TECHNICAL NOTES:
Methicillin-resistant *Staphylococcus aureus* and Vancomycin-resistant Enterococci Bloodstream Infections in California Hospitals, 2015

Introduction

Methicillin-resistant *Staphylococcus aureus* (MRSA) and vancomycin-resistant enterococci (VRE) are two of the most common multidrug-resistant organisms (germs) causing infections in hospital patients [1, 2].

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 or VRE bloodstream infections (BSI) identified in their facilities. CDPH produced these *Technical Notes* to describe the definitions, methods, and limitations associated with MRSA/VRE BSI data analyses for the reporting period, January 1, 2015, to December 31, 2015. California hospitals submitted MRSA/VRE BSI data to the Centers for Disease Control and Prevention (CDC) National Healthcare Safety Network (NHSN). CDPH accessed the NHSN data to produce this report.

NHSN is using HAI data reported by all U.S. hospitals in 2015 to establish new risk adjustment models and new national baselines against which future HAI prevention progress will be measured. Next year's CDPH annual report will show how California hospitals compared with the new 2015 national baselines and demonstrate if HAI prevention progress was made in 2016.

Methods

Reporting hospitals

In 2015, CDPH received data from 393 licensed general acute care hospitals representing 416 physical campuses that operated for the full 12 months of the reporting period. Of these, 21 hospitals reported combined MRSA/VRE BSI data for multiple hospital campuses under a single hospital license, and 372 hospitals reported data separately for each campus (Table A).

Table A. Reporting by General Acute Care Hospitals, 2015

	Reporting Hospitals	**Number of Campuses**
Hospitals that reported separately for each campus	372	372
Hospitals that reported multiple campuses together	21	44
Total	**393**	**416**

Long-term acute care (LTAC) and rehabilitation hospitals' MRSA BSI data were excluded by NHSN when the MRSA BSI risk adjustment model was developed. CDPH reported data from LTAC and rehabilitation hospitals separately from other general acute care hospital data (MRSA BSI Tables 3 and 4).

To analyze and report VRE BSI data, CDPH stratified California hospitals by six different hospital categories, LTAC, rehabilitation, pediatric, major teaching, critical access, and community.

Data sources

California hospitals entered MRSA BSI and VRE BSI data into the NHSN online reporting system using the surveillance and reporting protocols described in the Multidrug Resistant Organism (MDRO) Laboratory-Identified (LabID) Event Module [3]. Hospitals provided CDPH with electronic permission to access these data. On March 1, 2016, we downloaded the NHSN data set used to produce this 2015 report. The data files included numbers of MRSA BSI and VRE BSI LabID events, inpatient days, predicted MRSA BSI and VRE BSI events, and standardized infection ratios (SIR) and rate files.

Missing data

Some hospitals did not report MRSA BSI and/or VRE BSI LabID events or monthly counts of inpatient days for all 12 months of the reporting period. We excluded from analyses the hospitals that reported incomplete or inaccurately-reported MRSA BSI and/or VRE BSI data (MRSA-VRE BSI Table 12).

Definitions

CDPH required hospitals to comply with NSHN surveillance and reporting protocols, including NHSN standardized definitions [4]. Key definitions are:

- **Methicillin-resistant *Staphylococcus aureus* (MRSA**) is defined as a *S. aureus* identified by culture that tests oxacillin-resistant by standard susceptibility testing methods, or MRSA identified by molecular testing for specific genes (i.e., mecA or PBP2a), or identified by other Food and Drug Administration approved polymerase chain reaction tests for MRSA.

- **Vancomycin-resistant Enterococci (VRE)** are Enterococcus species that are resistant to the antibiotic, vancomycin.

- A **unique blood source** is a positive MRSA or VRE blood culture from a patient with no prior positive blood culture for the same organism in the previous two weeks. A two-week interval is used because a patient may have positive tests due to the same infection for up to two weeks.

- A **MRSA or VRE BSI laboratory-identified (LabID) event** includes all unique blood source isolates for MRSA and VRE.

