Methicillin-resistant *Staphylococcus aureus* on orthopaedic wards

INCIDENCE, SPREAD, MORTALITY, COST AND CONTROL

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We examined the rates of infection and colonisation by methicillin-resistant *Staphylococcus aureus* (MRSA) between January 2003 and May 2004 in order to assess the impact of the introduction of an MRSA policy in October 2003, which required all admissions to be screened. Emergency admissions were treated prophylactically and elective beds ring-fenced. A total of 5594 admissions were cross-referenced with 22 810 microbiology results. The morbidity, mortality and cost of managing MRSA-carrying patients, with a proximal fracture of the femur were compared, in relation to age, gender, American Society of Anaesthesiologists grade and residential status, with a group of matched controls who were MRSA-negative.

In 2004, we screened 1795 of 1796 elective admissions and MRSA was found in 23 (1.3%). We also screened 1122 of 1447 trauma admissions and 43 (3.8%) were carrying MRSA. All ten ward transfers were screened and four (40%) were carriers (all p < 0.001). The incidence of MRSA in trauma patients increased by 2.6% per week of inpatient stay \((r = 0.97, p < 0.001)\). MRSA developed in 2.9% of trauma and 0.2% of elective patients during that admission \((p < 0.001)\). The implementation of the MRSA policy reduced the incidence of MRSA infection by 56% in trauma patients \((1.57\% in 2003 (17 of 1084) to 0.69\% in 2004 (10 of 1447), p = 0.035)\). Infection with MRSA in elective patients was reduced by 70% \((0.56\% in 2003 (7 of 1257) to 0.17\% in 2004 (3 of 1806), p = 0.06)\). The cost of preventing one MRSA infection was £3200.

Although colonisation by MRSA did not affect the mortality rate, infection by MRSA more than doubled it. Patients with proximal fractures of the femur infected with MRSA remained in hospital for 50 extra days, had 19 more days of vancomycin treatment and 26 more days of vacuum-assisted closure therapy than the matched controls. These additional costs equated to £13 972 per patient.

From this experience we have been able to describe the epidemiology of MRSA, assess the impact of infection-control measures on MRSA infection rates and determine the morbidity, mortality and economic cost of MRSA carriage on trauma and elective orthopaedic wards.

Methicillin-resistant *Staphylococcus aureus* (MRSA) infection is an increasing health problem in the United Kingdom.\(^1\) Patients with MRSA bacteraemia have an increased mortality,\(^2\) when compared with patients with methicillin-sensitive *Staphylococcus aureus*. Bacterial infection in orthopaedic practice may result in chronic osteomyelitis or implant infection. Revision arthroplasty after infection is expensive and is associated with a high complication rate and a poor outcome.\(^3-5\) After revision secondary to a pathogen sensitive to beta-lactam antibiotics, there is an 81% to 89% chance of the patient having a functioning joint replacement.\(^6\) If resistant bacteria are the cause of a revision, only 18% of knee and 48% of hip replacements have such a positive outcome.\(^6\)

The University Hospitals of Leicester NHS Trust was formed from the amalgamation of three separate trusts in 2000. Convalescing trauma patients were frequently transferred to the elective orthopaedic wards in order to release beds for further trauma admissions. The elective orthopaedic wards also received medical outlying patients. An audit performed in 2001 found that MRSA infection in orthopaedic trauma patients had increased threefold between 1994 and 2001 (21 to 64 cases, Fig. 1). At the time of the audit, MRSA-positive patients were managed according to national guidelines.\(^7\) They were isolated where possible
wards, in three hospitals. This policy has not been described previously. In line with our protocol, all trauma admissions are treated as MRSA carriers until proven otherwise. They have screening swabs within 24 hours of admission, taken from the nose, perineum and sites such as wounds, sputum, tracheostomies or urinary catheters, if present. They receive a five-day prophylactic course of triclosan and mupirocin and have weekly surveillance swabs. Swabs are cultured overnight on Baird-Parker medium (Oxoid Ltd, Basingstoke, United Kingdom), allowing the MRSA status of the patient to be confirmed within 24 hours of admission to the ward. Patients identified as MRSA positive are moved to side rooms and managed with barrier nursing and continued topical treatment. Before surgery, MRSA-carrying patients are treated with 400 mg teicoplanin intravenously, instead of the usual cefuroxime at the induction of anaesthesia. Patients may be transferred to elective ward side rooms only if their MRSA swabs have been negative within the last seven days.

