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Increasing Burden of Methicillin-Resistant *Staphylococcus aureus* Hospitalizations at US Academic Medical Centers, 2003–2008

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Abstract

OBJECTIVE—The incidence of invasive methicillin-resistant *Staphylococcus aureus* (MRSA) infections in the United States decreased during 2005–2008, but noninvasive community-associated MRSA (CA-MRSA) infections also frequently lead to hospitalization. We estimated the incidence of all MRSA infections among inpatients at US academic medical centers (AMCs) per 1,000 admissions during 2003–2008.

DESIGN—Retrospective cohort study.

SETTING AND PARTICIPANTS—Hospitalized patients at 90% of nonprofit US AMCs during 2003–2008.

METHODS—Administrative data on MRSA infections from a hospital discharge database (University HealthSystem Consortium [UHC]) were adjusted for underreporting of the MRSA V09.0 *International Classification of Diseases, Ninth Revision, Clinical Modification* code and validated using chart reviews for patients with known MRSA infections in 2004–2005, 2006, and 2007.

RESULTS—The mean sensitivity of administrative data for MRSA infections at the University of Chicago Medical Center in three 12-month periods during 2004–2007 was 59.1%. On the basis of estimates of billing data sensitivity from the literature and the University of Chicago Medical Center, the number of MRSA infections per 1,000 hospital discharges at US AMCs increased from 20.9 (range, 11.1–47.7) in 2003 to 41.7 (range, 21.9–94.0) in 2008. At the University of Chicago Medical Center, among infections cultured more than 3 days prior to hospital discharge, CA-MRSA infections were more likely to be captured in the UHC billing–derived data than were healthcare-associated MRSA infections.

CONCLUSIONS—The number of hospital admissions for any MRSA infection per 1,000 hospital admissions overall increased during 2003–2008. Use of unadjusted administrative hospital discharge data or surveillance for invasive disease far underestimates the number of MRSA infections among hospitalized patients.

Staphylococcus aureus is the most commonly isolated human bacterial pathogen and causes uncomplicated skin and soft-tissue infections as well as invasive infections, such as

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pneumonia, endocarditis, and sepsis.[1] Methicillin-resistant *S. aureus* (MRSA) isolates are resistant to all available β-lactam antimicrobial drugs with one exception. From their first recognition in 1960[2] until the mid-1990s, MRSA infections were confined to hospitals, other healthcare environments, and patients frequenting these facilities, and thus they were considered to be healthcare-associated infections (HAIs).

Since the 1990s, an epidemic of MRSA infections has emerged in the United States among populations lacking risk factors for exposure to the healthcare system[3–9] caused by new community-associated MRSA (CA-MRSA) strains, ranging from minor skin abscesses to severe infections requiring hospitalization. CA-MRSA strains have also entered hospital environments and can be a cause of HAI.[5–11]

With this change in the epidemiology of MRSA, public health systems and medical care providers have only incomplete knowledge of the magnitude of the MRSA problem at the local or the national level. Estimates of MRSA infections among hospitalized patients in the United States have been limited to the subset of patients with invasive MRSA infections[12,13] or have relied on unadjusted administrative data-bases.[14–17] However, MRSA infections may not be recorded in administrative billing data if culture results are not available at the time of hospital discharge, if a limited number of diagnosis codes are available for each hospitalization, or if there are coding errors.[18,19] A recent study demonstrated that the unadjusted *International Classification of Diseases, Ninth Revision, Clinical Modification* (*ICD-9-CM*) code V09.0, for penicillin-resistant pathogens, is neither sensitive nor specific for the identification of MRSA infections at academic medical centers (AMCs).[20]

Because the majority of medically attended MRSA infections in the United States are noninvasive, we believe that the incidence trends for all MRSA infections among hospitalized patients will better reflect the incidence of MRSA infections in the United States than will surveillance for only invasive MRSA disease.[12,13] The purpose of this study was to estimate the annual MRSA burden for October 1, 2002, to September 30, 2008, among hospitalized patients at US AMCs for all clinical syndromes, linking microbiologic and clinical information to administrative patient-level data from a comprehensive database on hospitalized patients.

