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Community-Based Intervention to Manage an Outbreak of MRSA Skin Infections in a County Jail

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Abstract

This article describes a community-based intervention to manage an outbreak of community-associated methicillin-resistant *Staphylococcus aureus* (CA-MRSA) skin infections in a midwestern county jail. A systematic investigation conducted by a family medicine residency program identified 64 total cases and 19 MRSA cases between January 1 and December 31, 2007. Factors contributing to MRSA transmission included inadequate surveillance, lack of antibacterial soap, and a defective laundry process. All 19 isolates were CA-MRSA and all seven tested by pulsed-field gel electrophoresis (PFGE) were USA300. Four of the seven isolates showed variation of their PFGE patterns. A primary care approach using community-based resources effectively reduced the number of cases in this heterogeneous outbreak of CA-MRSA, with the last MRSA being isolated in October 2007.

Keywords

MRSA; pulsed-field gel electrophoresis; PFGE; USA300; jail health care

Methicillin-resistant *Staphylococcus aureus* (MRSA) infections have become a significant burden to the health care system of the United States, and their impact on nonhealth care aspects of our society is increasing (Barrett, McGehee, & Finland, 1968; Diekema et al., 2004; Gould, 2005; Jorgensen, 1986). MRSA isolated from individuals outside the health care setting has been termed community-associated (CA)-MRSA. CA-MRSA isolates often are susceptible to multiple antimicrobial agents (Naimi et al., 2003). Molecular epidemiological studies suggest the majority of CA-MRSA infections are caused by pulsed-field type USA300 or USA400 (McDougal et al., 2003; Okuma et al., 2002).

Previously reported clusters of non-health care-related MRSA infections include outbreaks in correctional facilities (McDougal et al., 2003; "Methicillin-resistant," 2003; "Methicillin-resistant," 2001; Wootton et al., 2004) and among military recruits (Zinderman et al., 2004),

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children (Buckingham et al., 2004), and athletes (Kazakova et al., 2005). These revealed MRSA isolates with identical pulsed-field gel electrophoresis (PFGE) patterns, indicating the presence of a single, highly stable strain, CA-MRSA USA300-0114, across communities in the United States (Tenover et al., 2006). Since then, CA-MRSA has been recognized as the predominant cause of skin and soft tissue infections in the community setting (King et al., 2006). Emerging data hold the prospect of ongoing clonal expansion and an increasing molecular diversification among MRSA strains (Felkner, Rohde, Valle-Rivera, Baldwin, & Newsome, 2007; Kennedy et al., 2008). Despite its endemic occurrence within the U.S. prison system (David, Mennella, Mansour, Boyle-Vavra, & Daum, 2008), there is a scarcity of published interventions describing the management of MRSA outbreaks in correctional facilities.

Background

The jail discussed in this article offers a biweekly health clinic staffed by residents from a family medicine residency program. During the first quarter of 2007, the resident physicians noticed an increased number of skin infections among inmates, and the use of β -lactam antibiotic agents frequently resulted in treatment failure. This prompted a systematic investigation into what eventually was recognized as an outbreak of CA-MRSA infections.

Human Participation Protection

The work reported here represents routine provision of medical attention at the standard of care, with data collected for public health purposes. No additional data were collected or medical intervention undertaken for the purposes of this study. Publication of the presented data was approved by the institutional review board of the Minnehaha County Jail, Sioux Falls, South Dakota.

Methods

Setting

The facility is a 400-bed capacity, minimum-security detention center for females and males in the Midwest. From January 1 to December 31, 2007, it housed an average of 360 inmates a day, of which 83% were male and 17% were female. The majority of inmates were Whites (51.1%), followed by Native Americans (21.2%), Blacks (13.4%), and Hispanics (13.1%). The average inmate stay was 11 days.