Orthopaedic MRSA policy summary – elective admissions. All elective admissions are screened for MRSA at the pre-admission clinic, or before transfer. Swabs are taken approximately two weeks before admission, but a period of up to ten weeks is permissible if the patient is admitted from their own home, four weeks if the patient is admitted from a nursing or residential home and seven days if transferred from another hospital ward. Elective beds are ring-fenced and only patients requiring surgical intervention may be admitted.

MRSA carriers identified at the pre-admission clinic receive five days of triclosan and mupirocin treatment in an attempt to eradicate the bacterium before admission. If three subsequent sets of swabs do not grow MRSA, the patient may be admitted to the open ward. However, if MRSA carriage persists, the treatment will be continued and admission delayed, where this is possible. When surgery cannot be deferred, the patient is admitted to a single room where they are barrier nursed and topical treatment continues. The patient also receives teicoplanin prophylaxis in the same way as the trauma patients. If a patient has to be admitted urgently and their MRSA status is unknown, they are treated as positive, until proven otherwise. If the number of positive MRSA cases exceeds the number of single rooms available, elective surgery is stopped.

Assessment of MRSA incidence and impact of the MRSA policy. In order to assess the incidence of MRSA and the impact of the MRSA policy, data were obtained on the rates of MRSA colonisation and infection between January and May 2003 and January and May 2004. These dates were chosen in order to allow comparison of an equivalent period before and after the introduction of the MRSA policy in October 2003. Antibiotic usage and surgical practice were unchanged between these dates. The MRSA status of trauma and elective orthopaedic patients was analysed at admission and throughout their hospital stay. This required the cross-referencing of 1084 trauma and 1257 elective

![Graph](image-url)
patients’ admission details in 2003 and 1447 trauma and 1806 elective patients’ admission details in 2004 from the hospital database, with the results of 22 810 MRSA swabs from the microbiology database. We excluded paediatric orthopaedic admissions as they were managed on separate wards. Before the introduction of the MRSA policy, all clinically infected wounds had microbiological analysis, but screening for asymptomatic MRSA colonisation was not routinely carried out unless there was an earlier history of MRSA carriage. Therefore, before and after the introduction of the MRSA policy, accurate comparison of data was possible for MRSA infection rates, but not for MRSA colonisation.

**Assessment of the influence of MRSA on morbidity and mortality.** Using patients with the diagnosis of proximal femoral fracture as a study group, the morbidity and mortality of MRSA-carrying patients were compared with matched MRSA-negative controls, in order to determine the influence of MRSA on mortality. This diagnosis was selected as it is a common disorder, frequently associated with MRSA carriage and also has a high mortality rate. All patients with this diagnosis admitted from January 2003 to May 2004 were included in the study.

The age, gender, American Society of Anaesthesiologists (ASA) grade and residential status (i.e. living at home, in a nursing or residential home) of the patients were obtained from computerised records. For each MRSA-positive patient, the closest matched MRSA-negative control was actively sought, by matching first for gender, then age, residential status and finally ASA grade, in order to eliminate variables that are known to influence mortality. In order to allow the comparison of the morbidity, mortality and economic cost of MRSA, the 12-month mortality, length of hospital stay, number of operative procedures and the number of days of vancomycin treatment and vacuum-assisted closure therapy were assessed. In addition, the costs of MRSA screening, eradication therapy and treatment of infection were calculated. Finally, statistical analysis was performed using Microsoft Excel (Microsoft Corp., Redmond, Washington) and SPSS (SPSS Inc., Chicago, Illinois). Tests used included chi-squared, t-tests, Pearson’s correlation and Kaplan-Meier survival analysis, with $p < 0.05$ considered significant.

