Mandatory surveillance of methicillin-resistant Staphylococcus aureus (MRSA) bacteraemia in England: the first 10 years

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Since 2001 it has been mandatory for acute hospital Trusts (groups of hospitals under the same management) in England to report all cases of bacteraemia due to Staphylococcus aureus together with information on their susceptibility or resistance to methicillin. This allowed the incidence of methicillin-resistant S. aureus (MRSA) bacteraemia (expressed as the number of cases per 1000 occupied bed days) to be determined for each Trust. In late 2005, the scheme was enhanced to collect demographic, clinical and epidemiological information on each case using a web-based data collection system. Analysis of this mandatory dataset has provided important information on the trends in MRSA bacteraemia in England and has documented a year-on-year decrease in incidence since 2006, following a government initiative in which Trusts were tasked with halving their MRSA bacteraemia rates over a 3 year period. In addition, the enhanced mandatory surveillance scheme has captured a wealth of data that have helped to further define the epidemiology of MRSA bacteraemia. It is to be hoped that based on the English experience of mandatory surveillance, other countries will consider the implementation of similar schemes, not only for MRSA but for other pathogens of public health importance.

Keywords: nosocomial infections, S. aureus, antibiotic resistance

Introduction

A long-running surveillance scheme in which hospital microbiology laboratories voluntarily report cases of bacteraemia to a national database (LabBase2) showed a dramatic rise in the occurrence of invasive methicillin-resistant Staphylococcus aureus (MRSA) infections in England, Wales and Northern Ireland throughout the 1990s. This seemingly inexorable rise in MRSA bacteraemia generated considerable public and media interest, with the result that MRSA became the subject of political debate, with opposition politicians using data on healthcare-associated infections to criticize the government of the day regarding their management of the health service. By way of response and in an effort to drive down rates of MRSA bacteraemia, the Department of Health in England decided to improve the robustness of surveillance by making the reporting of MRSA bacteraemia mandatory for all English acute hospital Trusts (groups of hospitals under the same management) from April 2001, with the resulting data for individual Trusts being put in the public domain. This article discusses the initiation, implementation, evolution and outputs of this innovative surveillance scheme over a 10 year period. Although this is a review of a scheme in a European country with a socialized healthcare system, lessons from it are likely to be applicable to other countries.

The introduction of mandatory surveillance of MRSA bacteraemia

The collection, analysis and feedback of data from the mandatory surveillance scheme were tasked to the then Public Health Laboratory Service, which became the HPA in 2003. Guidance on the mandatory surveillance scheme was published in a letter from the Chief Medical Officer (CMO), which outlined the minimum dataset to be collected by Trusts. This comprised: (i) the total number of blood cultures (sets taken, not individual bottles); (ii) the total number of positive blood cultures; (iii) the total number of blood cultures positive for S. aureus; and (iv) MRSA-positive blood cultures expressed as a proportion of all S. aureus-positive blood cultures. These data were to be collected quarterly by each Trust in England and submitted to the HPA via their regional offices. The CMO’s letter further explained that the government’s objective at that stage was the implementation of a national surveillance scheme that would allow comparison of MRSA bacteraemia rates between similar types of hospital, with data for 6 or 12 month periods being published.
from April 2002.5–8 In order to allow comparison of MRSA rates between similar types of hospital, Trusts were initially classified into three categories, namely: ‘single specialty’ (e.g. those only undertaking orthopaedics, cancer or children’s health services), ‘specialist’ (those with specialist services that receive patients referred from other Trusts for these services) and ‘general acute’ (which provide general acute healthcare services).4 Subsequently, this classification scheme was refined to comprise six categories, namely: small acute Trusts, medium acute Trusts, large acute Trusts, acute teaching Trusts, acute specialist Trusts and acute specialist Children’s Trusts (Figure S1, available as Supplementary data at JAC Online).

