Title

Inclusion of 30-Day Postdischarge Detection Triples the Incidence of Hospital-Onset Methicillin-Resistant Staphylococcus aureus

Journal

Infection Control and Hospital Epidemiology, 33(2)

ISSN

0899-823X

Authors

Avery, Taliser R

Kleinman, Ken P

Klompas, Michael

et al.

Publication Date

2012-02-01

DOI

10.1086/663714

ORIGINAL ARTICLE

Inclusion of 30-Day Postdischarge Detection Triples the Incidence of Hospital-Onset Methicillin-Resistant *Staphylococcus aureus*

Taliser R. Avery, MS;[1] Ken P. Kleinman, ScD;[1] Michael Klompas, MD, MPH;[1]
Ann Aschengrau, ScD, MS;[2] Susan S. Huang, MD, MPH[3]

(See the commentary by Schweizer and Rubin, on pages 122–123.)

BACKGROUND. Hospitalized patients are at increased risk for acquisition of methicillin-resistant *Staphylococcus aureus* (MRSA). As hospital length of stay shortens, hospital-acquired MRSA events may be more likely to be detected after discharge.

OBJECTIVE. We assessed the impact of attributing MRSA cases discovered within 30 days after discharge to the most recent hospitalization and identified patient characteristics associated with MRSA detection after discharge.

DESIGN. Retrospective cohort study.

SETTING. Twenty-seven acute care hospitals in Orange County, California.

PARTICIPANTS. Adult acute care admissions (2002–2007).

METHODS. Using a countywide hospital data set containing diagnostic codes with present-on-admission (POA) indicators, we identified the first admission with a MRSA code for each patient. This incident MRSA admission was defined as predischarge-detected (pre-DD) hospital-onset MRSA (HO-MRSA) when MRSA was not POA. If MRSA was POA and a prior admission occurred within 30 days, this prior admission was assigned postdischarge-detected (post-DD) HO-MRSA. We evaluated the impact of including post-DD HO-MRSA in the calculation of hospital HO-MRSA incidence using signed-rank tests and reviewed changes in hospital rankings. We conducted multivariate comparisons of patient characteristics of pre-DD versus post-DD HO-MRSA patients.

RESULTS. Among 1,217,253 at-risk hospitalizations, the inclusion of post-DD HO-MRSA tripled the median hospital HO-MRSA incidence, from 12.2 to 35.7 cases per 10,000 at-risk admissions ($P < .0001$). Hospital ranking changed substantially when including post-DD HO-MRSA. Patients with shorter stays were more likely to have post-DD MRSA.

CONCLUSIONS. On the basis of administrative claims data, the inclusion of post-DD HO-MRSA significantly increased the estimated HO-MRSA incidence and altered hospital rankings. This finding underscores the limitations of single-facility data when deriving HO-MRSA incidence and rank.

Infect Control Hosp Epidemiol 2012;33(2):114-121

Methicillin-resistant *Staphylococcus aureus* (MRSA) continues to garner national attention as an important source of healthcare-associated infections, with an estimated 278,000 hospitalizations associated with MRSA and 19,000 attributable deaths each year in the United States.[1] The current literature estimates that 5%–7% of hospitalized patients harbor MRSA, with much higher estimates in intensive care unit and nursing home settings.[2-5]

The Centers for Disease Control and Prevention (CDC) defines healthcare-associated MRSA as acquisition that occurs during a stay at a healthcare facility. The CDC recognizes, however, that regardless of where a patient acquires MRSA detection may take place after the patient leaves the acquisition site. Thus, the CDC parses healthcare-associated events into 2 groups: hospital-onset MRSA (HO-MRSA), which is acquired and detected during a hospital admission, and healthcare-associated community-onset MRSA (HACO-MRSA), which is detected on readmission and indicates acquisition during a healthcare exposure within the prior year.[6] HACO-MRSA detection represents 69% of all known healthcare-associated MRSA infections but is rarely tracked back to the hospital where the acquisition most likely occurred.[6] Attributing these HACO-MRSA detections to the prior hospitalization as postdischarge-detected (post-DD) HO-MRSA

Affiliations: 1. Department of Population Medicine, Harvard Medical School and Harvard Pilgrim Health Care Institute, Boston, Massachusetts; 2. Department of Epidemiology, School of Public Health, Boston University, Boston, Massachusetts; 3. Division of Infectious Diseases and Health Policy Research Institute, University of California, Irvine, School of Medicine, Irvine, California.

