ORIGINAL ARTICLE

The Impact of Methicillin-Resistant *Staphylococcus aureus* (MRSA) and Vancomycin-Resistant Enterococcus (VRE) Flags on Hospital Operations

Erica S. Shenoy, MD, PhD;[1,2,3,4] Hang Lee, PhD;[5] Taige Hou, MS;[3] Winston Ware;[6] Erin E. Ryan, MPH;[3] David C. Hooper, MD;[1,2,4,a] Rochelle P. Walensky, MD,MPH[2,3,4,a]

OBJECTIVE. To determine the impact of methicillin-resistant *Staphylococcus aureus* and vancomycin-resistant Enterococcus (MRSA/VRE) designations, or flags, on selected hospital operational outcomes.

DESIGN. Retrospective cohort study of inpatients admitted to the Massachusetts General Hospital during 2010–2011.

METHODS. Operational outcomes were time to bed arrival, acuity-unrelated within-hospital transfers, and length of stay. Covariates considered included demographic and clinical characteristics: age, gender, severity of illness on admission, admit day of week, residence prior to admission, hospitalization within the prior 30 days, clinical service, and discharge destination.

RESULTS. Overall, 81,288 admissions were included. After adjusting for covariates, patients with a MRSA/VRE flag at the time of admission experienced a mean delay in time to bed arrival of 1.03 hours (9.63 hours [95% CI, 9.39–9.88] vs 8.60 hours [95% CI, 8.47–8.73]). These patients had 1.19 times the odds of experiencing an acuity-unrelated within-hospital transfer [95% CI, 1.13–1.26] and a mean length of stay 1.76 days longer (7.03 days [95% CI, 6.82–7.24] vs 5.27 days [95% CI, 5.15–5.38]) than patients with no MRSA/VRE flag.

CONCLUSIONS. MRSA/VRE designation was associated with delays in time to bed arrival, increased likelihood of acuity-unrelated within-hospital transfers and extended length of stay. Efforts to identify patients who have cleared MRSA/VRE colonization are critically important to mitigate inefficient use of resources and to improve inpatient flow.

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Methicillin-resistant *Staphylococcus aureus* (MRSA) and vancomycin-resistant enterococci (VRE) are endemic in hospital settings and long-term care facilities, and the prevalence of colonization is increasing.[1,2] When admitted to hospitals, it is recommended that patients with a MRSA/VRE designation be placed in either a single-occupancy room or cohorted with another patient with the same designation in a double-occupancy room.[3,4] Few studies estimate the operational impact of MRSA/VRE designation, though limited studies based on either survey data or small retrospective studies suggest that the MRSA/VRE label may affect patient movement in the hospital through delays in bed assignments[5,6] and within-hospital transfers[7] as well as disposition through delayed discharge to post-acute care facilities.[8,9] In hospitals with double-occupancy accommodations, the additional requirement to match patients with MRSA/VRE designation can introduce inefficiencies when ready matches are not available and patients must queue. In institutions with uniformly single-occupancy accommodations, the impact of MRSA/VRE designation remains relevant through discharge disposition and costs of implementing contact precautions. We assembled a large data repository to examine the association between MRSA/VRE designation and time to bed arrival, acuity-unrelated within-hospital transfers, and length of stay. We hypothesized that these measures of operational efficiency would be adversely affected by the MRSA/VRE designation.

METHODS

Data Sources and Variables

In this study, we utilized a novel data warehouse created by merging several clinical and administrative databases to generate

Affiliations: 1. Infection Control Unit, Massachusetts General Hospital, Boston, Massachusetts; 2. Division of Infectious Diseases, Department of Medicine, Massachusetts General Hospital, Boston, Massachusetts; 3. Medical Practice Evaluation Center, Massachusetts General Hospital, Boston, Massachusetts; 4. Harvard Medical School, Boston, Massachusetts; 5. Department of Biostatistics, Massachusetts General Hospital, Boston, Massachusetts; 6. Clinical Care Management Unit, Massachusetts General Hospital, Boston, Massachusetts.

[a]Authors with equal contribution.

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complete records for inpatient admissions to the Massachusetts General Hospital (MGH) during 2010–2011, including MRSA/VRE flag status on admission, age, gender, residence, recent hospitalizations, admitting clinical service, discharge destination, and length of stay in each patient location.

