

ORIGINAL ARTICLE

Methicillin-Resistant *Staphylococcus aureus* Disease in Three Communities

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ABSTRACT

BACKGROUND

Methicillin-resistant *Staphylococcus aureus* (MRSA) infection has emerged in patients who do not have the established risk factors. The national burden and clinical effect of this novel presentation of MRSA disease are unclear.

METHODS

We evaluated MRSA infections in patients identified from population-based surveillance in Baltimore and Atlanta and from hospital-laboratory-based sentinel surveillance of 12 hospitals in Minnesota. Information was obtained by interviewing patients and by reviewing their medical records. Infections were classified as community-acquired MRSA disease if no established risk factors were identified.

RESULTS

From 2001 through 2002, 1647 cases of community-acquired MRSA infection were reported, representing between 8 and 20 percent of all MRSA isolates. The annual disease incidence varied according to site (25.7 cases per 100,000 population in Atlanta vs. 18.0 per 100,000 in Baltimore) and was significantly higher among persons less than two years old than among those who were two years of age or older (relative risk, 1.51; 95 percent confidence interval, 1.19 to 1.92) and among blacks than among whites in Atlanta (age-adjusted relative risk, 2.74; 95 percent confidence interval, 2.44 to 3.07). Six percent of cases were invasive, and 77 percent involved skin and soft tissue. The infecting strain of MRSA was often (73 percent) resistant to prescribed antimicrobial agents. Among patients with skin or soft-tissue infections, therapy to which the infecting strain was resistant did not appear to be associated with adverse patient-reported outcomes. Overall, 23 percent of patients were hospitalized for the MRSA infection.

CONCLUSIONS

Community-associated MRSA infections are now a common and serious problem. These infections usually involve the skin, especially among children, and hospitalization is common.

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IN THE UNITED STATES, *STAPHYLOCOCCUS aureus* is the most common cause of skin and soft-tissue infections, as well as of invasive infections acquired in hospitals.^{1,2} Treatment of serious *S. aureus* infections can be challenging, and the associated mortality rate remains 20 to 25 percent despite the availability of highly active antimicrobial agents.^{3,4} However, most antistaphylococcal agents are ineffective against methicillin-resistant *S. aureus* (MRSA), which was first identified as a hospital-acquired pathogen in the 1960s.^{2,3,5,6}

Over the past 40 years, MRSA infections have become endemic in most U.S. hospitals^{1,2} and hospitals worldwide,⁷ striking, with rare exception, only patients with established risk factors.^{8,9} More recently, however, MRSA infections have been described in patients without established risk factors who are living in the community.¹⁰⁻¹⁹ The current approach to suspected cases of community-associated (also referred to as community-acquired) *S. aureus* infections (suggested by findings of furuncles, abscesses, or cellulitis) commonly includes empirical treatment with β -lactam antibiotics. This approach may need to be reconsidered if community-associated MRSA becomes a clinically significant pathogen.

The Centers for Disease Control and Prevention (CDC) and three sites participating in the Emerging Infections Program began a specialized MRSA surveillance project in 2001 using the Active Bacterial Core Surveillance program, a population-based surveillance component of the Emerging Infections Program Network designed to study the epidemiologic features of invasive bacterial disease and to track drug resistance in the United States. We used these data to evaluate the incidence of endemic community-associated MRSA infection, racial disparities in the incidence, patterns of antimicrobial susceptibility, and clinical outcomes in several areas in the United States.

METHODS

SURVEILLANCE POPULATION

The MRSA Active Bacterial Core Surveillance project monitored all MRSA isolates from all body sites from patients in 11 Baltimore hospitals serving a population of 700,000; Health District 3 in greater Atlanta, comprising eight counties with a total population of 3.3 million; and 12 sentinel hospital-based laboratories representative of the state in Minnesota (6 rural and 6 urban, representing 16

percent of the licensed hospital beds in the state). Laboratories served both outpatient clinic networks and hospital inpatients; sites in Atlanta included several referral laboratories serving predominantly ambulatory care settings. Surveillance was performed consecutively for 12 months in Baltimore (beginning February 2002), 18 months in Atlanta (beginning July 2001), and 24 months in Minnesota (beginning January 2001). In Baltimore, 1 of 12 eligible hospitals declined to participate in the MRSA study; however, this omission would be unlikely to have a substantial effect. The laboratory in that hospital historically reports only about 5 percent of the cases of infections with other pathogens under surveillance as part of the Active Bacterial Core Surveillance system in Baltimore.