- **Community-onset (CO)** describes a LabID event specimen collected as an outpatient or an inpatient less than or equal to three days after admission to the facility (i.e., hospital days one, two, or three).

- **Hospital-onset (HO)** describes a LabID event that occurs more than three days after admission to the facility (i.e., on or after hospital day four). An infection with MRSA or VRE that has its onset in the hospital does not mean that the MRSA or VRE bacteria were necessarily acquired (picked up) in the hospital. A person may be colonized with MRSA and VRE; that is, the bacteria are present in the body without causing an infection. Infection can occur when MRSA or VRE enter into a sterile body site or wound.

- **Inpatient days** are the cumulative numbers of patients hospitalized each day during the reporting period.

- A **major teaching hospital** is an important part of the teaching program of a medical school, and the majority of medical students rotate through multiple clinical services within the hospital.

- A **pediatric hospital** is defined by CDPH Licensing and Certification (L&C) Program as a stand-alone children's hospital.

- A **long-term acute care (LTAC)** hospital is defined by the U.S. Centers for Medicare & 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 [5].

- A **rehabilitation hospital** has inpatient wards for the evaluation and restoration of function of patients who have lost function due to acute or chronic pain, musculoskeletal problems, stroke, or catastrophic events resulting in complete or partial paralysis.

- A **critical access hospital (CAH)** is designated by CMS. The CAH definition includes hospitals with 25 or fewer acute care inpatient beds, located more than 35 miles from another hospital (with some exceptions), and average annual length of stay of four days or less.

- A **community hospital** is a CDPH designation for hospitals not classified as major teaching, LTAC, pediatric, rehabilitation, or critical access.

Quality assurance and control

Hospital personnel were responsible for the quality and completeness of their MRSA/VRE BSI data. CDPH assisted hospitals in identifying systematic data errors by reviewing hospital-specific NHSN data and notifying hospitals of discrepancies. In September, October, November,

and December 2015, and in February and March 2016, CDPH distributed quality assurance and control reports that identified missing, incomplete, or potentially aberrant data for the reporting period. In February 2016, we also notified hospitals with fewer than 12 months of data or missing a complete annual hospital survey. We encouraged hospitals to conduct a final data review and complete corrections before the final data download on March 1, 2016. Hospitals were responsible for making data corrections in NHSN.

Validation

In 2014, CDPH validation efforts helped hospitals assess and improve case-finding and evaluate completeness in identifying and reporting MRSA BSI and VRE BSI. We targeted and provided additional assistance to hospitals found to have low case-finding in 2014 validation. In 2015, CDPH staff conducted 38 onsite re-validation visits to hospitals missing three or more MRSA BSI, VRE BSI, or *C. difficile* infection (CDI) cases and had less than 85% sensitivity. Of the 38 hospitals re-validated in 2015, eight were still missing three or more cases and had less than 85% sensitivity. In 2016, CDPH is continuing follow-up with these eight hospitals and their leadership representatives to review their surveillance practices, case finding processes, and reporting issues.

Data presentation and statistical analyses

A. MRSA BSI in general acute care hospitals (other than LTAC and rehabilitation hospitals)

We presented hospital-specific MRSA BSI standardized infection ratios (SIR) and 95% confidence intervals (CI) for general acute care hospitals other than LTAC and rehabilitation acute care hospitals (MRSA BSI Table 2). The NHSN SIR compared the reported number of HO incident cases with the predicted (expected) number based on the national baseline data, adjusting for the significant risk factors such as CO admission prevalence rate, facility bed size, and medical school affiliation [6]. Adjusting for these factors provided for a more fair comparison of hospitals' infections with the predicted. For more precise comparisons, NHSN provided an SIR only when at least 1.0 infection was predicted. In 2015, CDPH also calculated an SIR when the predicted number of infections was less than 1.0, but greater than or equal to 0.2. This change allowed more hospitals (e.g., small and rural hospitals) to compare their infection incidence to the national baselines. CDPH reported MRSA BSI results (i.e., incidence higher than or the same as predicted) for more California hospitals. In the past, these hospital results would have been missing, with an indication that there were "too few data to calculate." National MRSA BSI baselines for general acute care hospitals were calculated from data reported to NHSN in 2010-2011.