Definitions

An inmate clinically diagnosed with an infectious skin lesion including folliculitis, furuncle, abscess, or infected wound was defined as a *case*. We defined a *MRSA case* as an inmate with a skin lesion from which MRSA was isolated by standard culture techniques or an inmate with clinical signs of non-skin-related infections and documented MRSA isolation from other clinical specimens. Regular follow-up visits were not counted as cases. Seven inmates made repeat visits for new lesions that had occurred at least 4 weeks (4 to 10 weeks) after the previous visit and completion of therapy. Those visits were counted as separate cases. The *preintervention period* was prior to active surveillance of MRSA infections. For the preintervention period, clinical and microbiological data were collected by retrospective chart review (January 1 to March 30, 2007). The *intervention period* was the time of prospective acquisition of data (April 1 to December 31, 2007). The intervention period comprised three phases introduced sequentially in a complementary fashion (Figure 1). The *surveillance phase* began with microbiological MRSA surveillance by obtaining bacterial cultures from skin lesions as indicated. During the *active observation phase*, information

regarding existing infection control measures was gathered. The *implementation phase* consisted of initiation and maintenance of improved infection control measures.

Data Acquisition

We used a standardized patient evaluation form to collect case data including age, gender, race, comorbid conditions predisposing to infections (diabetes mellitus, renal disease, lung disease, heart disease, HIV and immune suppression, drug and alcohol abuse), diagnosis, culture specimen, culture results, antimicrobial susceptibility profile of MRSA, and treatment modality.

For the preintervention period, cases were identified retrospectively by searching jail clinic logs for skin lesion–related visits. During the prospective part of the study, inmates with skin lesions, both self-reported and noted by correctional staff, were evaluated in jail clinic by resident physicians using the standardized patient evaluation form, and specimens for bacterial cultures were obtained.

Microbiological and Molecular Analysis

Culture specimens were obtained from openly draining wounds or, if indicated, after incision and drainage of closed lesions, using culturette swabs (BBL, Becton Dickinson Microbiology Systems, Cockeysville, Maryland). Swabs were sent to a local hospital microbiological laboratory to be cultured using standard techniques. Single colonies were processed in the VITEK 2™ (Durham, North Carolina) for complete identification and sensitivities. Colonies with typical morphology, positive VITEK identification, and positive slide agglutination test for coagulase were identified as *S. aureus*. Seven isolates were available for molecular analysis by using PFGE, as previously described (Bannerman, Hancock, Tenover, & Miller, 1995).

Assessment of Infection Control Conditions

An interdisciplinary team including resident physicians, correctional medical staff, and the warden conducted a comprehensive survey of the infection control measures, including intake process and initial physical exam, reporting of skin infections, laundering, products for personal hygiene and surface cleaning, hand hygiene, other aspects of personal hygiene including sharing of items; inspection of living, bathroom, and recreational areas; correctional contact precautions; education of inmates and staff; wound care practices; and antimicrobial therapy.

Results

Documentation of a MRSA Outbreak in the Jail

In total, 64 clinic visits related to skin infections (cases) were documented for the observation period between January 1 and December 31, 2007. In 26 cases, bacterial cultures were obtained from spontaneously draining wounds or after incision and drainage of abscesses. Of these, 19 (73.1%) grew MRSA (MRSA cases). The other seven cases yielded methicillin-sensitive *Staphylococcus aureus* (MSSA), *Enterobacter cloacae*, and normal skin flora.

More than one third of all cases (23 of 64) occurred during the preintervention period (January to March), but only one culture was obtained during this period, resulting in the only microbiologically confirmed MRSA case for the preintervention period. We began culturing skin lesions during clinic visits in the surveillance phase. During the first 3 months of the intervention period (April through June), 26 cases were identified, and MRSA was isolated in 13 of 15 (86.7%) cultured skin lesions. These initial data suggested a MRSA

outbreak in the jail. Roughly two thirds of the cases (41 of 64) were reported after initiation of MRSA surveillance (April to December) and bacterial cultures were obtained in almost two thirds of those cases (24 of 41), resulting in 18 MRSA cases during the intervention. Demographic data showing the distribution of age, gender, race, source of admission, and comorbid conditions are presented in Table 1.

The active observation phase began between April and May, aimed at identifying factors promoting MRSA transmission among inmates. Key findings from this investigation as well as infection control measures implemented as a result of the active observation phase are described below.