METHODS

University HealthSystem Consortium (UHC) Clinical Database

UHC is an alliance of approximately 90% of nonprofit US AMCs and includes 160 centers and 260 of their affiliated hospitals, for which it amasses billing and demographic data. The UHC databases, which are used for projects to enhance quality, cost-effectiveness, and safety at member AMCs, includes nearly all *ICD-9-CM* codes assigned to each hospital discharge. An MRSA hospital discharge (MRSA HD) was defined as an inpatient discharge recorded in the UHC database bearing *ICD-9-CM* diagnosis code V09.0. Before October 2008, V09.0 was the sole *ICD-9-CM* code available to indicate an MRSA-related hospitalization. For each MRSA HD in a federal fiscal year (FFY) from 2003 to 2008 (ie, October 2002 to September 30, 2008), we determined patient age, date of admission, date of discharge, other discharge diagnoses, medical center, type of inpatient care unit, and the position of the V09.0 code in the list of reported *ICD-9-CM* codes (ie, whether it was listed second, third, and so on in the sequence of codes).

University of Chicago Medical Center MRSA Surveillance Project

The University of Chicago Medical Center is a tertiary care medical center in Chicago, Illinois, that has 577 inpatient beds and 26,200 annual admissions. In the University of Chicago Medical Center MRSA Surveillance Project, we collected microbiologic,

molecular, and clinical data on 312 consecutive hospitalized patients with MRSA infections from July 2004 through June 2005.[5] Patients were excluded from consideration if they had only asymptomatic MRSA colonization. For each patient, we determined the age, gender, race, and encounter date. We also recorded any previous known MRSA infection or colonization. We recorded the antibiotic susceptibilities of each MRSA isolate. We performed genotyping assays on each isolate, including staphylococcal chromosomal cassette *mec* typing.[5] For 2004–2005 data, we classified each patient with an MRSA infection as having a CA-MRSA infection by 3 separate criteria: the genotypic criterion for CA-MRSA infection, the Centers for Disease Control and Prevention (CDC) CA-MRSA case definition, and the 48-hour criterion for CA-MRSA infection (Table 1).

For calendar years 2006 and 2007, more limited patient and MRSA isolate data for the University of Chicago Medical Center were collected for inpatients with an MRSA infection. Each patient in 2006 and 2007 was classified as having a CA-or HA-MRSA infection by the 48-hour criterion for CA-MRSA infection.

The study was approved by the Institutional Review Board of the Biological Sciences Division of the University of Chicago.

Adjustment Model to Account for Incomplete Reporting of Hospital Discharge Billing Codes to UHC

Billing data such as those collected by UHC are notoriously incomplete and inaccurate due to both coding errors and undercounting of MRSA as an etiology for infections.[18,19,21] Furthermore, when fewer than all diagnosis codes recorded for a hospital discharge are reported to a research database such as the National Inpatient Sample, which limits its data to the first 7 recorded codes, MRSA infections are further undercounted. Therefore, we adjusted the incidence density of MRSA infections suggested by V09.0 counts in the raw billing data to account for incomplete reporting of billing codes from certain AMCs in certain years to UHC.

The number of *ICD-9-CM* diagnosis codes provided from individual AMCs to UHC for each hospital discharge varied during FFY 2003–2008; this figure ranged from hospital maxima of 9 to 99 diagnosis codes per hospital discharge. This resulted in an undercount of MRSA HDs coded by certain AMCs. For example, among 88 AMCs reporting hospital discharges allowing 30 or more diagnosis codes, only 40% of the MRSA HDs were captured when limiting consideration to the first 9 diagnosis codes, 70% were captured in the first 15 diagnosis codes, and 97% were captured in the first 30 diagnosis codes.