The issue of denominator data

The incidence of MRSA bacteraemia in individual Trusts was determined using figures derived from the KH03 national dataset as the denominator. The KH03 data, which are collated by the Department of Health, provide a count of the average number of beds occupied overnight in a Trust each day (bed days) and can be used as a measure of hospital activity in each Trust.9 For the purposes of comparison, the MRSA rate for each Trust was presented as the number of MRSA bacteraemia cases per 1000 occupied bed days. An initial report published after the first 6 months of mandatory surveillance (April–September 2001) indicated that single-specialty Trusts generally had lower mean rates of MRSA bacteraemia (0.0–0.23 per 1000 bed days) than general acute Trusts (0.01–0.41 per 1000 bed days), which in turn generally had lower rates than specialist Trusts (0.5–0.69 per 1000 bed days).6 The report commented that this ranking of Trust types was not unexpected, since patients with complicated clinical courses are frequently referred to specialist Trusts, which, as a result, often have high numbers of vulnerable patients prone to infection. In addition, specialist Trusts frequently receive patient referrals from other Trusts, which may include patients colonized with MRSA acquired in the first hospital. Colonization with MRSA was not recorded as part of the national mandatory surveillance, which only measured MRSA bacteraemia. However, colonization with MRSA is a risk factor for the development of infection with MRSA and any bloodstream infection developing in a colonized referred patient after admission to the specialist Trust would count towards its MRSA rate. A similar ranking of Trust types was noted after the mandatory surveillance scheme had been running for 3 years (April 2001–March 2004). The mean MRSA rates for single-specialty, general acute and specialist Trusts in the third year of surveillance being 0.09 (range 0–0.28), 0.16 (range 0.04–0.33) and 0.24 (0.07–0.45) cases per 1000 bed days, respectively.7

While bed occupancy figures were regarded as a useful denominator for undertaking broad comparisons of the MRSA rates in different Trusts, there was increasing awareness that they were not ideal in two regards. Firstly, the KH03 data for the current year are usually not available at the time the MRSA figures are being analysed, so bed occupancy figures from earlier time periods have to be used initially, with the data being reanalysed when newer figures become available. Secondly, bed occupancy data, which are based on overnight bed occupancy, are not applicable to specialties where patients do not remain in hospital overnight. As an example, renal patients are prone to develop bacteraemia with S. aureus (including MRSA), but mostly do not remain in hospital overnight. Thus, renal patients who develop MRSA bacteraemia would be included in the numerator data collected as part of the mandatory surveillance scheme, but would be excluded from the denominator used for calculating the rate of MRSA bacteraemia. Thus, further work is required to generate a fuller understanding of the relative risk of developing MRSA bacteraemia in this particular setting.

Enhancement of mandatory surveillance

The reporting of aggregate numbers of positive MRSA blood cultures provided robust figures on the total number of MRSA bacteraemias in England and the incidence of MRSA bacteraemia in individual Trusts. However, the purpose of surveillance is not simply to measure rates of infection per se, but to gather relevant clinical and epidemiological information so that potential interventions aimed at reducing rates of infection can be introduced and their impact assessed. With this in mind, the mandatory MRSA surveillance scheme was enhanced in 2005 to capture comprehensive data on individual cases of MRSA bacteraemia, including patient demographics, date of admission, date of bacteraemia, location at time of blood culture, consultant specialty and type of clinical care at the time the blood sample was taken. The implementation of this MRSA Enhanced Surveillance Scheme required all Trusts in England to submit data via a web-enabled data capture system with mandatory data fields from October 2005. This was in contrast to the earlier phase of surveillance when Trusts submitted data in a range of formats through a range of reporting routes. In 2006, this system was further enhanced to support the collection of data on the probable source of the MRSA bacteraemia, although these data were submitted by Trusts on a voluntary basis. Although the reporting of enhanced data for MRSA bacteraemia was made mandatory for English Trusts in 2005, the submission of enhanced data for cases of bacteraemia caused by methicillin-susceptible S. aureus (MSSA) was optional until January 2011, when it also became mandatory.11,12