CASE DEFINITIONS AND ASCERTAINMENT

A community-associated MRSA isolate was defined as an MRSA isolate recovered from a clinical culture from a patient residing in the surveillance area who had no established risk factors for MRSA infection. Established risk factors included the isolation of MRSA two or more days after hospitalization; a history of hospitalization, surgery, dialysis, or residence in a long-term care facility within one year before the MRSA-culture date; the presence of a permanent indwelling catheter or percutaneous medical device (e.g., tracheostomy tube, gastrostomy tube, or Foley catheter) at the time of culture; or previous isolation of MRSA. We reviewed the medical records of patients with suspected community-associated MRSA isolates to identify risk factors for infection. We attempted to interview by telephone all patients for whom no risk factors were identified to confirm the absence of established risk factors and to obtain a brief history of the clinical outcome. At least 15 attempts were made, after which suspected community-associated MRSA isolates were classified as confirmed in the case of patients who were successfully interviewed and confirmed to have no established risk factors or as probable in the case of patients who were not interviewed but who had no established risk factors on a review of medical records. The remaining isolates were classified as either health care-associated when established risk factors were identified or indeterminate if no information on the patient could be obtained.

A case of community-associated MRSA disease was defined as illness compatible with staphylococcal disease in a patient residing in the surveillance

areas and isolation of community-associated MRSA from a clinically relevant site. Only a subgroup of patients with community-associated MRSA isolates had actual disease and achieved case status.

To identify cases, surveillance personnel routinely contacted all clinical microbiology laboratories serving residents of each catchment area regarding MRSA isolated from clinical cultures (infection-control surveillance cultures were excluded). Periodic audits of laboratory records were conducted by surveillance personnel to identify any unreported cases and ensure the completeness of reporting. Surveillance personnel collected information on patients using a standardized questionnaire that included demographic and isolate data on all MRSA isolates; information on antimicrobial-susceptibility testing (with results characterized as susceptible, intermediate, or resistant) and clinical characteristics were obtained from available medical records (e.g., emergency room, primary care, or hospital) only for patients with confirmed or probable community-associated MRSA isolates. The collection of additional data on disease outcome, employment status, household structure, socioeconomic status, and level of education was limited to patients with confirmed cases of community-associated MRSA disease.

The study was approved by the appropriate institutional review boards at the participating sites, including all participating Baltimore hospitals, the Maryland Department of Health and Mental Hygiene, Johns Hopkins University Bloomberg School of Public Health, the Georgia Department of Human Resources, Emory University School of Medicine, the Minnesota Department of Health, and the CDC. Oral informed consent was obtained from all those who were interviewed.

STATISTICAL ANALYSIS

Statistical analysis was conducted with SAS software (SAS Institute). Annual cumulative incidence rates were calculated, after adjustment for the study period at each site, with the use of projections of the 2001 and 2002 population from the Census Bureau. Initial therapy was categorized as active if the patient received an antimicrobial agent with activity against *S. aureus* and to which the MRSA was susceptible in vitro. Therapy was categorized as inactive if initial therapy consisted of antimicrobial agents to which the isolate had intermediate resistance on testing or was resistant in vitro. If the results of susceptibility testing were not available for

a prescribed agent or the patient received no antimicrobial agents, the patient was excluded from analyses correlating inactive therapy and outcomes. The Mantel–Haenszel chi-square test was used to compare the incidence according to race and other categorical data, and the t-test was used for continuous data. All comparisons were initially stratified according to the reporting area, and rate ratios were pooled if there were no significant differences between areas according to the Breslow–Day test for homogeneity of the rate ratios.

RESULTS

SURVEILLANCE

During the study period, 12,553 patients with MRSA isolates were reported. Of these patients, 9972 (79 percent) were immediately classified as having health care–associated MRSA infection and did not require interviews. Interviews were attempted with 2581 patients with suspected cases of community-associated MRSA infection; 1063 of these patients (41 percent) were interviewed, allowing 280 (11 percent) to be reclassified as having health care–associated MRSA. Among the remaining patients with suspected cases of community-associated MRSA infection, 2107 (17 percent) were classified as having confirmed or probable community-associated MRSA isolates (Atlanta, 1590 of 7819 [20 percent]; Minnesota, 370 of 3714 [12 percent]; and Baltimore, 147 of 1720 [8 percent]; $P < 0.001$). MRSA isolates in 196 patients were classified as indeterminate (2 percent).

The overall incidence of invasive MRSA infection (i.e., MRSA recovered from a normally sterile site), regardless of whether the infection was acquired in the community or at a health care facility, was 19.3 infections per 100,000 population in Atlanta and 40.4 infections per 100,000 in Baltimore.

