134–153] and some are prospective in design.[25,70,90,147] This effect is consistent in all reports, and has most commonly been reported in connection with staphylococcal cross-infection (including MRSA) and central-venous-catheter-associated bloodstream infection. This association has been found in a wide range of individual hospital units, including adult and neonatal ICUs and burns units, and also at the whole-hospital and national level. Various methodologies for assessing nursing workload have been used in these studies, ranging from simple measures of staff and patient numbers, to more complex assessments of nursing capability and of patient care requirements. The whole issue of nursing staff working conditions and the resulting impact on nosocomial infection has been reviewed recently.[145]

There are obvious conflicts between the workload demands made on nursing and other staff and their ability to perform recommended hand hygiene procedures.[139,140] This was highlighted by Voss and Widmer, who emphasized that clinical workload pressures on nurses reduce the time available for performing routine infection control procedures and raise the likelihood that micro-organisms will be transferred among patients.[141] Similarly, in a large prospective study, Pittet *et al*. found that members of nursing staff were least likely to perform hand hygiene when they were most busy (and consequently when they had the highest frequency of times per hour when they should perform it).[142] The details of control measures themselves introduced in response to MRSA outbreaks also affect ward nursing staff workload (e.g. whether cohorting or closure of wards to new admissions is used[143]), and it is logical to infer that extra infection control procedures are unlikely to be fully implemented by overstretched staff. Finally, the inter-relationships among workload, performance of hand hygiene and MRSA transmission on an ICU were modelled by Grundmann *et al*. They estimated that a 12% improvement in performance of hand hygiene would have compensated for the increased transmission otherwise seen during periods of maximal pressure on staff.[25] One state in the USA has introduced minimum staffing ratios, while others have prohibited mandatory overtime for nurses and held hospitals accountable for implementing approved staffing plans.[146]

Recommendations
The Working Party emphasizes that inadequate nurse staffing is incompatible with effective infection control. Infection control teams and hospital managements should bear nursing workload in mind (including staff numbers, grades and levels of experience, and patient acuity) when planning local responses to MRSA and when reacting to outbreaks, and adequate staffing resources must be given a high priority for all patient care areas (Category 1a).

Improving nurse staffing levels on an affected ward may allow improved adherence to local infection control policies (Category 2), and should be considered as a component of a package of measures to control local outbreaks (Category 2).

6. *S. aureus* with reduced susceptibility to vancomycin

Susceptibility to vancomycin in *S. aureus* is defined as a minimum inhibitory concentration (MIC) $\leq$4 mg/L.[154,155] Until relatively recently, strains with an MIC nearing that breakpoint were unheard of. However, since the first description of VRE in the mid 1980s[156] and the subsequent demonstration *in vitro* that such resistance mediated by *vanA* genes was transmissible to *S. aureus*,[157] there was considerable anxiety and speculation amongst clinical microbiologists about the potential for the emergence of clinical isolates of *S. aureus* with reduced susceptibility to glycopeptide antibiotics. These fears were realized when the first case of clinical infection with *S. aureus* with reduced susceptibility to vancomycin was reported in Japan in 1997.[158]

Since that time, a small but increasing number of clinical isolates of *S. aureus* with reduced glycopeptide susceptibility have been reported.[27] Because these cases share common features (patients have

almost invariably had previous MRSA colonization/infection and have received long and repeated courses of glycopeptide therapy[159]) it is now apparent that this is not a homogeneous group and strains differ in their phenotypic expression and underlying genotypic mechanism of resistance. Further details of the nomenclature, mechanisms of resistance, characterization and laboratory detection of these strains is provided in recent recommendations.[3a] The following two paragraphs defining the terminology of VISA, VRSA, GISA, etc. are taken from the aforementioned document.

There is some confusion regarding the definition and nomenclature of reduced susceptibility to glycopeptides in *S. aureus*, which is compounded by differences in breakpoints. The first *S. aureus* with reduced susceptibility to vancomycin (MIC 8 mg/L) was designated 'VRSA' by the British Society of Antimicrobial Chemotherapy breakpoints. The first US report referred to these isolates as 'VISA' according to National Committee of Clinical Laboratory Standards breakpoints. The broader generic term 'GISA' was introduced as these isolates also had reduced susceptibility to teicoplanin, although some have reduced susceptibility to teicoplanin alone (TISA). In addition, two resistance phenotypes, heterogeneous and homogeneous, have been recognized. Isolates with heterogeneous intermediate resistance (hGISA or heteroGISA) appear to be susceptible to glycopeptides (vancomycin MIC $\leq$ 4 mg/L) but contain subpopulations of cells at frequencies of $>10^{-6}$ that exhibit reduced susceptibility (vancomycin MIC 8–16 mg/L). The term '*S. aureus* with reduced vancomycin susceptibility' has been suggested for isolates with vancomycin MIC of $\geq$4 mg/L, which may more closely resemble GISA than glycopeptide-susceptible *S. aureus* (GSSA).

These definitions are largely phenotypic. The Working Party recommends that the terms 'VISA', 'TISA' and 'GISA' should be used for isolates with homogeneous low-level resistance, hVISA, hTISA and hGISA should be used for isolates with heterogeneous low-level resistance, and VRSA should be used for isolates with higher levels of resistance to vancomycin (MIC $\geq$ 32 mg/L). It should be appreciated, however, that infections caused by strains with homogeneous low-level resistance are unlikely to respond to therapy with glycopeptides in serious infections, and this may also be the case with some heterogeneous low-level-resistant isolates.

6.1. Recent epidemiology

VISA/GISA and VRSA infections are still relatively rare. Only a handful of cases of infection caused by VISA[27,160–165] and three cases of infection caused by VRSA[28,166,167] have been reported in the USA. Although the first VISA isolate was described in Japan in 1997,[158] a recent nationwide survey suggested that such strains are not widely disseminated in Japanese hospitals.[168] France,[169] Germany,[170] the UK,[171] Spain,[172] Hong Kong,[173] Greece,[174] Italy,[175] Australia,[176] Brazil,[177] Korea[178] and Poland[179] have all described isolation of *S. aureus* strains with reduced susceptibility to vancomycin. While some of these isolates have been associated with failure of treatment of individual patients, most (especially hVRSA) have only been identified as part of retrospective testing surveys. Tenover argued that since MRSA may be highly transmissible in healthcare settings, it is prudent to assume that VISA/GISA (and by inference, VRSA) may be no less transmissible.[180] Although VISAs have been described in many parts of the world, these are comparatively rare and do not generally appear to be a problem.

As indicated above, in virtually all cases infections with these organisms have arisen in patients with significant previous morbidity, previous MRSA colonization or infection, and prior glycopeptide therapy. Fridkin *et al.* performed prospective surveillance and a nested case-control study of US patients infected with *S. aureus* with reduced vancomycin susceptibility.[159] This confirmed antecedent vancomycin use and prior MRSA infection in the two to three months prior to the current infection as independent risk factors.

Further elucidation of the epidemiology of these organisms will be dependent on clinical laboratory vigilance. It is particularly important that sufficiently robust methods are used to detect low levels of glycopeptide resistance in *S. aureus* isolates.[181]

6.2. General prevention and control measures

As a result of the relatively limited experience of VISA/GISA infections worldwide, and the even smaller number of documented VRSA infections, there is no randomized clinical trial data on which to base control measures for these organisms. Nonetheless, guidelines for the management of patients infected and/or colonized with isolates of *S. aureus* with reduced susceptibility to glycopeptides have been published and are broadly based upon existing guidance for the control of VRE infections.[182,183] This guidance has been implemented in those cases of VISA/GISA/VRSA infection described in the literature, and some of these reports provide limited evidence for the effectiveness of these measures, which is discussed in more detail below.

6.3. Effectiveness of control measures for VISA/GISA and VRSA

There have been no randomized controlled trials to assess the effectiveness of control measures for VISA/GISA and VRSA. The following suggested measures are based upon the interim guidelines of the CDC for prevention and control of staphylococcal infection associated with reduced susceptibility to vancomycin.[182,183] The evidence to support the effectiveness of this guidance is largely based upon observational studies that have looked either retrospectively or prospectively for evidence of transmission to known contacts after precautions have been implemented.

In the USA, all infection control personnel dealing with confirmed VISA/GISA infections to date have adopted practices based to a large extent upon the HICPAC guidelines. Approximately 400 culture specimens obtained from contacts (healthcare workers and family members) failed to identify any additional individuals colonized or infected with VISA/GISA.[160] In most of these patients, contact precautions were already in place as a result of pre-existing MRSA and/or VRE colonization. Retrospective analysis of chronic haemodialysis patients in the USA colonized with VISA/GISA also failed to find evidence of transmission to other patients or healthcare workers after implementation of the HICPAC recommendations.[184] Similar findings have been reported for a VISA-colonized patient in the home healthcare setting.[164] Similarly, secondary spread of VRSA has not been documented following implementation of this guidance.[28]

It has been demonstrated that these strains do have the potential for nosocomial transmission, as evidenced by dissemination within Japanese hospitals.[185] In a recent report from Brazil, the introduction of control measures based upon the HICPAC guidance was associated with cessation of ongoing transmission of VISA/GISA strains.[156] In another small study in a French ICU, eradication of VISA/GISA colonization in three staff members (one therapist and two nurses) was associated with a reduction of VISA/GISA colonization and/or infection rates of ICU patients from 1.5% to 0.2%.[186]

6.4. Recommendations for control of VISA and VRSA

In the absence of randomized controlled trial data and on the basis of the descriptive studies outlined above and a strong theoretical rationale, recommendations for the control of these organisms remain the province of existing best practice and professional opinion. These measures can be conveniently considered under the headings of prevention, surveillance and precautions.