Feedback of data to stakeholders

An essential component of surveillance is the analysis and feedback of collated data to relevant stakeholders. Hence, the HPA was tasked from the outset with providing data on MRSA bacteraemia rates for each acute Trust, the data (expressed as total cases per 1000 occupied bed days) initially being published at 6 or 12 monthly intervals.5–8 Following enhancement of the mandatory surveillance programme, the additional data collected allowed Trusts to determine the number of cases where MRSA bacteraemia was likely to have been acquired while patients were in their care (referred to as ‘Trust-apportioned’ cases). Trust-apportioned cases were defined as inpatients, day-patients or emergency assessment patients in their Trust who had a positive blood culture taken ≥2 days after the date of admission.13 MRSA bacteraemia data analysed on the basis of these criteria were published from May 2010 onwards. In addition, surveillance outputs were extended to include data on
MRSA bacteraemia rates for each Primary Care Organisation (PCO), which are the bodies responsible for commissioning primary and secondary care from providers, such as hospital Trusts. From 2009, the reporting frequency was amended, with data thereafter being published on a monthly, quarterly and annual basis; the data being produced according to the code of practice for the production of official statistics. The same criteria were subsequently applied to the routine publication of mandatory surveillance data on MSSA bacteraemia. From June 2010, however, data have also been made available on a weekly basis (as a rolling 12 week period of MRSA bacteraemia counts) via the HPA web site and the government web site data.gov.uk. However, the weekly data are not official statistics but are provisional, as they simply reflect the best data available at the time of publication and can change as outstanding laboratory test results for susceptibility to methicillin become available. The HPA also produces quarterly Commentaries, which aim to disseminate collated information on the epidemiology of MRSA bacteraemia derived from analysis of the enhanced mandatory dataset.

**Setting of a national target to reduce MRSA bacteraemia**

Having established a surveillance system for monitoring rates of MRSA bacteraemia in hospital Trusts, the Health Secretary, speaking at the Chief Nursing Officer’s conference in November 2004, announced that the government was setting Trusts a target of reducing MRSA bloodstream infections by 50% by 2008. This target was made a priority by the Department of Health and additional resource was made available to reinforce the work of hospital infection control teams. Strategic Health Authorities [organizations with management responsibility for the National Health Service (NHS) at a local level, such as all acute Trusts and PCOs within a defined geographical area] were required to produce Trusts-level trajectories for reducing bacteraemia numbers over this period for all Trusts within their boundaries. Any Trusts deviating from their target trajectory were subject to inspection by teams of relevant experts brought together by the Department of Health Improvement Team. In addition, Trusts were required to show a reduction from the first year, so that the onus for the reduction should not fall to an incoming Chief Executive should a Trust change its senior management near the end of the period.

Given the pressure placed on Trusts by the setting of a government target for a 50% reduction in their rates of MRSA bacteraemia, there was concern that some Trusts might be tempted to manipulate their data to facilitate a favourable outcome. Hence, a number of measures were put in place to minimize the risk of this happening. To prevent Trusts spuriously claiming that isolates of MRSA from blood culture were contaminants or not clinically significant and thus not reportable, the Department of Health stipulated that all positive blood cultures yielding growth of MRSA must be reported. A downside of this is that the rationale for introducing mandatory surveillance (i.e. to generate robust data on the incidence of MRSA bacteraemia) was potentially compromised by introducing a source of bias that might overestimate the scale of the problem. An additional check undertaken by the HPA involved routine comparison of the numbers reported by Trusts through the mandatory surveillance system with other available data sources, such as the numbers of blood culture isolates of MRSA reported by hospital microbiology laboratories through the voluntary scheme. Any inconsistencies detected through such checking were fed back to Trusts for investigation and comment.

An additional measure to ensure accurate reporting by Trusts was the announcement by the CMO in March 2006, that the Chief Executive of each Trust would assume personal responsibility for the accuracy of their data; it being implicit in this statement that Chief Executives supplying erroneous data would be liable to severe penalties. Critically, for Trusts failing to meet their target, the onus was on the Chief Executive to explain why and to develop a plan to remedy this in agreement with the Department of Health. In addition, the CMO’s letter stipulated a shorter timescale for the reporting of data to the HPA, as the HPA was to subsequently supply the data to the Healthcare Commission (now the Care Quality Commission) for inclusion in their annual ‘health checks’, which assessed whether standards of patient care and safety were being met. The introduction of these measures marked a shift in approach, as previously the burden of responsibility would have fallen on the Trust’s infection control team, which may not have had access to the resources needed to remedy the problem. In this way, Trust management teams became responsible for addressing the issue and allocating the necessary resources.