**Results**

**Policy compliance.** Between January and May 2004 there were 1806 admissions to the elective wards. Of these, 1796 were via the pre-admission clinic and ten were ward transfers; five were medical outliers and five were transferred from the trauma wards. The patients were all screened for MRSA, with the exception of one patient who failed to be screened at the pre-admission clinic. Of the 1447 trauma admissions, 975 (67%) were screened for MRSA within 24 hours and a further 147 (10%) between 24 and 72 hours of admission (total screened 1122, 78%). The 325 patients (23%) not screened within this time period were deemed to have missed screening. There were no reported cases of mupirocin-resistant MRSA.

**MRSA incidence before and after the introduction of the MRSA policy.** On the trauma wards between January and May 2004, there were 94 cases of MRSA, comprising 84 colonisation and 10 infection cases. Of the 94, 48 (51%) were MRSA positive on admission to the ward, 15 (16%) were found to be positive after missed screening tests and 31 (33%) acquired MRSA as in-patients. The detection of MRSA colonisation rose significantly when compared with the previous year. In 2003, only 1.8% of patients were identified as being colonised by MRSA, while screening in 2004 revealed that 5.8% of trauma patients were MRSA carriers (19 of 1084 in 2003, to 84 of 1447 in 2004, $p < 0.001$ chi-squared). The incidence of MRSA infection fell from 1.57% of all trauma admissions (17 of 1084) in 2003 to 0.69% (10 of 1447) in 2004, a 56% reduction ($p = 0.035$).

For elective patients between January and May 2004, there were 31 cases of MRSA, comprising 28 colonisations and three infections. A total of 23 carriers was identified in the pre-admission clinic, four were ward transfers and four patients acquired MRSA having returned a negative screen in the pre-admission clinic. Of those found to carry MRSA in the pre-admission clinic, one (4%) was admitted for treatment of active MRSA infection, while eradication was successful in 13 (57%) and unsuccessful in nine (39%), who required admission to side rooms.

The detection of MRSA carriage at the pre-admission clinic did not change a great deal between 2003 and 2004 (1.43% (18 of 1257) to 1.27% (23 of 1806), $p = 0.71$). The incidence of MRSA infection reduced by 70%, from 0.56% of admissions in 2003 (7 of 1257) to 0.17% of admissions in 2004 (3 of 1806, $p = 0.06$).

**MRSA cross-infection.** Trauma admissions were more likely to carry MRSA than elective patients seen in the pre-admission clinic (48 of 1122 (4.3%) vs 23 of 1795 (1.3%); $p < 0.001$). Despite there only being low numbers, ward transfers were shown to be a very high-risk group with three in five medical outliers and one in five trauma transfers carrying MRSA (40%, 4 of 10, $p < 0.001$). There was a strong correlation between length of stay on the trauma ward and the likelihood that a patient would carry MRSA. Of the trauma patients remaining on the ward for eight weeks, 25% (6 of 24) tested positive for MRSA (increase per week 2.6%, 95% confidence interval (CI) 2.2 to 3.6, $r = 0.97$, $p < 0.001$). On the elective wards, despite fewer cases of MRSA and most patients having shorter lengths of stay, there was still a strong correlation between length of stay and MRSA carriage ($r = 0.80$, $p = 0.03$, Fig. 2).

In 2004, 1074 trauma patients were appropriately screened at admission and were negative for MRSA, 31 of these acquired MRSA during their admission. There were 1772 elective patients that had screened negative at pre-assessment and only four of these acquired MRSA during their admission. The risk of acquiring MRSA was therefore
The risk of acquiring MRSA appeared to increase with the duration of stay. The weekly incidence of MRSA cross-infection on the trauma wards increased with length of stay, at a rate of approximately 0.8 times the number of weeks admitted (r = 0.72, p = 0.01), with 8.3% of patients (2 of 24) becoming cross-infected with MRSA in their eighth week of admission. The cumulative risk of acquiring MRSA at some point during the hospital stay increased at a rate of 3.7% per week since admission (r = 0.99; p < 0.001; 95% CI 3.4 to 4.0; Fig. 2).