Prevention

Antibiotic resistance flourishes when antimicrobial drugs are 'abused, misused and dispensed at levels lower than treatment guidelines dictate'.[187] Virtually all strains of *S. aureus* with reduced susceptibility to glycopeptide antibiotics described to date are thought to have arisen from pre-existing reservoirs of MRSA, usually in patients with chronic underlying disease who have received multiple and/or prolonged courses of glycopeptide treatment.[159,188] It seems logical, therefore, to ensure that measures outlined elsewhere in this document for control of MRSA are implemented within the healthcare institution, and that careful antibiotic stewardship is employed to minimize the inappropriate use of glycopeptide agents (Category 1b).[83]

Where the use of such agents is deemed appropriate, clinicians should ensure that adequate dosages are given to ensure that that therapeutic levels are obtained at the site of infection and that the duration of therapy is not unnecessarily prolonged. These measures will help to reduce the likelihood of resistant strains arising de novo (Category 1b).

Surveillance

It is vital that clinicians and microbiologists remain aware of the potential for emergence of strains of *S. aureus* with reduced susceptibility to glycopeptide antibiotics, and that this awareness is reflected in ongoing laboratory-based surveillance programmes.[189] The detection of intermediate-level resistance is challenging for laboratories.[190,191] This is especially true for strains that are heterogeneous in their expression of glycopeptide resistance.[28,192–194] A high level of suspicion must be maintained, particularly in patients who have received multiple and/or prolonged courses of glycopeptide antibiotics or who are known to be colonized/infected with MRSA and VRE. Detailed recommendations and levels of evidence for the laboratory detection of these strains are given in Ref. 3a.

The laboratory must notify the relevant clinician and infection control personnel as soon as possible after the isolation of a presumptive *S. aureus* isolate with reduced glycopeptide sensitivity in order that control measures can be implemented with minimum delay. The isolate should also be forwarded to a reference laboratory. It is also important that the relevant national surveillance network is notified to ensure that accurate

information about the epidemiology and spread of these organisms is gathered (Category 1b).

Control precautions (all Category 1b)
Action to be taken on identification of a case of VISA/GISA or VRSA

- The laboratory should immediately notify the relevant clinician and infection control personnel;
- The infection control team should immediately identify where the patient is and where the patient has been during all of the current admission, including transfers from other healthcare facilities;
- The relevant national surveillance organization, e.g. the Health Protection in Scotland, the Health Protection Agency in England and Wales, and the Health Protection Agency (Communicable Disease Surveillance Centre) in Northern Ireland, should be notified.

If the patient is still an inpatient

- The number of healthcare workers caring for the patient should be reduced. This will cause problems for those who are allocated to care for the patient;
- Healthcare workers with chronic skin conditions, e.g. eczema or psoriasis, should not be involved in direct care of the patient;
- All staff caring for the patient must be aware of how the organism is transmitted and the precautions necessary to prevent this;
- The patient should be cared for in a single room with toilet facilities and a wash hand basin;
- The patient and visitors need to understand the need for isolation;
- Fans should not be used to control the patient's temperature;
- Appropriate infection control procedures should be implemented.
  1. Use standard precautions. Gowns/disposable aprons and disposable gloves should be worn by all those entering the patient's room. Clean, non-sterile gloves and gowns/aprons are adequate. Staff should use theatre-style scrub suits in addition to protective clothing to ensure that healthcare workers do not take uniforms home to launder.
  2. Disposable masks and eye protection should be worn by carers for procedures likely to generate aerosols/splashing. Use of closed suction systems will help to reduce aerosols.
  3. Hand hygiene should be performed with an antibacterial preparation, before and after patient contact. Visibly soiled hands should be washed with soap prior to disinfection.
  4. Non-disposable items that cannot be easily cleaned or disinfected (e.g. sphygmomanometer cuffs) should be dedicated for use solely by the infected/colonized patient.
  5. Patient charts and records should be kept outside the isolation room.
  6. Linen should be treated as infected. It must be discarded into alginate bags within the patient's room and a secondary bag outside the room.
  7. All waste should be discarded into a clinical waste bag inside the room, and bags should subsequently be disposed of as per hospital policy.
  8. Transfers of colonized/infected patients within and between institutions should be avoided unless essential, and the receiving institution should be made aware of the patient's colonization/infection status prior to transfer.
  9. After discharge, the room in which the patient has been cared for should be cleaned, with special attention given to horizontal surfaces and dust-collecting areas. Hot water and detergent are usually satisfactory. Curtains should be changed.
  10. Compliance with infection control procedures should be monitored.

Screening (all Category 1b)
Patients

- Nose, axillae, perineum, skin lesions and manipulated sites of the index case and all other patients in the unit should be screened for carriage of VISA/GISA or VRSA;
- The infection control team should review the admission history of the patient and determine if screening needs to be extended to other areas.

Staff

- Agreement with staff on the need for screening should be sought;
- Nose, axillae and perineum of healthcare workers and others with close physical contact with the case should be screened for carriage of VISA/GISA or VRSA;
- Healthcare workers who maintain contact with the patient will require weekly screening.

This may require significant support for these staff;
- Feedback of results and maintenance of confidentiality should be considered.

Eradication (all Category 1b)

- Eradication of colonization/carriage of patients and healthcare workers should be attempted (see section on eradication of MRSA carriage);
- Colonized staff should be excluded from work until eradication of carriage is achieved.

7. Recommendations for future research

- The Working Party recommend a study of the clinical and cost-effectiveness of rapid screening methods (such as polymerase chain reaction) for MRSA, linked to their ability to direct efficient use of physical isolation facilities and procedures, decolonization procedures and glycopeptide surgical prophylaxis;
- The Working Party recommend that studies should be carried out to determine the sensitivity and clinical effectiveness of different screening strategies for considering patients free from MRSA carriage (or as not having acquired carriage after exposure); e.g. whether two or three sets of swabs should be taken between 48 h and one week apart, and of what sites;
- The Working Party recommend performance of studies investigating the impact of staff workload on MRSA infection and control, on the value of setting limits on staff workload, and on the impact of infection control measures on staff workload. The Working Party endorse the recommendations in this area made by the EPIC guideline project;[144]
- The Working Party advocate an assessment of the effectiveness of current and emerging approaches to environmental decontamination and their impact on MRSA colonization and infection rates;
- The Working Party recommend that research should be carried out in comparing the effectiveness of different cleaning regimens and technologies together with an assessment of their cost-effectiveness. For example, a comparison of conventional cleaning techniques with steam cleaning or cleaning with hydrogen peroxide vapour in their ability to eradicate *S. aureus* and other important pathogens, e.g. *C. difficile*;
- The Working Party recommend that research should be conducted into the effectiveness of different skin decolonization/disinfection regimens in eradicating MRSA and the cost-effectiveness of the regimens. Suitable agents may include triclosan, hexachlorophene, chlorhexidine or povidone iodine alone and in combination;
- The Working Party recommend that research should be carried out into the effectiveness of using local treatment for throat carriage of MRSA; e.g. a comparison of vancomycin or tyrothricin throat lozenges and the use of mupirocin, alone or in combination, together with a cost/benefit analysis;
- The Working Party recommend that further research should be done to produce guidelines for the management of MRSA in the community, e.g. care homes and primary care. It would be useful to attempt to link the strain of community-acquired MRSA with the frequency and nature of hospital attendance. This will need to be linked to an assessment of different case definitions for hospital- and healthcare-associated MRSA, as well as community-acquired MRSA. Agreement on appropriate denominators and what constitutes a 'new case' of MRSA is also required.

Acknowledgements

This exercise was initiated by the Specialist Advisory Committee on Antimicrobial Resistance, an independent advisory committee set up to provide expert scientific advice on resistance issues arising from medical, veterinary and agricultural use of antimicrobials. Established in 2001 following recommendations in the House of Lords Select Committee on Science and Technology's original report 'Resistance to Antibiotics and other Antimicrobial Agents', the Committee advises the UK Government on its strategy to minimize illness and death due to antimicrobial-resistant infection and to maintain the effectiveness of antimicrobial agents in their medical, veterinary and agricultural use.

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Comment on the editorial process

This Working Party Report was put out for consultation on 30 June 2005 (the consultation period closed on 1 August 2005) and was amended in light of the comments received prior to its submission to the *Journal of Hospital Infection*. This national consultation exercise amongst major stakeholders and other interested parties replaced the Journal's peer review process.

