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Challenges of Applying the SHEA/HICPAC Metrics for Multidrug-Resistant Organisms to a Real-World Setting

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Abstract

OBJECTIVE—To test in a real-world setting the recommendations for measuring infection with multidrug-resistant organisms (MDRO) from the Society for Healthcare Epidemiology of America (SHEA) and the Centers for Disease Control and Prevention’s Healthcare Infection Control Practices Advisory Committee (HICPAC).

METHODS—Using data from 3 hospital settings within a healthcare network, we applied the SHEA/HICPAC recommendations to measure methicillin-resistant *Staphylococcus aureus* (MRSA) infection and colonization. Data were obtained from the hospitals’ electronic surveillance system and were supplemented by manual medical record review as necessary. Additionally, we tested (1) different definitions for nosocomial incidence, (2) the effect of excluding patients not at risk from the denominator for hospital-onset incidence, and (3) the appropriate time period to use when including or excluding patients with a prior history of MRSA infection or colonization from nosocomial rates. Negative binomial regression models were used to test for differences between rate definitions. A rating scale was created for each metric, assessing the extent to which manual or electronic data elements were required.

RESULTS—There was no statistically significant difference between using 72 hours or 3 calendar days as the cutoff to define hospital-onset incidence. Excluding patients not at risk from the denominator when calculating hospital-onset incidence led to statistically significant increases in rates. When excluding patients with a prior history of MRSA infection or colonization from nosocomial incidence rates, rates were similar regardless of whether we looked at 1, 2, or 3 years’ worth of prior data.

CONCLUSIONS—The SHEA/HICPAC MDRO metrics are useful but can be challenging to implement. We include in our description of the data sources and processes required to calculate these metrics information that may simplify the process for institutions.

Multidrug-resistant organisms (MDROs) are a growing problem for hospitals. In many institutions, consequently, departments of infection prevention and control measure and track infection with these organisms. Until now, however, there has been little standardization or guidance for how to perform these measurements.

The Society for Healthcare Epidemiology of America (SHEA) and the Centers for Disease Control and Prevention's (CDC's) Healthcare Infection Control Practices Advisory Committee (HICPAC) recently convened experts to publish recommendations providing guidance and standardization on how to measure infection with MDROs.¹ These include a variety of incidence and prevalence measures, as well as items such as antibiograms and line listings. These recommendations are largely based on expert opinion, and the authors point to the need for more data to elucidate these issues.

We undertook to test the various SHEA/HICPAC metrics at our institution, focusing on methicillin-resistant *Staphylococcus aureus* (MRSA) as a common MDRO in most US hospitals. Our institution has the advantage of comprising 3 distinct hospital settings in which to compare the metrics. We attempted to ascertain how easily these metrics can be applied in these real-world settings; additionally, we tested a number of the suggestions for future research from the SHEA/HICPAC article by comparing slightly differing metric definitions. Finally, we summarized the data sources and formats needed to perform the metrics, assessed whether manual or electronic data collection is needed, and made recommendations on the most appropriate metrics for various health-care settings.

METHODS

Settings

We used data from 3 different hospital settings within a healthcare network in New York City: (1) hospital A, a 700-bed academic tertiary care center that has adult patients only; (2) hospital B, a 240-bed academic tertiary care center that has pediatric patients only; and (3) hospital C, a 220-bed community hospital that has a substantial cohort of patients transferred from long-term care facilities. All 3 hospitals have an electronic data warehouse in which information from electronic medical records is stored.

The 3 hospitals share a single department of infection prevention and control and have the same general policies. Patients known to be infected or colonized with MRSA are placed on contact precautions according to CDC guidelines.² In addition, active surveillance testing (AST) for MRSA infection and colonization by nares swab sampling is performed in several units: the medical and surgical intensive care unit (ICU) in hospital A, the neonatal ICU in hospital B for infants transferred from other institutions, and the medical ICU in hospital C.

Electronic Data Extraction

The hospital's electronic surveillance system was used to access the necessary data. Detailed information (medical record number; accession number; date, time, and location of the collection of a specimen for culture; and specimen source) was extracted for cultures performed from January 2005 through December 2008. Patient registration information (medical record number, admission date and time, discharge date and time, and transfer or discharge locations) was extracted for 2008. Data elements were extracted from central line documentation to determine the presence of central lines and to calculate central line-days.