Received August 15, 2011; accepted October 17, 2011; electronically published December 23, 2011.

 0899-823X/2012/3302-0003$15.00. DOI: 10.1086/663714

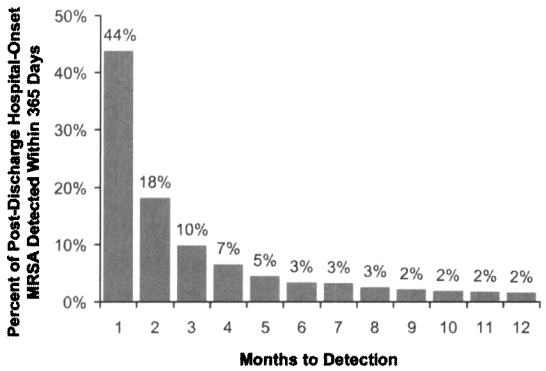

FIGURE 1. Bar graph displaying the proportion of postdischarge-detected methicillin-resistant *Staphylococcus aureus* (MRSA) cases by time since hospital discharge. Proportion is among cases detected within 365 days after discharge.

may result in substantially different estimates of hospital HO-MRSA risk.

Given that as a national standard hospital infection control programs ascertain acquisition rates of multidrug-resistant organisms in their facilities, including MRSA, the measurement and inclusion of post-DD HO-MRSA may play an important role in a hospital's assessment of MRSA risk.[7,8] Current surveillance methods do not take into account postdischarge events, and thus hospitals may be underestimating their risk of HO-MRSA acquisition. In addition, the proportion of unreported post-DD HO-MRSA may vary across hospitals. If so, lack of accounting for postdischarge events may impact the validity of interhospital comparisons and rankings.

The purpose of this study was to assess how inclusion of post-DD HO-MRSA changed the estimated risk of HO-MRSA and to identify the patient characteristics associated with post-DD versus predischarge-detected (pre-DD) HO-MRSA. Understanding the influence of postdischarge detection on HO-MRSA incidence and rankings may inform the validity of self-reported hospital risk in the absence of postdischarge surveillance and help identify high-risk patient groups for prevention and intervention before discharge.

METHODS

We conducted a retrospective cohort study of all adult acute care inpatient hospitalizations in Orange County, California, present in the California mandatory hospital discharge data set from 2002 through 2007.[9] These state-mandated data include line-item detail about each hospitalization and an encrypted identification number that allows tracking of patients across hospitalizations. Data from 2000–2001 were used only to identify patients with a history of MRSA. Data from 2008 were used only for surveillance of MRSA after discharge. Our results are thus based on individuals without a history of MRSA admitted from 2002 through 2007. We included 27 of the 35 hospitals located in Orange County, omitting 3 children's hospitals, 1 physical rehabilitation center, 1 hospital that did not code for MRSA, and 3 hospitals that did not operate for the whole study period. This study was approved by the institutional review boards of the Harvard Pilgrim Health Care Institute, the University of California Regents, and the California Health and Human Services Agency.

Data collection included the following admission characteristics: age, sex, race, ethnicity, insurance (commercial, Medicare, Medicaid, and other), and hospital length of stay. The data set also included up to 25 diagnosis codes from the *International Classification of Diseases, Ninth Revision* (*ICD-9*). Each diagnosis had an associated code designating whether it was present on admission (POA). Prior research with these data found good face validity and consistency for the POA flag across California hospitals.[10,11]

The Romano score, a comorbidity index, was calculated for each admission using diagnosis codes from admissions within the prior year.[12-14] This score was categorized as 0, 1–4, or 5 or above, as in previous studies.[15] We additionally assessed individual components of the Romano score, including the presence of diabetes, renal disease, liver disease, or cancer during the current admission. We also identified whether patients underwent surgery during the admission or 30 days before the admission.

MRSA was identified using any diagnosis location with an *ICD-9* code of 041.11 (*S. aureus* bacterial infection), 038.11 (*S. aureus* septicemia), or 482.41 (*S. aureus* pneumonia) when paired with the V09.0 (antibiotic resistance) code.[16-19] Previous studies have shown that *ICD-9* codes have relatively poor specificity and sensitivity for identifying MRSA infection;[20,21] however, claims data are used for national estimates of MRSA infections and numerous studies.[1,16-19] Few data exist regarding the validation of *ICD-9* codes for the identification of MRSA carriage, which encompasses either infection or colonization, and it is possible that *ICD-9* codes are better suited to identify carriage, the outcome of this study.