Of the 2107 confirmed or probable isolates of community-associated MRSA, 1647 (78 percent) were associated with clinical illness and were classified as cases of community-associated MRSA disease. Among these cases, the confirmed and the probable community-associated MRSA isolates were obtained from similar body sites and demonstrated similar susceptibilities to antimicrobial agents with one exception, i.e., there was variable sensitivity to erythromycin (details are provided in the Supplementary Appendix, available with the full text of this article at www.nejm.org). The annual incidence of community-associated MRSA disease

in the two areas that performed population-based surveillance was 25.7 cases per 100,000 in Atlanta and 18.0 per 100,000 in Baltimore (rate ratio, 0.70; 95 percent confidence interval, 0.58 to 0.85) (Fig. 1). In both surveillance areas, the incidence was significantly higher among persons who were less than two years old than among those who were two years of age or older (unadjusted relative risk, 1.51; 95 percent confidence interval, 1.19 to 1.92) (Fig. 1). Incidence rates were significantly higher among blacks than whites in Atlanta among all age groups (age-adjusted relative risk, 2.74; 95 percent confidence interval, 2.44 to 3.07); racial differences in incidence were not significant in the Baltimore population, even in the youngest age group (relative risk, 2.58; 95 percent confidence interval, 0.31 to 21.5).

CLINICAL CHARACTERISTICS

The type of infection varied slightly among the surveillance areas (Table 1); of the 1647 patients with community-associated MRSA disease, most (1266 [77 percent]) were categorized as having skin or soft-tissue infections. Specific types included abscess in 751 patients (59 percent), cellulitis in 528 patients (42 percent), folliculitis in 88 patients (7 percent), and impetigo in 33 patients (3 percent). Among the other types of infection reported, 103 (6 percent) were invasive, including bacteremia, septic arthritis, and osteomyelitis; 157 were in wounds (10 percent); and 31 were pneumonia (2 percent) (Table 1).

Most patients (1333 [81 percent]) were treated

with antimicrobial agents; specific antimicrobial agents were documented for 1297 patients (97 percent). Among these 1297 patients, 757 (58 percent) received β -lactam antibiotics alone, 199 (15 percent) received a β -lactam with a non- β -lactam agent, and 341 (26 percent) received only non- β -lactam therapy. Among the patients whose antibiotic regimens were documented, significantly more of the 1099 patients with skin infections than of the 198 patients with other types of infection received β -lactam agents alone (64 percent vs. 28 percent, $P < 0.001$).

Antimicrobial susceptibilities were obtained from the medical records of 1345 of the 1647 patients with community-associated MRSA disease (82 percent). With few exceptions, the patterns of susceptibility were similar among the study areas. However, isolates from patients in Atlanta and Baltimore were significantly less likely than those from Minnesota to be susceptible to erythromycin and ciprofloxacin (Table 2). Susceptibility data and documented information on empirical therapy were available for most patients who received empirical therapy (1215 of 1297 [94 percent]); 884 (73 percent) received inactive therapy.

Limited information on the effect of the disease was available from the medical records; 506 patients (31 percent) were hospitalized, including 371 (23 percent) who were hospitalized specifically for MRSA disease (Table 1). For these 371 patients, hospitalization was unlikely to be the result of the clinician's receiving the MRSA-culture report. The interval between specimen collection and admis-

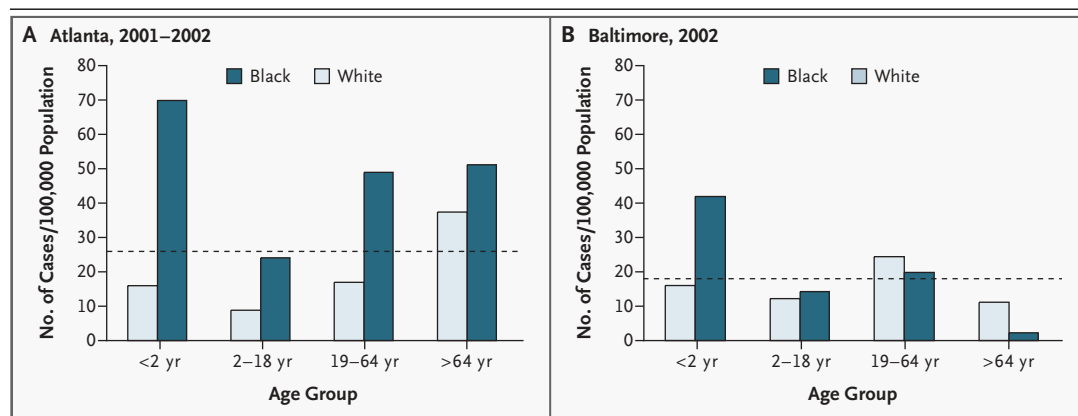


Figure 1. Incidence of Community-Associated MRSA Disease in Atlanta and Baltimore, According to Race and Age Group. The horizontal line in each graph is the overall site-specific annual incidence. Race was determined in most cases by study personnel.