Hospital Structure

Between January 2010 and September 2011, MGH had 782 adult licensed beds (excluding obstetrics and psychiatry). Overall, 6 adult intensive care units (ICUs) accounted for 98 single-occupancy beds (64 surgical, 34 medical); 2 step-down units accounted for 57 beds; 23 general care units accounted for 613 beds (294 surgical, 319 medical); and an observation unit accounted for 14 beds. All ICUs feature only single-occupancy rooms. Outside of ICUs, 31% of beds were single occupancy and the remainder were double occupancy. In September 2011, a new inpatient building opened, increasing the number of adult licensed beds by 26 to 808 (excluding obstetrics and psychiatry). The overall proportion of double-occupancy rooms decreased from 60% to 50% for the final 4 months of the study; thus, overall hospital occupancy remained stable. MGH operates at occupancy levels well above national esimates[10] and those of other academic teaching hospitals.[11]

Study Sample

The study sample was restricted to adult medical, surgical, and observation inpatient encounters completed during the 2010–2011 study period (N = 81,288; Figure 1).

MRSA/VRE Flags

Patients with a MRSA/VRE flag on admission were identified (or "flagged") within the hospital's electronic health record (EHR). Flag status was defined by an absent or present flag within 48 hours of admission. Patients flagged after 48 hours were considered to be in the no-flag category. The institutional policy for active surveillance included culture-based surveillance on admission for MRSA and VRE for ICU patients and those admitted to specific high-risk units. Although a hospital protocol was in place for screening and deflagging both MRSA- and VRE-flagged patients, both were implemented infrequently.[12]

Study Outcomes

We assessed 3 statistical outcomes of interest: (1) mean time to bed arrival, (2) the likelihood of experiencing acuity-unrelated within-hospital transfers, and (3) mean length of stay. The adjusted geometric means were reported to reflect the non-normal distribution for time to bed arrival and length of stay.

Time to Bed Arrival. Time to bed arrival was defined as the time (in hours) until a patient reached his or her first inpatient bed. The first stamp recorded for patients entering the bed queue was considered to represent the beginning of this process. For emergency department (ED) patients, postoperative patients, direct admission, and transfer patients, these times corresponded to registration in the ED, time of admission to the post-anesthesia care unit, arrival in the admissions office, and registration and initiation of bed placement prior to physical transfer, respectively. The statistical summary outcome for this variable was mean time to bed arrival in hours.

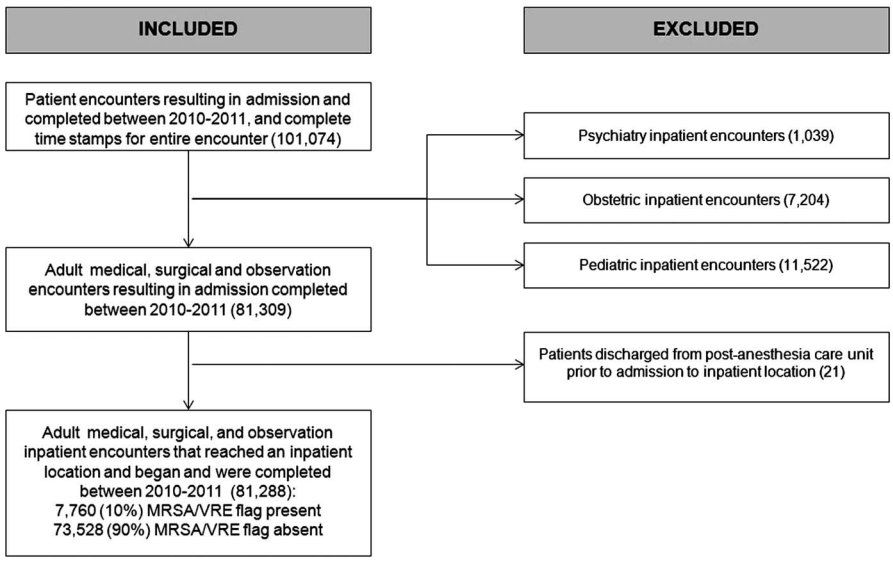

FIGURE 1. Flow diagram of patient inclusion for analyses. The data warehouse includes all patient encounters at the Massachusetts General Hospital between 2010 and 2011. A subset of the cohort, inclusive of all patient encounters resulting in admissions completed between January 1, 2010, and December 31, 2011, for which complete time stamps were available documenting patient movement, were included in the analyses. The final sample excluded patients admitted to inpatient psychiatry, obstetric, and pediatric services as well as patients who were discharged to home directly from a post-anesthesia care unit.