With combined data from 2004–2005, 2006, and 2007 from the University of Chicago Medical Center MRSA Surveillance Project, we sequentially assessed the percentage of MRSA infections that would be captured by UHC data if only the first 10, 15, 25, or 30 diagnosis codes were considered. On the basis of these criteria, 39.3%, 58.5%, 73.3%, and 83.9%, respectively, of reported UHC MRSA HDs from the University of Chicago Medical Center were captured. We then calculated during each FFY from 2003 to 2008 the proportion of AMCs that provided to UHC less than 10 ($HD_{<10}$), 10–14 ($HD_{10–14}$), 15–20 ($HD_{15–20}$), 21–25 ($HD_{21–25}$), or more than 25 ($HD_{>25}$) discharge diagnoses. The corrected figure (MRSA HD_{corr}) was calculated for each FFY from 2003 to 2008 according to the formula shown in Table 1.

Adjustment for the Sensitivity of *ICD-9-CM* Code V09.0 to Detect True MRSA Infections

In both the UHC and the University of Chicago Medical Center databases, we identified each inpatient with an MRSA infection, including only the first MRSA infection in a given year. All MRSA HDs in the UHC database were identified during July 1, 2004, through

June 30, 2005, and in calendar years 2006 and 2007. Unique inpatients in the University of Chicago Medical Center MRSA Surveillance Project were matched with MRSA HD cases in the UHC database; each patient was categorized as being included in the University of Chicago Medical Center MRSA Surveillance Project only ("University of Chicago Medical Center MRSA"), in both databases ("concordant MRSA"), or in the UHC database only ("UHC MRSA"; Table 1).

Among UHC MRSA, some patients were incorrectly reported as having had an MRSA infection, while others were identified who did have an MRSA infection that was not captured in the University of Chicago Medical Center MRSA Surveillance Project. For each UHC MRSA patient, we therefore reviewed the electronic medical record. The combined set of (1) UHC MRSA patients at the University of Chicago Medical Center who truly had an MRSA infection, (2) all University of Chicago Medical Center MRSA, and (3) all concordant MRSA together made up the "complete University of Chicago Medical Center MRSA set" for each 12-month period studied (Table 1).

The number of MRSA HDs identified by the UHC database was divided by the complete University of Chicago Medical Center MRSA set to obtain the fraction of true MRSA patients identified by the UHC database (u). This is the sensitivity of the UHC data to detect true MRSA infections, and it was calculated separately for July 2004–June 2005, 2006, and 2007. A mean value of u was calculated for these three 12-month periods. Other estimates of the sensitivity of *ICD-9-CM* coding data for 3 additional AMCs during 2001–2007 were obtained from Schweizer et al.[20]

Capture of CA- and HA-MRSA by the *ICD-9-CM* Administrative Coding Data

Sequentially, for each of the 3 CA-MRSA criteria (Table 1), using the x^2 test (Stata 11; StataCorp) we assessed differences between concordant MRSA and University of Chicago Medical Center MRSA in capturing CA- and HA-MRSA, defined by 3 criteria, from 2004 to 2005. Similar analyses were performed for 2006 and 2007, but concordant MRSA and University of Chicago Medical Center MRSA were compared for CA-MRSA cases only by the 48-hour criterion for these 2 years. These analyses excluded isolates obtained less than 3 days prior to patient discharge because these cases would not likely be included in hospital chart coding. This approach may exclude many brief hospital stays and stays in which patients were clinically doing well at the time of their culture. However, with this analysis we aimed to eliminate a class of hospital discharges that would systematically lead to under-coding of V09.0 when a true MRSA infection was present.

RESULTS

Sensitivity of UHC Data

The classification of data from the University of Chicago Medical Center surveillance project and the UHC clinical database are shown in Figure 1. In 2004–2005, there were 312 unique inpatients with MRSA infections; 44.6% (139/312) of these patients were classified as having concordant MRSA, and 55.4% (173/312) were classified as having University of Chicago Medical Center MRSA. There were 113 patients with UHC MRSA, and 36% (42/113) of them were found on electronic medical record review to have had a clinical MRSA infection in the study year; 64% (71/113) of them did not have an MRSA infection. There were 354 MRSA HDs in the complete University of Chicago Medical Center MRSA set (Figure 1*A*). The sensitivity of the UHC database for 2004–2005 for the complete University of Chicago Medical Center MRSA set was 51.1%, and this increased to 61.2% in 2006 (data in Figure 1*B*) and to 64.9% in 2007 (data in Figure 1*C*).