If an SIR was generated for a hospital, the calculated 95% confidence interval determined if the observed number of infections is significantly different from predicted. If the confidence interval included the value of 1.0, the SIR indicated that the observed number of infections was not considered different from the predicted number of infections. Based on the 95% confidence

interval, we labeled each hospital's MRSA BSI SIR as "no difference" between the number of observed and predicted infections, "higher" because more infections were observed than predicted, or "lower" because fewer infections were observed than predicted.

B. MRSA BSI in LTAC and rehabilitation hospitals

We reported key MRSA BSI measures for LTAC hospitals (MRSA BSI Table 3) and free-standing rehabilitation acute care hospitals and rehabilitation units with their own CMS certification number (CCN) (MRSA BSI Table 4). Measures included the numbers of HO MRSA BSI LabID events and inpatient days, unadjusted HO MRSA BSI incidence rates per 10,000 inpatient days, and 95% confidence intervals assuming an exact Poisson distribution [7]. The incidence rate calculation and comparison methodologies were similar to those for VRE BSI, shown in the next section.

C. *VRE BSI in general acute care hospitals*

There are no accepted methods for risk adjusting or stratifying VRE BSI incidence rates and no published national benchmarks. CDPH sorted hospitals into categories that reflected their patients' severity of illness and other factors that can affect their infection risk, such as age, average length of hospitalization, and the type of care received. Specifically, we stratified hospitals into six categories, major teaching, LTAC, pediatric, rehabilitation, critical access, or community. The community hospital category includes specialty hospitals such as surgery and oncology [cancer treatment] hospitals. The stratification method used by CDPH has not been used elsewhere for evaluating or reporting VRE BSI incidence rates.

We presented the California pooled mean (average) rate for each hospital category and the percentile distribution of hospital-specific rates for each hospital category (VRE BSI Table 5). We reported the number of HO VRE BSI LabID events, case mix indices (CMI) when available, inpatient days, unadjusted HO VRE BSI rates per 10,000 inpatient days, and 95% confidence intervals assuming an exact Poisson distribution [7].

CDPH calculated the HO Incidence rate for each hospital that reported VRE BSI data for all 12 months of the reporting period:

$$HO\ Rate\ per\ 10{,}000\ inpatient\ days\ = \frac{Number\ of\ HO\ Cases}{Total\ Inpatient\ Days} \times 10{,}000$$

The rate numerators were VRE BSI LabID events categorized as HO. The rate denominators were total inpatient days for all inpatient locations. We used 10,000 as the multiplier to yield whole numbers or large fractions because BSI rates are generally low. We also calculated the statewide pooled mean (average) rate for each hospital category by dividing the sum of all HO VRE BSI LabID events by the sum of all inpatient days and multiplying by 10,000.

We used the 95% confidence interval to compare each hospital-specific rate with the pooled mean rate (average rate) of the hospital's category. The calculated 95% confidence interval determined if the calculated infection rate was significantly different from the pooled mean rate. A hospital-specific VRE BSI rate was considered 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 considered 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 considered no different than the pooled mean rate if the hospital's confidence interval contained the pooled mean rate. For example, the rate for a single community hospital was 2.15 VRE BSI cases per 10,000 patient days and its 95% confidence interval was 1.14, 3.67. The confidence interval showed that the hospital's rate could have been anywhere between 1.14 and 3.67 VRE BSI cases per 10,000 patient days. The 2015 statewide pooled mean rate for community hospitals was 0.28 VRE BSI cases per 10,000 patient days. Thus, the 1.14 lower bound of the hospital's confidence interval being higher than the statewide average rate of 0.28 made the hospital's rate statistically higher than the state average rate for the community hospital category.