All data were stored at the patient and visit level, and the hospital-assigned medical record number was used as a common parameter to link the elements.

Definitions and Metric Calculations

The SHEA/HICPAC metric definitions¹ were used to measure MRSA infection and colonization (Table 1). We excluded 2 of the metrics—line list and point prevalence rate—because the former does not provide a rate and the latter is based on a point prevalence survey that has not been consistently performed for our institution. Although the SHEA/HICPAC article¹ recommends calculating monthly rates, we opted to calculate yearly rates, because of the large number of metrics and the small monthly sample sizes that lead to less stable monthly rates. Rates were calculated for 2008 because data were most complete and readily available for that period at the time the data extraction was performed. Rates were calculated for all 3 hospitals combined and for each hospital individually.

Healthcare-associated infection measures typically require manual medical record review using criteria from the CDC's National Healthcare Safety Network (NHSN); for these we selected measures for which surveillance was either already being conducted or easily accomplished using microbiology data for case finding. For a nosocomial infection rate, we calculated hospital-onset MRSA urinary tract infection (UTI) rates. We identified an initial pool of patients for review by electronically extracting data on all hospitalized patients who had urine culture results of either 10,000–100,000 or greater than 100,000 colony-forming units of MRSA per milliliter. We then excluded all community-onset cases and manually reviewed the remaining cases on the basis of NHSN criteria for symptomatic UTI. For a device-associated infection rate, we used existing infection control surveillance data for central line-associated bloodstream infection rates, which are calculated for all ICUs (using NHSN criteria), and we then extracted those cases due to MRSA. Finally, for a procedure-specific infection rate, we used existing infection control surveillance data for surgical site infection (SSI). Surveillance is performed for coronary artery bypass grafts, craniotomies, hip replacements, and colon surgeries. From these SSI rates, we extracted cases due to MRSA. Because numbers were low for individual procedure types, we calculated an aggregate MRSA SSI rate for all procedure types under surveillance.

Additionally, we explored 2 of the suggestions of the SHEA/HICPAC article¹ for future research: (1) definitions for nosocomial infection or colonization and (2) determining the effect of including or excluding at-risk patients in the denominator. For the first, we used different time intervals to define the incidence of hospital-onset MRSA infection or colonization: 48 hours, 72 hours, 2 calendar days, and 3 calendar days after admission. For the second, we removed patients not at risk for nosocomial acquisition of MRSA infection or colonization from the denominator by multiplying the number of admissions in a time period by 3 and subtracting this number from the total number of patient-days (Table 1).¹

Finally, because we found it challenging to electronically identify and exclude all patients with a previous history of MRSA infection or colonization from incidence measures, we evaluated the effect of looking back for various periods (1, 2, and 3 years) to see if a patient had MRSA infection or colonization identified during a previous hospitalization at our institution.

Statistical Analysis

Negative binomial regression models were used to test for differences in prevalence and incidence rates calculated using different case definitions. The significant tests of model coefficients were based on the χ^2 test. All *P* values reported are 2-sided, and a *P* value of less than .05 was considered to represent a significant difference. All comparisons between

rate definitions were performed for the 3 hospitals combined, as well as for each individual hospital.

Rating Scale

To assess the ease or difficulty of calculating various metrics, we created a rating scale evaluating the extent to which each metric requires manual and electronic data elements. Metrics were rated on a scale of 1–4, with 1 representing the greatest degree of manual data review required; typically these require infection preventionists manually reviewing medical records and applying NHSN criteria. On the opposite end of the scale, 4 represents the greatest use of electronic data elements and manipulation. In the middle, 2 represents mostly manual data review with some electronic extraction and manipulation, and 3 represents mostly electronic extraction with some manual review.

This study was approved by the Institutional Review Board of our institution.

RESULTS

Rates of MRSA infection or colonization for the various metrics, along with the numerators and denominators, are shown in Table 1 for all 3 hospitals combined. Individual hospital findings differed from overall findings only where specified below in the text.