Adjustment for Incomplete Reporting of Discharge Diagnoses to UHC

The estimated number of MRSA HDs per 1,000 hospital discharges, adjusted for incomplete reporting of UHC discharge diagnoses, demonstrated an underestimation of coded MRSA infections ranging from 10.9% in 2005 to 26.8% in 2008 (Table 2).

Sensitivity Analysis for Mean and Range of Values Estimating MRSA HDs at US AMCs

The mean sensitivity of the V09.0 *ICD-9-CM* code to detect true MRSA infections measured over three 12-month periods (July 2004–June 2005, 2006, and 2007) was 59.1% at the University of Chicago Medical Center. The mean sensitivity for the 3 AMCs for 2001–2007 included in the report from Schweizer et al[20] was 21.3%, 34.2%, and 23.3%, respectively. The range for the sensitivity obtained from the present study and from Schweizer et al[20] in a given year, reflecting data from 4 AMCs, was 15.1% to 64.9%; the mean sensitivity for all 4 centers was 34.5%. This range and the mean value were used to adjust the raw data on annual incidence of MRSA HDs per 1,000 total discharges at US AMCs (Table 2).

Capture of CA- and HA-MRSA by the *ICD-9-CM* Administrative Coding Data

We compared the ability of the UHC clinical database to capture CA-MRSA infections relative to HA-MRSA infections. We excluded patients cultured less than 3 days prior to discharge, who made up varying percentages of patients in University of Chicago Medical Center surveillance in 2004–2005 (25.6%), 2006 (28.4%), and 2007 (36.9%).

In 2004–2005, among patients cultured more than 3 days prior to their discharge, concordant MRSA, compared with University of Chicago Medical Center MRSA, were more likely to include CA-MRSA than HA-MRSA patient discharges by all 3 criteria tested for CA-MRSA patients and strains. In 2006, in this group of patients, among concordant MRSA, 74% were CA-MRSA patients by the 48-hour criterion, but among University of Chicago Medical Center MRSA, 56% were CA-MRSA ($P < .001$); in 2007, these figures were 73% and 62% ($P = .06$), respectively (Table 3).

Comparison with HIV/AIDS and Influenza

In unadjusted data from all UHC AMCs in 2006, 2007, and 2008, MRSA accounted for 12.9, 13.6, and 14.2 hospital discharges per 1,000 hospital discharges, respectively. In comparison, in 2006, 2007, and 2008, HIV-related hospital stays (*ICD-9-CM* code 042) were recorded for 9.39, 9.39, and 8.81 and influenza-associated hospital stays (*ICD-9-CM* codes 487.0, 487.1, 487.8) were recorded for 1.99, 1.94, and 3.99 hospital discharges per 1,000 hospital discharges, respectively.

DISCUSSION

We demonstrated that the rate of MRSA-associated hospitalizations increased rapidly during 2003–2008 at US AMCs and rose to the highest recorded level of approximately 41.7 per 1,000 hospitalizations in 2008. We found that MRSA was associated with a greater number of hospitalizations than either HIV/AIDS or influenza in each year that we studied. In fact, our estimates showed a larger number of hospitalizations at AMCs in the United States in 2005, 2006, and 2007 related to MRSA than related to HIV/AIDS and influenza combined. This represents a great burden of MRSA disease requiring hospitalization at US AMCs.

The increase in MRSA HDs during 2003–2005 was likely related to the emergence of infections caused by CA-MRSA strains in the United States, which have become common in the community and in the healthcare setting.