Incident MRSA detection was identified by selecting the first admission coding MRSA for each person within the study period. Once incident MRSA was identified, future admissions for that patient were removed from the analysis. To address surveillance bias in the earliest years of our data set, we used 2000–2001 data to exclude patients with a previous history of MRSA. All descriptions that follow exclude individuals with MRSA before the study period.

Among admissions with incident MRSA, the POA flag linked to the V09.0 code was used to differentiate the location of MRSA acquisition. Incident MRSA not present on admission (POA = no) was defined as HO-MRSA that was pre-DD HO-MRSA.

Conversely, incident MRSA present on admission (POA = yes) indicated that the patient had acquired MRSA at a previous location. If the patient had any prior hospitalizations within 30 days of the MRSA diagnosis, the most recent of these prior hospitalizations was categorized as having a post-

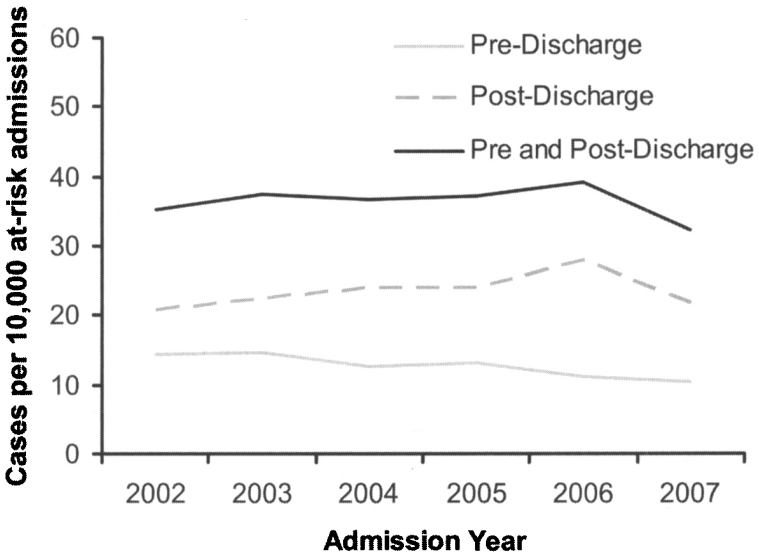

FIGURE 2. Graph depicting the countywide incidence of hospital-onset methicillin-resistant *Staphylococcus aureus* (MRSA) from 2002 through 2007 in Orange County, California. The solid black line shows the rise in incidence when postdischarge-detected cases are included in incidence estimates.

DD HO-MRSA event. The 30-day time frame was selected to increase the accuracy of assigning postdischarge HO-MRSA events to specific hospitals. However, we also conducted analyses using a 365-day interval consistent with the CDC definition of MRSA acquisition associated with healthcare exposure. Post-DD refers to the 30-day time interval unless otherwise specified. Incident MRSA events with no history of hospitalization found within the past 365 days were categorized as community-associated MRSA (CA-MRSA).

The annual countywide incidence of HO-MRSA across the 27 hospitals was calculated using (*a*) pre-DD HO-MRSA only, (*b*) post-DD HO-MRSA only, and (*c*) pre-DD plus post-DD HO-MRSA. Countywide trends in HO-MRSA per year were evaluated using the Mantel-Haenszel χ^2 test for trend.

We additionally assessed the hospital-specific incidence of MRSA acquisition based on pre-DD HO-MRSA only compared with pre-DD plus post-DD HO-MRSA. The median difference was compared using the Wilcoxon signed-rank test. As a sensitivity analysis, we omitted patients with post-DD HO-MRSA who had a stay at a skilled nursing facility or another acute care setting between the incident POA MRSA detection and previous hospitalization, as indicated by the location after discharge or location before admission. Since public reporting methodology often indicates hospitals in the worst-performing quartile, we display changes in hospital rank as well as in quartile rank.[22]

We conducted bivariate and multivariate comparisons of patient characteristics among pre-DD HO-MRSA patients versus post-DD HO-MRSA patients. These analyses used generalized linear mixed models and accounted for clustering by hospital.[23] Analyses were performed in SAS, version 9.2 (SAS Institute).