Table 1. Infections and Outcomes Associated with Community-Associated MRSA Disease, 2001–2002.

Variable	Atlanta (N=1267)	Baltimore (N=115)	Minnesota (N=265)	Total (N=1647)	P Value*
Invasive infections — no. (%)†					
Bacteremia	30 (2)	7 (6)	6 (2)	43 (3)	0.66
Meningitis	1 (<1)	1 (1)	0	2 (<1)	0.84
Osteomyelitis	11 (1)	6 (5)	7 (3)	24 (1)	<0.01
Bursitis	12 (1)	0	7 (3)	19 (1)	0.04
Arthritis	13 (1)	0	2 (1)	15 (1)	0.52
Other infections — no. (%)†					
Skin and soft tissue	973 (77)	95 (83)	198 (75)	1266 (77)	0.71
Wound	136 (11)	8 (7)	13 (5)	157 (10)	<0.01
Pneumonia	23 (2)	4 (3)	4 (2)	31 (2)	0.97
Urinary tract	57 (4)	4 (3)	3 (1)	64 (4)	0.01
Sinus	60 (5)	0	1 (<1)	61 (4)	<0.01
Underlying illness — no. (%)	594 (47)	70 (61)	80 (30)	744 (45)	0.08
Hospitalization — no. (%)	339 (27)	72 (63)	95 (36)	506 (31)	0.68
MRSA disease primary reason — no./total no. (%)	251/339 (74)	41/72 (57)	79/95 (83)	371/506 (73)	0.62
Intensive care unit stay — no./total no. (%)	26/339 (8)	7/72 (10)	4/95 (4)	37/506 (7)	0.14
Discharged from hospital — no./total no. (%)	323/339 (95)	71/72 (99)	86/95 (91)	480/506 (95)	0.07
Median stay — days	5	5	3	4	0.20

* P values were determined by means of the Cochran–Mantel–Haenszel summary statistic and indicate significant differences in infection rates among sites.

† Patients could have more than one infection.

Table 2. Number of Community-Associated MRSA Isolates That Were Susceptible to Selected Antimicrobial Agents, 2001–2002.*

Agent Tested	Atlanta	Baltimore	Minnesota	Total	P Value†
	<i>no. of susceptible isolates/total no. (percent)</i>				
Ciprofloxacin	408/648 (63)	6/31 (19)	146/182 (80)	560/861 (65)	<0.001
Clindamycin	840/970 (87)	78/92 (85)	211/239 (88)	1129/1301 (87)	0.58
Erythromycin	98/907 (11)	11/94 (12)	110/235 (47)	219/1236 (18)	<0.001
Gentamicin	429/444 (97)	66/71 (93)	184/188 (98)	679/703 (97)	0.59
Rifampin	682/694 (98)	6/9 (67)	179/184 (97)	867/887 (98)	0.21
Tetracycline	726/814 (89)	43/70 (61)	163/179 (91)	932/1063 (88)	0.44
Vancomycin‡	1016/1017 (100)	95/96 (99)	232/232 (100)	1343/1345 (100)	0.88
Linezolid	13/13 (100)	11/12 (92)	0	24/25 (96)	0.30
Trimethoprim– sulfamethoxazole	912/943 (97)	30/36 (83)	236/239 (99)	1178/1218 (97)	0.32

* Results were obtained at local facilities.

† P values were determined by means of the Cochran–Mantel–Haenszel summary statistic.

‡ Two isolates were nonsusceptible with the use of automated testing methods, but these results were not confirmed with the use of recommended methods.^{20,21}

sion was less than one day for 226 of the 371 patients (61 percent), one to two days for 115 (31 percent), and more than two days for 22 (6 percent) (2 percent had missing data). A total of 37 patients (10 percent) required hospitalization in the intensive care unit. Hospitalization lasted a median of four days, and only 1 of the 37 patients who died during hospitalization had documentation that the community-associated MRSA was causal or contributory to the death.

Information on other outcomes associated with community-associated MRSA infection was available for 575 patients with confirmed cases (i.e., interviewed patients). Among these patients, 560 (97 percent) received some antimicrobial agents, 136 (24 percent) were hospitalized, 226 (39 percent) underwent incision and drainage, and 176 (31 percent) required a follow-up visit with their physician.

