ORIGINAL ARTICLE

Outbreak of Invasive Methicillin-Resistant *Staphylococcus aureus* Infection Associated With Acupuncture and Joint Injection

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OBJECTIVE. To describe an outbreak of invasive methicillin-resistant *Staphylococcus aureus* (MRSA) infection after percutaneous needle procedures (acupuncture and joint injection) performed by a single medical practitioner.

SETTING. A medical practitioner's office and 4 hospitals in Perth, Western Australia.

PATIENTS. Eight individuals who developed invasive MRSA infection after acupuncture or joint injection performed by the medical practitioner.

METHODS. We performed a prospective and retrospective outbreak investigation, including MRSA colonization surveillance, environmental sampling for MRSA, and detailed molecular typing of MRSA isolates. We performed an infection control audit of the medical practitioner's premises and practices and administered MRSA decolonization therapy to the medical practitioner.

RESULTS. Eight cases of invasive MRSA infection were identified. Seven cases occurred as a cluster in May 2004; another case (identified retrospectively) occurred approximately 15 months earlier in February 2003. The primary sites of infection were the neck, shoulder, lower back, and hip: 5 patients had septic arthritis and bursitis, and 3 had pyomyositis; 3 patients had bacteremia, including 1 patient with possible endocarditis. The medical practitioner was found to be colonized with the same MRSA clone [ST22-MRSA-IV (EMRSA-15)] at 2 time points: shortly after the first case of infection in March 2003 and again in May 2004. After the medical practitioner's premises and practices were audited and he himself received MRSA decolonization therapy, no further cases were identified.

CONCLUSIONS. This outbreak most likely resulted from a breakdown in sterile technique during percutaneous needle procedures, resulting in the transmission of MRSA from the medical practitioner to the patients. This report demonstrates the importance of surveillance and molecular typing in the identification and control of outbreaks of MRSA infection.

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Staphylococcus aureus is highly successful at causing serious infection in humans. This versatile organism is also well recognized for its ability to be transmitted from person to person by direct or indirect contact. Methicillin-resistant *S. aureus* (MRSA) is endemic in many healthcare institutions worldwide and is a well-known cause of outbreaks of infection in these settings.[1] In recent years, MRSA infection has been increasingly described in individuals with no history of recent healthcare contact or other traditional risk factors for MRSA colonization,[2-4] and a number of outbreaks of "community-onset" MRSA infection have been reported. With the exception of a recently described outbreak of MRSA infection in children who were vaccinated by a single MRSA-colonized healthcare worker,[5] the sources for these outbreaks have not been identified. We describe the clinical, epidemiological, and microbiological features of an outbreak of "community-onset" MRSA infection associated with percutaneous needle procedures (joint injection and acupuncture) performed by a medical practitioner who was colonized with the same MRSA clone [ST22-MRSA-IV (EMRSA-15)].

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TABLE 1. Characteristics of and Outcomes for 8 Patients Who Developed Invasive Methicillin-Resistant *Staphylococcus aureus* Infection After Percutaneous Needle Procedures Performed by a Single Medical Practitioner, February 2003 and May 2004

Patient	Age in years, sex	Procedure performed	Site of procedure	Clinical presentation	Bacteremia status	Definitive antimicrobial therapy administered
1	72, M	Joint injection	Left shoulder	Left shoulder joint septic arthritis	No	Vm; Tcp; Rif and FA
2	78, F	Acupuncture	Right shoulder	Right shoulder joint septic arthritis	No	Vm; rif and fa
3	76, M	Acupuncture	Right shoulder	Right shoulder joint septic arthritis	Yes	Vm; Rif and FA
4	38, F	Acupuncture	Lower back	Lumbar paravertebral pyomyositis	Yes	Vm; Lzd
5	55, F	Acupuncture	Neck	Posterior neck soft-tissue abscess	No	Vm; Rif and FA
6	65, F	Joint injection	Right shoulder	Right shoulder joint septic arthritis	No	Vm; Rif and FA
7	76, F	Acupuncture	Lower back	Lumbar paravertebral pyomyositis	Yes[a]	Vm; Rif, FA, and Dox
8	43, M	Acupuncture	Right hip	Right gluteus maximus/minumus pyomyositis	No	Vm; Rif and FA

NOTE. Dox, doxycycline; FA, fusidic acid; Lzd, linezolid; Rif, rifampicin; Tcp, teicoplanin; Vm, vancomycin.
[a] Patient 7 also had possible tricuspid valve endocarditis.