RESULTS

From 2002 through 2007, there were a total of 1,217,253 adult admissions after removing admissions that either lacked a unique identification number (118,572 [8%]) or were from patients already identified as having MRSA (27,403 [2%]). We located 15,329 incident MRSA cases during the surveillance period, 13% of which were missing a POA code for the V09 diagnosis and were not evaluated. Future visits for these subjects were omitted.

Of the 13,379 cases with a POA code, 5,302 (40%) were

TABLE 1. Comparison of Hospital-Onset Methicillin-Resistant *Staphylococcus aureus* (HO-MRSA) Incidence (Cases per 10,000 At-Risk Admissions) With and Without Postdischarge-Detected HO-MRSA

HO-MRSA detection time frame	Median (IQR)	Median difference (IQR)	*P*
Predischarge	12.2 (7.9)	Referent	...
Predischarge and 30-day postdischarge	35.7 (17.7)	10.0 (10.7)	<.0001
Predischarge and 365-day postdischarge	66.5 (28.3)	39.3 (15.8)	<.0001

NOTE. IQR, interquartile range.

https://doi.org/10.1086/663714 Published online by Cambridge University Press

TABLE 2. Hospital Rank by Hospital-Onset Methicillin-Resistant *Staphylococcus aureus* (HO-MRSA) Incidence Using Only Predischarge-Detected (Pre-DD) versus Pre-DD and Postdischarge-Detected (Post-DD) HO-MRSA Incidence (Cases per 10,000 At-Risk Admissions)

	Pre-DD HO-MRSA		Pre-DD and post-DD HO-MRSA		
Quartile, hospital	Rank	Incidence	Rank	Incidence	Quartile change
1					
a	1	1.8	1	8.9	
b	2	3.3	5	25.7	
c	3	4.1	2	12.4	
d	4	4.8	3	19.7	
e	5	5.2	7	29.1	
f	6	6.1	8	29.2	1 to 2
g	7	8.3	4	23.5	
2					
h	8	8.7	10	30.9	
i	9	8.9	18	41.5	2 to 3
j	10	9.4	6	26.1	2 to 1
k	11	9.5	9	30.6	
l	12	9.9	17	36.3	2 to 3
m	13	11.3	13	33.0	
n	14	12.2	22	48.7	2 to 4
3					
o	15	12.3	14	35.7	3 to 2
p	16	13.1	12	32.8	3 to 2
q	17	13.3	15	36.0	
r	18	13.4	11	31.3	3 to 2
s	19	15.8	21	46.8	
t	20	16.1	16	36.0	
u	21	16.1	20	44.7	
4					
v	22	17.4	25	55.1	
w	23	17.4	19	42.5	4 to 3
x	24	21.5	24	51.4	
y	25	21.6	23	49.1	
z	26	230.8	27	381.3	
aa	27	253.8	26	341.1	

classified as CA-MRSA. The remaining 8,077 events were classified as HO-MRSA. This included 1,552 (19%) that were pre-DD HO-MRSA, 2,866 (36%) that were post-DD HO-MRSA detected within 30 days after discharge, and 3,659 (45%) that were post-DD HO-MRSA detected between 31 and 365 days. When restricting MRSA events to those identified after discharge, 44% of post-DD HO-MRSA detection occurred within 1 month after discharge (Figure 1). Among post-DD HO-MRSA detected within 30 days after discharge, the median time to detection was 12 days (interquartile range, 15 days). This increased to 38 days (interquartile range, 88 days) when evaluating post-DD HO-MRSA within 365 days.

Countywide, the annual incidence of MRSA for 2002–2007 is reported in Figure 2. Overall, total HO-MRSA (pre-DD and post-DD) remained relatively stable across the years, with a mean of 36.3 and a range of 32.2–39.1 cases per 10,000 at-risk admissions annually ($P = .40$, χ^2 test for trend). However, the pre-DD HO-MRSA incidence decreased significantly from 14.3 to 10.4 cases per 10,000 at-risk admissions ($P < .0001$, χ^2 test for trend), and the post-DD HO-MRSA incidence increased from 20.8 to 27.9 cases per 10,000 at-risk admissions until 2006, when it decreased to 21.7 cases per 10,000 at-risk admissions ($P = .03$, χ^2 test for trend).