Appendices

Standard principles for preventing hospital-acquired infections†,[195]

Hospital environmental hygiene

- The hospital environment must be visibly clean, free from dust and soilage, and acceptable to patients, their visitors and staff.
- Where a piece of equipment is used for more than one patient (e.g. commode, bath hoist), it must be cleaned following every episode of use.
- Statutory requirements must be met in relation to the safe disposal of clinical waste, laundry arrangements for used and infected linen, food hygiene and pest control.
- All staff involved in hospital hygiene activities must be included in education and training related to the prevention of hospital-acquired infection.

Hand hygiene

- Hands must be decontaminated immediately before each and every episode of direct patient contact/care and after any activity or contact that potentially results in hands becoming contaminated.
- Hands that are visibly soiled or potentially grossly contaminated with dirt or organic material must be washed with liquid soap and water.
- Application of an alcohol-based hand rub or handwashing with liquid soap and water must be performed to decontaminate hands between caring for different patients, or between different caring activities for the same patient.
- All wrist and (ideally) hand jewellery must be removed at the beginning of each clinical shift before regular hand decontamination begins. Cuts and abrasions must be covered with waterproof dressings.
- Effective handwashing involves three stages: preparation, washing and rinsing, and drying. Preparation requires wetting hands under tepid running water before applying liquid soap or an antimicrobial preparation. The handwash solution must come into contact with all the surfaces of the hand. The hands must be rubbed together vigorously for a minimum of 10—15 s, paying particular attention to the tips of the fingers, the thumbs and the areas between the fingers. Hands should be rinsed thoroughly prior to drying with good-quality paper towels.
- When decontaminating hands with an alcohol hand rub, hands should be free of dirt and organic material. The hand rub solution must come into contact with all surfaces of the hand. The hands must be rubbed together vigorously, paying particular attention to the tips of the fingers, the thumbs and the areas between the fingers, until the solution has evaporated and the hands are dry.
- An emollient hand cream should be applied regularly to protect skin from the drying effects of regular hand decontamination. If a particular soap, antimicrobial handwash or alcohol product causes skin irritation, occupational health advice should be sought.

The use of personal protective equipment

- Protective equipment should be selected on the basis of an assessment of the risk of transmission of micro-organisms to the patient, and the risk of contamination of healthcare practitioners' clothing and skin by patients' blood, body fluids, secretions and excretions.
- Gloves must be worn for invasive procedures, contact with sterile sites, non-intact skin and mucous membranes, all activities that have been assessed as carrying a risk of exposure to blood, body fluids, secretions and excretions, and when handling sharp or contaminated instruments.
- Gloves should be worn as single-use items. Gloves should be put on immediately before an episode of patient contact or treatment and should be removed as soon as the activity is completed. Gloves should be changed between caring for different patients, or between different care/treatment activities for the same patient.

† These guidelines on the standard principles for preventing hospital-acquired infections are being reviewed and will be published as a supplement to the *Journal of Hospital Infection* during 2006.

- Gloves must be disposed of as clinical waste and hands should be decontaminated following the removal of gloves.
- Gloves conforming to European Community standards and of an acceptable quality must be available in all clinical areas.
- Alternatives to natural rubber latex (NRL) gloves must be available for use by practitioners and patients with NRL sensitivity.
- Powdered and polythene gloves should not be used in healthcare activities.
- Disposable plastic aprons should be worn when there is a risk that clothing or uniform may become exposed to blood, body fluids, secretions and excretions, with the exception of sweat.
- Full-body fluid-repellent gowns should be worn where there is a risk of extensive splashing of blood, body fluids, secretions and excretions, with the exception of sweat, on to the skin of healthcare practitioners.
- Plastic aprons should be worn as single-use items for one procedure or episode of patient care, and then discarded and disposed of as clinical waste.
- Face masks and eye protection should be worn where there is a risk of blood, body fluids, secretions and excretions splashing into the face and eyes.
- Respiratory protective equipment should be used when clinically indicated.

The safe use and disposal of sharps

- Sharps must not be passed directly from hand to hand, and handling should be kept to a minimum.
- Needles must not be bent or broken prior to use or disposal.
- Needles and syringes must not be disassembled by hand prior to disposal.
- Needles should not be recapped.
- Used sharps must be discarded into a sharps container (conforming to UN3291 and BS 7320 standards) at the point of use. These must not be filled above the mark indicating that they are full. Containers in public areas must not be placed on the floor and should be located in a safe position.
- The use of needlestick-prevention devices should be considered where there are clear indications that they will provide safe systems of working for healthcare practitioners.
- A rigorous evaluation of needlestick-prevention devices should be conducted to determine their effectiveness, acceptability to practitioners, impact on patient care and cost benefit prior to widespread introduction.

References

1. Report of a Combined Working Party of the Hospital Infection Society and British Society for Antimicrobial Chemotherapy. Guidelines for the control of meticillin-resistant *Staphylococcus aureus*. *J Hosp Infect* 1986;**7**:193–201.
2. Working Party Report. Guidelines for the control of epidemic methicillin-resistant *Staphylococcus aureus*. *J Hosp Infect* 1990;**16**:351–377.
3. Duckworth G, Cookson B, Humphreys H, Heathcock R. Revised methicillin-resistant *Staphylococcus aureus* infection control guidelines for hospitals. Report of a Working Party of the British Society for Antimicrobial Chemotherapy, the Hospital Infection Society and the Infection Control Nurses Association. *J Hosp Infect* 1998;**39**:253–290.

3a. Brown DFJ, Edwards DI, Hawkey PM, *et al*. Guidelines for the laboratory diagnosis and susceptibility testing of methicillin-resistant *Staphylococcus aureus* (MRSA). *J Antimicrob Chemother* 2005;**56**:1000–1018.

4. Jevons MP. Celbenin-resistant staphylococci. *BMJ* 1961;**1**: 124–125.
5. Barber M. Methicillin-resistant staphylococcus. *J Clin Pathol* 1961;**14**:385–393.
6. Harbarth S, Pittet D. Methicillin-resistant *Staphylococcus aureus*. *Lancet Infect Dis* 2005;**5**:653–663.
7. Hiramatsu K. Reduced susceptibility of *Staphylococcus aureus* to vancomycin — Japan, 1996. *MMWR Morb Mortal Wkly Rep* 1997;**46**:624–626.
8. Centers for Disease Control and Prevention. *Staphylococcus aureus* resistant to vancomycin — United States. *JAMA* 2002;**288**:824–825.
9. European Antimicrobial Resistance Surveillance System (EARSS). *Annual report EARSS — 2003*. Bilthoven, The Netherlands: RIVM; 2004.
10. Salgado CD, Farr BM, Calfee DP. Community-acquired methicillin-resistant *Staphylococcus aureus*: a meta-analysis of prevalence and risk factors. *Clin Infect Dis* 2003;**36**: 131–139.
11. Communicable Disease Surveillance Centre, Public Health Laboratory Service. *Antimicrobial resistance in 2000. England and Wales*. London: Public Health Laboratory Service; 2002.
12. Johnson AP, Pearson A, Duckworth G. Surveillance and epidemiology of MRSA bacteraemia in the UK. *J Antimicrob Chemother* 2005;**56**:455–462.
13. 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.
14. Tiemersma EW, Bronzwaer SLAM, Lyytikäinen O, *et al*. Methicillin-resistant *Staphylococcus aureus* in Europe, 1999–2002. *Emerg Infect Dis* 2004;**10**:1627–1634.
15. Lacey RW. Multi-resistant *Staphylococcus aureus* — a suitable case for inactivity? *J Hosp Infect* 1987;**9**:103–105.
16. Barrett SP, Mummery RV, Chattopadhyay B. Trying to control MRSA causes more problems than it solves. *J Hosp Infect* 1998;**39**:85–93.
17. Teare EL, Barret SP. Stop the ritual of tracing colonised people. *BMJ* 1997;**314**:665–666.
18. Farrington M, Redpath C, Trundle C, Coomber S, Brown NM. Winning the battle but losing the war: methicillin-resistant *Staphylococcus aureus* (MRSA) infection at a teaching hospital. *Q J Med* 1998;**91**: 539–548.