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Within-Hospital Transfers. Within-hospital transfers were defined as a physical move from one inpatient hospital location to another. Acuity-unrelated transfers were identified as 2 consecutive inpatient beds matching in acuity level (ie, a transfer not resulting from a change in acuity level). Transfers were defined as a binary variable, categorizing each patient encounter as having experienced or not having experienced any acuity-unrelated transfer. Acuity-related transfers were not included in this analysis because the odds of experiencing such moves are dominated by acuity on admission (data not shown). In this analysis, we focused on acuity-unrelated transfers because this phenomenon encompasses efforts to optimize the use of single- and double-occupancy accommodations. The statistical summary outcome presented was likelihood of experiencing any acuity-unrelated transfer.

Patient Length of Stay. Length of stay is number of days a patient remains in the hospital from arrival in his or her initial bed to discharge. The statistical summary outcome for this variable was mean length of stay in days.

Study Predictors

The primary predictor of interest was MRSA/VRE flag status. Patients were categorized having a MRSA/VRE flag on admission or no flag for MRSA/VRE on admission. A flag for MRSA, VRE, or both, were grouped together as having a MRSA/VRE flag. Covariates, many of which were included in multivariate models to account for patient severity of illness during the hospitalization, included age, gender, severity of illness (acuity) on admission, admission day of week, residence, hospitalization at the same institution within previous 30 days, admitting clinical service, and discharge destination. Acuity on admission was inferred from the patient's initial admission location: observation unit, general care unit, step-down unit, or intensive care unit (ICU). This proxy measure of patient severity of illness was utilized because it corresponded most readily to staffing levels and available support services that are considered indicators of patient acuity. Residence was noted as either home or facility. Prior hospitalization in the preceding 30 days was included as well as a proxy for patient severity of illness. Admitting clinical service was defined as either surgical or medical. Discharge destination was categorized as home, a facility, or deceased and was considered an additional proxy measure of patient severity of illness.

Statistical Analysis

Baseline characteristics of the cohort were summarized using counts and proportions, mean ± standard deviation, or median with lower and upper quartiles, as appropriate. Univariate models were initially fit to describe the unadjusted associations between MRSA/VRE flag status and each of the study outcomes, and these associations were adjusted, by multivariate models, for the impacts of the covariates. For the adjusted analyses, associations of MRSA/VRE status with the likelihoods of transfer was modeled using multivariate logistic models, and those with length of stay and time to bed arrival were modeled using exponential models for time-to-event outcomes, and least-squares means (LSMEANS) were reported.[13]

RESULTS

Patient and Admission Characteristics

Of 81,288 patient admissions included in the analysis, 7,760 (10%) were admitted with a flag and 73,528 (90%) were admitted with no flag (Table 1). The majority of admissions were through the ED (65%), followed by PACU (25%), direct admissions (6%), and transfers (4%). The route of admission did not influence the study outcomes (data not shown). Patients with a flag at admission were less often female (43% vs 49%) and were older (64 vs 60 years) than patients without a flag. Compared with patients without flags, a larger proportion of flagged patients were admitted to an ICU (12% vs 8%), were admitted from a facility (19% vs 10%), were hospitalized at the same institution within the previous 30 days (39% vs 19%), were admitted to a medical rather than surgical service (65% vs 53%), were discharged to a facility (19% vs 15%), or died during their hospitalization (5% vs 2%). Patients with flags had a longer mean time to bed arrival (10 ± 7 vs 9 ± 6 hours) compared with patients without flags. A larger proportion of flagged patients experienced any within-hospital transfer (39% vs 30%). Flagged patients had more of both acuity-related within-hospital transfers (19% vs 16%) and acuity-unrelated transfers (27% vs 20%) compared with those without a flag. Patients with a flag had a longer total mean length of stay (7 ± 8 days vs 5 ± 6 days) and length of stay spent in mixed-occupancy units (6 ± 7 days vs 4 ± 5 days).