The implementation phase began at the end of June, and most interventions aimed at improved infection control were instituted by the end of July. Subsequently, the number of cases decreased from 26 (April to June) to 12 (July to September), with a further decline to only three cases between October and December (Figure 1). The percentage of MRSA-positive cultures also decreased from 86.7% to 50% between July and September and further to 33.3% between October and December (Figure 1). Of note, the only MRSA case during the last quarter of the study occurred in October, and none was documented for November and December.

Analysis and Improvement of Infection Control Measures

During the active observation phase, we systematically reviewed the facility's hygienic conditions as well as existing infection control policies and practices. The observed deficits and subsequent interventions fell into three broad categories: primary prevention, early identification, and treatment.

Primary prevention—The generic bar soap used prior to intervention did not have antibacterial activity and since has been discontinued. Every inmate is now given an antibacterial bar containing triclocarban (Dial; Breneman, Hanifin, Berge, Keswick, & Neumann, 2000; Suller & Russell, 1999). Liquid antibacterial soap dispensers previously not present now have been installed in dormitories. Chlorhexidine-based liquid soap is now dispensed to inmates with any signs of skin or known MRSA infection (Jarvis, Wynne, Enwright, & Williams, 1979; Suller & Russell, 1999; Wendt et al., 2007). Additional interventions were implemented in accordance with the Federal Bureau of Prisons Clinical Practice Guidelines (Federal Bureau of Prisons, 2005): Inmates are encouraged to shower twice daily. Sharing of personal hygiene items such as razors, deodorants, soaps, or towels is discouraged. Showers, cleaned weekly prior to the intervention, are now cleaned twice weekly with an antiseptic solution. After meals, tables are cleaned with bleach instead of soap and water. In addition, inmates and correctional staff now regularly receive personal hygiene education with emphasis on preventing transmission of MRSA.

Cohorting of inmates with skin infections until completion of successful treatment or when cultures indicate absence of MRSA infection was initiated (Federal Bureau of Prisons, 2005).

Review of the facility's laundry process revealed several deficits, and changes were implemented accordingly. The thermostat of the laundry machines was defective, resulting in inadequately low temperatures. In addition, laundry machines were overloaded and an insufficient amount of laundry soap was used due to dispenser malfunction.

Early identification—The intake questionnaire and exam were modified to include specific sections addressing skin infections and a history of MRSA. If skin infections or boils are present on intake, contact isolation or cohorting is initiated, chlorhexidine-based

liquid soap is dispensed, and the inmate is scheduled for evaluation at the jail clinic. Antibiotic therapy may be initiated before the first scheduled clinic evaluation. Bacterial cultures are obtained from skin infections as medically indicated for MRSA surveillance. Antimicrobial susceptibility patterns of MRSA isolates are regularly reviewed to guide containment measures and antimicrobial therapy.

Effective treatment—Prior to the implementation period, the choice of empiric antibiotic therapy encompassed a spectrum of agents commonly used to treat skin infections, including cephalexin, augmentin, trimethoprim-sulfamethoxazole (TMP/SMX), and doxycycline. β -lactams were most frequently used for initial empiric therapy. A guideline was implemented favoring the use of TMP/SMX for initial antimicrobial treatment in the absence of contraindication, with doxycycline or clindamycin as alternative agents. In addition, the importance of early incision and drainage for diagnostic and therapeutic purposes has been emphasized.

Antimicrobial Susceptibility Patterns of MRSA Isolates

Antimicrobial susceptibility profiles were available for all 19 MRSA isolates and were consistent with susceptibilities previously reported for CA-MRSA (Figure 2). All of the isolates were resistant to β -lactams and susceptible to clindamycin, bactrim, gentamicin, vancomycin, linezolid, and synercid. All except one of the isolates were erythromycin resistant. The majority of strains differed only in their susceptibility to ciprofloxacin, with 12 strains being sensitive and six strains being resistant to this fluorquinolone agent (Figure 2).

Molecular Analysis of MRSA Isolates

Seven of the 19 isolates were available for molecular typing using PFGE. All had a pulsed-field type consistent with the CA-MRSA USA300 pulsed-field type (Figure 3). Three strains had identical patterns compared to the reference strain MRSA 8325. The other four strains each had unique pulsed-field profiles within the USA300 group.