19. Shannon T, Edgar P, Villarreal C, Herndon DN, Phillips LG, Heggers JP. Much ado about nothing: methicillin-resistant *Staphylococcus aureus*. *J Burn Care Rehabil* 1997;**18**: 326–331.
20. Kotilainen P, Routamaa M, Peltonen R, *et al*. Elimination of epidemic methicillin-resistant *Staphylococcus aureus* from a university hospital and district institutions, Finland. *Emerg Infect Dis* 2003;**9**:169–175.
21. Kerttula A-M, Lyytikäinen O, Salmenlinna S, Vuopio-Varkila J. Changing epidemiology of methicillin-resistant *Staphylococcus aureus* in Finland. *J Hosp Infect* 2004;**58**: 109–114.
22. 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.
23. Boyce JM, Havill NL, Kohan C, Dumigan DG, Ligi CE. Do infection control measures work for methicillin-resistant *Staphylococcus aureus*? *Infect Control Hosp Epidemiol* 2004;**25**:395–401.
24. McBryde ES, Bradley LC, Whitby M, McElwain DLS. An investigation of contact transmission of methicillin-resistant *Staphylococcus aureus*. *J Hosp Infect* 2004;**58**: 104–108.
25. Grundmann H, Hori S, Winter B, Tami A, Austin DJ. Risk factors for the transmission of methicillin-resistant *Staphylococcus aureus* in an adult intensive care unit: fitting a model to the data. *J Infect Dis* 2002;**185**:481–488.
26. Muto CA, Jernigan JA, Ostrowsky BE, *et al*. SHEA guidelines for preventing nosocomial transmission of multi-drug-resistant strains of *Staphylococcus aureus* and *Enterococcus*. *Infect Control Hosp Epidemiol* 2003;**24**:362–386.
27. Srinivasan A, Dick JD, Perl TM. Vancomycin resistance in staphylococci. *Clin Microbiol Rev* 2002;**15**:430–438.
28. *Staphylococcus aureus* resistant to vancomycin – United States, 2002. *MMWR Morb Mortal Wkly Rep* 2002;**51**:565–567.
29. Anon. Report: Deaths involving MRSA: England and Wales, 1999–2003. *Health Stat Q* 2005;**25**:60–65.
30. Selvey LA, Whitby M, Johnson B. Nosocomial methicillin-resistant *Staphylococcus aureus* bacteremia: is it any worse than nosocomial methicillin-sensitive *Staphylococcus aureus* bacteremia? *Infect Control Hosp Epidemiol* 2000;**21**:645–648.
31. Romero-Vivas J, Rubio M, Fernandez C, Picazo JJ. Mortality associated with nosocomial bacteraemia due to methicillin-resistant *Staphylococcus aureus*. *Clin Infect Dis* 1995;**21**:1417–1423.
32. Whitby M, McLaws M-L, Berry G. Risk of death from methicillin-resistant *Staphylococcus aureus* bacteraemia: a meta-analysis. *Med J Aust* 2001;**175**:264–267.
33. Cosgrove SE, Sakoulas G, Perencevich EN, Schwaber MJ, Karchmer AW, Carmeli Y. Comparison of mortality associated with methicillin-resistant and methicillin-susceptible *Staphylococcus aureus* bacteremia: a meta-analysis. *Clin Infect Dis* 2003;**36**:53–59.
34. Rello J, Torres A, Ricart M, *et al*. Ventilator-associated pneumonia by *Staphylococcus aureus*: comparison of methicillin-resistant and methicillin-sensitive episodes. *Am J Respir Crit Care Med* 1994;**150**:1545–1549.
35. Engeman JJ, Carmeli Y, Cosgrove SE, *et al*. Adverse clinical and economic outcomes attributable to methicillin resistance amongst patients with *Staphylococcus aureus* surgical site infection. *Clin Infect Dis* 2003;**36**: 592–598.
36. Stamm AM, Long MN, Belcher B. Higher overall nosocomial infection rate because of increased attack rate of methicillin-resistant *Staphylococcus aureus*. *Am J Infect Control* 1993;**21**:70–74.
37. Abramson M, Sexton DJ. Nosocomial methicillin-resistant and methicillin-susceptible *Staphylococcus aureus* primary bacteraemia: at what costs? *Infect Control Hosp Epidemiol* 1999;**20**:408–411.
38. Kim T, Oh PI, Simor AE. The economic impact of methicillin-resistant *Staphylococcus aureus* in Canadian hospitals. *Infect Control Hosp Epidemiol* 2001;**22**:99–104.
39. Vriens M, Blok H, Fluit A, Troelstra A, van der Werken C, Verhoef J. Costs associated with a strict policy to eradicate methicillin-resistant *Staphylococcus aureus* in a Dutch university medical centre: a 10 year survey. *Eur J Clin Microbiol Infect Dis* 2002;**21**:782–786.
40. Chaix C, Durand-Zaleski I, Alberti C, Brun-Buisson C. Control of endemic methicillin-resistant *Staphylococcus aureus*. A cost–benefit analysis in an intensive care unit. *JAMA* 1999;**282**:1745–1751.
41. Karchmer TB, Durbin LJ, Simonton BM, Farr BM. Cost-effectiveness of active surveillance cultures and contact/droplet precautions for control of methicillin-resistant *Staphylococcus aureus*. *J Hosp Infect* 2002;**51**: 126–132.
42. 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.
43. Cooper BS, Stone SP, Kibbler CC, *et al*. Isolation measures in the hospital management of methicillin resistant *Staphylococcus aureus* (MRSA): systematic review of the literature. *BMJ* 2004;**329**:1–8.
44. Souweine B, Traore O, Aublet-Cuvelier B, *et al*. Role of infection control measures in limiting morbidity associated with multi-resistant organisms in critically ill patients. *J Hosp Infect* 2000;**45**:107–116.
45. Blumberg LH, Klugman KP. Control of methicillin-resistant *Staphylococcus aureus* bacteraemia in high-risk areas. *Eur J Clin Microbiol Infect Dis* 1994;**13**:82–85.
46. Stone S, Kibbler C, How A, Balestrini A. Feedback is necessary in strategies to reduce hospital acquired infection. *BMJ* 2000;**321**:302.
47. Cosseron-Zerbib M, Roque Afonson AM, Naas T, *et al*. A control programme for MRSA (methicillin-resistant *Staphylococcus aureus*) containment in a paediatric intensive care unit: evaluation and impact on infections caused by other micro-organisms. *J Hosp Infect* 1998;**40**: 225–235.
48. Valls V, Gómez-Herruz P, González-Palacios R, *et al*. Long-term efficacy of a program to control methicillin-resistant *Staphylococcus aureus*. *Eur J Clin Microbiol Infect Dis* 1994;**13**:90–95.
49. Rumbak MJ, Cancio MR. Significant reduction in methicillin-resistant *Staphylococcus aureus* ventilator-associated pneumonia associated with the institution of a prevention protocol. *Crit Care Med* 1995;**23**:1200–1203.
50. Cepeda JA, Whitehouse T, Cooper B, *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;**365**:295–304.
51. Huskins WC, Goldmann DA. Controlling methicillin-resistant *Staphylococcus aureus*, aka 'Superbug'. *Lancet* 2005;**365**:273–275.
52. Papia G, Louie M, Tralla A, *et al*. Screening high-risk patients for methicillin-resistant *Staphylococcus aureus* on admission to the hospital: is it cost effective? *Infect Control Hosp Epidemiol* 1999;**20**:473–477.
53. Kunori T, Cookson B, Roberts JA, Stone S, Kibbler CC. Cost-effectiveness of different MRSA screening methods. *J Hosp Infect* 2002;**51**:189–200.

