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Authors

Datta, Rupak
King, Melissa Kuo
Kim, Diane
et al.

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What Is Nosocomial? Large Variation in Hospital Choice of Numerators and Denominators Affects Rates of Hospital-Onset Methicillin-Resistant *Staphylococcus aureus*

Rupak Datta, MPH;^{1,a} Melissa Kuo King, MD;^{1,a}
Diane Kim, BS;¹ Christopher Nguyen, MD, MPH;¹
Kristen Elkins, BS;¹ Adrijana Gombosev, BS;¹
Taliser R. Avery, MS;² Hildy Meyers, MD, MPH;³
Michele Cheung, MD, MPH;³
Susan S. Huang, MD, MPH^{1,4}

We calculated hospital-onset methicillin-resistant *Staphylococcus aureus* (HO-MRSA) rates for Orange County, California, hospitals using survey and state data. Numerators were variably defined as HO-MRSA occurring more than 48 hours (37%), more than 2 days (30%), and more than 3 days (33%) postadmission. Survey-reported denominators differed from state-reported patient-days. Numerator and denominator choices substantially impacted HO-MRSA rates.

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Widespread mandates for surveillance and reporting of hospital-onset methicillin-resistant *Staphylococcus aureus* (HO-MRSA) assume that reported rates can and should be compared.^{1,2} However, rate comparisons between hospitals have many caveats. First, case definitions vary. The Centers for Disease Control and Prevention (CDC) definition of health-care-associated events occurring more than 48 hours after admission³ is often operationalized as more than 2 or 3 calendar-days after admission to define cases.^{4,5} Thus, hospitals using more than 3 calendar-days will classify fewer cases as HO-MRSA than those using more than 2 calendar-days.

Beyond variations in numerator definitions, it is widely assumed that patient-day denominators are uniformly measured. This assumption has not been evaluated. We sought to assess this assumption by comparing data collected by our study survey to line-item length-of-stay data from mandatory state-reported discharge data.

Additionally, HO-MRSA rates, typically reported as cases per 10,000 total patient-days, should restrict denominators to when patients are at risk to become a case.^{6,7} For example, if HO-MRSA cases are defined as newly detected MRSA events occurring more than 2 calendar-days after admission, then denominators should exclude the first 2 days of hospitalization because events occurring within 2 days of admission are ineligible to become cases. We also sought to assess how variations in numerator definitions could be mit-

igated by using at-risk patient-days calculated from mandatory state-reported discharge data.

METHODS

We surveyed all 32 acute care hospitals in Orange County, California, for infection prevention program numerator and denominator definitions of HO-MRSA rates. Using hospital-specific definitions, each program provided monthly counts of newly detected HO-MRSA cases (colonization or infection) occurring during a hospitalization or within 2 days of discharge for a consecutive 12-month period between January 1, 2007, and December 31, 2008. Screening cultures were excluded because active MRSA screening was variably implemented across hospitals at the time of the survey. Monthly hospital-wide patient-day denominators were requested to calculate HO-MRSA rates. Patient-day denominators were also obtained from the mandatory California discharge data set,⁸ which includes line-item admission and demographic information from all California hospitals. The Institutional Review Boards of the University of California Regents and California State Committee for the Protection of Human Subjects approved this study.

We assessed the proportion of hospitals using HO-MRSA case definitions occurring more than 48 hours, more than 2 calendar-days, or more than 3 calendar-days after admission. We then compared survey-reported patient-day denominators to those calculated from the mandatory California discharge data set. For hospitals defining HO-MRSA as cases occurring after hospital day 2 or 3, we determined at-risk patient days by summing patient-days after removing the first 2 or 3 days of every admission, respectively, using mandatory state discharge data. For the subset of hospitals using calendar-day definitions, we also calculated annual HO-MRSA incidence density per 10,000 patient-days using survey-reported cases as the numerator and 3 separate denominators: survey-reported and state-reported total patient-days, and state-reported at-risk patient-days.

We calculated the percent difference between hospital-specific survey and state-reported total patient-days and compared these denominators using 2-tailed *t* tests. For the subset of hospitals using calendar-day definitions, we assessed the percent difference between (a) survey-reported and state-reported total patient-days and (b) state-reported total versus at-risk patient-day denominators and HO-MRSA rates using 2-tailed *t* tests.