METHODS

Initial Case Identification

In May 2004, 3 patients with invasive community-onset MRSA infection (patients 2–4; Table 1) presented to a single teaching hospital in Perth, Western Australia, during a 16-day period. None of the patients had risk factors for healthcare-associated MRSA infection according to previously published criteria.[6] It was noted in the routine diagnostic laboratory that the organisms isolated from the 3 cases had the typical phenotypic characteristics of ST22-MRSA-IV (EMRSA-15); that is, they were resistant to ciprofloxacin and erythromycin and tested negative for urease production. This finding was unusual, as this MRSA clone is rarely found in the general community in our region, other than in individuals with recent healthcare facility contact.[3]

The 3 patients were reviewed by medical staff from the Department of Microbiology and Infectious Diseases shortly after their presentation. All 3 patients reported a history of having undergone 1 or more percutaneous needle procedures, described by them as either "acupuncture" or "joint injection," performed by a medical practitioner (Dr. A) in solo general practice (primary care) in the Perth metropolitan area, shortly before developing symptoms and signs of infection.

The infection cluster was reported to the Communicable Disease Control Directorate at the Western Australian Department of Health, who initiated a broader investigation (MRSA infection is a notifiable disease in Western Australia).

Further Case Ascertainment and Outbreak Investigation

Infectious disease physicians and clinical microbiologists in clinical practice in the state of Western Australia were contacted by e-mail to determine whether they were aware of any recent or current cases of infection caused by ST22-MRSA-IV (EMRSA-15) in patients with a prior history of percutaneous needle procedures. Those who reported being aware of, or having consulted on or managed, such a case were sent a case report form to complete. The data collected included demographic information, names of hospitals, dates of hospital admission and discharge, the dates and nature of percutaneous needle procedures reportedly performed before admission, site and type of infection, antimicrobial therapy received before and after admission, and details of surgery or percutaneous drainage procedures performed during hospitalization.

In addition, to identify further cases, Dr. A provided access to his patient database, and demographic details (eg, patient name and date of birth) were cross-referenced with the MRSA database at the Western Australian Gram-Positive Bacteria Typing and Research Unit (GPTU). Patients who were identified in both databases had their medical records reviewed.

Surveillance and Infection Control Interventions

MRSA surveillance. Swab specimens from the anterior nares, hands, and throat of Dr. A were obtained for MRSA culture. In brief, swab specimens were inoculated onto MRSA-selective agar (methicillin-aztreonam mannitol salt [MAMSA] agar) and placed into MRSA-selective enrichment broth (methicillin-aztreonam salt nutrient broth), both of which were incubated at 35°C for 20 hours, as described elsewhere.[7] The enrichment broth was then subcultured onto MAMSA agar and incubated for another 20 hours. Yellow colonies that grew on MAMSA agar that tested positive in the tube coagulase test (ie, suspected MRSA) were sent to the GPTU for confirmation of identification and for molecular typing, as described below.

In addition, surveillance swab specimens to detect environmental MRSA contamination were taken from Dr. A's premises. Swab specimens were taken from numerous surfaces and objects in the treatment room; in addition, swab specimens of the contents of bottles of 10% povidone-iodine (Betadine) solution and 2.5% iodine tincture used for skin disinfection were also taken.