To assess the relationship between inactive antimicrobial therapy and outcome more closely, we

attempted to identify a homogeneous group of patients in which to compare clinical outcomes on the basis of empirical antimicrobial treatment. We limited further analysis to 453 patients with confirmed cases of community-associated MRSA disease involving skin or soft-tissue infections who received antimicrobial therapy at the time of the isolation of community-associated MRSA and for whom information on initial treatment and clinical outcome was available from the interview. Neither initial incision and drainage nor initial antimicrobial therapy that was inactive was significantly associated with an increased frequency of the following patient-reported outcomes after the initial evaluation for illness: follow-up visits to a health care provider, subsequent incision and drainage, or subsequent change in antimicrobial therapy (Table 3). Also, among the subgroup of patients who did not initially undergo incision and drainage, there were no significant differences in outcomes ac-

Table 3. Effect of Initial Therapy on Selected Outcomes among 453 Patients with Confirmed Skin or Soft-Tissue Infections Due to Community-Associated MRSA, 2001–2002.*

Initial Therapy	No. of Patients	Follow-up Visit to Health Care Provider		Incision and Drainage on Follow-up Visit	New Anti-microbial Agent Prescribed on Follow-up Visit
		≥1 Times	≥2 Times		
Incision and drainage					
Yes — no. (%)	196	54 (28)	30 (15)	19 (10)	45 (23)
No — no. (%)	257	69 (27)	43 (17)	14 (5)	66 (26)
Rate ratio (95% CI)	—	1.01 (0.80–1.29)	0.94 (0.70–1.27)	1.37 (1.00–1.87)	0.92 (0.71–1.18)
Inactive therapy					
Yes — no. (%)	254	59 (23)	35 (14)	15 (6)	55 (22)
No — no. (%)	199	64 (32)	38 (19)	18 (9)	56 (28)
Rate ratio (95% CI)	—	0.81 (0.66–1.00)	0.83 (0.65–1.07)	0.80 (0.54–1.17)	0.85 (0.69–1.05)
Incision and drainage					
Inactive therapy — no. (%)	108	20 (19)	11 (10)	8 (7)	16 (15)
Active therapy — no. (%)	88	34 (39)	19 (22)	11 (12)	29 (33)
Rate ratio (95% CI)	—	0.60 (0.41–0.87)	0.63 (0.39–1.02)	0.75 (0.43–1.28)	0.58 (0.39–0.88)
No incision and drainage					
Inactive therapy — no. (%)	146	39 (27)	24 (16)	7 (5)	39 (27)
Active therapy — no. (%)	111	30 (27)	19 (17)	7 (6)	27 (24)
Rate ratio (95% CI)	—	0.99 (0.78–1.26)	0.98 (0.73–1.31)	0.87 (0.51–1.49)	1.05 (0.83–1.34)

* The outcomes were reported during the interview with each patient. Only patients who were interviewed were included in the analysis. Initial therapy was categorized as active if the patient received an antimicrobial agent with activity against *S. aureus* and to which the MRSA was susceptible in vitro. Therapy was categorized as inactive if initial therapy included only antimicrobial agents to which the isolate had intermediate susceptibility on testing or was resistant in vivo. The rate ratio is the ratio of the rate of the outcome among the exposed group to the rate of the outcome among the group that was not exposed. CI denotes confidence interval.

ording to whether the initial therapy was inactive (Table 3).

POTENTIAL EXPOSURES TO MRSA

Although none of the established risk factors for MRSA infection were documented in any patient, 744 patients (45 percent) had underlying conditions or factors that were associated with skin infections or suggested some contact with the health care system. Among the 1250 patients whose age was known to be at least 18 years, 653 (52 percent) reported 1249 underlying conditions, including smoking (35 percent), previous skin infections (21 percent), diabetes (19 percent), asthma (12 percent), infection with the human immunodeficiency virus (HIV) (9 percent), intravenous drug use (7 percent), alcohol abuse (6 percent), and coronary vascular disease (5 percent). Among 345 patients who were younger than 18 years old, 76 (22 percent) reported 90 preexisting conditions, including skin disease (42 percent), asthma (35 percent), and smoking (7 percent). Among the 575 patients with confirmed community-associated MRSA disease, detailed information on household characteristics and employment status was obtained from the interview, and several points of contact with the health care system exclusive of established risk factors for MRSA infection were identified (Table 4).

DISCUSSION

In this study, 8 to 20 percent of all MRSA isolates collected as part of prospective population-based surveillance were not associated with traditional risk factors and were classified as community-associated MRSA. Most of these isolates were associated with clinically relevant infections that required treatment. The most common infections involved skin and soft tissues; however, 6 percent were considered invasive. Attributable mortality was low, but 23 percent of patients were hospitalized for these infections.