54. Rampling A, Wiseman S, Davis L, *et al*. Evidence that hospital hygiene is important in the control of methicillin-resistant *Staphylococcus aureus*. *J Hosp Infect* 2001;**49**:109—116.
55. Haley RW, Culver DH, White JW, *et al*. The efficacy of infection surveillance and control programs in preventing nosocomial infections in US hospitals. *Am J Epidemiol* 1984;**121**:182.
56. Curran ET, Benneyan JC, Hood J. Controlling methicillin-resistant *Staphylococcus aureus*: a feedback approach using annotated statistical process control charts. *Infect Control Hosp Epidemiol* 2002;**23**:13—18.
57. Coello R, Fernández C, Arroyo P, *et al*. Success and failure in the control of methicillin-resistant *Staphylococcus aureus*. In: Coello R, Casewell MW, *et al*, editors. *Methicillin-resistant Staphylococcus aureus*. Royal Tunbridge Wells, Kent: Wells Medical Limited; 1993. p. 95—98.
58. Hartstein AI, Denny MA, Morthland VH, LeMonte AM. Control of methicillin-resistant *Staphylococcus aureus* in a hospital and an intensive care unit. *Infect Control Hosp Epidemiol* 1995;**16**:405—411.
59. Spicer JW. Three strategies in the control of staphylococci including methicillin-resistant *Staphylococcus aureus*. *J Hosp Infect* 1995;**5**(Suppl. A):45—49.
60. Vandenbroucke-Grauls CM. Control of methicillin-resistant *Staphylococcus aureus* in the Netherlands. In: Coello R, Casewell MW, editors. *Methicillin-resistant Staphylococcus aureus*. Royal Tunbridge Wells, Kent: Wells Medical Limited; 1993. p. 75—78.
61. Curran E. MRSA: monitoring quality. *Br J Infect Control* 2000;**2**:20—23.
62. Gaynes RP. Surveillance of nosocomial infections. In: Bennett JV, Brachman PS, editors. *Hospital infections*. Boston: Lippincott-Raven; 1998. p. 65—84.
63. Giesecke J. Routine surveillance of infectious diseases. In: Giesecke J, editor. *Modern infectious disease epidemiology*. London: Arnold; 2002. p. 148—159.
64. Public Health Laboratory Service. The first year of the Department of Health's mandatory MRSA bacteraemia surveillance scheme in acute NHS Trusts in England: April 2001—March 2002. *CDR Wkly* 2002;**12**(25):1—17, http://www.hpa.org.uk/cdr/PDFfiles/2002/cdr2502.pdf. Last accessed 26 January 2006.
65. Department of Health Press Release. New MRSA figures published. Available on Department of Health (UK) website at: http://www.dh.gov.uk/PublicationsAndStatistics/PressReleases/PressReleases/Notices/fs/en?CONTENT_ID=4085856&chk=WsJjaB; http://www.dh.gov.uk/assetRoot/04/08/58/94/04085894.pdf2004. Last accessed 26 January 2006.
66. Health Protection Agency Communicable Disease Surveillance Centre for the Department of Health 2005. *MRSA surveillance system — results*. Available on Department of Health's website at: http://www.dh.gov.uk/PublicationsAndStatistics/Publications/PublicationsStatistics/PublicationsStatisticsArticle/fs/en?CONTENT_ID=4085951&chk=HBt2QD; 2002. Last accessed 26 January 2006.
67. Department of Health. *Bloodborne MRSA infection rates to be halved by 2008*. London: Department of Health. Available from: http://www.dh.gov.uk/PublicationsAndStatistics/PressReleases/PressReleasesNotices/fs/en?CONTENT_ID+4093533&chk+MY%BkD/; 2004. Last accessed 26 January 2006.
68. 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 USA* 2002;**99**:7687—7692.
69. Thomas JC, Bridge J, Waterman S, Vogt J, Kilman L, Hancock G. Transmission and control of methicillin-resistant *Staphylococcus aureus* in a skilled nursing facility. *Infect Control Hosp Epidemiol* 1989;**10**:106—110.
70. Shimada M, Kamakura T, Itasaka H, Matsumata T, Hashizume M, Sugimachi K. The significance of methicillin-resistant *Staphylococcus aureus* infection in general surgery: a multivariate analysis of risk factors and preventive approaches. *Surg Today* 1993;**23**:880—884.
71. Onorato M, Borucki MJ, Baillargeon G, *et al*. Risk factors for colonization or infection due to methicillin-resistant *Staphylococcus aureus* in HIV-positive patients: a retrospective case—control study. *Infect Control Hosp Epidemiol* 1999;**20**:26—30.
72. Washio M, Mizoue T, Kajioka T, *et al*. Risk factors for methicillin-resistant *Staphylococcus aureus* (MRSA) infection in a Japanese geriatric hospital. *Public Health* 1997;**111**:187—190.
73. Safdar N, Maki DG. The commonality of risk factors for nosocomial colonization and infection with antimicrobial-resistant *Staphylococcus aureus*, enterococcus, Gram-negative bacilli, *Clostridium difficile*, and *Candida*. *Ann Intern Med* 2002;**136**:834—844.
74. Dziekan G, Hahn A, Thune K, *et al*. Methicillin-resistant *Staphylococcus aureus* in a teaching hospital: investigation of nosocomial transmission using a matched case—control study. *J Hosp Infect* 2000;**46**:263—270.
75. Hori S, Sunley R, Tami A, Grundmann H. The Nottingham *Staphylococcus aureus* population study: prevalence of MRSA among the elderly in a university hospital. *J Hosp Infect* 2002;**50**:25—29.
76. Crowcroft NS, Ronveaux O, Monnet DL, Mertens R. Methicillin-resistant *Staphylococcus aureus* and antimicrobial use in Belgian hospitals. *Infect Control Hosp Epidemiol* 1999;**20**:31—36.
77. Campillo B, Dupeyron C, Richardet JP. Epidemiology of hospital-acquired infections in cirrhotic patients: effect of carriage of methicillin-resistant *Staphylococcus aureus* and influence of previous antibiotic therapy and norfloxacin prophylaxis. *Epidemiol Infect* 2001;**127**:443—450.
78. Frank MO, Batteiger BE, Sorensen SJ, *et al*. Decrease in expenditures and selected nosocomial infections following implementation of an antimicrobial-prescribing improvement program. *Clin Perform Qual Health Care* 1997;**5**:180—188.
79. Fukatsu K, Saito H, Matsuda T, Ikeda S, Furukawa S, Muto T. Influences of type and duration of antimicrobial prophylaxis on an outbreak of methicillin-resistant *Staphylococcus aureus* and on the incidence of wound infection. *Arch Surg* 1997;**132**:1320—1325.
80. Stelfox HT, Bates DW, Redelmeier DA. Safety of patients isolated for infection control. *JAMA* 2003;**290**:1899—1905.
81. Paterson DL. Reduced susceptibility of *Staphylococcus aureus* to vancomycin — a review of current knowledge. *Commun Dis Intell* 1999;**23**:69—73.
82. Fridkin SK, Lawton R, Edwards JR, Tenover FC, McGowan Jr JE, Gaynes RP. Monitoring antimicrobial use and resistance: comparison with a national benchmark on reducing vancomycin use and vancomycin-resistant enterococci. *Emerg Infect Dis* 2002;**8**:702—707.
83. Centers for Disease Control and Prevention. Recommendations for preventing the spread of vancomycin resistance: recommendations of the Hospital Infection Control Advisory Committee (HICPAC). *MMWR Morb Mortal Wkly Rep* 1995;**44**:1—33.
84. Sanford MD, Widmer AF, Bale MJ, Jones RN, Wenzel RP. Efficient detection and long-term persistence of the carriage