The SHEA/HICPAC article¹ recommends 2 metrics for hospital-onset incidence, 1 including clinical cultures only and 1 including both clinical and AST cultures. As mentioned above, at our institution AST for MRSA infection or colonization is routinely performed in only 4 ICUs (accounting for 114 beds). The difference between hospital-onset incidence rates for MRSA infection or colonization when AST data were included in the numerator compared with when they were excluded did not quite achieve statistical significance ($P = .06$; Table 1). AST accounted for an additional 27 patients (representing a 14% increase) with hospital-onset MRSA infection or colonization being identified. By contrast, prevalence rates for MRSA colonization or infection were significantly higher when AST data were included than when they were not ($P < .001$); rates nearly doubled, with an additional 674 patients (a 78% increase) being identified.

Table 2 compares the results for hospital-onset incidence of MRSA infection or colonization when different time periods were used to define hospital onset (48 hours, 72 hours, 2 calendar days, and 3 calendar days after admission). Rates were highest with 2 calendar days and lowest with 72 hours. The most inclusive time period for counting cases as nosocomial was more than 2 calendar days: specimens with positive culture results obtained as early as 28 hours after admission fell into the category of more than 2 calendar days and were thus counted as hospital-onset MRSA infection or colonization. Similarly, the category of more than 3 calendar days was more inclusive than the category of more than 72 hours, in that specimens with positive culture results obtained as early as 52 hours after admission fell within the category of more than 3 calendar days. However, there was no significant difference between using 48 hours and 2 calendar days or between using 72 hours and 3 calendar days to define hospital-onset incidence of MRSA infection or colonization ($P > .05$). By contrast, overall and for hospital A, incidence rates were significantly different from each other when comparing 2 calendar days with 3 calendar days ($P < .05$). There were no differences between any of the time periods for hospitals B and C.

As shown in Table 2, there was no difference between looking back to the beginning of the evaluation time period (2008) or using 1, 2, or 3 years of historical data to exclude patients with a history of MRSA infection or colonization. In fact, we saw diminishing returns when looking back for longer periods.

Finally, we evaluated the effect of excluding patients who were not at risk from the denominator of the hospital-onset incidence. This significantly increased the incidence density rate, almost doubling it (Table 2).

Table 3 summarizes the data sources and formats needed to calculate each metric and provides its score on the manual-electronic scale. The incidence and prevalence measures require many data elements and the ability to manipulate them electronically, whereas the infection measures based on NHSN definitions require manual review and data collection.

DISCUSSION

To our knowledge, this is the first article to present data on the application of the SHEA/HICPAC metrics in the real world, specifically to an institution with different types of hospital settings. Aside from testing the process, our analyses yielded some interesting findings, which are described below.

Analysis of Rates

Numerator: defining hospital-onset or nosocomial rates—The purpose of measuring healthcare-associated or hospital-onset incidence rates is to provide a proxy measure of nosocomial transmission by measuring hospital-onset cases of MDRO infection or colonization. By using a cutoff time of 3 calendar days after admission, these rates are intended to distinguish between community acquisition and hospital acquisition, but this distinction is a rough one at best. Although the authors of the SHEA/HICPAC article¹ provide a rationale for the cutoff of more than 3 calendar days, they acknowledge that there is little consensus on the matter and few data to justify the cutoff. Following their recommendation for future research, we performed a comparison of 4 different time periods (48 hours, 72 hours, 2 calendar days, and 3 calendar days) and found that 2 calendar days appears to be equivalent to 48 hours and that 3 calendar days appears to be equivalent to 72 hours. For all hospitals combined and for hospital A, rates were significantly different for 48 hours compared with 72 hours and for 2 calendar days compared with 3 calendar days; however, for 2 of the 3 hospitals we evaluated within our healthcare system, hospital-onset incidence rates were equivalent regardless of the period used (ie, 48 hours, $\approx$ 72 hours and 2 calendar days, $\approx$ 3 calendar days), likely as a result of smaller sample sizes. These results suggest that hospitals may choose to use either calendar days or hours, whichever is more convenient, to determine hospital-onset rates. In choosing between 48 hours or 2 calendar days and 72 hours or 3 calendar days, the latter may be preferred because it is less likely to overestimate nosocomial incidence. For smaller hospitals, however, the difference may be minimal.