The incidence of clinically relevant community-associated MRSA disease varied between the Atlanta surveillance area (25.7 per 100,000) and the Baltimore surveillance area (18.0 per 100,000), and we found marked disparity in the incidence of community-associated MRSA disease between blacks and whites in Atlanta but not in Baltimore, even among the youngest age group. Several reports have highlighted the increased incidence of staphylo-

coccal disease among Pacific Islanders, American Indians, and Alaskan Natives.^{16,18,22,23} Black race was associated with increased rates of invasive *S. aureus* disease in 1998 in one population-based study in Connecticut²⁴ and in other studies evaluating invasive pneumococcal disease.²⁵⁻²⁸ The increased prevalence of certain underlying diseases (e.g., diabetes and HIV infection), differences in immune response, or differences in other socioeconomic factors (e.g., crowding in the household or decreased access to medical care), which are correlated with black race, may contribute to these findings.²⁹

The differences observed in incidence rates between Baltimore and Atlanta can probably be explained on the basis of the different populations under surveillance. The lower overall incidence of community-associated MRSA disease in Baltimore suggests that this surveillance population may be more likely to have established risk factors for MRSA infection. The incidence may also be falsely low, since 1 of 12 eligible laboratories declined to participate in the study. However, it is unlikely that the Baltimore surveillance underreported cases from the remaining laboratories, since the rates of invasive MRSA disease (regardless of whether the infection was acquired in the community or at a health care facility) were higher in Baltimore (40 per 100,000) than Atlanta (19 per 100,000). The Atlanta surveillance area encompassed an eight-county urban and suburban area and included a large referral laboratory; the Baltimore surveillance area was limited to urban hospital-based laboratories likely to serve persons with more frequent contact with the hospitals.

Our large, prospective series of community-associated MRSA infections identified with the use of standardized methods to measure rates of endemic disease allows for an accurate description of the clinical course and effect of these infections. In a manner consistent with previous reports from outbreaks and smaller surveillance studies, we found that most patients who were treated empirically received β -lactam antimicrobial agents. Measuring the effect of inactive therapy on these infections has been difficult owing to the small numbers of cases and imprecise outcome measurements.³⁰⁻³⁵ Although we relied on self-reported measures, our data suggest that patients with community-associated MRSA skin or soft-tissue disease who initially receive inactive antimicrobial therapy have out-

comes similar to those among patients who are treated with antimicrobial agents to which the organism is susceptible in vitro. Prospective evaluations with more objective measurements are needed to clarify whether the addition of active systemic therapy to topical agents or surgical drainage increases the beneficial effect in patients with community-associated MRSA infections involving the skin and soft tissues.

Our report reflects the results of one to two years of active surveillance in three large and diverse geographic areas. However, certain limitations should be borne in mind. First, we were unable to perform population-based estimates in Minnesota, where sentinel surveillance was conducted. However, the descriptive data probably reflect the patient mix in that state. Second, our surveillance required isolation of MRSA from a clinically relevant culture; since *S. aureus* skin disease is often treated empirically without a diagnostic test, our results probably underestimate the true burden of disease. Some caution must be taken in generalizing our findings to the U.S. population. First, we were able to interview only 41 percent of eligible patients, eliminating a majority of patients from the outcome analysis. Second, although there were rarely significant differences among the reporting areas, the majority of cases were reported in the Atlanta area. Also, patients who could not be interviewed may have been misclassified as having community-associated MRSA infection, since no interview data were available. However, we believe pooling the patients with probable and confirmed cases of community-associated MRSA disease was justified on the basis of the similarities between both patients' and isolates' characteristics, reflecting a pattern typically seen in previously reported outbreaks of community-associated MRSA infection.^{10,11,15,36-38}

To avoid clinical complications from community-acquired MRSA infections, clinicians should now consider MRSA as a potential pathogen in patients with suspected *S. aureus* infections in the community setting. Clinicians should obtain appropriate material for bacterial culture; should follow up on the results of susceptibility testing of all *S. aureus* isolates, since by definition MRSA organisms are not susceptible to β -lactam antibiotics; and should recommend surgical drainage of infections when feasible. The choice of appropriate antimicrobial agents for suspected *S. aureus* infections of skin and soft tissue in patients in the community

Table 4. Frequency of Characteristics Potentially Related to Infection among 575 Patients with Confirmed Community-Associated MRSA Disease, 2001–2002.*

Potential Risk Factor	No. of Patients (%)
Any visit to a physician's office in past yr	357 (62)
Receipt of any antimicrobial agents in past yr	224 (39)
Chronic noninfectious skin disease	190 (33)
Stayed >2 wk in non-health care high-risk setting in past 5 yr†	10 (2)
Health care–related employment in past 5 yr	69 (12)
Health care provider or direct care	23 (4)
Health care–delivery support services	26 (5)
Other type of health care	46 (8)
Acute care or skilled-nursing facility	30 (5)
Clinic or ambulatory care facility	12 (2)
Crowded household (>1 person/bedroom)‡	121 (51)
≥1 Household member ≤2 yr old	132 (23)
≥1 Household member >60 yr old	109 (19)
≥1 Household member with established risk factor for MRSA infection	92 (16)
Job in the health care setting	69 (12)
Attendance at day care§	52 (9)
History of MRSA infection	35 (6)
Receipt of home care services	17 (3)
Self-reported annual income¶	
<\$20,000	144 (29)
\$20,000–\$50,000	178 (36)
>\$50,000	173 (35)
Receipt of public assistance	92 (16)

* The categories are not mutually exclusive.