of methicillin-resistant *Staphylococcus aureus*. *Clin Infect Dis* 1994;**19**:1123—1128.
85. New Zealand Ministry of Health. *Guidelines for the control of methicillin-resistant Staphylococcus aureus* in New Zealand. Wellington: New Zealand Ministry of Health, http://www.moh.govt.nz/cd/mrsa; 2002. Accessed 9 January 2005.
86. Farr BM, Jarvis WR. Would active surveillance cultures help control healthcare-related methicillin-resistant *Staphylococcus aureus* infection? *Infect Control Hosp Epidemiol* 2002;**23**:65—68.
87. Jernigan JA, Titus MG, Groschel DRM, Getchell-White SL, Farr BM. Effectiveness of contact isolation during a hospital outbreak of methicillin-resistant *Staphylococcus aureus*. *Am J Epidemiol* 1996;**142**:496—504.
88. Salmenlinna S, Lyytikainen O, Kotilainen P, Scotford R, Siren E, Vuopio-Varkila J. Molecular epidemiology of methicillin-resistant *Staphylococcus aureus* in Finland. *Eur J Clin Microbiol Infect Dis* 2000;**19**:101—107.
89. Thompson RL, Cabezudo I, Wenzel RP. Epidemiology of nosocomial infections caused by methicillin-resistant *Staphylococcus aureus*. *Ann Intern Med* 1982;**97**: 309—317.
90. 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.
91. Jernigan JA, Clemence MA, Stott GA, *et al*. Control of methicillin resistant *Staphylococcus aureus* at a university hospital: one decade later. *Infect Control Hosp Epidemiol* 1995;**16**:686—696.
92. Jans B, Suetens C, Struelens M. Decreasing MRSA rates in Belgian hospitals: results from the national surveillance network after introduction of national guidelines. *Infect Control Hosp Epidemiol* 2000;**21**:419.
93. Back NA, Linnemann Jr CC, Staneck JL, Kotagal UR. Control of methicillin-resistant *Staphylococcus aureus* in a neonatal intensive-care unit: use of intensive microbiologic surveillance and mupirocin. *Infect Control Hosp Epidemiol* 1996;**17**:227—231.
94. Calfee DP, Farr BM. Infection control and cost control in the era of managed care. *Infect Control Hosp Epidemiol* 2002;**23**:407—410.
95. Law MR, Gill ON. Hospital-acquired infection with methicillin-resistant and methicillin-sensitive staphylococci. *Epidemiol Infect* 1988;**101**:623—629.
96. Murray-Leisure KA, Geib S, Graceley D, *et al*. Control of epidemic methicillin resistant *Staphylococcus aureus*. *Infect Control Hosp Epidemiol* 1990;**11**:343—350.
97. Nicolle LE, Dyck B, Thompson G, *et al*. Regional dissemination and control of epidemic methicillin-resistant *Staphylococcus aureus*. *Infect Control Hosp Epidemiol* 1999;**20**: 202—205.
98. Kotilainen P, Routamaa M, Peltonen R, *et al*. Eradication of methicillin-resistant *Staphylococcus aureus* from a health center ward and associated nursing home. *Arch Intern Med* 2001;**161**:859—863.
99. Geffers C, Farr BM. Risk of transmission of nosocomial methicillin-resistant *Staphylococcus aureus* (MRSA) from patients colonized with MRSA. *Infect Control Hosp Epidemiol* 2005;**26**:114—115.
100. Vriens MR, Fluit AC, Troelstra A, Verhoef J, Van Der Werken C. Are MRSA more contagious than MSSA in a surgical intensive care unit? *Infect Control Hosp Epidemiol* 2002;**23**:491—494.
101. Forceville X, Faibis F, Lahilaire P, *et al*. Decrease of infection rate of methicillin resistant *Staphylococcus aureus* acquired in a French intensive care unit, under reinforcement of specific isolation. *Med Mal Infect* 2002;**32**: 346—358.
102. Pan A, Carnevale G, Catenazzi, *et al*. Trends in methicillin-resistant *Staphylococcus aureus* (MRSA) bloodstream infections: effect of the MRSA 'search and isolate' strategy in a hospital in Italy with hyperendemic MRSA. *Infect Control Hosp Epidemiol* 2005;**26**:127—133.
103. Bannister BA. Management of patients with epidemic methicillin-resistant *Staphylococcus aureus*: experience at an infectious diseases unit. *J Hosp Infect* 1987;**9**:126—131.
104. Vriens MR, Blok HEM, Gigengack ACM, *et al*. Methicillin-resistant *Staphylococcus aureus* carriage among patients after hospital discharge. *Infect Control Hosp Epidemiol* 2005;**26**:629—633.
105. Loeb M, Main C, Walker-Dilks C, Eady A. Antimicrobial drugs for treating meticillin resistant *Staphylococcus aureus* colonisation [Cochrane Review]. In: *The Cochrane Library, Issue 3*. Chichester: John Wiley & Sons, Ltd; 2003.
106. The AGREE Collaboration. *Appraisal of guidelines for research and evaluation (AGREE) instrument*. London: St. Georges Hospital Medical School. Available from: www.agreecollaboration.org; 2001.
107. Doebbeling BN, Breneman DL, Neu HC, *et al*. Elimination of *Staphylococcus aureus* nasal carriage in health care workers: analysis of six clinical trials with mupirocin calcium ointment. The Mupirocin Collaborative Study Group. *Clin Infect Dis* 1993;**17**:466—474.
108. Karchmer TB, Jernigan JA, Simonton BM, Farr BM. Eradication of meticillin-resistant *S. aureus* (MRSA) colonisation with different regimens. Presented at the Ninth Annual Meeting of the Society for Healthcare Epidemiology of America, 18—20 April 1999, San Francisco, CA, USA. Abstract 65.
109. Walker ES, Vasquez JE, Dula R, Bullock H, Sarubbi FA. Mupirocin-resistant meticillin-resistant *Staphylococcus aureus*: does mupirocin remain effective? *Infect Control Hosp Epidemiol* 2003;**24**:342—346.
110. Hitomi S, Kubota M, Mori N, *et al*. Control of meticillin-resistant *Staphylococcus aureus* outbreak in a neonatal intensive care unit by selective use of nasal mupirocin ointment. *J Hosp Infect* 2000;**46**:123—129.
111. Dupeyron C, Campillo B, Bordes M, Faubert E, Richardet JP, Mangeney N. A clinical trial of mupirocin in the eradication of meticillin-resistant *Staphylococcus aureus* nasal carriage in a digestive diseases unit. *J Hosp Infect* 2002;**52**:281—287.
112. Wang JT, Lin SF, Chiu L, *et al*. Molecular epidemiology and control of nosocomial meticillin-resistant *Staphylococcus aureus* infection in a teaching hospital. *J Formos Med Assoc* 2004;**103**:32—36.
113. Maraha B, van Halteren J, Verzijl JM, Wintermans RG, Buiting AG. Decolonisation of meticillin-resistant *Staphylococcus aureus* using oral vancomycin and topical mupirocin. *Clin Microbiol Infect* 2002;**8**:671—675.
114. Wilcox MH, Hall J, Pike H, *et al*. Use of peri-operative mupirocin to prevent meticillin-resistant *Staphylococcus aureus* (MRSA) orthopaedic surgical site infection. *J Hosp Infect* 2003;**54**:196—201.
115. Mody L, Kauffman CA, McNeil SA, Galecki AT, Bradley SF. Mupirocin-based decolonisation of *Staphylococcus aureus* carriers in residents of 2 long term care facilities: a randomised, double-blind, placebo-controlled trial. *Clin Infect Dis* 2003;**37**:1467—1474.
116. Department of Health. *Hospital infection control: guidance on the control of infection in hospitals*. Prepared by

the Hospital Infection Working Group of the Department of Health and PHLS. London: Department of Health; 1995.
117. Department of Health. *Winning ways: working together to reduce healthcare associated infection in England*. Report from the Chief Medical Officer. London: Department of Health; 2003.
118. Department of Health. *Infection control in the built environment*. HBN 30. London: NHS Estates; 2002.
119. Department of Health. *In patient accommodation: options for choice*. Supplement 1. Isolation facilities in acute settings. HBN 4. London: NHS Estates; 1997.
120. Report by the Controller and Auditor General. *Improving patient care by reducing the risk of hospital acquired infection: a progress report*. HC 876 Session 2003–2004; London: HMSO 2004.
121. Department of Health. *Standards for better health*. London: Department of Health, http://www.dh.gov.uk/PublicationsAndStatistics/Publications/PublicationsPolicyAndGuidance/PublicationsPolicyAndGuidanceArticle/fs/en?CONTENT_ID=4086665&chk=jXDWU6; 2004. Last accessed 30 October 2005.
122. Cooper BS, Stone SO, Kibbler CC, *et al*. Systematic review of isolation policies in the hospital management of methicillin-resistant *Staphylococcus aureus*: a review of the literature with epidemiological and economic modelling. *Health Technol Assess* 2003;**7**:1–194.
123. Department of Health. *The patient's charter: privacy and dignity and the provision of single sex accommodation*. London: Department of Health, http://www.dh.gov.uk/assetRoot/04/01/14/24/04011424.pdf; 1997. Last accessed 30 October 2005.
124. Boyce JM, Pittet D. 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. *Infect Control Hosp Epidemiol* 2002;**23**(Suppl.):S3–S41.
125. Ayliffe GAJ, Babb JR, Taylor LJ. *Hospital-acquired infection. Principles and prevention*. 3rd ed. Oxford: Butterworth-Heinemann; 1999.
126. French GL, Otter JA, Shannon KP, *et al*. Tackling contamination of the hospital environment by methicillin-resistant *Staphylococcus aureus* (MRSA): a comparison between conventional terminal cleaning and hydrogen peroxide vapour decontamination. *J Hosp Infect* 2004; **57**:31–37.
127. Duckworth GL, Jordens JZ. Adherence and survival properties of an 'epidemic' methicillin-resistant strain of *Staphylococcus aureus* compared with those of methicillin-sensitive strains. *J Med Microbiol* 1990;**32**: 195–200.
128. Wiseman S. Implementing effective infection control in the hospital. *Nurs Times* 2004;**100**:36.
129. NHS Estates. *Standards for cleanliness in the NHS: a framework in which to measure performance outcomes*. Leeds: NHS Estates, http://www.patientexperience.nhsestates.gov.uk/clean_hospitals/ch_content/home/home.asp; 2003. Accessed 28 May 2005.
130. Health Care Standards Unit. *Standards for better health*. Signpost C4e (Waste). London: HMSO, http://www.hcsu.org.uk/index.phf?option=com_content&task=view&id=47&Itemid=0; 2003. Accessed 28 May 2005.
131. NHS Executive. *Hospital laundry arrangements for used and infected linen. HSG(95)18*. Heywood: Health Publications Unit; 1995.
132. Ayliffe GAJ, Fraise AP, Geddes AM, Mitchell K. *Control of hospital infection. A practical handbook*. 4th ed. London: Arnold; 2000.
133. Hoffman PN, Williams J, Stacey A, *et al*. Report of a Working Party of the Hospital Infection Society. Microbiological commissioning and monitoring of operating theatre suites. *J Hosp Infect* 2002;**52**:1–28.
134. Haley RW, Bregman DA. The role of understaffing and overcrowding in recent outbreaks of staphylocccal infection in a neonatal special-care unit. *J Infect Dis* 1982; **145**:875–885.
135. Arnow PM, Allyn PA, Nichols EM, Hill DL, Pezzio M, Bartlett RH. Control of methicillin resistant *Staphylococcus aureus* in a burn unit: role of nurse staffing. *J Trauma* 1982;**22**:954–959.
136. 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.
137. Vicca AF. Nursing staff workload as a determinant of methicillin-resistant *Staphylococcus aureus* spread in an adult intensive care unit. *J Hosp Infect* 1999;**43**: 109–113.
138. Harbarth S, Sudre P, Dharan S, Cadenas M, Pittet D. Outbreak of *Enterobacter cloacae* related to understaffing, overcrowding, and poor hygiene practices. *Infect Control Hosp Epidemiol* 1999;**20**:598–603.
139. Pittet D. Improving compliance with hand hygiene in hospitals. *Infect Control Hosp Epidemiol* 2000;**21**:381–386.
140. HICPAC. Guideline for hand hygiene in health-care settings. *MMWR Morb Mortal Wkly Rep* 2002;**51**:RR-16, http://www.cdc.gov/mmwr/PDF/rr/rr5116.pdf. Last accessed 23 January 2006.
141. Voss A, Widmer AF. No time for handwashing!? Handwashing versus alcoholic rub: can we afford 100% compliance? *Infect Control Hosp Epidemiol* 1997;**18**:205–208.
142. Pittet D, Mourouga P, Perneger TV. Compliance with hand washing in a teaching hospital. *Ann Int Med* 1999;**130**: 126–130.
143. Farrington M, Trundle C, Redpath C, Anderson L. Effects on nursing workload of different MRSA control strategies. *J Hosp Infect* 2000;**46**:118–122.
144. Epic Guideline Project. *The epic project: developing national evidence-based guidelines for preventing healthcare association infections phase 1: guidelines for preventing hospital-acquired infections*. London: HMSO, http://www.dh.gov.uk/assetRoot/04/07/73/68/04077368.pdf; 2001. Last accessed 27 January 2006.
145. Stone PW, Clark SP, Cimiotti J, Corres-de-Araujo R. Nurses' working conditions: implications for infectious disease. *Emerg Infect Dis* 2004;**10**:1984–1989.
146. Kovner C, Jones C, Zhan C, Gergen PJ, Basu J. Nurse staffing and postsurgical adverse events: an analysis of administrative data from a sample of U.S. hospitals, 1990–1996. *Health Serv Res* 2002;**37**:611–629.
147. Alonso-Echanove J, Edwards JR, Richards MJ, *et al*. Effect of nurse staffing and antimicrobial-impregnated central venous catheters on the risk for bloodstream infections in intensive care units. *Infect Control Hosp Epidemiol* 2003;**2**:916–925.
148. Anderson BM, Lindemann R, Bergh R, *et al*. Spread of methicillin-resistant *Staphylococcus aureus* in a neonatal intensive care unit associated with understaffing, overcrowding and mixing of patients. *J Hosp Infect* 2002;**50**: 18–24.
149. Stenenga J, Bell E, Matlow A. The role of nurse understaffing in nosocomial viral gastrointestinal infections on a general pediatrics ward. *Infect Control Hosp Epidemiol* 2002; **23**:133–136.