Across 2002–2007, the inclusion of post-DD HO-MRSA cases tripled the median HO-MRSA incidence per hospital from 12.2 to 35.7 cases per 10,000 at-risk admissions ($P < .0001$), as shown in Table 1. These results were also significant in the sensitivity analysis, which excluded patients with a stay at a skilled nursing or acute care facility before MRSA detection, showing an increase in HO-MRSA incidence from 12.2 to 26.0 cases per 10,000 at-risk admissions ($P < .0001$).

Table 2 provides a comparison of hospital rankings based on the incidence of HO-MRSA using pre-DD HO-MRSA alone compared with pre-DD plus post-DD HO-MRSA. On average, the incidence increased 3-fold, and the incidence in the top 2 hospitals increased at least 5-fold when including

https://doi.org/10.1086/663714 Published online by Cambridge University Press

TABLE 3. Patient Characteristics and Comparison of Postdischarge-Detected (Post-DD) versus Predischarge-Detected (Pre-DD) Hospital-Onset Methicillin-Resistant *Staphylococcus aureus* (HO-MRSA) Using Clustered Analysis

	All at-risk admissions[a] (n = 1,217,253)	Post-DD HO-MRSA (n = 2,866)	Pre-DD HO-MRSA (n = 1,552)	P
Age				.2
<65 years	710,604 (58)	974 (34)	494 (32)	
≥65 years	506,649 (42)	1,892 (66)	1,058 (68)	
Sex[b]				.6
Female	762,840 (63)	1,352 (47)	724 (47)	
Male	454,407 (37)	1,514 (53)	828 (53)	
Race				.4
White	969,582 (80)	2,388 (83)	1,271 (82)	
Black	26,740 (2)	63 (2)	27 (2)	
Asian	122,565 (10)	240 (8)	141 (9)	
Other	98,366 (8)	175 (6)	113 (7)	
Hispanic ethnicity[c]	199,732 (16)	351 (12)	195 (13)	.4
Insurer type				.6
Commercial	520,626 (43)	548 (19)	280 (18)	
Medicare	486,154 (40)	1,903 (66)	1,063 (68)	
Medicaid	122,129 (10)	248 (9)	124 (8)	
Other	88,344 (7)	167 (6)	85 (5)	
Romano score				.004
≥5	185,170 (15)	1,081 (38)	646 (42)	
1–4	432,555 (36)	1,295 (45)	702 (45)	
0	599,528 (49)	490 (17)	204 (13)	
Diabetes	210,762 (17)	908 (32)	487 (31)	.7
Renal disease	49,861 (4)	327 (11)	170 (11)	.2
Liver disease	24,391 (2)	116 (4)	53 (3)	.3
Cancer	103,049 (8)	351 (12)	197 (13)	.4
Recent surgery	430,780 (35)	1,062 (37)	648 (42)	<.0001
Length of stay				<.0001
≥5 days	428,426 (35)	1,948 (68)	1,439 (93)	
3–4 days	516,311 (42)	625 (22)	76 (5)	
1–2 days	272,516 (22)	293 (10)	37 (2)	
Location before admission				.003
Home	1,138,455 (93)	2,371 (83)	1,147 (74)	
Acute inpatient care	32,780 (3)	155 (5)	221 (14)	
Skilled nursing	20,102 (2)	257 (9)	144 (9)	
Other	25,916 (2)	83 (3)	40 (3)	
Location after discharge[d]				<.0001
Home	888,550 (75)	976 (34)	193 (12)	
Acute inpatient care	26,152 (2)	78 (3)	302 (19)	
Skilled nursing	114,913 (10)	1,159 (40)	495 (32)	
Home health services	103,117 (9)	426 (15)	180 (12)	
Other	56,597 (5)	227 (8)	176 (11)	
Detection at different hospital	...	714 (25)	...	
Location before detection admission				
Home	...	2,242 (78)	...	
Acute inpatient care	...	87 (3)	...	
Skilled nursing	...	464 (16)	...	
Other	...	73 (3)	...	

NOTE. Data are no. (%).

[a] At-risk admissions include admissions before the use of the MRSA code and the admission where the MRSA code is first used (incident MRSA).

[b] Missing for 6 admissions.