Audit of premises and practices. Dr. A voluntarily initiated an infection control audit of his premises and practices; this audit was performed by an infection control professional in accordance with local, state, and national standards and guidelines (references available on request). Firstly, a comprehensive review of Dr. A's work and treatment areas was performed, which included an inspection of hand hygiene facilities, personal protective equipment, single-use devices and medication, injectable cosmetic and therapeutic agents, linen and laundry services, the handling and disposal of needles and other sharp devices, the management of clinical and related waste, the reprocessing of reusable instruments and equipment, the collection and refrigeration of specimens, and the management of environmental hygiene and spills, as well as a review of the infection control policies and education and training requirements. Secondly, we directly observed Dr. A simulating the setup and sterile technique he used during deep percutaneous needle procedures (eg, "deep" acupuncture and joint injection), which included equipment setup, hand hygiene, sterile gloving, and skin disinfection techniques. After this initial audit, a report was provided to Dr. A, and another audit was performed to assess adherence with recommendations made after the initial audit.

Organism Identification and Epidemiologic Typing

All MRSA isolates from all microbiology laboratories in Western Australia recovered from patients with no prior history of MRSA infection or colonization within the previous year are routinely sent to the GPTU for confirmation and epidemiological typing. Isolates were identified as *S. aureus* in the referring laboratories on the basis of positive results of standard laboratory tests (Gram staining, catalase test, and tube coagulase test). These laboratories used resistance to oxacillin, methicillin, or cefoxitin to determine that the isolate was probable MRSA prior to sending the isolate to the GPTU. Comprehensive typing was performed on MRSA isolates from the 8 cases and on 2 isolates recovered from surveillance swab specimens from Dr. A, using a combination of phenotypic and genotypic methods, as described below.

Phenotypic typing methods. Urease production was tested by inoculation of the MRSA isolate onto Christensen agar in diagonally oriented test tubes, which were incubated for 24 hours at 35°C. An antibiogram was determined by testing the isolates on Mueller-Hinton agar, using the disk diffusion method in accordance with the methodology of the Clinical and Laboratory Standards Institute (CLSI, formerly the National Committee on Clinical Laboratory Standards).[8] Methicillin resistance was confirmed by testing a 1 μg oxacilline disk; other antimicrobials tested included erythromycin, tetracycline, trimethoprim, ciprofloxacin, gentamicin, rifampicin, fusidic acid, and mupirocin.[8] Standard French susceptibility testing interpretative criteria were used for fusidic acid results,[9] and previously published interpretative criteria were used for mupirocin results.[10] CLSI criteria were used to interpret results for the other agents.[11] A resistogram was determined by the disk diffusion method for each isolate's resistance to cadmium acetate (concentration, 10 mmol/L), sodium arsenate (0.2 μmol/L), ethidium bromide (15 mmol/L), propanimide isethionate (2% [wt/vol]), mercuric chloride (0.4 μmol/L), and phenylmercuric acetate (5 mmol/L), as described elsewhere.[12,13] Bacteriophage typing was also performed using the International Basic, International MRSA, and Australian MRSA phage sets, as described elsewhere.[14]

Genotypic typing methods. Confirmatory molecular MRSA identification tests performed included multiplex real-time polymerase chain reaction to detect the *mecA* and *nuc* genes.[15] Coagulase gene restriction fragment–length polymorphism (*coa*RFLP) analysis was performed according to a method described elsewhere.[16] Contour-clamped homogenous electric field (CHEF) electrophoresis analysis of chromosomal DNA following digestion with both *Sma*1 and *Apa*1 restriction enzymes was performed as described elsewhere,[17] using the CHEF DR III System (Bio-Rad Laboratories). CHEF patterns were visualized and grouped according to the criteria of Tenover et al.[18]; isolates with 80% or greater similarity (by Dice coefficient) were considered to belong to the same strain. A band-based dendrogram was produced by using Dice coefficients and an unweighted pair group method using arithmetic averages (UPGMA). An optimization tolerance of 0.50% and a band position tolerance of 1.00% were used.