A possible correlation exists between the occurrence of cross-infection and MRSA load (Fig. 3), with similar peaks and troughs. This suggests that the presence of MRSA carriers on the ward influenced MRSA cross-infection.

**Methicillin-resistant Staphylococcus aureus (MRSA) incidence (r = 0.97; p < 0.001), MRSA cross-infection (r = 0.72; p = 0.017) and cumulative risk of MRSA cross-infection (r = 0.99; p < 0.001) during a hospital stay.**

**Fig. 2**

**Correlation between episodes of high methicillin-resistant Staphylococcus aureus (MRSA) load and number of cross-infections.**

**Fig. 3**

2.9% (31 of 1074) on the trauma wards and 0.2% (4 of 1772) on the elective wards (p < 0.0001).

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Of the 979 suitable patients with a proximal fracture of the femur, 57 (5.8%) had MRSA colonisation and 18 (1.8%) had MRSA infection. When compared with the 904 MRSA-negative patients with proximal fracture of the femur, MRSA carriers had similar ASA grades (MRSA-positive mean 2.95 (2 to 5); MRSA-negative mean 2.89 (1 to 4)) and gender distribution (21% (16 of 75) and 26% (235 of 904) male, respectively; p = 0.20). However, they were significantly older (mean age 83 (56 to 99) vs 78 (38 to 100) years, respectively; p < 0.001) and more likely to be from a nursing home (36% (27 of 75) vs 25% (226 of 904), respectively; p = 0.04), both factors are known to influence mortality.

After matching MRSA-positive patients to the closest 75 MRSA-negative ones, we found that 100% of the controls were matched for gender, 96% were the same age within three years, 97% had the same residential status and 85% had the same ASA grade (Table I).

**Table I. Accuracy of matching cases of methicillin-resistant Staphylococcus aureus (MRSA) colonisation and infection in patients with a proximal fracture of the femur with MRSA-negative controls**

<table>
<thead>
<tr>
<th>Colonisation</th>
<th>Infection</th>
</tr>
</thead>
<tbody>
<tr>
<td>MRSA-positive</td>
<td>MRSA-negative</td>
</tr>
<tr>
<td>Number of patients</td>
<td>57</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
</tr>
<tr>
<td>Male:female (% exact match)</td>
<td>11:46</td>
</tr>
<tr>
<td>Mean age in years (SD) (% within 3 yrs)</td>
<td>83 (8.8)</td>
</tr>
<tr>
<td>From nursing home (% (% exact match)</td>
<td>32</td>
</tr>
<tr>
<td>Mean ASA* grade (SD) (% exact match)</td>
<td>2.9 (0.5)</td>
</tr>
</tbody>
</table>

* ASA, American Society of Anaesthesiologists
Economic analysis. An MRSA screening swab costs £5.50 and a course of mupirocin and triclosan costs £6.30. During the five-month study period in 2004, an additional 4618 MRSA swabs were sent from the orthopaedic wards costing £25,400. Furthermore, 1447 emergency admissions and 31 MRSA-positive patients identified in pre-assessment required treatment costing £9300. Over the course of a year this equates to approximately £83,300. We observed a reduction of 11 MRSA infections among trauma and elective orthopaedic patients over the two five-month periods of observation, equating to about 26 patients per year. The cost of preventing one MRSA infection is therefore £3200.

We tried to estimate the cost of managing MRSA infection by comparing the length of hospital stay, number of surgical procedures and number of days of vancomycin treatment and vacuum-assisted closure therapy in our group of matched MRSA-positive and negative patients with proximal fractures of the femur. Based on the additional requirements of the MRSA-positive patients, we estimated the cost of MRSA infection to be £13,972 (Table II).