150. Amravadi RK, Jacobson BC, Solomon DH, Fischer MA. ICU nurse-to-patient ratio is associated with complications and resource use after esophagectomy. *Inten Care Med* 2000;**26**:1857—1862.
151. Robert J, Fridkin SK, Blumberg HM, *et al*. The influence of the composition of the nursing staff on primary bloodstream infection rates in a surgical intensive care unit. *Infect Control Hosp Epidemiol* 2000;**21**:12—17.
152. Kovner C, Gergen PJ. Nurse staffing levels and adverse events following surgery in U.S. hospitals. *J Nurse Scholarsh* 1998;**30**:315—321.
153. Archibald LK, Manning ML, Bell LM, Banerjee S, Jarvis WR. Patient density, nurse-to-patient ratio and nosocomial infection risk in a pediatric intensive care unit. *Pediatr Infect Dis J* 1997;**16**:1045—1048.
154. Working Party of the British Society for Antimicrobial Chemotherapy. Supplementary report. *J Antimicrob Chemother* 1996;**38**:1103—1105.
155. National Committee for Clinical Laboratory Standards. *Methods for dilution. Antimicrobial susceptibility tests for bacteria that grow aerobically. Approved standard, M7-A4*. 4th edn. Vilanova: NCCLS; 1997.
156. Kaplan AH, Gilligan PH, Facklam RR. Recovery of resistant enterococci during vancomycin prophylaxis. *J Clin Microbiol* 1988;**26**:1216—1218.
157. Noble WC, Virani Z, Cree RG. Co-transfer of vancomycin and other resistance genes from *Enterococcus faecalis* NCTC 12201 to *Staphylococcus aureus*. *FEMS Microbiol Lett* 1992;**72**:195—198.
158. Hiramatsu K, Hanaki H, Ino T, Yabuta K, Oguri T, Tenover FC. Methicillin-resistant *Staphylococcus aureus* clinical strain with reduced vancomycin susceptibility. *J Antimicrob Chemother* 1997;**40**:135—136.
159. Fridkin SK, Hageman J, McDougal LK, *et al*. Vancomycin-intermediate *Staphylococcus aureus* Epidemiology Study Group. Epidemiological and microbiological characterization of infections caused by *Staphylococcus aureus* with reduced susceptibility to vancomycin, United States, 1997—2001. *Clin Infect Dis* 2003;**36**:429—439.
160. Smith TL, Pearson ML, Wilcox KR, *et al*. Emergence of vancomycin resistance in *Staphylococcus aureus*. Glycopeptide-intermediate *Staphylococcus aureus* Working Group. *N Engl J Med* 1999;**340**:493—501.
161. Rotun SS, McMath V, Schoonmaker DJ, *et al*. *Staphylococcus aureus* with reduced susceptibility to vancomycin isolated from a patient with fatal bacteremia. *Emerg Infect Dis* 1999;**5**:147—149.
162. Khurshid MA, Chou T, Carey R, *et al*. *Staphylococcus aureus* with reduced susceptibility to vancomycin — Illinois, 1999. *MMWR Morb Mortal Wkly Rep* 2000;**48**:1165—1167.
163. Naimi TS, Anderson D, O'Boyle C, *et al*. Vancomycin-intermediate *Staphylococcus aureus* with phenotypic susceptibility to methicillin in a patient with recurrent bacteremia. *Clin Infect Dis* 2003;**36**:1609—1612.
164. Hageman JC, Pegues DA, Jepson C, *et al*. Vancomycin-intermediate *Staphylococcus aureus* in a home health-care patient. *Emerg Infect Dis* 2001;**7**:1023—1025.
165. Walsh TR, Howe RA. The prevalence and mechanisms of vancomycin resistance in *Staphylococcus aureus*. *Ann Rev Microbiol* 2002;**56**:657—675.
166. Weigel LM, Clewell DB, Gill SR, *et al*. Genetic analysis of a high-level vancomycin-resistant isolate of *Staphylococcus aureus*. *Science* 2003;**302**:1569—1571.
167. Tenover FC, Weigel LM, Appelbaum PC, *et al*. Vancomycin-resistant *Staphylococcus aureus* isolate from a patient in Pennsylvania. *Antimicrob Agents Chemother* 2004;**48**:275—280.
168. Ike Y, Arakawa Y, Ma X, *et al*. Nationwide survey shows that methicillin-resistant *Staphylococcus aureus* strains heterogeneously and intermediately resistant to vancomycin are not disseminated throughout Japanese hospitals. *J Clin Microbiol* 2001;**39**:4445—4451.
169. Ploy MC, Grelaud C, Martin C, de Lumley L, Denis F. First clinical isolate of vancomycin-intermediate *Staphylococcus aureus* in a French hospital. *Lancet* 1998;**351**:9110—9112.
170. Bierbaum G, Fuchs K, Lenz W, Szekat C, Sahl HG. Presence of *Staphylococcus aureus* with reduced susceptibility to vancomycin in Germany. *Eur J Clin Microbiol Infect Dis* 1999;**18**:691—696.
171. Howe RA, Bowker KE, Walsh TR, Feest TG, MacGowan AP. Vancomycin-resistant *Staphylococcus aureus*. *Lancet* 1998;**351**:602.
172. 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.
173. Wong SS, Ho PL, Woo PC, Yuen KY. Bacteremia caused by staphylococci with inducible vancomycin heteroresistance. *Clin Infect Dis* 1999;**29**:760—767.
174. Kantzanou M, Tassios PT, Tseleni-Kotsovili A, Legakis NJ, Vatopoulos AC. Reduced susceptibility to vancomycin of nosocomial isolates of methicillin-resistant *Staphylococcus aureus*. *J Antimicrob Chemother* 1999;**43**:729—731.
175. Marchese A, Balistreri G, Tonoli E, Debbia EA, Schito GC. Heterogeneous vancomycin resistance in methicillin-resistant *Staphylococcus aureus* strains isolated in a large Italian hospital. *J Clin Microbiol* 2000;**38**:866—869.
176. Ward PB, Johnson PD, Grabsch EA, Mayall BC, Grayson ML. Treatment failure due to methicillin-resistant *Staphylococcus aureus* (MRSA) with reduced susceptibility to vancomycin. *Med J Aust* 2001;**175**:480—483.
177. Oliveira GA, Dell'Aquila AM, Masiero RL, *et al*. Isolation in Brazil of nosocomial *Staphylococcus aureus* with reduced susceptibility to vancomycin. *Infect Control Hosp Epidemiol* 2001;**22**:443—448.
178. Kim MN, Hwang SH, Pyo YJ, Mun HM, Pai CH. Clonal spread of *Staphylococcus aureus* heterogeneously resistant to vancomycin in a university hospital in Korea. *J Clin Microbiol* 2002;**40**:1376—1380.
179. Krzyszton-Russjan J, Gniadkowski M, Polowniak-Pracka H, Hagmajer E, Hryniewicz W. The first *Staphylococcus aureus* isolates with reduced susceptibility to vancomycin in Poland. *J Antimicrobial Chemother* 2002;**50**:1065—1069.
180. Tenover FC. Implications of vancomycin-resistant *Staphylococcus aureus*. *J Hosp Infect* 1999;**43**(Suppl):S3—S7.
181. 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—1027.
182. Edmond MB, Wenzel RP, Pasculle AW. Vancomycin-resistant *Staphylococcus aureus*: perspectives on measures needed for control. *Ann Intern Med* 1996;**124**:329—334.
183. Hospital Infection Control Practises Advisory Committee, CDC, Atlanta, USA Interim guidelines for prevention and control of staphylococcal infection associated with reduced susceptibility to vancomycin. *MMWR Morb Mortal Wkly Rep* 1997;**46**:626—628.
184. D'Agata EM. Antimicrobial-resistant, Gram-positive bacteria among patients undergoing chronic hemodialysis. *Clin Infect Dis* 2002;**35**:1212—1218.