[c] Missing for 20,445 admissions.

[d] Missing for 27,924 admissions. For bivariate analysis, 208 pre-DD HO-MRSA patients who died were omitted from the analysis, as patients with post-DD HO-MRSA by definition could not have died at the original admission.

TABLE 4. Clustered Multivariate Analysis of Characteristics Associated with Postdischarge-Detected Hospital-Onset Methicillin-Resistant *Staphylococcus aureus* (HO-MRSA) Compared with Predischarge Detection

	OR (95% CI)	*P*
Recent surgery	0.9 (0.8–1.0)	.06
Romano score		.2
≥5	Referent	
1–4	1.1 (0.9–1.2)	
0	1.2 (1.0–1.5)	
Length of stay		<.0001
≥5 days	Referent	
3–4 days	5.5 (4.3–7.0)	
1–2 days	5.2 (3.7–7.4)	

NOTE. CI, confidence interval; OR, odds ratio.

post-DD HO-MRSA. In addition to the large increase in incidence, there were also substantial changes in hospital ranking. In fact, almost all hospitals changed their individual ranking, and 9 of the 27 hospitals changed quartile rank. The most dramatic shift in quartile rank was a hospital that dropped 8 positions from the second to the fourth quartile.

Patients with post-DD HO-MRSA were very similar to those with pre-DD HO-MRSA in age, insurance provider, race, and ethnicity (Table 3). Patients with post-DD HO-MRSA were less likely to have had recent surgery and were more likely to have minimal comorbidities (Romano score of 0) and a shorter hospital length of stay. For 25% of the post-DD HO-MRSA, the hospital detecting MRSA was different from the hospital where MRSA acquisition was assumed to have occurred. This proportion was similar when evaluating post-DD HO-MRSA within 365 days (data not shown).

In the multivariate model, only length of stay remained significantly associated with post-DD HO-MRSA detection (Table 4). These results did not vary materially when using the outcome of post-DD HO-MRSA within 365 days.

DISCUSSION

In this study, the identification and inclusion of post-DD HO-MRSA, identified within 30 days after discharge, tripled the amount of estimated HO-MRSA. We note that extension of post-DD HO-MRSA assessments to 365 days beyond discharge confirmed that the vast majority of postdischarge detection of MRSA occurred within the first few months after discharge. Since current surveillance methods do not account for postdischarge detection, this indicates that a sizeable portion of HO-MRSA events are not attributed to the hospital where acquisition may have occurred. More comprehensive methods for postdischarge detection of hospital-associated MRSA events may be needed to fully monitor the burden and understand the need for prevention of MRSA acquisition.

In contrast to current hospital surveillance methods for MRSA acquisition, use of claims data from insurer databases or comprehensive state hospitalization databases allows the tracking and monitoring of postdischarge events regardless of where medical care is sought. This is important since 25% of postdischarge MRSA events were detected at a hospital different from the acquisition location. In addition, our data suggest that the detection of hospital-associated MRSA acquisition is increasingly occurring after discharge, with postdischarge detection rising while predischarge detection declines based on claims data alone. This may be due to increasing pressure to shorten hospital length of stay as well as to increasing admission screening practices that newly detect MRSA after a recent hospitalization. If true, this would further support the importance of identifying and validating methods that enable postdischarge surveillance.

Although the validity of ranking on the basis of administrative data is unknown, we found that hospital rankings using this method for HO-MRSA detection shifted substantially when post-DD HO-MRSA was included. A third of hospitals shifted quartile rank. This suggests that claims-based rankings using pre-DD HO-MRSA alone have limited validity and that further research is needed to identify valid methods for hospital assessments that account for both pre- and postdischarge events. Hospitals, public health officials, and consumers should consider the potential impact of postdischarge detection when interpreting reports of HO-MRSA.

We found that having a short length of stay was predictive of post-DD HO-MRSA. This may be because patients who are discharged quickly may not have been observed long enough to have MRSA detected. This could lead to a bias in HO-MRSA hospital rankings whereby hospitals with short lengths of stay misleadingly appear to have consistently lower HO-MRSA rates than hospitals with longer lengths of stay.

