

TECHNICAL NOTES

Methicillin-Resistant *Staphylococcus Aureus* and Vancomycin-Resistant Enterococci Bloodstream Infections, 2012

Introduction

Methicillin-resistant *Staphylococcus aureus* (MRSA) and vancomycin-resistant Enterococci (VRE) are two of the most common multidrug-resistant germs, or organisms (MDROs) causing infections in hospital patients [1]. California Health and Safety Code Section 1288.55 (a)(1) requires general acute care hospitals to report to the California Department of Public Health (CDPH) all cases of MRSA and VRE bloodstream infections (BSIs) associated with inpatient treatment, and the number of inpatient days. It requires the department to post on its web site the incidence rate of these infections. These *Technical Notes* describe the definitions, methods, and limitations associated with this CDPH data release on MRSA and VRE BSIs. The reporting period for this data release is January through December 2012. This data release used data submitted by California hospitals to the Centers for Disease Control and Prevention (CDC) National Healthcare Safety Network (NHSN).

The distribution of information on the health of the community is a core function and essential service of public health. CDPH strongly supports the goals of public reporting on HAIs including the production and distribution of quality data that are valid, fair to hospitals, and useful to the public. Bearing in mind important limitations, the public can use these data as a starting point to discuss patient safety and quality of care with their healthcare providers and to make more informed healthcare decisions. Hospitals and health care providers can also use these data to examine their patient safety practices and improve quality of care, as appropriate.

Materials and Methods

Reporting hospitals

At the end of 2012, 388 California general acute care hospitals (GACHs) were enrolled in NHSN. As indicated in the table below, we identified 377 licensed general acute care hospitals representing 429 physical campuses with active acute care beds that operated continuously (for the full 12 months) during the reporting period. Of these, 46 licensed hospitals had more than one campus associated with its license. We defined a multi-campus reporting facility as a licensee that reported HAI data combined for two or more jointly operated general acute care campuses (38 licenses comprising 79 campuses). We defined a single-campus reporting facility as an individual general acute care

campus whose license included: (a) only one general acute care campus (331 licenses comprising 331 acute care campuses) or (b) more than one jointly-operated general acute care campus each of which reported infection information separately (8 licenses representing 19 campuses). In total, there were 388 reporting entities, hereafter referred to as hospitals. We referred to multi-campus hospitals by the business name of the licensee in CDPH Licensing and Certification (L&C) records except for the licenses involving University of California hospitals, which are described as such.

General Acute Care Hospitals (GACHs)	Number of Licenses	Number of Campuses
With active beds (total)	377	429
Consolidated license, <i>reported together</i>	38	79
Consolidated license, <i>reported separately</i>	8	19
<i>Single license, reporting separately</i>	331	331
Reporting entities	38 + 19 + 331 = 388	

LTAC and rehabilitation hospital patients have clinically complex problems, such as multiple acute or chronic conditions and are admitted with an expectation that their hospitalization will be long. LTACs are defined by the Centers for Medicare and Medicaid Services (CMS) as a licensed general acute care hospital providing care for patients with medically complex conditions requiring an average length of stay for all patients of greater than 25 days [2]. California LTAC hospitals were identified through CMS and assessments by HAI Program staff.

NHSN defines rehabilitation as evaluation and restoration of function to patients who have lost function due to acute or chronic pain, musculoskeletal problems, stroke, or catastrophic events resulting in complete or partial paralysis. The underlying hospital definitions for both are in Social Security Administration regulations [http://www.ssa.gov/OP_Home/ssact/title18/1886.htm#act-1886-d-1-b]. Because the NHSN risk adjustment process for MRSA BSI was developed for GACHs and not LTACs and rehabilitation hospitals, the latter two hospital categories are treated separately in this report in Tables 3 and 4.

Data sources

The primary sources of data for this data release are those submitted by hospitals using NHSN. Beginning April 1, 2010, all California licensed general acute care hospitals were required to report MRSA and VRE BSIs using the NHSN MDRO LabID module facility-wide [3] and provide CDPH electronic permission to access this data. On May 10, 2013, we accessed from NHSN MRSA and VRE BSI data reported for the period January 1, 2012 through December 31, 2012. These data included NHSN-produced summary files listing all MRSA and VRE BSIs reported by California hospitals (MRSA and VRE BSIs

event files) and NHSN-produced files containing counts of MRSA and VRE BSIs, patient days and MRSA BSI SIR and VRE BSI rates per 1000 patient days for each hospital (MRSA BSI SIR and VRE BSI rate files).