Our data show a trend opposite to that found by the CDC's Active Bacterial Core Surveillance (ABCs) program, which limited its analysis to invasive MRSA infections among patients with healthcare exposures. The ABCs program defines hospital-onset (HO) MRSA patients as those diagnosed with an infection more than 3 days after admission to a hospital. It uses the term "healthcare-associated community-onset" (HACO) to designate patients diagnosed as outpatients or after less than 3 days of hospital admission who have certain risk factors for healthcare exposure, including an indwelling catheter at the time of culture or hospitalization, stay in a long-term care facility, surgery, or hemodialysis in the previous year. The ABCs data during 2005–2008 showed a decrease in the incidence of invasive MRSA infections categorized as HO-MRSA of 9.4% per year and a decrease in those categorized as HACO-MRSA of 5.7% per year. Overall, ABCs data showed a decrease in the incidence of invasive MRSA infection during 2005–2008 of 28% among HO-MRSA and 17% among HACO-MRSA patients. Importantly, the recent ABCs estimates did not include invasive infections considered to be CA-MRSA by the CDC case definition.[13]

In contrast, we found that there was a dramatic increase in all MRSA infections among hospitalized patients through 2008 at US AMCs. The difference in our findings is likely because, unlike the ABCs investigators, we did not limit our analysis to patients with invasive infections. Although the MRSA infections we included were serious enough to require hospitalization, we did not distinguish among HO-, HACO-, and CA-MRSA infections according to the CDC/ABCs criteria, and we did not attempt to estimate population-based incidence.

We demonstrated that billing data did not capture HA-MRSA and CA-MRSA infections equally well. By any of the 3 examined criteria, CA-MRSA infections were more likely to be captured in the UHC billing–derived data than were HA-MRSA infections in 2004–2005. In 2006 and 2007, by the 48-hour criterion alone the *ICD-9-CM* codes disproportionately captured CA-MRSA infections. Public reporting of certain HAIs by hospitals has become legally required in some states.[20] We demonstrated that unadjusted administrative data are not reliable to document trends of increasing or decreasing rates of HAI, particularly for infections caused by MRSA.

There are several likely explanations for the bias in disproportionately capturing CA-MRSA infections in the UHC administrative database. MRSA acquisition now occurs both inside and outside the healthcare setting. Perhaps among otherwise healthy individuals, patients with CA-MRSA infections are more likely to be hospitalized with an MRSA infection as the primary in reason for admission. Conversely, HA-MRSA infections may be manifest during long, complex hospital stays, and the MRSA infection was not coded because of the perceived relatively minor contribution of the MRSA infection to the hospital course, especially when a limited number of codes are allowed.

We found that 3 types of error contribute to the underestimating of MRSA hospital discharges by *ICD-9-CM* discharge data. First, many MRSA infections were simply not recorded in the billing data. We found that while correcting "missed" MRSA infections, UHC MRSA HDs had underestimated MRSA infections among inpatients at the University of Chicago Medical Center by nearly half in 2004–2005 and by about one-third in 2006 and 2007. The second type of error in the UHC data is different. Because the *ICD-9-CM* diagnosis code V09.0 is often not included among the first few codes in billing databases, it is often excluded when data are transferred to larger databases that limit the number of codes allowed.[18,19] Third, many MRSA patients were discharged within 3 days of obtaining the defining culture; therefore, the result of an MRSA culture was not likely to be included in the medical record before hospital discharge and thus not coded for billing purposes.

The increasing sensitivity of the UHC data for true MRSA infections over time at the University of Chicago Medical Center is interesting. The reasons for this are not known, but the phenomenon may be due to increased awareness by coding personnel or perhaps improved documentation by healthcare providers.

This study has several limitations. Our validation data were obtained from 1 AMC. Coding practices may differ at other AMCs, and data from additional AMCs would provide more robust estimates. However, we extrapolated from a comprehensive database from 2004–2005 that allowed us to assess which MRSA HDs were captured in billing data and whether these patients had CA-MRSA by 3 criteria. It is possible that the University of Chicago Medical Center is not a typical AMC in terms of the local epidemiology of MRSA, although this is unlikely given the many published reports from urban AMCs documenting experiences similar to ours.[5,22] Coding practices may have changed over time. We have partially accounted for this possibility by using data from 3 calendar years. Our conclusions may not be applicable to hospitals that are not AMCs. In October 2008, CMS approved new *ICD-9-CM* diagnosis codes for MRSA infections.[23] With these, it may be possible to better identify MRSA infections by means of billing data; therefore, our adjustment model requires further calibration for data after October 2008.