† A high-risk setting was defined as a department-of-corrections facility or military barracks.

‡ Data on crowding were available for 236 of the 575 interviewed patients.

§ Day-care attendance among household members was for a median of 20 hours per week (range, 20 to 60).

¶ Data on income were available for 495 interviewed patients.

must now take into account the emergence of community-associated MRSA; providers should be aware that several available antimicrobial agents should be effective in treating these infections.

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REFERENCES

- National Nosocomial Infections Surveillance System. National Nosocomial Infections Surveillance (NNIS) System report, data summary from January 1992 to June 2002, issued August 2002. *Am J Infect Control* 2002;30:458-75.
- Chambers HF. The changing epidemiology of *Staphylococcus aureus*? *Emerg Infect Dis* 2001;7:178-82.
- Archer GL. *Staphylococcus aureus*: a well-armed pathogen. *Clin Infect Dis* 1998;26:1179-81.
- Cosgrove SE, Sakoulas G, Perencevich EN, Schwaber MJ, Karchmer AW, Carmeli Y. Comparison of mortality associated with methicillin-resistant and methicillin-susceptible *Staphylococcus aureus* bacteremia: a meta-analysis. *Clin Infect Dis* 2003;36:53-9.
- Jorgensen JH. Laboratory and epidemiologic experience with methicillin-resistant *Staphylococcus aureus* in the USA. *Eur J Clin Microbiol* 1986;5:693-6.
- Barrett FF, McGehee RF Jr, Finland M. Methicillin-resistant *Staphylococcus aureus* at Boston City Hospital: bacteriologic and epidemiologic observations. *N Engl J Med* 1968;279:441-8.
- Diekema DJ, Pfaller MA, Schmitz FJ, et al. Survey of infections due to *Staphylococcus* species: frequency of occurrence and antimicrobial susceptibility of isolates collected in the United States, Canada, Latin America, Europe and the Western Pacific region for the SENTRY Antimicrobial Surveillance Program, 1997-1999. *Clin Infect Dis* 2001;32:S114-S132.
- Lowy F. *Staphylococcus aureus* infections. *N Engl J Med* 1998;339:520-32.
- Brumfitt W, Hamilton-Miller J. Methicillin-resistant *Staphylococcus aureus*. *N Engl J Med* 1989;320:1188-96.
- Methicillin-resistant *Staphylococcus aureus* infections in correctional facilities — Georgia, California, and Texas, 2001–2003. *MMWR Morb Mortal Wkly Rep* 2003;52:992-6.
- Methicillin-resistant *Staphylococcus aureus* infections among competitive sports participants — Colorado, Indiana, Pennsylvania, and Los Angeles County, 2000–2003. *MMWR Morb Mortal Wkly Rep* 2003;52:793-5.
- Outbreaks of community-associated methicillin-resistant *Staphylococcus aureus* skin infections — Los Angeles County, California, 2002–2003. *MMWR Morb Mortal Wkly Rep* 2003;52:88.
- Methicillin-resistant *Staphylococcus aureus* skin or soft tissue infections in a state prison — Mississippi, 2000. *JAMA* 2002;287:181-2.
- Herold BC, Immergluck LC, Maranan MC, et al. Community-acquired methicillin-resistant *Staphylococcus aureus* in children with no identified predisposing risk. *JAMA* 1998;279:593-8.
- Naimi TS, LeDell KH, Como-Sabetti K, et al. Community- and health care-associated methicillin-resistant *Staphylococcus aureus* infection. *JAMA* 2003;290:2976-84.
- Groom AV, Wolsey DH, Naimi TS, et al. Community-acquired methicillin-resistant *Staphylococcus aureus* in a rural American Indian community. *JAMA* 2001;286:1201-5.
- Gorak EJ, Yamada SM, Brown JD. Community-acquired methicillin-resistant *Staphylococcus aureus* in hospitalized adults and children without known risk factors. *Clin Infect Dis* 1999;29:797-800.
- Baggett HC, Hennessy TW, Leman R, et al. An outbreak of community-onset methicillin-resistant *Staphylococcus aureus* skin infections in southwestern Alaska. *Infect Control Hosp Epidemiol* 2003;24:397-402.
- Sattler CA, Mason EO Jr, Kaplan SL. Prospective comparison of risk factors and demographic and clinical characteristics of community-acquired, methicillin-resistant versus methicillin-susceptible *Staphylococcus aureus* infection in children. *Pediatr Infect Dis J* 2002;21:910-7.