This study has several limitations. First, we assumed that when MRSA was detected on readmission, the prior admission within 30 days was the source of that MRSA acquisition. Our finding that most of the postdischarge detections within 30 days occurred within 2 weeks lends credibility to this claim. However, it is possible that the true source of MRSA was community-onset MRSA, admission to another facility before the index admission, or admission to another healthcare facility in the interim between the index admission and readmission. The latter is a particular possibility given that 43% of patients designated as having post-DD MRSA were discharged to a skilled nursing or acute care facility. Nevertheless, even when these cases were removed from the analysis, the incidence of HO-MRSA was still significantly higher when including the remaining post-DD MRSA events.

Second, the use of coded administrative data has limitations in the ascertainment of MRSA. Missing data, such as the lack of a POA code for 13% of incident MRSA cases, may have led to an underestimate of MRSA. In addition, although administrative data have been used for national estimates of MRSA infection and several studies,[1,16-19] *ICD-9* codes have shown poor sensitivity and modest positive pre-

https://doi.org/10.1086/663714 Published online by Cambridge University Press

dictive value for active MRSA infection.[20,21] More research is needed to validate the use of claims data to identify MRSA carriage as opposed to infection.

Furthermore, the sensitivity of identifying patients harboring MRSA is reliant on coding practices, MRSA screening protocols, and clinical culturing practices at each hospital. Differences in capture of MRSA may limit the reliability of hospital ranking as an indicator of hospital performance. For example, hospitals that screen all patients on admission are less prone to mislabel preexisting MRSA colonization as HO-MRSA, whereas hospitals that screen on discharge may identify more HO-MRSA. We presume that screening practices varied from hospital to hospital since state-mandated screening was enacted in California only in January 2009, after our study period.

Finally, this study was specific to Orange County, a large metropolitan county. It may not be representative of other counties. Hospital density and the underlying patient population may play a role in the detection of postdischarge MRSA. Additional studies using regional data sets are needed to replicate these findings.

Overall, this study suggests that inclusion of post-DD HO-MRSA may significantly increase estimated HO-MRSA incidence and substantially influence hospital rank. These results underscore the limitations of using single-facility data to derive HO-MRSA incidence and assign hospital rankings. Regional data sets provide a valuable resource for enhancing detection of postdischarge events and may be an important consideration for surveillance of healthcare-associated pathogens, particularly in states where comprehensive hospitalization data sets exist or when integrated insurer data sets exist in the near future.[24]

ACKNOWLEDGMENTS

We thank Leah Terpstra for her assistance in securing the data.

Financial support. Financial support was provided by the National Institutes of Health's Models of Infectious Disease Agent Study consortium (grant U01 GM76672) and the Centers for Disease Control and Prevention's Prevention Epicenter Program (grant 1U01 CI000344).

Potential conflicts of interest. All authors report no conflicts of interest relevant to this article. All authors submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest, and the conflicts that the editors consider relevant to this article are disclosed here.

Address correspondence to Taliser Avery, MS, Department of Population Medicine, Harvard Medical School and HPHC Institute, 133 Brookline Avenue, 6th Floor, Boston, MA 02215 (taliser_avery@hphc.org).