Despite some doubts that the required reduction in MRSA rates could be achieved in the designated timescale, national data from the mandatory surveillance scheme showed a 56% reduction in the number of reports of MRSA bacteraemia between 2004 and 2008 (Figure 1). The interventions used by Trusts in their efforts to reduce MRSA bacteraemia have not been formally documented at a national level, but would likely have included improved hand hygiene (actively promoted by the National Patient Safety Agency’s ‘CleanYourHands’ campaign), contact precautions, active surveillance cultures, improved management of intravascular lines, changes in antibiotic prescribing and deep cleaning of clinical areas. Many hospitals are also likely to have introduced the ‘care bundle’

![Figure 1. Numbers of MRSA bacteraemias in England reported through the mandatory surveillance system, 2002–10.](https://academic.oup.com/jac/article-abstract/67/4/802/858360)
approach, particularly for indwelling lines, following the Department of Health’s ‘Saving Lives’ initiative.\textsuperscript{27} One author has specifically suggested that the decolonization of MRSA carriers, particularly in intensive care units, may have played a central role.\textsuperscript{28} However, it may prove difficult to unequivocally define which interventions were critical in reducing MRSA bloodstream infections, as most hospitals probably introduced multiple interventions simultaneously. A confounding factor is that strain typing data have indicated that the prevalence of EMRSA-16, one of the two dominant strains of MRSA in England, was already in decline at the time Trusts were implementing measures to reduce their rates of MRSA bacteraemia, making it difficult to determine what contribution active interventions made to the overall decrease in MRSA bacteraemia.\textsuperscript{29} Despite these uncertainties as to the reasons for the decline in MRSA bacteraemia in English Trusts, the decline has continued since 2008 (Figure 1), with <1500 cases reported in the financial year 2010/11 (a 22% reduction from the number of cases seen in 2009/10 and a 50% reduction from the number of cases in 2008/09).\textsuperscript{30} With specific regard to Trust-apportioned cases, there was a 57% reduction in the number cases between 2008/09 and 2010/11, the corresponding incidence rates decreasing from 4.3 to 1.8 cases per 100 000 bed days.\textsuperscript{30}

**Epidemiology of MRSA bacteraemia**

Analysis of patient demographic data has shown that the majority of MRSA bloodstream infections occurred in elderly patients (Figure 2), with patients >60 years old accounting for about three-quarters of cases.\textsuperscript{31,32} The mean age of patients with MRSA bacteraemia between 2008 and 2010 was 69 years, with the mean age in individual months during this time ranging from 65 to 71 years.\textsuperscript{31,32} For reasons that are not currently known, MRSA bacteraemia was more common in males than females, this differential effect being seen in all age groups (Figure 2).

Analysis of the timing of detection of MRSA bacteraemia (i.e. taking of blood samples for culture) relative to the date of admission (and hence not thought likely to have been acquired during that admission), the majority (67%) were admitted from home, but a further 18% were admitted from nursing homes and 8% from another hospital.\textsuperscript{31} With regard to the last of these findings, the pressure on Trusts to meet the government target of halving their MRSA bacteraemia rates was such that, on occasion, the early (i.e. within 2 days of admission) isolation of MRSA from the blood of a patient transferred between hospitals occasionally resulted in interhospital disputes as to the location where the patient developed their MRSA bacteraemia, and which hospital Trust should take responsibility for reporting the case. A further study of probable sources of MRSA bacteraemia (discussed in more detail below) also found that while bacteraemias associated with central venous catheters (CVCs) or other invasive devices were more often seen in cases provisionally classified as hospital-associated on the basis that blood cultures had been taken >2 days after admission, 20% of CVC-associated MRSA bacteraemias were in cases classified as community-associated as their blood cultures were taken within 2 days of admission.
admission. However, the presence of a CVC clearly indicates recent contact with the healthcare system. Hence, it is not possible to reliably infer the proportion of MRSA bacteraemias that are genuinely community-associated, as bloodstream infections incubating at the time (or within 2 days) of admission may often have been associated with prior healthcare contact.