185. 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.
186. Ploy MC, Francois B, Mounier M, Vignon P, Denis F. Nasal carriage of vancomycin-intermediate *Staphylococcus aureus* among intensive care unit staff. *Clin Infect Dis* 2001;**33**:1951.
187. World Health Organization. *Report on infectious diseases*. Geneva: World Health Organization. Available from: www.who.int/infectious-disease-report/2000/index.html; 2000. Last accessed 25 January 2006.
188. Wenzel RP, Edmond MB. Vancomycin-resistant *Staphylococcus aureus*: infection control considerations. *Clin Infect Dis* 1998;**27**:245—249.
189. Kralovic SM, Danko LH, Roselle GA. Laboratory reporting of *Staphylococcus aureus* with reduced susceptibility to vancomycin in United States Department of Veterans Affairs Facilities. *Emerg Infect Dis* 2002;**8**:402—407.
190. Tenover FC, Biddle JW, Lancaster MV. Increasing resistance to vancomycin and other glycopeptides in *Staphylococcus aureus*. *Emerg Infect Dis* 2001;**7**:327—332.
191. Hussain FM, Boyle-Vavra S, Shete PB, Daum RS. Evidence for a continuum of decreased vancomycin susceptibility in unselected *Staphylococcus aureus* clinical isolates. *J Infect Dis* 2002;**186**:661—667.
192. Midolo PD, Korman TM, Kotsanas D, Russo P, Kerr TG. Laboratory detection and investigation of reduced susceptibility to vancomycin in oxacillin-resistant *Staphylococcus aureus*. *Eur J Clin Microbiol Infect Dis* 2003; **22**:199—201.
193. Wootton M, Howe RA, Hillman R, Walsh TR, Bennett PM, MacGowan AP. A modified population analysis profile (PAP) method to detect hetero-resistance to vancomycin in *Staphylococcus aureus* in a UK hospital. *J Antimicrob Chemother* 2001;**47**:399—403. Erratum appears in *J Antimicrob Chemother* 2001;**48**:161.
194. Howe RA, Wootton M, Walsh TR, Bennett PM, MacGowan AP. Heterogeneous resistance to vancomycin in *Staphylococcus aureus*. *J Antimicrob Chemother* 2000; **45**:130—131.
195. National Institute for Clinical Excellence. *Infection control: prevention of healthcare associated infection in primary and community care*. London: NICE; 2003.

Glossary of terms

Bacteraemia: presence of bacteria in the blood.

Bloodstream infection: the presence of microbes in the blood with significant clinical consequences, e.g. shock.

Carrier of MRSA: a person who harbours MRSA with no overt expression of clinical disease, but who is a potential source of infection. Recognized carrier sites for MRSA include the nose, throat and certain skin sites including the perineum, groin, axilla and buttock. The carriage of MRSA can be transient, intermittent or chronic.

Clinical trial: A statistical method of determining the efficacy of a drug, or other intervention, in comparison with a placebo, an existing drug or a conventional intervention (see 'Double-blind randomized controlled trial').

Cohort nursing: a group of patients with a disease or infection who are separated from patients who do not harbour the disease or infection and who are nursed in a geographically distinct area or with physical separation in the same room. Isolation in separate rooms is preferable to cohort nursing. Ideally, the same nursing staff should provide daily care for the same cohort for the duration of the isolation period.

Colonization with MRSA: the presence and multiplication of MRSA at a body site without tissue invasion, damage or clinical disease.

Double-blind randomized controlled trial: a method of experimentation in which neither the patient nor the experimenter (doctor) knows beforehand which treatment has been assigned to the patient, i.e. drug, intervention or placebo. In each arm (control/placebo or treatment), the subjects should be assigned at random, taking care that they are matched as far as is possible for sex, age range and condition to be treated.

Endemic disease: the continued presence of a disease-causing organism with or without infection in a given hospital, a given group of patients in a hospital, or a geographical area despite standard control procedures (see 'Epidemic').

Epidemic: the outbreak of or acquisition of a disease-causing organism spreading widely among people at the same time in a hospital or community (e.g. in a residential facility) or in a geographical area with a frequency that is clearly in excess of normal expectancy. Certain phage types of MRSA are known to spread easily among and within hospitals and are designated, e.g. EMRSA 15, EMRSA 16, etc. (see 'Endemic disease/phage type').

Epidemiology: the study of the distribution and determinants of an infection or disease and/or colonization in specific populations with particular reference to the reservoirs, sources, routes of transmission and portals of entry.

Fomites, n. pl, sing., fome, Lat. tinder, kindling: inanimate objects that when contaminated with a viable pathogen can transfer the pathogen to a host. Examples include door handles, telephones, computer keyboards or any shared item. Note: the word is almost invariably used in the plural and is equally invariably mis-pronounced as 'foamights'. The singular is pronounced 'foamay' and the plural 'foamitays'.

Hospital-acquired infection or healthcare-associated infection: also known as nosocomial infection. This includes infection acquired in a variety of institutions and not just acute hospitals.

Heteroresistance: often referring to glycopeptide (usually vancomycin) drugs. These are isolates of *S. aureus* with heterogeneous glycopeptide-intermediate resistance of *S. aureus* (hGISA or heteroGISA). These appear to be susceptible to glycopeptides (typically with an MIC of <4 mg/L), but contain subpopulations of cells at frequencies of approximately 10^{-6} cells that exhibit decreased susceptibility (i.e. vancomycin MIC of >4—16 mg/L).

Health Protection Agency: formerly the Public Health Laboratory Service. The Head Office is in Colindale, London, UK.

Infection control committee: this normally consists of a chairperson, the infection control doctor, infection control nurse(s), the consultant in communicable diseases control, occupational health physician or nurse, clinician representatives and the chief executive or their representative. Other members may be co-opted as appropriate, e.g. a pharmacist or engineer. The infection control committee is responsible to the hospital's chief executive and provides specialist advice, formulates and monitors the implementation of policies, and determines and monitors the progress of the annual infection control programme.

Infection control team: these are designated staff responsible for day-to-day hospital infection control. The team usually consists of an infection control doctor, normally a consultant medical microbiologist, a consultant medical microbiologist if the infection control doctor is from another speciality, and an infection control nurse or nurses. The infection

control team has direct access to the hospital's chief executive or their representative and is responsible to the infection control committee.

Infection with MRSA: the entry and multiplication of MRSA in the tissues of the host where tissue damage is caused. This results in clinical disease that may be local (e.g. surgical site wound) or systemic (e.g. bloodstream infection) (see 'Bloodstream infection').

Incidence: the frequency with which new cases of a given disease presents in a defined population within a specific period of time (see 'Prevalence').

Isolation of patients: separation of patients with a disease or infection in an individual room in order to prevent or limit the direct or indirect transmission of the disease or infection to other people who are susceptible.

Isolation room or unit: a single room or unit often with its own handwashing and toilet facilities and also preferably with an anteroom for healthcare workers to wash hands and don protective clothing, e.g. plastic aprons. The air supply may be under negative pressure, or in balance, with respect to the area outside the room.

Minimum inhibitory concentration: the lowest concentration of a drug or agent that will inhibit the growth of the organism. MICs apply to testing agents against bacteria, protozoa and fungi.

Morbidity: the state of being ill and suffering, the sickness rate in a community or population.

Mortality: the death of individuals in a population.

Nosocomial infection: (see 'Hospital acquired infection').

Outbreak: often used interchangeably with 'epidemic'. May be used to refer to a local cluster of cases or a small, limited outbreak.

Phage type: MRSA and other staphylococci can be divided into distinct strains or types by testing their susceptibility to bacterial viruses or 'phages' in the laboratory. Certain phage types of MRSA show characteristic patterns of spread and occur more commonly in distinct geographical areas (see 'Epidemic').

Prevalence: (of a disease) the total number of people with the disease at a defined point in time.

Prospective study: an assessment of data that are collected as they are being generated (see 'Retrospective study').

Randomized controlled trial: subjects with a disease are allocated randomly to one of two or more treatments, one of which may be a control (or placebo) treatment, and the outcomes of treatment are compared.

Retrospective study: the assessment of information or data collected in the past and not concurrently.

Virulence: the capacity of an organism to cause disease (also referred to as 'pathogenicity').