An independent laboratory performed automated ribosomal DNA analysis (ribotyping) using an automated system (RiboPrinter; Dupont Qualicon) on the isolates, together with a collection of other ST22-MRSA-IV (EMRSA-15) isolates obtained from patients who were not epidemiologically linked to the infection cluster. A UPGMA dendrogram of the ribotyping patterns was generated using BioNumerics software, version 3.5 (Applied Maths); bands were based on densitometric curves using the cosine coefficient. Finally, multilocus sequence typing (MLST) and staphylococcal cassette chromosome *mec* (SCC*mec*) allotyping were performed, according to previously described methods,[19] on selected isolates to confirm previously described associations between *coa* RFLP, CHEF patterns, and MLST and SCC*mec* type in MRSA clones in our region.[20] Sequence types were allocated after a BURST (Based Upon Related Sequence Types) analysis.[21]

RESULTS

Description of the Outbreak

Invasive community-onset MRSA infection was identified in 8 patients who had undergone 1 or more percutaneous needle

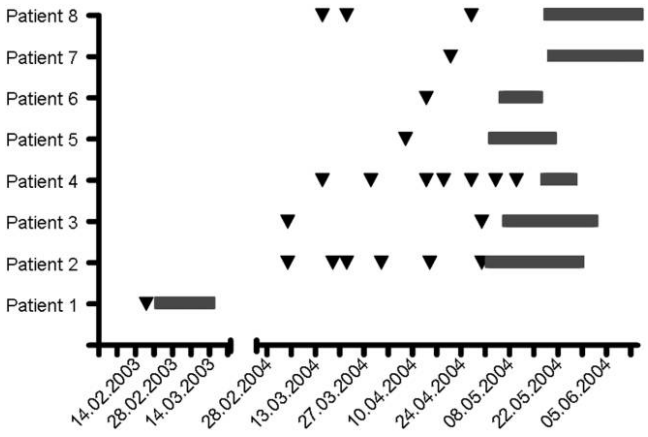

FIGURE 1. Timeline showing the dates of acupuncture or joint injection *(solid triangles)* and the dates of admission to hospital for treatment of invasive methicillin-resistant *Staphylococcus aureus* infection *(solid bars)* for patients involved in the outbreak.

procedures performed by Dr. A. Patients described the nature of the procedure(s) performed as either "deep acupuncture" or "joint injection." Seven patients (patients 2–8) presented to 4 different hospitals in the Perth metropolitan area in May 2004. The other patient (patient 1) presented in February 2003, approximately 15 months before the cluster of 7 cases occurred (Figure 1).

Dr. A's medical records were examined to determine the exact dates of the procedures performed. Dr. A was unable to recall the specific details of many of the procedures, including what medications were injected; however, he reported always using single-use needles and medication vials.

The demographic and clinical characteristics of the patients, the clinical presentation of the infections, and the definitive antimicrobial therapy, are presented in Table 1. All patients presented with deep-seated MRSA infection in the same anatomical area where Dr. A had performed a percutaneous needle procedure. One patient (patient 7) had at least 1 procedure performed at home. Three patients had bacteremia at the time of presentation, 1 of whom had possible tricuspid valve endocarditis, according to modified Duke criteria.[22] All patients required hospitalization to undergo surgery and/or percutaneous drainage and to receive intravenous antimicrobial therapy. The median duration of hospitalization was 22 days (range, 7–62 days). All patients required prolonged antimicrobial therapy (median duration, 72 days; range, 21–127 days). None of the patients died.

Epidemiological Typing of MRSA Isolates

All of the MRSA isolates from the 8 case patients demonstrated an identical phenotype, consistent with the ST22-MRSA-IV (EMRSA-15 MRSA) clone (ie, negative urease test results, resistance to ciprofloxacin and erythromycin, resistance to cadmium acetate and sodium arsenate, and not typeable with phage sets from International Basic, International MRSA, and Australian MRSA). In addition, the isolates were genotypically indistinguishable by the 3 different methods used (ie, *coa*RFLP analysis, CHEF electrophoresis, and ribotyping). Two isolates (1 isolate from patient 1 and 1 isolate from Dr. A's 2003 nasal specimen) were confirmed to be ST22-MRSA-IV by use of MLST and SCC*mec* allotyping.