REFERENCES

1. Klein E, Smith DL, Laxminarayan R. Hospitalizations and deaths caused by methicillin-resistant *Staphylococcus aureus*, United States, 1999–2005. *Emerg Infect Dis* 2007;13(12):1840–1846.
2. Robicsek A, Beaumont JL, Paule SM, et al. Universal surveillance for methicillin-resistant *Staphylococcus aureus* in 3 affiliated hospitals. *Ann Intern Med* 2008;148(6):409–418.
3. Huang SS, Rifas-Shiman SL, Warren DK, et al; Centers for Disease Control and Prevention Epicenters Program. Improving methicillin-resistant *Staphylococcus aureus* surveillance and reporting in intensive care units. *J Infect Dis* 2007;195(3):330–338.
4. Mody L, Kauffman CA, Donabedian S, Zervos M, Bradley SF. Epidemiology of *Staphylococcus aureus* colonization in nursing home residents. *Clin Infect Dis* 2008;46(9):1368–1373.
5. Reynolds C, Quan V, Kim D, et al. Methicillin-resistant *Staphylococcus aureus* (MRSA) carriage in 10 nursing homes in Orange County, California. *Infect Control Hosp Epidemiol* 2011;32(1):91–93.
6. Klevens RM, Morrison MA, Nadle J, et al; Active Bacterial Core Surveillance (ABCs) MRSA Investigators. Invasive methicillin-resistant *Staphylococcus aureus* infections in the United States. *JAMA* 2007;298(15):1763–1771.
7. Community and Healthcare-Associated Infections Reduction Act of 2007, S.2278, 110th Cong, 1st Sess (2007).
8. MRSA Infection Prevention and Patient Protection Act, H.R.2937, 111th Cong, 1st Sess (2009).
9. Office of Statewide Health Planning and Development. *California Inpatient Data Reporting Manual.* 7th ed, version 7.6; September 2011. http://www.oshpd.ca.gov/HID/MIRCal/Text_pdfs/ManualsGuides/IPManual/TofC.pdf. Accessed December 16, 2011.
10. Glance LG, Dick AW, Osler TM, Mukamel DB. Accuracy of hospital report cards based on administrative data. *Health Serv Res* 2006;41(4 Pt 1):1413–1437.
11. Technical Advisory Committee meeting minutes, Office of Statewide Health Planning and Development, April 1, 2008. http://www.oshpd.ca.gov/Boards/CHPDAC/MeetingMinutes/TAC20080811.pdf. Accessed April 8, 2011.
12. Romano PS, Roos LL, Jollis JG. Adapting a clinical comorbidity index for use with ICD-9-CM administrative data: differing perspectives. *J Clin Epidemiol* 1993;46(10):1075–1079.
13. Schneeweiss S, Seeger JD, Maclure M, Wang PS, Avorn J, Glynn RJ. Performance of comorbidity scores to control for confounding in epidemiologic studies using claims data. *Am J Epidemiol* 2001;154(9):854–864.
14. Schneeweiss S, Wang PS, Avorn J, Maclure M, Levin R, Glynn RJ. Consistency of performance ranking of comorbidity adjustment scores in Canadian and U.S. utilization data. *J Gen Intern Med* 2004;19(5 Pt 1):444–450.
15. Huang SS, Placzek H, Livingston J, et al. Use of medicare claims to rank hospitals by surgical site infection risk following coronary artery bypass graft surgery. *Infect Control Hosp Epidemiol* 2011;32(8):775–783.
16. Byrd KK, Holman RC, Bruce MG, et al. Methicillin-resistant *Staphylococcus aureus*–associated hospitalizations among the American Indian and Alaska Native population. *Clin Infect Dis* 2009;49(7):1009–1015.
17. Gerber JS, Coffin SE, Smathers SA, Zaoutis TE. Trends in the incidence of methicillin-resistant *Staphylococcus aureus* infection in children's hospitals in the United States. *Clin Infect Dis* 2009;49(1):65–71.
18. Kuehnert MJ, Hill HA, Kupronis BA, Tokars JI, Solomon SL, Jernigan DB. Methicillin-resistant–*Staphylococcus aureus* hospitalizations, United States. *Emerg Infect Dis* 2005;11(6):868–872. Erratum in: *Emerg Infect Dis* 2006;12(9):1472.
19. McCaig LF, McDonald LC, Mandal S, Jernigan DB. *Staphylo-*

coccus aureus–associated skin and soft tissue infections in ambulatory care. *Emerg Infect Dis* 2006;12(11):1715–1723.

20. Schaefer MK, Ellingson K, Conover C, et al. Evaluation of *International Classification of Diseases, Ninth Revision, Clinical Modification* codes for reporting methicillin-resistant *Staphylococcus aureus* infections at a hospital in Illinois. *Infect Control Hosp Epidemiol* 2010;31(5):463–468.
21. Schweizer ML, Eber MR, Laxminarayan R, et al. Validity of *ICD-9-CM* coding for identifying incident methicillin-resistant *Staphylococcus aureus* (MRSA) infections: is MRSA infection coded as a chronic disease? *Infect Control Hosp Epidemiol* 2011;32(2):148–154.
22. §3008. Payment adjustment for conditions acquired in hospitals. Patient Protection and Affordable Care Act, H.R.3590, 111th Cong, 2nd Sess (2009).
23. Breslow NE, Clayton DG. Approximate inference in generalized linear mixed models. *J Am Stat Assoc* 1993;88:9–25.
24. Behrman RE, Benner JS, Brown JS, McClellan M, Woodcock J, Platt R. Developing the Sentinel System—a national resource for evidence development. *N Engl J Med* 2011;364(6):498–499.