Definitions

CDPH required hospitals to comply with NSHN surveillance and reporting protocols and NHSN standardized definitions [3-5], including the definitions used in this data release:

MRSA: Includes *S. aureus* cultured from any specimen that tests oxacillin-resistant by standard susceptibility testing methods, or by a positive result from molecular testing for *mecA* and *PBP2a*. These methods may also include positive results of specimens tested by any other Food and Drug Administration (FDA) approved polymerase chain reaction (PCR) test for MRSA.

VRE: Any Enterococcus spp. (regardless of whether identified to the species level), that is resistant to vancomycin.

Unique Blood Source: A MDRO isolate from blood in a patient with no prior positive blood culture for the same MDRO in less than or equal to 2 weeks, even across calendar months. The 2-week interval is because some patients may have positive tests from the same infection for up to two weeks.

Laboratory-Identified (LabID) Event: All Unique Blood Source isolates for MRSA and VRE.

Community-Onset (CO): LabID Event specimen collected as an outpatient or an inpatient less than or equal to 3 days after admission to the facility (i.e., days 1, 2, or 3 of admission).

Healthcare Facility/Hospital-Onset (HO): LabID Event specimen collected more than 3 days after admission to the facility (i.e., on or after day 4). An infection with an MDRO that has its onset in the hospital does not mean that the MDRO itself (the MRSA or VRE bacteria in this case) was necessarily acquired (picked up) in this hospital. As mentioned above, a person may be colonized with MRSA and VRE; that is, the bacteria are present in the body without causing an infection. MRSA and VRE can be carried by a person for a year or more, and can cause an infection at any time.

Major teaching hospital: Hospital that is an important part of the teaching program of a medical school and the majority of medical students rotate through multiple clinical

services [7]. Before extracting the data for this release we asked each California hospital enrolled in NHSN self-identified as teaching to review their classification in regard to the NHSN definitions and to change their classification if appropriate. Each classification was reviewed and confirmed as appropriate according to NHSN definitions by HAI Program staff.

Pediatric hospital: Hospital defined by CDPH L&C Program as a stand-alone children's hospital.

Long-term Acute Care (LTAC): Hospital as defined by CMS as a licensed general acute care hospital providing care for patients with medically complex conditions requiring an average length of stay for all patients of greater than 25 days. California LTAC hospitals were identified through CMS and assessments by HAI Program staff.

Rehabilitation: Hospitals with inpatient wards for evaluation and restoration of function to patients who have lost function due to acute or chronic pain, musculoskeletal problems, stroke, or catastrophic events resulting in complete or partial paralysis. These hospitals were self-identified through NHSN.

Critical access hospital: Legislation enacted as part of the Balanced Budget Act (BBA) of 1997 authorized states to establish State Medicare Rural Hospital Flexibility Programs (Flex Program), under which certain facilities participating in Medicare can become Critical Access Hospitals (CAHs). CAH is a CMS designation implemented by states through a protocol.

Prison hospital: Hospitals associated with correctional institutions in California that were identified through the HAI Program staff.

Community hospital: Hospital not classified as major teaching, LTAC, pediatric, rehabilitation, critical access, or prison.

Reporting Period: January 1, 2012, through December 31, 2012.

Quality assurance and control

Hospital personnel were solely responsible for the quality and completeness of their MRSA and VRE BSI data. CDPH assisted hospitals in identifying potential systematic data errors by reviewing hospital-specific NHSN data and notifying hospitals of potential discrepancies. We distributed quality assurance and control reports, which identified missing, incomplete, or potentially aberrant data for the reporting period, to hospitals in

July and November 2012 and April 2013. We strongly encouraged hospitals to investigate and resolve any data issues, as appropriate. CDPH made available to hospitals the assistance of regional infection prevention staff to help resolve NHSN enrollment or reporting issues. Additionally, March and/or April 2013, we emailed those hospitals with less than twelve months of data indicating their hospital was identified as having missing data (both numerator and denominator) in NHSN. We encouraged hospitals to do a final review to make corrections and enter missing data before the final data download in May, 2013. Facilities made all corrections in NHSN.