The nasal swab specimens obtained from Dr. A after recognition of the outbreak in May 2004 yielded a strain of MRSA on culture that was phenotypically and genotypically indistinguishable from the strains isolated from the 8 patients (Figures 2 and 3). On review of the GPTU MRSA database, it was determined that swab specimens obtained from Dr. A in March 2003 (after the initial case of invasive MRSA infection in patient 1, in February 2003) had yielded MRSA on culture. This strain was also phenotypically and genotypically indistinguishable from the strain recovered from the 8 patients during 2003–2004 and from the strain isolated from swab specimens of Dr. A's anterior nares obtained in May 2004.

CHEF and ribosomal DNA analysis results are presented in detail in Figures 2 and 3. Ribotyping demonstrated that MRSA isolates from the 8 patients and from Dr. A clustered in 1 ribogroup (designated 124-S-6), which was distinguishable (by a single band difference) from other ST22-MRSA-IV (EMRSA-15) isolates obtained from case patients with invasive MRSA infection not epidemiologically related to the outbreak (designated 102-S-3).

Infection Control Interventions

The audit of Dr. A's premises and practices identified multiple areas of nonadherence to standards outlined in local infection control guidelines and recommendations. The procedure room was small, cluttered with nonessential items, had excessive dust on several surfaces, and contained numerous products that were beyond their expiration dates (eg, alcohol chlorhexidine handrub, sterile gloves, single-use acupuncture needles, scalp vein needles, scalpels, dressings, medical equipment and instrument cleaner, purified water, and single-use medication vials of atropine sulfate

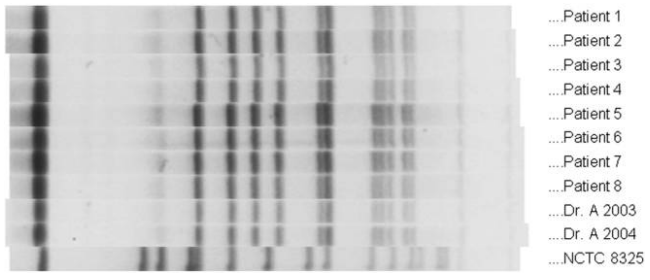

FIGURE 2. Pulsed-field gel electrophoresis band patterns for chromosomal DNA (after *Sma*I enzyme restriction) of methicillin-resistant *Staphylococcus aureus* isolates obtained from the 8 patients involved in the outbreak and from the medical practitioner (Dr. A) in March 2003 and May 2004. The band pattern for *S. aureus* strain NCTC 8325 was used as a size marker.