Numerator: effect of active surveillance—Another concern regarding hospital-onset incidence rates is that unless active surveillance is performed on admission and on a regular basis thereafter, these rates can overestimate actual transmission by misclassifying newly recognized colonization as newly acquired colonization. However, implementation of universal surveillance for MRSA infection or colonization remains variable in US hospitals,³ despite recent mandates requiring greater or lesser degrees of active surveillance for certain hospitals (those in the Veterans Health Administration⁴ and those in a growing number of states⁵).

If an institution does perform AST, the authors of the SHEA/HICPAC article¹ suggest that rates that include the results of AST cultures could supplant those that include the results of clinical cultures only. However, we found that comparison of these rates can provide an interesting perspective on the additional patients identified solely by AST. Even though we perform AST in only 4 ICUs, patients identified solely by AST accounted for a 78%

increase in the number of identified prevalent cases of MRSA infection or colonization (accounting for 44% of the total number of prevalent cases of MRSA infection or colonization in our institution). Hence, this analysis reveals that performing targeted active surveillance for MRSA infection or colonization can have a significant effect on its detection in hospitalized patients, as has been shown in other studies.⁶⁻⁸

Denominator: excluding patients not at risk—When calculating hospital-onset incidence density rates, the denominator typically used is the total number of patient-days for the given location and time period. However, as the authors of the SHEA/HICPAC article¹ point out, it is not completely accurate to include in the denominator patient-days from patients who are not at risk for nosocomial MRSA infection or colonization (because they have been in the hospital for fewer than 3 calendar days). The authors acknowledged this inaccuracy and explained why they recommended not excluding patients who are not at risk, but, as we found, including patient-days from these patients in the denominator significantly underestimates the hospital-onset incidence of MRSA infection or colonization compared with excluding them.

Process of Rate Calculations: Challenges Encountered

We encountered a number of challenges in calculating these metrics. The first challenge was correctly interpreting the SHEA/HICPAC metrics, particularly regarding the calendar-day rule. It took many conversations to reach a consensus on how to program the appropriate rules to identify calendar days, particularly since the calendar day for the purposes of defining hospital-onset incidence is distinct from the patient-day definition used for the denominator. We found that it was easiest to conceptualize it as the “3 midnight” rule described in Table 1 of the SHEA/HICPAC article.¹

An even greater challenge was the technical resources needed to perform these calculations. There are 20 metrics listed in Table 1 of the SHEA/HICPAC article;¹ we performed 18. Despite having a preexisting electronic data warehouse and preliminary programming for incidence and prevalence rates, a great deal of data cleaning, data extraction, and electronic rule creation and application was required. One especially problematic factor was the practice of looking at prior records to identify patients with previous MRSA infection or colonization. Even when done semielectronically, it was time-consuming to obtain historical microbiology records and match patients with a previous MRSA-positive specimen to those with a current (during 2008) MRSA-positive specimen. In looking back for various time periods (the beginning of the evaluation period, 2008; 2007; 2006; and 2005), we were surprised to find that few additional patients with a history of MRSA infection or colonization were identified by looking back beyond the evaluation period—certainly very few patients were identified by looking back more than 1 year prior. This finding can help hospitals save time and resources by minimizing retrospective review of records.

Regarding the selection of which metrics to calculate, the SHEA/HICPAC article¹ provides some guidance regarding which metrics are considered basic and which are considered advanced. We take a different approach in Table 3 here; we identify what data sources and processes are needed to calculate each metric, and we rate each metric on the basis of how electronic or manual the process required to perform the calculation is. This provides a general guideline as well as a supplement to Table 3 of the SHEA/HICPAC article.¹

Limitations

The metrics were applied only to 1 organism in 1 institution (albeit an institution with several types of hospital settings), and thus results may not be generalizable to other institutions or other organisms. Furthermore, most of the metrics require some degree of

electronic data extraction and thus are not applicable to hospitals that do not have electronic medical records. The selection of UTI as the nosocomial infection measure was made for purposes of feasibility, because electronic data could be used and other infection measures were thought to be more difficult to assess for a large sample size. Nonetheless, we acknowledge that nosocomial UTI due to MRSA is an uncommon event.