- Raney PM, Williams PP, McGowan JE, Tenover FC. Validation of Vitek version 7.01 software for testing staphylococci against vancomycin. *Diagn Microbiol Infect Dis* 2002;43:135-40.
- Fridkin SK, Hageman J, McDougal LK, et al. Epidemiological and microbiological characterization of infections caused by *Staphylococcus aureus* with reduced susceptibility to vancomycin, United States, 1997-2001. *Clin Infect Dis* 2003;36:429-39.
- Taylor G, Kirkland T, Kowalewska-Grochowska K, Wang Y. A multistrain cluster of methicillin-resistant *Staphylococcus aureus* based in a native community. *Can J Infect Dis* 1990;1:121-6.
- Community-associated methicillin-resistant *Staphylococcus aureus* infections in Pacific Islanders — Hawaii, 2001–2003. *MMWR Morb Mortal Wkly Rep* 2004;53:767-70.
- Morin CA, Hadler JL. Population-based incidence and characteristics of community-onset *Staphylococcus aureus* infections with bacteremia in 4 metropolitan Connecticut areas, 1998. *J Infect Dis* 2001;184:1029-34.
- Albanese BA, Roche JC, Pass M, Whitney CG, McEllistrem MC, Harrison LH. Geographic, demographic, and seasonal differences in penicillin-resistant *Streptococcus pneumoniae* in Baltimore. *Clin Infect Dis* 2002;34:15-21.
- Flannery B, Schrag S, Bennett NM, et al. Impact of childhood vaccination on racial disparities in invasive *Streptococcus pneumoniae* infections. *JAMA* 2004;291:2197-203.
- Robinson KA, Baughman W, Rothrock G, et al. Epidemiology of invasive *Streptococcus pneumoniae* infections in the United States, 1995-1998: opportunities for prevention in the conjugate vaccine era. *JAMA* 2001;285:1729-35.
- Watt JP, O'Brien KL, Benin AL, et al. Invasive pneumococcal disease among Navajo adults, 1989-1998. *Clin Infect Dis* 2004;38:496-501.
- Lorenz E, Mira JP, Cornish KL, Arbour NC, Schwartz DA. A novel polymorphism in the toll-like receptor 2 gene and its potential association with staphylococcal infection. *Infect Immun* 2000;68:6398-401.
- Iyer S, Jones DH. Community-acquired methicillin-resistant *Staphylococcus aureus* skin infection: a retrospective analysis of clinical presentation and treatment of a local outbreak. *J Am Acad Dermatol* 2004;50:854-8.
- Lee MC, Rios AM, Aten MF, et al. Management and outcome of children with skin and soft tissue abscesses caused by community-acquired methicillin-resistant *Staphylococcus aureus*. *Pediatr Infect Dis J* 2004;23:123-7.
- Martinez-Aguilar G, Hammerman WA, Mason EO Jr, Kaplan SL. Clindamycin treatment of invasive infections caused by community-acquired, methicillin-resistant and methicillin-susceptible *Staphylococcus aureus* in children. *Pediatr Infect Dis J* 2003;22:593-8.
- Marcinak JF, Frank AL. Treatment of community-acquired methicillin-resistant *Staphylococcus aureus* in children. *Curr Opin Infect Dis* 2003;16:265-9.
- Frank AL, Marcinak JF, Mangat PD, et al. Clindamycin treatment of methicillin-resistant *Staphylococcus aureus* infections in children. *Pediatr Infect Dis J* 2002;21:530-4.
- Daum RS, Seal JB. Evolving antimicrobial chemotherapy for *Staphylococcus aureus* infections: our backs to the wall. *Crit Care Med* 2001;29:Suppl 4:N92-N96.
- Public health dispatch: outbreaks of community-associated methicillin-resistant *Staphylococcus aureus* skin infections — Los Angeles County, California, 2002-2003. *JAMA* 2003;289:1377.
- Four pediatric deaths from community-acquired methicillin-resistant *Staphylococcus aureus* — Minnesota and North Dakota, 1997-1999. *JAMA* 1999;282:1123-5.
- Methicillin-resistant *Staphylococcus aureus* skin or soft tissue infections in a state prison — Mississippi, 2000. *MMWR Morb Mortal Wkly Rep* 2001;50:919-22.

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CORRECTION

**Methicillin-Resistant *Staphylococcus aureus* Disease
in Three Communities**

Methicillin-Resistant *Staphylococcus aureus* Disease in Three Communities . In the Abstract on page 1436, the Methods and Results sections should have referred to "community-associated" infection, rather than "community-acquired" infection, as printed. We regret the error.