Discussion

In this study, we describe a community-based intervention that successfully reduced the number of MRSA infections at a Midwestern county jail. In a coordinated effort that included resident physicians of the local family medicine residency program, we studied factors that contributed to the failure of infection control in the facility. The investigation led to the implementation of measures aimed at improved treatment, containment, and surveillance. This resulted in successful management of the outbreak.

Most previous studies on MRSA in correctional facilities described its prevalence in the facilities and identified the risk factors associated with the spreading of disease (Baillargeon, Kelley, Leach, Baillargeon, & Pollock, 2004; David et al., 2008; Felkner et al., 2007; “Outbreaks of community-associated,” 2003). However, we found only few published interventions in the correctional setting where infection control is especially challenging due to the closed environment, crowded conditions, and higher infection prevalence among inmates (Felkner et al., 2007). In addition, there is a scarcity of experimental data describing the efficacy of intervention methods in controlling MRSA infections in general (Allen, 2006). Except for a brief report by the Centers for Disease Control and Prevention, only one study described in detail an intervention to manage an outbreak of MRSA skin infection in a correctional facility (“Methicillin-resistant,” 2003; Wootton et al., 2004).

In the current study, we systematically documented a total of 64 visits for skin infections over the course of 1 year. An initial retrospective analysis for the first quarter of 2007 indicated inadequate surveillance practices. As part of the intervention, subsequent microbiological confirmation was achieved in almost two thirds of cases.

After implementation of measures to decrease transmission of MRSA among inmates, both the number of skin infections and the number of culture-confirmed MRSA-positive cases decreased dramatically. This observation suggests that the majority of skin infections were caused by MRSA and that the true number of MRSA cases likely was substantially higher than indicated by culture results.

Previous MRSA-related interventions in correctional settings reported only culture-confirmed MRSA cases ("Methicillin-resistant," 2003; Wootton et al., 2004). In contrast, we defined a "case" based on clinical criteria and reported a case from which MRSA was isolated as "MRSA case." This approach appears to be more useful for a number of reasons. First, some skin lesions may never develop an actively draining lesion or may not be amenable to incision and drainage, and in the absence thereof, culture may not be feasible. Second, early antibiotic treatment may prevent the development of a draining skin lesion. Third, our data are consistent with more recent epidemiological studies indicating that CA-MRSA has become the predominant cause of skin infections in various community settings (King et al., 2006). Accordingly, studies in which the prevalence of MRSA cases is based on microbiological criteria without taking into account the number of clinical skin infections may underestimate the true extent of an outbreak.

The average number of days between booking date and case diagnosis was 49.8 days. Only four cases were identified in fewer than 7 days (1 to 5 days) after the booking date. The observed time course between admission and discovery of a lesion favors in-facility transmission as the main driving force for the outbreak. However, the small number of cases diagnosed less than a week after intake suggests that importation of cases from the community may have played a role, as well. In addition, the average time lag between booking and case diagnosis was substantially longer than the average stay in jail (almost 50 vs. 11 days, respectively), indicating that the majority of cases occurred in inmates with longer incarceration times (data not shown). Molecular typing of a subset of isolates using PFGE allowed for a more detailed epidemiological analysis. The pulsed-field types of all seven isolates tested could be classified within the CA-MRSA USA300 group, consistent with previous reports of CA-MRSA USA300 as being the etiologic agent of outbreaks in correctional facilities (Davis et al., 2007). To our knowledge, this is the first documented cluster of MRSA USA300 infections in South Dakota.

Despite their classification as USA300, the PFGE patterns of our MRSA isolates were heterogeneous, whereas all except one ("Methicillin-resistant," 2001) of the earlier investigations of outbreaks in U.S. correctional facilities reported identical PFGE patterns among MRSA strains (Tenover et al., 2006; Wootton et al., 2004). For example, an intervention in a correctional facility in Georgia found that all MRSA isolates available for PFGE analysis revealed an indistinguishable pulsed-field type suggesting a common origin and clonal transmission within the facility (Wootton et al., 2004). In contrast, our results suggest that several closely related but differing strains were circulating within the facility during the study period. Similar results have recently been reported in a different outbreak setting (Hall, Bixler, & Haddy, 2008). One possible explanation of our findings is that MRSA strains endemic in the community were introduced into the facility at different times and the breakdown of infection-control measures facilitated the transmission among inmates, leading to a multiclonal expansion of CA-MRSA.