Conclusions

In applying the SHEA/HICPAC metrics to calculate rates of MRSA infection or colonization in our institution, we found that although the metrics were useful in providing guidance, they were sometimes challenging to interpret and required a significant amount of time to perform, despite our having considerable technical support and capability. Here we provide information on the specific data sources and processes required to calculate these metrics, as well as an evaluation of each metric regarding how electronic or manual the process is. We hope that our experience can help inform the process of performing these metrics for other institutions. Ultimately, each institution must determine the costs and benefits of data collection and assess the usefulness of such metrics to inform practice and policy changes.

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Society for Healthcare Epidemiology of America/Healthcare Infection Control Practices Advisory Committee Metrics and Institutional Rates for Methicillin-Resistant *Staphylococcus aureus* (MRSA) Infection and Colonization, 2008

TABLE 1

Metric	Numerator	Denominator	Rate
Incidence			
Hospital-onset MRSA infection or colonization (clinical cultures only)			
Incidence rate for hospital-onset MRSA infection or colonization	No. of first MRSA isolates from clinical specimens per patient per building >3 calendar days after admission to building (excluding patients with previous history)	100 patient admissions	0.3 (188/63,353 × 100)
Incidence density rate for hospital-onset MRSA infection or colonization	No. of first MRSA isolates from clinical specimens per patient per building >3 calendar days after admission to building (excluding patients with previous history)	1,000 patient-days	0.49 (188/381,685 × 1,000)
Hospital-onset MRSA infection or colonization (clinical plus AST cultures)			
Incidence rate for hospital-onset MRSA infection or colonization	No. of first MRSA isolates per patient per building >3 calendar days after admission to building (excluding patients with previous history)	100 patient admissions	0.34 (215/63,353 × 100)
Incidence density rate for hospital-onset MRSA infection or colonization	No. of first MRSA isolates per patient per building >3 calendar days after admission to building (excluding patients with previous history)	1,000 patient-days	0.56 (215/381,685 × 1,000)
Hospital-onset MRSA bacteremia			
Incidence rate for hospital-onset MRSA bacteremia	No. of MRSA blood isolates (separated by 14 days) for building >3 calendar days after admission to building	100 patient admissions	0.07 (43/63,353 × 100)
Incidence density rate for hospital-onset MRSA bacteremia	No. of MRSA blood isolates (separated by 14 days) for building >3 calendar days after admission to building	1,000 patient-days	0.11 (43/381,685 × 1,000)
Nosocomial MRSA infection ^a			
Incidence rate for nosocomial MRSA infection	No. of hospital-onset infections meeting NHSN criteria	100 patient admissions	0.003 (2/63,353 × 100)
Incidence density rate for nosocomial MRSA infection	No. of hospital-onset infections meeting NHSN criteria	1,000 patient-days	0.005 (2/381,685 × 1,000)
Device-associated MRSA infection ^b			
Incidence density rate for device-associated MRSA infection	No. of device-associated infections	1,000 device-days	0.07 (5/68,133 × 1,000)
Procedure-specific MRSA infection ^c			
Incidence rate for procedure-specific MRSA infection	No. of procedures associated with MRSA infection	100 procedures	0.24 (9/3,771 × 100)
Prevalence			
Overall prevalence of MRSA infection or colonization (clinical cultures only)			
Prevalence rate for overall MRSA infection or colonization	No. of first MRSA isolates per patient per building <i>and</i> no. of patients with previous history	100 patient admissions	1.36 (862/63,353 × 100)