Data presentation, organization and statistical analyses

New in this release, we present hospital specific MRSA BSI SIRs and 95% confidence interval (CI) for general acute care hospitals other than long-term and rehabilitation acute care hospitals. The NHSN SIR compares the actual number of HO incident cases with the predicted (expected) number based on the national baseline data, adjusting for the significant risk factors such as admission prevalence rate, facility bedsize, and medical school affiliation [8]. Adjusting for these factors provides for a more fair comparison of hospitals' infections to the predicted. For more precise comparisons, NHSN provides an SIR only when at least one infection is predicted. Baseline data and the time period are defined as the MRSA BSI data reported from facilities as in-plan data in each month's Patient Safety Monthly Reporting Plan, during 2010-2011. If an SIR was generated for a hospital, the calculated 95% CI determines if the observed number of infections was significantly different from predicted. Based on the 95% CI, we labeled each SIR as indicating either: N (no difference in number of observed and predicted infections), high (H, more infections than predicted), or low (L, fewer infections than predicted). The 95% CI is a range of values that includes the true SIR, knowing that the reported SIR in Table 2 is the most likely value. If the CI includes the value of one, then the SIR is not significant.

We present long term acute care (LTAC) and rehabilitation hospital specific MRSA BSI incidence rates as in prior releases, because few LTAC and rehabilitation hospitals reported MRSA BSI data during the baseline period (2010-2011), and were excluded from all SIR analyses. The rate calculation and comparison methodologies are similar to those for VRE BSI in LTAC and rehabilitation hospitals.

As in prior releases we present hospital specific VRE BSI incidence rates, case mix indices (CMI), when available and a California pooled mean (average) rate for each of the seven hospital categories. Numbers of VRE BSIs, patient days, unadjusted VRE BSI incidence rates, and 95% confidence intervals, stratified by hospital type, and the percentile distribution of the hospital-specific rates for each hospital category are the primary measures reported. We stratified hospitals according to status as a major

teaching, LTAC, pediatric, rehabilitation, critical access, prison, or community hospital. Those hospitals not classified as major teaching, LTAC, pediatric, rehabilitation, critical access, or prison were termed community hospitals. This category includes specialty hospitals such as surgery and oncology (cancer treatment) hospitals.

There are no accepted methods for risk adjusting or stratifying VRE BSI incidence rates and no published national benchmarks. The method of stratification used in this release has not been used elsewhere for evaluating VRE BSI incidence rates. We sorted hospitals into categories that reflect their patients' severity of illness and other factors that can affect their risk of infection, such as age and length of hospitalization, and the type of care that they receive.

We performed the following calculations on VRE BSI data submitted to NHSN during the reporting period. The numerators for the rates were all LabID Events categorized as defined above. The denominators for the rates were total inpatient days. The equation for the rate calculations are shown below:

Incidence Density Rate for hospital onset VRE BSIs [4]:

$$\frac{\text{Number of Unique Blood Source Hospital Onset (HO) LabID Events} \times 10,000}{\text{Total inpatient days}}$$

We used 10,000 as the multiplier rather than 1,000 to yield whole numbers or large fractions because BSI rates are low. Also, total patient days were most commonly in the tens of thousands. For this data release, incidence density rate will be referred to as incidence rate. Hospitals summed and entered into NHSN the denominator data (patient days and admissions) for all inpatient days. We calculated HO incidence rates for every hospital that reported data in NHSN for 12 months during the reporting period.

For each rate we calculated 95% confidence intervals using the Poisson distribution [6]. We calculated the statewide pooled mean rate (average rate) for each hospital category, e.g., community, by dividing the sum of all BSI cases for all hospitals in that category by the sum of all inpatient days from all hospitals in that category x 10,000.

A 95% confidence interval is a range of values used to quantify the precision of a rate that is associated with random variation (it provides no information about systematic errors or 'bias'). The wider the interval, the greater the uncertainty associated with the rate. The width of the confidence interval is, in part, related to the reported numbers of cases and patient days. Smaller hospitals with fewer infections and patient days have the least precision associated with their rates and the widest confidence intervals.