RESULTS

Of the 32 total hospitals in Orange County, 5 did not respond. Three hospitals did not provide patient-day denominators by survey, and state denominator data were unavailable for 2

additional hospitals. Among the 27 responding hospitals, 10 (37%), 8 (30%), and 9 (33%) hospitals used case definitions of events occurring more than 48 hours, more than 2 calendar-days, and more than 3 calendar-days after admission, respectively. Significant denominator differences were also found between survey-reported patient-days (mean 39,648; median 38,150) and patient-days derived from mandatory California discharge data (mean 49,014; median 41,163) ($n = 22$, paired t test, $P = .02$).

Patient-day denominator discrepancies were common (Table 1). One hospital excluded psychiatric patients, causing survey and state patient-days to differ substantially. Of the remaining hospitals, 17 reported fewer patient-days (range, 4%–165%; median, 21%) in the survey than in the state data set, whereas 4 reported more patient-days (range, 4%–41%; median, 21%). The difference between survey and state-reported total patient-days was accounted for by excluding discharge days (6/22, 27%), psychiatric and rehabilitation admissions (2/22, 9%), or both (6/22, 27%). Differences were unexplained for 8 hospitals (36%).

After excluding 1 hospital with incomplete numerator data, 16 hospitals remained that used calendar-day definitions. For this subset, we assessed HO-MRSA rates using 3 denominator

choices (survey-reported total, state-reported total, and state-reported at-risk patient-days; Table 2). Mean HO-MRSA rates using at-risk patient-days were significantly higher than rates using state-reported total patient-days (mean, 6.5 vs 3.7, paired t test, $P = .002$). Compared to HO-MRSA rates using at-risk patient-days, there was a larger reduction in HO-MRSA rates when using total patient-days for hospitals using a more than 3 calendar-day versus more than 2 calendar-day definition (50% vs 30%, t test, $P = .03$).

DISCUSSION

Despite national attempts at standardization, we found that many hospitals used varying methods of HO-MRSA case finding to comply with CDC recommendations for using a window greater than 48 hours. Across a large metropolitan county, approximately one-third of hospitals each used case definitions of 48 hours, more than 2 calendar-days, and more than 3 calendar-days. These differences in definition are not limited to HO-MRSA and will affect the interhospital comparability of all publicly reported healthcare-associated infections. Our data support the need for a standardized definition for comparisons.

TABLE 1. Descriptive Characteristics of 22 Acute Care Hospitals in Orange County, California, Surveyed for Hospital-Onset Methicillin-Resistant *Staphylococcus aureus* (HO-MRSA)

HO-MRSA definition	Annual admissions	No. of beds	Patient-days		
			Survey	State ^a	% Difference
48 hours	4,000	<150	12,954	15,482	20
	4,000 ^b	<150	38,334	32,558	-15
	7,000	150–250	30,635	35,567	16
	13,000	150–250	46,517	84,412	81
	15,000	>250	66,434	80,583	21
2 calendar-days	2,000	<150	10,049	12,323	23
	3,000	>250	79,557	46,759	-41
	4,000	<150	3,305	33,969	928 ^c
	5,000	<150	14,776	18,595	26
	8,000	150–250	48,312	50,740	5
	11,000	>250	53,813	56,060	4
	15,000	>250	61,076	71,009	16
3 calendar-days	16,000	>250	75,969	105,912	39
	1,000 ^b	150–250	2,514	5,911	135
	2,000	<150	15,410	14,739	-4
	5,000	<150	16,805	19,925	19
	5,000	150–250	37,965	28,090	-26
	10,000	150–250	26,431	66,469	151
	14,000	>250	62,809	88,494	41
	17,000	150–250	43,327	51,095	18
	21,000	150–250	9,534	25,235	165
27,000	>250	115,719	134,377	16	

NOTE. Characteristics shown for adult patients only, except for children's hospitals. Mean survey-reported (39,648) and state-reported total (49,014) patient-days differed (paired t test, $P = .02$).

^a Obtained from the mandatory California hospital data set.⁸

^b Long-term acute care facility.

^c Psychiatric patients were excluded from total patient-days reported by survey, leading to substantial differences between survey and state patient-days.