### Table II. Additional costs to treat methicillin-resistant *Staphylococcus aureus* (MRSA)-infected patients with a fracture of the proximal femur, compared with MRSA-negative controls

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Number of days required</th>
<th>Cost per day (£)</th>
<th>Total cost (£)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prolonged admission</td>
<td>50</td>
<td>179*</td>
<td>8950</td>
</tr>
<tr>
<td>Operations</td>
<td>1.6</td>
<td>2040†</td>
<td>3264</td>
</tr>
<tr>
<td>Vancomycin</td>
<td>19</td>
<td>20</td>
<td>380</td>
</tr>
<tr>
<td>Vacuum-assisted closure therapy</td>
<td>26</td>
<td>53</td>
<td>1378</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>13972</td>
</tr>
</tbody>
</table>

* Leicester Royal Infirmary (LRI) base rate
† based on each procedure lasting 120 minutes at £17 per minute; Source: LRI finance department

Despite increased vigilance, the incidence of patients acquiring MRSA was still 2.9% for trauma admissions and 0.2% for elective admissions. There are a number of reasons why cross-infection continued, such as not all trauma admissions being swabbed and treated within 24 hours, either because of poor policy compliance or because their length of stay was brief. Even if the patient is screened appropriately, a further 24 hours is required to establish the MRSA status, when the sensitivity for detecting MRSA is only 22% using Baird-Parker medium, increasing to 26% after 48 hours. In the absence of a sufficient number of side rooms in which to care for every admission, there is an opportunity for MRSA to spread. At times, the demand for side rooms was so great that MRSA carriers had to be barrier nursed on the open ward increasing the risk of cross-infection. Hospital staff and patients’ relatives are not screened for MRSA and doctors working at both the trauma and elective hospitals may play a role in the inter-hospital spread of the organism.

In addition to the introduction of an MRSA policy there was a simultaneous infection-control awareness campaign with the emphasis on hand washing, and increased media coverage, which may have confounded our results.

### Discussion

The study collected data on the incidence of MRSA on elective and trauma orthopaedic wards, providing an insight into its spread between patients and hospitals. Our rate of MRSA infection before the introduction of the MRSA policy was similar to the recent national data of 0.7% incidence of MRSA surgical-site infections for elective total hip replacements (0.56% at University Hospitals Leicester) and 1.5% in trauma hemiarthroplasties (1.57% at University Hospitals Leicester). Although a Cochrane review found no strong evidence for using topical antimicrobials to eradicate MRSA, other reports have shown that topical antimicrobials, when combined with other infection-control measures, can control the spread of MRSA in elective settings. Our policy of routine MRSA screening, surveillance, prophylactic treatment and ring-fencing of beds reduced the incidence of MRSA infection by 56% on the trauma wards and 70% on the elective wards.
riage, such as a recent hospital admission, nursing home residence, indwelling urinary catheter or a recent course of antibiotics.\textsuperscript{18} Other risk factors include being elderly (> 80 years), male, suffering from diabetes, peripheral vascular disease or varicose ulcers.\textsuperscript{19,21} We also found that MRSA patients were older and more likely to be from a nursing home, but did not find a correlation with ASA-grade. In addition, we found that MRSA was much more prevalent in ward transfers and among long-stay patients. This is not surprising as many of the risk factors for having a prolonged hospital admission are the same as for carrying MRSA.\textsuperscript{3,22-24} We note that once this pattern of patient transfer was stopped there was a reduction in MRSA-infected elective cases.

**MRSA morbidity, mortality and economic burden.** When other influencing factors are taken into account, the mortality of patients with MRSA colonisation was only slightly different from their controls. This suggests that it is not a risk for death but it may be a surrogate marker for poor health. However, around 19\% to 25\% of patients colonised by MRSA subsequently developed MRSA infection\textsuperscript{25} and when this occurs, patients who have proximal fractures of the femur and have MRSA infection have a 2.7 times greater mortality than their closely matched MRSA controls. This increase in mortality is similar to a recent meta-analysis of MRSA bacteraemia, finding an increased relative risk of 2.12.\textsuperscript{3} The morbidity of MRSA-infected patients was considerable, with an extended stay and supplementary surgical and medical treatment. The cost of care for such patients greatly exceeds the cost of introducing a policy to prevent MRSA infection.

This study has shown, in the absence of an adequate system of control, that MRSA infection is frequently encountered on orthopaedic wards. Introducing a surveillance and treatment policy is a cost-effective way of reducing its incidence.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

**References**