For a measure of the severity of illness in hospital patient populations, we used CMI published by the California Office of Statewide Health Planning and Development (OSHPD) for fiscal year 2014 (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 and not for campuses that reported under a consolidated hospital license. The CMI provided a useful reference point when examining individual hospital VRE BSI rates as it indicated whether a hospital served patients with higher or lower severity of illness. Severity of illness was one factor associated with a hospital having a higher or lower VRE BSI rate when compared with the pooled mean. For example, a hospital caring for patients with higher severity of illness could be predicted to have higher VRE BSI rates. 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

In 2012, NHSN developed a standardized MRSA BSI risk-adjustment method to account for differences in significant risk factors among general acute care hospitals [6]. NHSN excluded LTAC and rehabilitation hospitals from the MRSA BSI risk adjustment and SIR analyses because too few LTAC and rehabilitation hospitals reported MRSA BSI data during the 2010-2011 baseline period. NHSN has not developed a method for risk adjusting VRE BSI incidence data. Therefore, CDPH presented unadjusted MRSA BSI rates for LTAC and rehabilitation hospitals, and unadjusted VRE BSI rates for all hospitals. These rates may not be comparable between hospitals.

The MRSA BSI SIR adjusted for significant risk factors that influenced MRSA BSI rates in hospitals, specifically, CO admission prevalence rate, facility bed size, and medical school affiliation. Hospital MRSA BSI incidence may also differ due to other factors not included in the NHSN risk adjustment model, such as different patient populations with different risks for infection, and differences in clinical and infection control practices among hospitals.

Differences in unadjusted VRE BSI rates, and unadjusted MRSA BSI rates for LTAC and rehabilitation hospitals/units, may have resulted from differences in laboratory methods and testing protocols, patient populations, infection and transmission prevention practices, antibiotic utilization, and/or CO rates. Hospital HAI rates may also differ due to patient populations with different infection risks such as age.

CDPH stratified VRE BSI rates by hospital categories to make the rates more comparable. However, we also recommend caution when making comparisons. The data were not adjusted to account for different patient populations and different levels of risk among hospitals within each category. Some hospitals had significantly higher or lower rates when compared with other hospitals in their respective categories. We presented the CMI to explain some of the differences in severity of illness in patient populations among hospitals. However, the CMI does not explain all rate differences and may not adequately represent the severity of illness in all hospitals.

CDPH recommends caution if comparing the 2015 MRSA/VRE BSI data with previous years' data because 2015 data were affected by the following surveillance improvements and changes:

- Data validation improved the quality of the data reported by California hospitals and the quality of this CDPH annual report. Validation conducted by CDPH in 2014 and 2015 was designed to help hospitals assess and improve HAI reporting. These validation efforts appear to have been successful, as indicated by more HAIs being reported in 2015 than in previous years. CDPH now has greater assurance that this annual HAI public report reflects that all California hospitals are performing standardized surveillance and are accurately and completely reporting their infections. Hospitals need accurate and complete HAI data to know their true infection incidence, to implement targeted interventions, and to track HAI prevention progress over time.

- NHSN changed how hospitals report infections identified in the emergency department and 24-hour hold units. In past years, a positive MRSA BSI, VRE BSI, or CDI lab test result from a patient in the hospital emergency department or 24-hour hold location was attributed to an inpatient community-onset infection if the patient was admitted to the hospital on the same day that the test was ordered. In 2015, MRSA/VRE BSI test results from these locations are no longer included in the hospital's inpatient community-onset prevalence (even if the patient is admitted to the hospital). Because community-onset prevalence is an important risk adjustment factor used in the reporting of MRSA BSI data, hospitals that report fewer

inpatient community-onset cases will have fewer predicted hospital-onset infections. Thus, this NHSN change contributed to calculated MRSA BSI incidence being higher than in previous years, as compared with the number of infections predicted by the national baseline data.

- HAI are less common in inpatient rehabilitation and psychiatric facilities. In 2015, NHSN required hospitals with inpatient rehabilitation and inpatient psychiatric units to report data separately from other general acute care hospital data. Rehabilitation and psychiatric patient days were no longer included in the overall hospital-wide patient days reported for 2015. This NHSN change contributed to higher calculated MRSA/VRE BSI incidence for some hospitals, compared with previous years' incidence estimates.

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