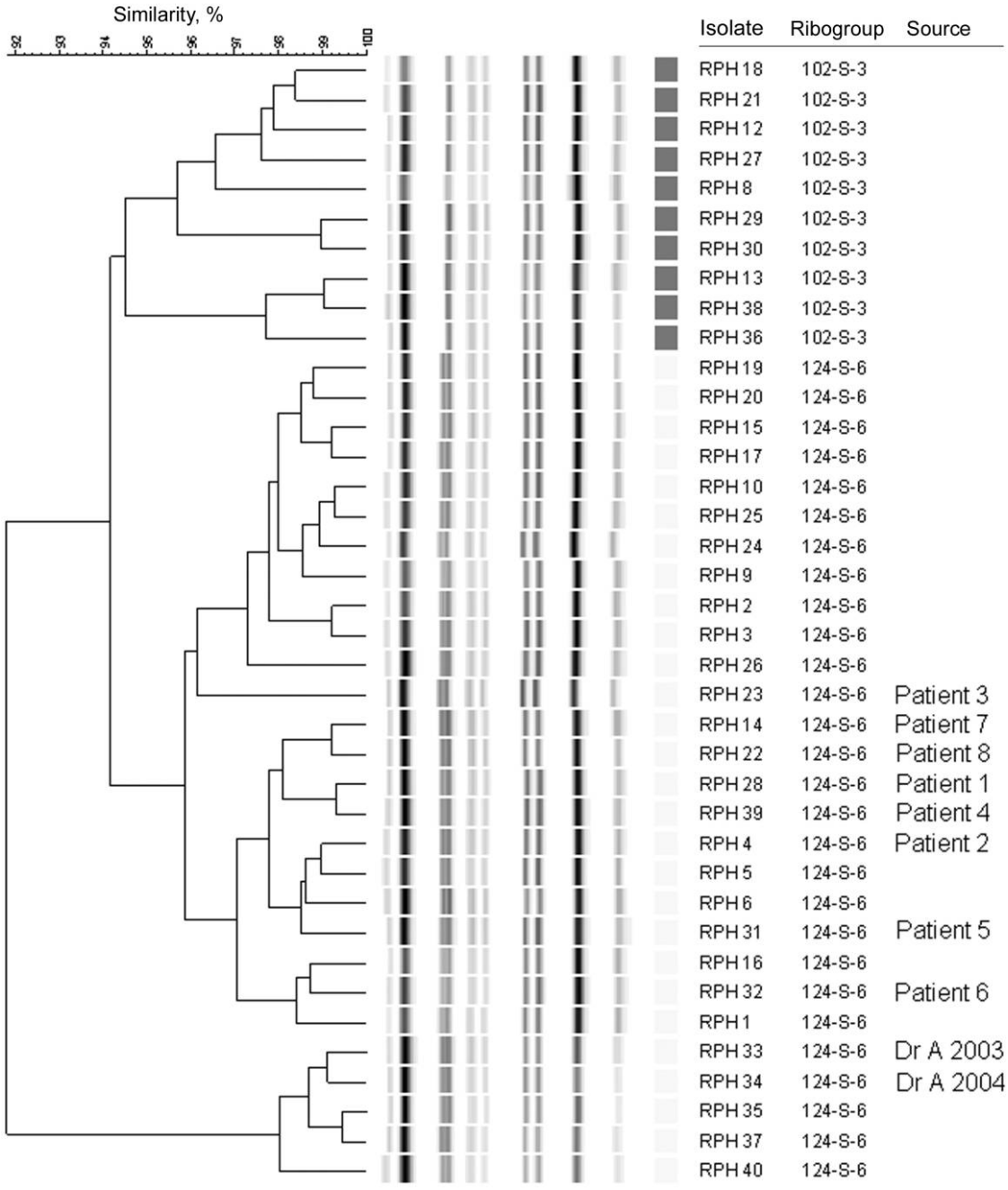

FIGURE 3. Ribotyping results and a dendrogram for methicillin-resistant *Staphylococcus aureus* (MRSA) isolates recovered from the 8 patients involved in the outbreak and the medical practitioner (Dr. A) in March 2003 and May 2004. The other isolates tested are a random selection of ST-22-MRSA-IV (EMRSA-15) isolates obtained from the culture collection of the Western Australian Gram-Positive Bacteria Typing and Research Unit.

at a concentration of 600 μg/mL, bupivicaine at a concentration of 0.5%, and adrenaline at a concentration of 1:1,000). The observed simulation of sterile technique during a percutaneous needle procedure demonstrated a number of potentially significant deficiencies (eg, turning the tap off with clean hands; touching a sterile, gloved hand with an ungloved hand; and use of nonsterile tissue paper to remove excess povidone-iodine solution used for skin disinfection). None of the environmental swab specimens yielded MRSA.

At a subsequent reaudit (3 weeks after the initial audit), significant improvement was demonstrated in infection control standards and practices and in sterile technique during a simulated percutaneous needle procedure. No further audits were performed.

After receipt of the MRSA-positive culture results in May 2004, Dr. A commenced on a 10-day course of decolonization therapy, which consisted of 2% mupirocin nasal ointment applied 3 times daily to each nostril, 3% hexachlorophene body wash applied daily while bathing, and 20% cetrimide shampoo applied every third day, in accordance with local MRSA decolonization protocols. Surveillance swab specimens that were collected 5 days after decolonization therapy was completed were found to be negative for MRSA on culture; further follow-up swab specimens for culture surveillance of MRSA were not obtained.