Factors Influencing Time to Bed Arrival

In the unadjusted model, patients with a flag on admission experienced an excess mean time to bed arrival of 47 minutes (10.14 hours [95% CI, 9.92–10.37] vs 9.36 hours [95% CI, 9.29–9.43]). In the multivariate model, flagged patients had an excess mean time to bed arrival of 62 minutes (9.63 hours [95% CI, 9.39–9.88] vs 8.60 hours [95% CI, 8.47–8.73]) compared with patients with no flag for MRSA/VRE (Table 2). This effect exceeded the estimated impact of gender, age, day of week of admission, residence prior to admission, and recent hospitalization. Patient severity of illness on admission, and admitting clinic service were associated with significant and substantial effects on time to bed arrival. Among acuity levels, the time to bed arrival for step-down unit beds was the longest, at 14.71 hours. Patients requiring surgical beds experienced close to a 2-hour delay in bed arrival compared with patients awaiting medical beds.

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TABLE 1. Patient Cohort Characteristics (N = 81,288)

	Overall Patients, No. (%)	MRSA/VRE Flag Status, No. (%)	
		MRSA/VRE Flag[a]	No flag for MRSA/VRE
Patients	81,288	7,760 (10)	73,528 (90)
Gender, No. (% female)	39,596 (49)	3,352 (43)	36,244 (49)
Age, y (mean ± SD)	60 ± 18	64 ± 18	60 ± 18
Severity of illness (acuity) on admission, No. (%)			
Observation unit	12,395 (15)	599 (8)	11,796 (16)
General care unit	55,582 (68)	5,780 (74)	49,802 (68)
Step-down unit	6,196 (8)	457 (6)	5,739 (8)
Intensive care unit	7,115 (9)	924 (12)	6,191 (8)
Residence prior to admission, No. (%)			
Home	72,514 (89)	6,272 (81)	66,242 (90)
Facility	8,774 (11)	1,488 (19)	7,286 (10)
Hospitalization within previous 30 d, No. (%)	16,921 (21)	3,033 (39)	13,888 (19)
Clinical service, No. (%)			
Surgical	36,966 (45)	2,688 (35)	34,278 (47)
Medical	44,322 (55)	5,072 (65)	39,250 (53)
Discharge destination, No. (%)			
Home	66,479 (82)	4,852 (63)	61,627 (84)
Facility	13,242 (16)	2,541 (19)	10,701 (15)
Death	1,567 (2)	367 (5)	1,200 (2)
Time to bed arrival, h[b]			
Mean ± SD	9 ± 7	10 ± 7	9 ± 6
Geometric mean	8	8	8
Median (25^{th}–75^{th} percentiles)	8 [5–11]	8 [5–12]	8 [5–11]
Occurrence of within-hospital transfers, No. (%)[b]			
No transfers	56,036 (69)	4,756 (61)	51,280 (70)
Any transfers[c]	25,252 (31)	3,004 (39)	22,248 (30)
Acuity-related transfers	13,050 (16)	1,475 (19)	11,575 (16)
Acuity-unrelated transfers	16,566 (20)	2,126 (27)	14,440 (20)
Length of stay, d[b]			
Total			
Mean ± SD	5 ± 6	7 ± 8	5 ± 6
Geometric mean	3	5	3
Median (25^{th}–75^{th} percentiles)	3 [1–6]	5 [3–9]	3 [1–5]
Spent in double-occupancy units			
Mean ± SD	4 ± 5	6 ± 7	4 ± 5
Geometric mean	2	4	2
Median (25^{th}–75^{th} percentiles)	3 [1–5]	4 [2–8]	2 [1–5]

NOTE. MRSA, methicillin-resistant *Staphylococcus aureus*; vancomycin-resistant Enterococcus; SD, standard deviation.

[a]Of the 7,760 patients (10%) with an MRSA/VRE flag, 2,949 (38%) had a history of MRSA, 3,181 (41%) had a history of VRE, and 1,630 (21%) had a history of both MRSA and VRE.

[b]There was no significant difference in time to bed arrival, occurrence of within-hospital transfers or length of stay during the study period prior to the new inpatient building opening (January 1, 2010 through September 7, 2011) and afterward (September 8, 2011 through December 31, 2011).