Our methodology may be applicable to other infectious disease diagnoses among inpatients to improve the accuracy of billing data for epidemiologic studies. If administrative data are used for policy change, quality improvement, or payment linked to improved medical care, it is essential that they be validated using accurate medical records and that sources of systematic bias be considered carefully.

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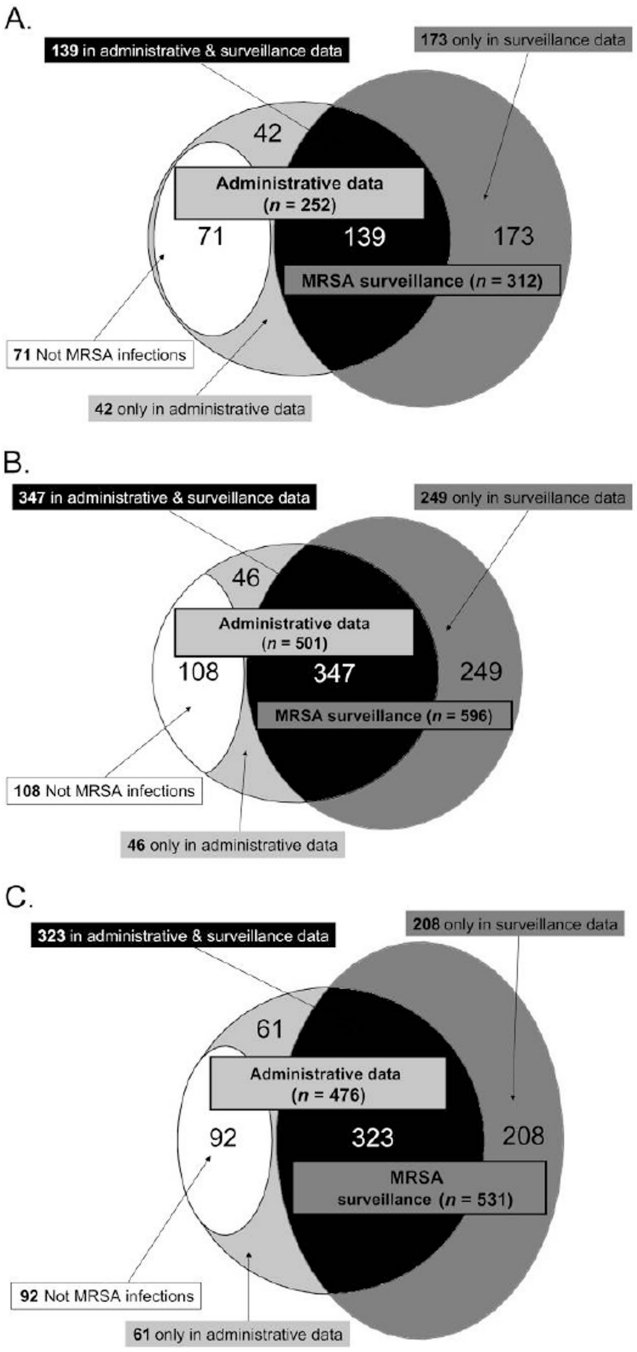

FIGURE 1.

Overlap of methicillin-resistant *Staphylococcus aureus* (MRSA) surveillance data from University of Chicago Medical Center (UCMC) surveillance and University HealthSystem Consortium (UHC) administrative data. *A*, From July 1, 2004, through June 30, 2005, of the 312 different inpatients identified through clinical microbiology laboratory surveillance who had MRSA infections, 139 were also identified by administrative (billing) data. Of the 252 hospitalized patients identified by administrative data as having an MRSA-related hospital stay, 113 were not identified by surveillance. All of these patients had medical records reviewed: 71 did not have MRSA infections, and 42 did have MRSA infections. The total number of patients with MRSA infections in 2004–2005, then, was 354 (ie, the sum of 173,

139, and 42). A similar analysis was performed for the calendar years 2006 (*B*) and 2007 (*C*).