We used 95% confidence intervals to compare hospital-specific rates with the pooled mean rate (average rate) for each hospital category. This approach assumes that the statewide average rate (pooled mean rate) in each hospital category is the 'true value' for the rate. A hospital-specific VRE BSI rate was significantly higher than the pooled mean rate if the hospital's entire 95% confidence interval was higher than the pooled mean rate. The BSI rate was significantly lower than the pooled mean rate if the hospital's entire confidence interval was lower than the pooled mean rate. The BSI rate was no different than the pooled mean rate if the hospital's confidence interval contained the pooled mean rate.

For example, if the rate for a community hospital is 2.15 VRE BSI cases per 10,000 patient days, the 95% confidence interval for this hospital rate is (1.14,3.67) which includes the rate of 2.15. The hospital rate could be anywhere between 1.14 and 3.67. The statewide pooled mean rate for community hospitals is 0.35 BSI cases per 10,000 patient days. The 95% confidence interval with the lower bound of 1.14 being higher than the statewide average rate of 0.35 makes this hospital rate statistically higher than the state average rate for the community hospital category.

Confidence intervals for the stratified rates (classified by type of hospital) in this release may be used, with caution, to make comparisons between hospitals [7]. This method is useful as a quick but potentially inconclusive guide. Its interpretation differs from those made when comparing a hospital rate to a benchmark such as a pooled mean rate for the hospital group. If two hospitals' confidence intervals do not overlap, the rates are significantly different from one another.

For a measure of the severity of illness in hospital patient populations, we utilized campus-specific case mix indices (CMI), when available, published by the California Office of Statewide Health Planning and Development (OSHPD) for fiscal year 2011 (<http://www.oshpd.ca.gov/HID/Products/PatDischargeData/CaseMixIndex/>), and rounded indices to two decimal places. Although the CMI was derived using weights based on resource consumption by Medicare patients, OSHPD applied the CMI calculation to all patient discharge data reported by California hospitals. The CMI was available only for individual hospital campuses rather than for consolidated licensed hospitals, as a whole. The CMI provides a useful reference point when examining individual hospital VRE BSI rates as it can indicate whether a hospital serves patients with higher or lower severity of illness. Severity of illness is one factor associated with a hospital having a higher or lower VRE BSI rate when compared to the pooled mean. For example, a hospital caring for patients with higher severity of illness could be predicted to have higher rates of VRE BSIs. It is important to note that the CMI is only one factor that may explain the difference between a hospital's VRE BSI rate and the pooled mean

rate for that hospital category. Additionally, CMI may not completely account for differences in severity of illness between hospital patient populations.

Limitations and Context

Rates of infection can be risk adjusted, or risk stratified, to account for differences in the types of patients in different hospitals and allow for comparisons that are fairer. Risk adjustment means adjusting the rate for each hospital based on information on all patients in the hospitals, whether they have infections or not. The rates in this data release are not risk adjusted for VRE BSI in all hospital categories and for MRSA BSI in LTAC and rehabilitation hospitals, as there are no such methods available at this time. The unadjusted BSI rates are affected by clinical and infection control practices, patient-based risk factors, and surveillance methods. While stratifying VRE BSI rates by different hospital categories makes rates more comparable, it cannot control for all individual patient factors that can affect VRE BSI rates. Comparisons between hospitals within these groups (strata) should still be made with caution given that adjusting for different patient populations among the hospitals within these groups cannot be performed. Thus, differences in rates can represent differences in patient populations or differences in infection and transmission prevention practices. Comparisons must also assume that all laboratory and patient day data have been entered into NHSN accurately and correctly according to NHSN protocols. Misclassification of cases could result in a falsely lower or higher rate.

A number of hospitals had significantly higher or lower rates when compared to other hospitals in their respective categories. Differences in the severity of illness in their patient populations, as measured in this release through the CMI for VRE BSI, may explain some but not all of these differences. It is possible that CMI does not adequately represent the severity of illness in all hospitals. The risk of BSIs may also be related to factors other than severity of illness, including differences in infection prevention efforts.

We cannot compare the risk-adjusted SIRs to rates from the previous report for general acute care hospitals other than long-term and rehabilitation acute care hospitals because of using different measures of risk and adjustment factors in this report. There are no other reports of VRE BSI incidence rates in all hospital categories from NHSN data for comparison with this release except for the CDPH report from the previous release, so it is not possible to compare these rates from California hospitals with national or other state data. However, these data could be used to evaluate rates in California hospitals over time.

References

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