Metric	Numerator	Denominator	Rate
Prevalence density rate for overall MRSA infection or colonization	No. of first MRSA isolates per patient per building <i>and</i> no. of patients with previous history	1,000 patient-days	2.26 (862/381,685 $\times$ 1,000)
Overall prevalence of MRSA infection or colonization (clinical plus AST cultures)	No. of first MRSA isolates per patient per building <i>and</i> no. of patients with previous history	100 patient admissions	2.42 (15,36/63,353 $\times$ 100)
Prevalence rate for overall MRSA infection or colonization	No. of first MRSA isolates per patient per building <i>and</i> no. of patients with previous history	1,000 patient-days	4.02 (1,536/381,685 $\times$ 1,000)
Admission prevalence of MRSA infection or colonization	No. of first MRSA isolates per patient per building $\leq$ 3 calendar days after admission to building <i>and</i> no. of patients with previous history	100 patient admissions	2.13 (1,351/63,353 $\times$ 100)
Antibiogram	No. of first <i>S. aureus</i> isolates susceptible to methicillin per patient per building	Total no. of <i>S. aureus</i> isolates per patient per building	48% (872/1,823)

NOTE. Denominator data were as follows: no. of admissions, 63,353; no. of patient-days, 381,685; no. of central line-days in intensive care units, 68,133; and no. of surgical procedures, 3,771. AST, active surveillance testing; NHSN, National Healthcare Safety Network.

^aUrinary tract infection.

^bCentral line-associated bloodstream infection in intensive care units.

^cSurgical site infection in cardiac, colon, and hip surgeries.

TABLE 2

Additional Metrics for Methicillin-Resistant *Staphylococcus aureus* (MRSA) Infection and Colonization Based on Recommendations for Future Research

Metric	Definition for hospital onset, by time after admission ^d				Possible time periods for excluding patients with previous history of MRSA				Excluding patients not at risk from denominator ^b	
	48 h	72 h	2 CDs	3 CDs	Starting 1/1/2008	1 yr	2 yr	3 yr	Standard	With exclusion
Hospital-onset MRSA infection or colonization (clinical culture only), no. of cases	202	167	233	188	228	190	189	188	188	188
Incidence rate for hospital-onset MRSA infection or colonization, cases per 100 patient admissions	0.32 ^c	0.26 ^c	0.37 ^c	0.3 ^c	0.36 ^d	0.3 ^d	0.3 ^d	0.3 ^d	NA	NA
Incidence density rate for hospital-onset MRSA infection or colonization, cases per 1,000 patient-days	0.53 ^c	0.44 ^c	0.61 ^c	0.49 ^c	0.6 ^d	0.5 ^d	0.5 ^d	0.49 ^d	0.49 ^e	0.98 ^e
Hospital-onset MRSA infection or colonization (clinical plus AST culture), no. of cases	234	193	278	215	270	220	216	215	215	215
Incidence rate for hospital-onset MRSA infection or colonization, cases per 100 patient admissions	0.37 ^c	0.3 ^c	0.44 ^c	0.34 ^c	0.43 ^d	0.35 ^d	0.34 ^d	0.34 ^d	NA	NA
Incidence density rate for hospital-onset MRSA infection or colonization, cases per 1,000 patient-days	0.61 ^c	0.51 ^c	0.73 ^c	0.56 ^c	0.71 ^d	0.58 ^d	0.57 ^d	0.56 ^d	0.56 ^e	1.12 ^e

NOTE. AST, active surveillance testing; CD, calendar day; NA, not applicable.

^aNo. of admissions, 63,353; no. of patient-days, 381,685.

^bThe no. of admissions is multiplied by 3, and the result is subtracted from the no. of patient-days; denominator, 191,626.

^c $P < .05$ for the comparison between 48 and 72 hours and between 2 and 3 CDs; differences between 48 hours and 2 CDs and between 72 hours and 3 CDs were not significant.

^dAll differences between time periods were not significant.

^e $P < .05$ for all comparisons between standard calculation and exclusion from denominator.