TABLE 1

Definition of Terms

Term	Definition
Genotypic criterion for CA-MRSA infection	Defined as a patient from whom an MRSA isolate that carries *SCCmec* type IV was obtained. *SCCmec* is a chromosomal resistance element that bestows β-lactam resistance upon *S. aureus* strains; *SCCmec* type IV is usually present in US CA-MRSA strains and is rarely carrie0d by HA-MRSA strains.
CDC CA-MRSA case definition[a]	Infection in a patient without known previous exposures to the healthcare environment. To be considered a CA-MRSA infection, the culture must have been obtained from an outpatient or from an inpatient <48 hours after hospital admission; without any indwelling catheters at the time of culture; without any hospitalization, stay in a long-term care facility, or hemodialysis in the previous year; and without surgery in the previous 6 months.
48-hour criterion for CA-MRSA infection	Culture obtained from an outpatient or from an inpatient <48 hours after hospital admission.
MRSA HD	MRSA-associated hospital discharge; that is, a hospital discharge with the V09.0 code recorded.
UHC MRSA	A V09.0 diagnosis was identified in the UHC database during at least 1 hospital stay for a patient during a given year but with no evidence of a corresponding MRSA infection in the University of Chicago Medical Center surveillance database. For each of these patients, the University of Chicago Medical Center electronic medical record was reviewed to determine whether an MRSA infection was recorded.
University of Chicago Medical Center MRSA	A V09.0 diagnosis was not identified in the UHC database for a patient, but the University of Chicago Medical Center surveillance database does document an MRSA infection for that patient.
Concordant MRSA	A V09.0 diagnosis for a patient was identified in the UHC database during at least 1 hospital stay during a given year, and a corresponding MRSA infection was documented in the patient's medical record at the University of Chicago Medical Center.
Complete University of Chicago Medical Center MRSA set	The cohort of patients identified by University of Chicago Medical Center data who had actual MRSA infections.
Adjustment for underreporting of *ICD-9-CM* codes to UHC	A correction factor that differed for each year, determined by the no. of member institutions reporting ranges of no. of discharge diagnoses; it was calculated according to the formula $HD_{corr} = [\text{MRSA HD}][(HD_{<10})/0.393 + (HD_{10-14})/0.585 + (HD_{15-20})/0.733 + (HD_{21-25})/0.839 + HD_{>25}]$, where MRSA HD is the no. of MRSA infections identified by the UHC database in a given year and HD_{x-y} is the proportion of all HDs reported to UHC database in that year that have between x and y diagnosis codes reported. Data from July 2004–June 2005, 2006, and 2007 from the University of Chicago Medical Center showed that if the first 10, 15, 20, or 25 diagnosis codes were considered, 39.3%, 58.5%, 73.3%, and 83.9% of reported MRSA HDs were captured by UHC, respectively. MRSA HD_{corr} is a conservative estimate of the actual no. of MRSA HDs at US AMCs during each year because of 2 assumptions. For any AMC reporting >25 HD diagnosis codes in a given year, it is assumed that this includes 100% of MRSA HDs, while it is known that even if 30 codes are reported, not all MRSA HDs are included. In addition, for each range in the no. of diagnosis codes considered (eg, 10–14 codes), it is assumed that AMCs would report the predicted percentage of MRSA HDs for the upper bound of the interval (eg, if 10–14 codes were reported, we assume that 58.5% of MRSA HDs actually coded would be captured).