TABLE 2. Hospital-Onset Methicillin-Resistant *Staphylococcus aureus* (HO-MRSA) Rates at 16 Surveyed Acute Care Hospitals in Orange County, California

Survey patient-days	HO-MRSA rates, per 10,000		% difference, state total	
	State total patient-days ^a	At-risk patient-days ^b	Versus survey rate	Versus at-risk rate
0.4	0.2	0.3	-60	-43
1.0	0.4	0.8	-62	-49
1.3	1.4	2.4	5	-43
1.6	2.1	4.0	35	-47
2.0	1.6	2.6	-18	-37
2.6	2.3	3.9	-14	-42
3.5	2.9	6.0	-15	-51
3.8	3.3	7.4	-14	-56
3.9	3.7	5.4	-5	-30
4.5	7.7	7.2	70	7
4.7	3.8	6.9	-21	-45
5.7	4.1	6.7	-28	-40
6.5	5.5	12.2	-16	-55
8.0	3.4	9.1	-57	-63
18.2	1.8	2.2	-90	-20
22.0	15.6	26.9	-29	-42

NOTE. HO-MRSA rate numerators consisted of survey-reported newly detected HO-MRSA cases per hospital.

^a Total patient-days obtained from mandatory California discharge data set.⁵

^b Adjusted for hospital-specific HO-MRSA definitions. Denominators excluded the first 2 or 3 days of admission in hospitals using >2 or >3 calendar-day definitions, respectively.

Our work not only suggests variation in the collection of denominator-days for healthcare-associated infection rates, but also provides insight into the different ways in which hospital patient-days are calculated. Some hospitals included discharge days and all licensed acute care beds (including psychiatric and rehabilitation beds), whereas others did not. Because hospitals assess daily census at different times of day, this discrepancy will persist despite CDC recommendation to count patients at the same time each day.⁹ Additionally, infection prevention programs were often unaware of how patient-day values were calculated. Surveyed programs reported obtaining denominators for hospital-associated infection reporting from numbers posted on internal websites or received from other departments.

The differences in numerator and denominator choices compared to a uniform strategy of calculating patient-days is germane to the public reporting of nearly all healthcare-associated infections. Although many are familiar with inconsistencies in numerator definitions, widespread discrepancies in patient-day denominators were unexpected. Differences in denominator choice caused an average discrepancy in HO-MRSA rates of 20%, with a maximum discrepancy of 90% in 1 hospital. Consistent with prior reports,^{6,7} adjusting denominators for at-risk patient-days significantly increased HO-MRSA rates. Importantly, the impact of denominator choices on HO-MRSA rates may be magnified by continued reductions in hospital length-of-stay, with over half of hospitalizations of 3 days or more.¹⁰

This study has important limitations. First, we assessed hospitals in only 1 county. Nevertheless, this study is larger than prior work that was limited to single-institution data.⁶ Second, patient-days occurring after conversion to MRSA positivity were not excluded. Finally, it is likely that some case counts represented prevalent carriers. However, this limitation does not affect the study objective.

In summary, we show that use of nonstandardized numerators and denominators for reporting healthcare-associated metrics is widespread and significantly impacts healthcare-associated infection rates. Although internal consistency in numerator and denominator choices can provide hospitals with internal benchmarks for healthcare-associated infection rates, lack of standardization is increasingly problematic in an era of public reporting and interfacility comparisons. The economic and public opinion implications of hospital rates for healthcare-associated infection make the use and implementation of standard definitions critical for healthcare facilities and future comparative research.

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Affiliations: 1. Division of Infectious Diseases and Health Policy Research Institute, University of California Irvine School of Medicine, Irvine, California; 2. Department of Population Medicine, Harvard Medical School and Harvard Pilgrim Health Care, Boston, Massachusetts; 3. Epidemiology and Assessment, Orange County Health Care Agency, Santa Ana, California; 4. Channing Laboratory, Brigham and Women's Hospital and Harvard Medical School, Boston, Massachusetts.

Address correspondence to Rupak Datta, MPH, University of California Irvine School of Medicine, Health Policy Research Institute, 100 Theory, Suite 110, Irvine, CA 92697 (rdatta@uci.edu).

^a These authors contributed equally to this work.

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