After recognition of the outbreak and the institution of the above-mentioned interventions, ongoing passive surveillance has not detected any further cases of MRSA infection associated with percutaneous needle procedures performed by Dr. A.

DISCUSSION

To our knowledge, this is the first description of an outbreak of invasive community-onset MRSA infection associated with either acupuncture or joint injection. Recently, an outbreak of MRSA infection associated with routine childhood vaccination was reported in Vietnam,[5] and it shares many of the features described in our report. In the outbreak in Vietnam reported by Tang et al.,[5] the resultant MRSA infections were moderate to severe (including 1 that resulted in death), requiring hospitalization for surgical intervention and/or administration of systemic antimicrobial therapy. Several patients were admitted to the same hospital in a short period of time, thereby alerting clinicians to the outbreak and allowing further case identification and interventions to prevent further cases, and a healthcare worker performing needle-based percutaneous procedures was found to be colonized with the same MRSA clone that caused the infection in the patients.

The outbreak that we investigated was likely caused by a breakdown in hand hygiene and/or sterile technique during percutaneous needle procedures, resulting in transmission of MRSA from Dr. A to the patients. This is supported by the findings that (1) Dr. A was colonized with the same MRSA clone that caused the infections at 2 time points, separated by 15 months, and (2) the infection control audit demonstrated multiple breaches in infection control standards and practices that could have provided the opportunity for MRSA transmission. Although it is theoretically possible that an unidentified environmental source was responsible for the outbreak (eg, contaminated medication or skin preparation solution, or reused needles that were not reported), we consider this unlikely, particularly because 1 patient was treated exclusively in their home.

There are numerous reports in the medical literature of single cases and outbreaks of serious infection associated with acupuncture. Large prospective studies of acupuncture have reported low rates of serious adverse events, including infection[23,24]; however, these studies are significantly limited by the fact that practitioners were asked to self-report adverse events. When serious and/or invasive bacterial infection has been associated with acupuncture, *S. aureus* has frequently been the cause. A recent literature review of *S. aureus* infections associated with acupuncture described 9 cases, the majority of which resulted in bone and/or joint infections and/or bacteremia.[25]

Minimal published data exist on the incidence of serious infection after joint injection. A recent report described an outbreak of *S. aureus* joint and soft-tissue infections after therapeutic injections performed by a single physician; in that outbreak, a multiple-dose vial of lidocaine was implicated as (but not proven to be) the likely source for these infections.[26] Like the outbreak of invasive MRSA associated with percutaneous needle procedures that we investigated, the outbreak described in Kirschke et al.[26] was terminated after identification of the potential source.

This study has a number of limitations. Firstly, we did not perform a case-control study to more precisely determine risk factors for MRSA infection after acupuncture or joint injection performed by Dr. A. Secondly, it is possible that unidentified cases of less severe MRSA infection occurred but were not recognized, because appropriate specimens were not collected for culture and susceptibility testing. Thirdly, we were unable to perform long-term surveillance of MRSA colonization on Dr. A, so we were unable to determine whether Dr. A's decolonization therapy was successful.

Outbreaks of MRSA in either healthcare or community settings may be difficult to detect, but it is important to do so because they can result in considerable morbidity and even mortality. In Western Australia, the long-term MRSA surveillance program based in the GPTU has allowed for a comprehensive characterization of the epidemiology of MRSA in our region. In addition, effective and timely collaboration between the GPTU, referring laboratories, infection control practitioners, and the Communicable Diseases Control Directorate at the Western Australian Department of Health has facilitated the control of endemic MRSA in hospitals and other healthcare facilities in our region for more than 20 years.[20] Together with the recent report of control of an outbreak of the New York/Japan MRSA clone in our region,[27] this report demonstrates that identification and control of MRSA outbreaks outside of large healthcare facilities is also possible.

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Potential conflicts of interest. R.J.M and M.R. received payment for expert witness services provided to the Medical Board of Western Australia with regard to proceedings initiated as a result of this outbreak. All other authors report no conflicts of interest relevant to this article.

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