NOTE. AMC, academic medical center; CA-MRSA, community-associated MRSA; CDC, Centers for Disease Control and Prevention; HA-MRSA, healthcare-associated MRSA; HD, hospital discharge; *ICD-9-CM, International Classification of Diseases, Ninth Revision, Clinical Modification*; MRSA, methicillin-resistant *Staphylococcus aureus; SCCmec*, staphylococcal chromosomal cassette *mec*; UHC, University HealthSystem Consortium.

[a] Our criteria differ from the CDC criteria in that we consider only the previous 6 months in evaluating a history of recent surgery; the CDC criteria include any patient with surgery in the previous 12 months.

TABLE 2

Reported and Corrected Number of Methicillin-Resistant *Staphylococcus aureus* (MRSA) Hospital Discharges (HDs) and Corrected MRSA HDs per 1,000 HDs at University HealthSystem Consortium (UHC) Member US Academic Medical Centers, UHC Data, 2003–2008

Federal fiscal year	UHC-reported MRSA HDs	MRSA HDs per 1,000 total HDs, unadjusted	MRSA HD_{corr}[a]	Total HDs	MRSA HDs per 1,000 total HDs, corrected for incomplete *ICD-9-CM* code reporting[b]	MRSA HDs per 1,000 total HDs,[c] mean (likely range)
2003	19,280	7.2	25,779	2,674,684	9.64	20.9 (11.1–47.7)
2004	24,960	9.0	30,238	2,773,708	10.9	26.1 (13.9–59.6)
2005	35,454	11.8	40,535	3,015,306	13.4	34.2 (18.2–78.2)
2006	41,632	12.9	46,358	3,237,734	14.3	37.4 (19.9–85.4)
2007	47,678	13.6	52,483	3,506,947	15.0	39.4 (21.0–90.1)
2008	52,249	14.2	65,958	3,668,422	18.0	41.7 (21.9–94.0)

NOTE. *ICD-9-CM, International Classification of Diseases, Ninth Revision, Clinical Modification.*

[a] $MRSA\ HD_{corr} = [MRSA\ HD][(HD_{<10})/0.393 + (HD_{10–14})/0.585 + (HD_{15–20})/0.733 + (HD_{21–25})/0.839 + HD_{>25}]$, where $HD_{x–y}$ indicates the proportion of HDs in a given year that reported between *x* and *y* discharge diagnoses. See Table 1 for details.

[b] $(MRSA\ HD_{corr}/total\ HD) \times 1{,}000$.

[c] Derived from range and mean values of sensitivity of UHC data to predict true MRSA infection from the University of Chicago Medical Center (2004–2005, 2006, and 2007) and 3 other medical centers (2001–2007). Mean values assume a sensitivity of unadjusted coding data of 34.5%, and the range of likely sensitivities is 15.1%–64.9%.[20]

TABLE 3

Comparison of University of Chicago Medical Center Methicillin-Resistant *Staphylococcus aureus* (MRSA) and Concordant MRSA, Excluding Patients Discharged within 3 Days of Their Culture Being Obtained, July 1, 2004, through June 30, 2005, and Calendar Years 2006 and 2007

Year	CA-MRSA characteristic[a]	University of Chicago Medical Center MRSA,[a] no./total (%)	Concordant MRSA,[a] no./total (%)	*P*
July 1, 2004, to June 30, 2005	Genotypic criterion for a CA-MRSA infection	57/139 (41)	57/93 (61)	.001
	CA-MRSA by CDC case definition	15/139 (11)	19/93 (20)	.04
	48-hour criterion for CA-MRSA infection	72/139 (52)	69/93 (74)	.001
2006	48-hour criterion for CA-MRSA infection	76/135 (56)	215/292 (74)	<.001
2007	48-hour criterion for CA-MRSA infection	53/85 (62)	183/250 (73)	.06

NOTE. Patients identified by University of Chicago Medical Center surveillance who were cultured less than 3 days prior to their discharge were not included because it is doubtful that the results were available in the paper medical record when *International Classification of Diseases, Ninth Revision, Clinical Modification* codes were generated for the hospital discharge. CA-MRSA, community-associated MRSA; CDC, Centers for Disease Control and Prevention.

[a] For definitions of terms, see Table 1.