This has important implications for the prevention of MRSA infections in correctional facilities. In such a concept, the key event is not so much the introduction of MRSA into a facility, as this would be difficult to prevent in an endemic situation. Rather, the focus needs to be on surveillance and prevention of transmission, limiting the expansion of circulating strains in the facility. This concept is consistent with more recent epidemiological studies showing higher than previously described degrees of molecular diversity among CA-MRSA isolates in community as well as correctional settings (Davis et al., 2007; Felkner et al., 2007). What we are observing in the correctional setting may be a manifestation of the changing landscape of CA-MRSA prevalence in the community: non-health care-related MRSA is becoming the predominant cause for infections of the skin and soft tissues and molecular diversity is increasing with the number of MRSA circulating in the community (Kennedy et al., 2008).

Deficiencies of the facility's infection control measures included but were not limited to inadequate screening and surveillance, lack of soap with antibacterial activity, and an inconsistent policy for isolation and cohorting of inmates with openly draining skin lesions. Even though we cannot separate the effect of individual interventions based on our data, it should be noted that the laundry process was identified to be deficient at the beginning of the active observation phase and also was the first area where changes were implemented. This resulted in a prompt decline of observed skin infections even before other measures could be implemented (data not shown). This suggests that the laundry process may have been a major factor in the breakdown of infection control in the facility. In contrast, we found no problems with wound care practices, a shortcoming previously associated with MRSA transmission among inmates (Wootton et al., 2004).

Our work shows that a primary care approach using community-based resources under participation of a family medicine residency program is effective in managing emerging public health problems in the correctional setting. Exposing physicians early in their training to this aspect of community medicine may lead to better response in the event of an outbreak.

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Figure 1. Methicillin-resistant *Staphylococcus aureus* (MRSA) infections at a South Dakota county jail in 2007. Black columns = number of clinic visits for skin infections (all cases); gray columns = number of cases from which bacterial cultures were obtained; white columns = number of cases from which MRSA was isolated (MRSA cases).

Figure 2.

Microbial and molecular analysis of skin infections during the study period. Cipro-R = ciprofloxacin resistant; ery-R = erythromycin-resistant; ery-S = erythromycin-sensitive; MRSA = methicillin-resistant *Staphylococcus aureus*; MSSA = methicillin-sensitive *Staphylococcus aureus*; PFGE = pulsed-field gel electrophoresis.

a. All isolates were resistant to β -lactams and susceptible to clindamycin, trimethoprim-sulfomethoxazole, gentamicin, vancomycin, linezolid, and synergid.

Figure 3.

Pulsed-field gel profiles of *SmaI* digested chromosomal DNA from methicillin-resistant *Staphylococcus aureus* (MRSA) isolates. Similarity among isolates was determined by the Dice coefficient (1.5% optimization, 2% tolerance) and the dendrogram constructed using unweighted pair groups mathematical averages. The numbers indicate the percentage of similarity. Isolates from skin infections are designated with an abbreviation. *S. aureus* NCTC 8325 (USA300) was used as a reference strain (19). Additional pulse-field types are indicated.

Table 1
Characteristics of Skin Infection Cases

Characteristics	All Cases (n = 64)	Cases From Which Cultures Were Obtained (n = 26)	MRSA Cases (n = 19)
Age (Years)			
20	9	2	1
21-30	23	13	11
31-40	16	5	2
41-50	13	5	4
51-60	3	1	1
Gender			
Male	48	19	13
Female	16	7	6
Race			
White	22	9	7
African American	24	9	6
Hispanic	5	2	2
Native American	13	6	4
Source of admission			
Street	51	20	15
Transfer	11	5	3
Unknown	2	1	1
Comorbid condition			
Diabetes mellitus	8	1	1
Lung disease	2	1	1
HIV/immunosuppression	7	4	3
Drug abuse	12	4	4
Alcohol abuse	16	5	5
Chronic renal disease	0	0	0

MRSA = methicillin-resistant *Staphylococcus aureus*.