TABLE 3
Recommendations for Methicillin-Resistant *Staphylococcus aureus* (MRSA) Metrics

Metric	Data sources and formats needed	Manual-electronic scale ^d	Utility
Incidence			
Hospital-onset MRSA infection or colonization (clinical cultures only)	<i>Data:</i> Microbiology data with date and time of specimen collection, specimen source, and specimen collection location (year of evaluation plus historical data); visit information per patient, per admission (year of evaluation plus historical data); admission and census data (total no. of admissions, patient-days) <i>Process:</i> Extract microbiology and visit information electronically, with common identifiers to match each patient's visit; identify and separate surveillance cultures; obtain historical microbiology and visit data; calculate calendar days to positivity per admission; calculate rates in cases per patient admissions and patient-days	4	Measure of nosocomial transmission (infection plus colonization), with and without patients identified by active surveillance
Incidence rate for hospital-onset MRSA infection or colonization (cases per 100 patient admissions)			
Incidence density rate for hospital-onset MRSA infection or colonization (cases per 1,000 patient-days)			
Hospital-onset MRSA infection or colonization (clinical plus AST cultures)			
Incidence rate for hospital-onset MRSA infection or colonization (cases per 100 patient admissions)			
Incidence density rate for hospital-onset MRSA infection or colonization (cases per 1,000 patient-days)			
Hospital-onset MRSA bacteremia			
Incidence rate for hospital-onset MRSA bacteremia (cases per 100 patient admissions)			
Incidence density rate for hospital-onset MRSA bacteremia (cases per 1,000 patient-days)			
Nosocomial MRSA infection ^b			
Incidence rate for nosocomial MRSA infection (cases per 100 patient admissions)			
Incidence density rate for nosocomial MRSA infection (cases per 1,000 patient-days)			
Device-associated MRSA infection ^c			
Incidence density rate for device-associated MRSA infection (cases per 1,000 central line-days)			
Procedure-specific MRSA infection ^d			

Metric	Data sources and formats needed	Manual-electronic scale ^a	Utility
Incidence rate for procedure-specific MRSA infection (cases per 100 procedures)	records regarding date and time of surgical procedure, risk stratification of procedures (ASA score, etc) <i>Process:</i> Extract microbiology and visit information electronically, with common identifiers to match each patient's visit; identify and separate appropriate cultures; determine infections and link appropriate subsequent cultures; calculate rates in cases per procedures		
Prevalence			
Overall prevalence of MRSA infection or colonization (clinical cultures only)	<i>Data:</i> Microbiology data as described above; visit information as described above; admission or census data as described above <i>Process:</i> Extract microbiology and visit information electronically, with common identifiers to match each patient's visit; identify and separate surveillance cultures; obtain historical microbiology and visit data; calculate rates in cases per patient admissions and patient-days	4	Measure of overall organism burden in the institution
Prevalence rate for overall MRSA infection or colonization (cases per 100 patient admissions)			
Prevalence density rate for overall MRSA infection or colonization (cases per 1,000 patient-days)			
Overall prevalence of MRSA infection or colonization (clinical plus AST cultures)			
Prevalence rate for overall MRSA infection or colonization (cases per 100 patient admissions)			
Prevalence density rate for overall MRSA infection or colonization (cases per 1,000 patient-days)			
Admission prevalence of MRSA infection or colonization	<i>Data:</i> Microbiology data as described above; visit information as described above; admission or census data as described above <i>Process:</i> Extract microbiology and visit information electronically, with common identifiers to match each patient's visit; identify and separate surveillance cultures; obtain historical microbiology and visit data; calculate calendar days to positivity per admission; calculate rates in cases per patient admissions and patient-days	4	Measure of admission (community-onset) burden of organism entering the institution
Prevalence rate for admission MRSA infection or colonization (cases per 100 patient admissions)			
Antibiogram			
Percentage of <i>S. aureus</i> isolates susceptible to methicillin (inpatient isolates)	<i>Data:</i> Microbiology data (all <i>S. aureus</i> isolates with methicillin or oxacillin susceptibility information) <i>Process:</i> Sort microbiology data by patient (to remove duplicates); calculate percentage with methicillin susceptibility	4	Measure of MDRO as a proportion of the total organism no. (percent susceptibility)

NOTE. ASA, American Society of Anesthesiologists; AST, active surveillance testing; MDRO, multidrug-resistant organism; NHSN, National Healthcare Safety Network.

^a A value of 1 represents the greatest degree of manual data review required; a value of 4 represents the greatest use of electronic data elements and manipulation.

^b Urinary tract infection.

^c Central line-associated bloodstream infection in intensive care units.

^d Surgical site infection in cardiac, colon, and hip surgeries.