A further analysis of those patients whose bacteraemia was detected ≥2 days after admission was undertaken with regard to the hospital specialties in which they were being treated. The numbers of bed days in a range of hospital specialties was derived from the Hospital Episode Statistics available from the NHS Information Centre. Using these as the denominator, the incidence of MRSA bacteraemia, expressed as the rate per 10000 bed days, was found to vary between specialties, ranging from 2.48 for nephrology to 0.43 in trauma and orthopaedics (Figure 4). However, it is important to bear in mind that a high incidence of MRSA bacteraemia in a particular specialty does not necessarily equate to a large number of such infections, if the number of bed days is relatively low. In terms of the data shown in Figure 4, the actual counts of MRSA bacteraemia were highest in general medicine and general surgery, reflecting the higher numbers of admissions to these specialties relative to nephrology.

As mentioned above, from 2006, Trusts have been able to voluntarily report data on the probable source of the MRSA bacteraemia. A recent analysis of 4404 episodes of MRSA bacteraemia reported between 2006 and 2009 showed that nearly half were attributed to intravascular devices (20%) or skin or soft tissue infection (28%). However, there was a significant decline in the proportion of bacteraemia associated with invasive devices such as CVCs and with surgical site infections between 2006 and 2009. This may reflect increased standards of line management and surgical wound care introduced when hospitals actively sought to reduce their rates of MRSA bacteraemia in response to the targets set by the government.

**Discussion**

Most surveillance systems aimed at healthcare-associated infections or at infections caused by antibiotic-resistant bacteria include MRSA, as this pathogen is still often deemed to be a marker of healthcare-associated infection in general (despite this picture being muddied by the emergence of community-associated MRSA in the USA). The majority of surveillance schemes collect data on a voluntary basis, but in 2001, the government in England took the bold step of deciding to make the reporting of MRSA bacteraemia mandatory for all acute hospital Trusts in light of concerns about the rising incidence and its effect on public confidence in national hospitals. This review has highlighted how this mandatory surveillance scheme has evolved over a 10 year period, from an initial scheme solely collecting data on numbers of blood cultures yielding S. aureus and the proportion that were MRSA to an enhanced system collecting demographic and clinical data that give considerable insight into the epidemiology of MRSA bacteraemia. Although not discussed in this review, the same data system has also allowed the mandatory surveillance of intestinal infections caused by *Clostridium difficile* and bacteraemia caused by vancomycin-resistant enterococci.

In contrast to many other national surveillance schemes that report either total national numbers of MRSA infections or the proportion of *S. aureus* infections that are due to MRSA, the mandatory surveillance scheme in England reported the incidence of MRSA bacteraemia in individual acute hospital Trusts. This made Trust managers aware of the extent of the problem they faced locally and how it compared with other hospitals. The fact that Trust incidence rates were put in the public domain further served to put both public and political pressure on Trust managers to reduce their rates of MRSA infections. The well-known definition of surveillance is ‘information for action’, and in the case of the mandatory surveillance scheme, the information produced was used for rigorous performance management against the target set by the government, namely the halving of rates of MRSA bacteraemia over a 3 year period. To enhance the achievement of this target, the whole panoply of government might and influence was rolled out, including the involvement of organizations such as the Healthcare Commission, as well as the full management hierarchy of the NHS, including Strategic Health Authorities and PCOs. A result of these initiatives was that the issue of MRSA rates in individual Trusts was no longer a matter solely for the infection control team and their Chief Executive.

**Figure 4.** Incidence of MRSA bacteraemia (per 10000 bed days) by specialty in England between April 2006 and March 2008. *Specialties clinical haematology and haematology, and clinical oncology and medical oncology have been combined into haematology and oncology, respectively.*
The requirement to halve rates of MRSA bacteraemia clearly had an impact on the surveillance system, as the minimal dataset initially collected proved inadequate for allowing Trusts and NHS management above them to determine whether individual patients with MRSA bacteraemia acquired their infection in that Trust (Trust-apportioned cases) or elsewhere, be it another Trust or in the community. Thus, enhancements to the dataset were driven by the necessity to determine (attribute) where the infection was acquired, which is crucial for performance management, as interventions aimed at preventing hospital acquisition of MRSA bacteraemia (e.g. improved line care) are unlikely to prevent the importation of cases. This need for close performance management also made demands on both the timeliness and completeness of the data collection, and contributed to the decision to develop and introduce a web-enabled system to ensure rapid, accurate and secure data transmission.

In terms of the 50% reduction in the number of cases of MRSA bacteraemia required by the government, it is notable that this target was met nationally. However, while there was an undoubted decline in the incidence of MRSA bacteraemia (and other healthcare-associated infections not discussed here) there is a question as to whether this can be ascribed to the surveillance system and allied interventions. The answer to this is not straightforward, since as with any preventive measure, whether infection control or immunization, the counterfactual is impossible to prove, as the evidence is largely circumstantial. It is sometimes stated that the particularly ‘spreadable’ EMRSA-16 was on the wane and so the incidence of MRSA bacteraemia would have dropped naturally. However, this underplays the enormous burden of MRSA infections faced by most hospitals at the time the targets were set, when the problem seemed intractable and some healthcare workers were even discussing abandoning control measures against MRSA, arguing that it should be regarded in the same way as penicillin-resistant S. aureus. Reflecting this confusion, the wide variation in experts’ viewpoints on the appropriate approach to MRSA prevention and control made the 2006 update of the national MRSA guidelines the most difficult to write since 1986 (G. D., personal comment). Moreover, although EMRSA-16 waned, the other major epidemic strain of MRSA continued in circulation. Hence, it would be presumptuous to argue that the decline in MRSA was simply due to the waning of an epidemic strain.

If it is accepted that the reductions in MRSA bacteraemia were in large measure associated with the measures taken by hospitals, which elements made a difference? Again, it is difficult to say, as in many instances multiple measures were introduced simultaneously. For example, it is clear from an evaluation of the ‘CleanYourHands’ campaign that the procurement of soap and alcohol hand gel increased, suggesting that increased levels of hand hygiene may have played a prominent role. Conversely, others have highlighted the likely impact of decolonization of MRSA carriers. There is also debate about the factors that motivated Trusts to reduce their rates of MRSA and other healthcare-associated infections, in particular the role of the government. While the government undoubtedly took a proactive approach, their actions were seen by some as punitive. This begs the question as to whether Trusts would have reduced their rates of MRSA bacteraemia to the same extent or over the same timeframe if there had not been an intense regimen of monitoring and performance managing of Trusts. While many think this unlikely, hard evidence is difficult to come by. What does seem clear, however, is that following the prominence given to the fight against MRSA, infection control was no longer seen as a backwater but became a key quality indicator for Trusts that was increasingly regarded as everybody’s business, from the Chief Executive of the Trust down.

Several aspects of the mandatory surveillance system described here were innovative. These included the coupling of epidemiological surveillance with performance management, as well as the development of a web-based reporting system to enable fast transfer of standard data, with instant, controlled access by specified personnel at different levels of the NHS. The mandatory system also highlights the value of linking the epidemiological numerator data collected via surveillance with other available datasets, such as the routinely generated information on hospital bed occupancy (used as the denominator). Other notable aspects of the system include the evolution of a categorization system for hospitals by case mix to enable fairer comparisons and the capture of epidemiological information on patient admission to hospital. However, the dramatic fall in MRSA bacteraemia in England means that it is now time to take stock. Bacteraemia was a useful measure when it was common, and served its purpose in drawing attention to the problem posed by MRSA and the need for rigorous interventions. However, now that the prevalence is very low in some hospitals it would arguably be more worthwhile to use other measures for surveillance, such as infections generally, colonization or both.

At the start of the mandatory surveillance in 2001, the proportion of S. aureus bacteraemia in the UK that was due to MRSA was one of the highest in Europe and many were sceptical that a reduction in MRSA infections was feasible. The subsequent decline in MRSA bacteraemia seen in England, particularly over the last 5 years, is testimony to the importance of surveillance coupled with feedback of data to stakeholders together with political pressure for change can have in reducing rates of infection.

Transparency declarations
A. P. J. is Editor-in-Chief of JAC, but took no part in and did not influence the editorial process. Other authors: none to declare.

Supplementary data
Figure S1 is available as Supplementary data at JAC Online (http://jac.oxfordjournals.org/).

References