[c]Patients contributing to the frequency of "Any transfers" may contribute to either OR both of the "Acuity-related transfers" or "Acuity-unrelated transfers" categories.

Factors Influencing Within-Hospital Transfers

Patients with a MRSA/VRE flag on admission had odds of 1.55 (95% CI, 1.47–1.36) for experiencing an acuity-unrelated transfer compared with patients without the flag in the unadjusted model. In the multivariate model, flagged patients had odds of 1.19 (95% CI, 1.13–1.26) for experiencing an acuity-unrelated transfer compared with patients with no flag for MRSA/VRE (Table 3). Considering patients admitted to general care units as the referent population, the odds of experiencing such transfers were similar to that of patients admitted to ICUs (1.24 [95% CI, 1.16–1.31]), although these

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TABLE 2. Factors Influencing Time to Bed Arrival

Factors	LS Mean Time to Bed Arrival, h (95% CI)[a]	Adjusted Increase in Time to Bed Arrival, Compared With Referent Group[b]	*P* Value
MRSA/VRE Flag Status			
MRSA/VRE Flag[c]	9.63 (9.39–9.88)	62 min	<.0001
No flag for MRSA/VRE	8.60 (8.47–8.73)	Reference	
Gender			
Female	9.29 (9.12–9.47)	23 min	<.0001
Male	8.92 (8.76–9.08)	Reference	
Age			
<65 y	9.29 (9.12–9.46)	22 min	<.0001
≥65 y	8.92 (8.76–9.09)	Reference	
Acuity on admission			
Observation unit	6.25 (6.10–6.41)	Reference	<.0001
General care unit	10.20 (10.04–10.37)	4 h	
Step-down unit	14.71 (14.29–15.15)	8 h 30 min	
Intensive care unit	7.31 (7.12–7.51)	1 h	
Admission day of the week			
Weekday (M–F)	9.37 (9.21–9.53)	32 min	<.0001
Saturday/Sunday	8.84 (8.66–9.03)	Reference	
Residence prior to admission, home			
No	9.12 (8.90–9.34)	2 min	0.7666
Yes	9.09 (8.94–9.23)	Reference	
Hospitalization within previous 30 d			
No	9.03 (8.88–9.19)	Reference	0.0864
Yes	9.17 (8.98–9.36)	8 min	
Admitting inpatient service			
Surgical	10.14 (9.94–10.34)	2 h	<.0001
Medical	8.17 (8.03–8.32)	Reference	

NOTE. LS, Least-Squares; MRSA, methicillin-resistant *Staphylococcus aureus*; vancomycin-resistant Enterococcus;
[a]LS mean time to bed arrival: the multivariate model based on predicted mean, the average of predicted marginal mean over the classes of the simultaneously controlled covariates. Unadjusted observed means for MRSA/VRE flag status were 10.14 hours [95% CI, 9.92–10.37] for patients with a flag and 9.36 hours [95% CI, 9.29–9.43] for patients with no flag, which is an adjusted increase of 47 minutes for patients with a flag on admission (data not shown).
[b]Length of delay was rounded to the nearest integer.
[c]MRSA flag, VRE flag, and both MRSA and VRE flag were associated with an excess mean time to bed arrival of 55 min, 51 min, and 95 min, compared with patients with no flag, respectively.

odds were less than those attributable to admission to a step-down unit (1.41 [95% CI, 1.32–1.5]). Clinical service had minimal influence on acuity-unrelated transfers. Considering patients discharged to home as the referent population, the odds of experiencing an acuity-unrelated transfer were 2.23 (95% CI, 2.13–2.33) for patients ultimately discharged to a facility. Because patients with longer lengths of stay are expected to have a greater likelihood of experiencing an acuity-unrelated transfer, we stratified the analysis by encounters with length of stay in double-occupancy units (ie, the time during which patients are at risk for experiencing acuity-unrelated transfers). For encounters of <24 hours, flagged patients had 0.754 times the odds (95% CI, 0.587–0.970) of experiencing acuity-unrelated within-hospital transfers compared with patients with no flag for MRSA/VRE. However, for encounters with ≥24 hours in double-occupancy units, flagged patients had 1.19 times the odds (95% CI, 1.12–1.26) of experiencing acuity-unrelated transfers compared with patients with no flag for MRSA/VRE.

Factors Influencing Length of Stay

In the unadjusted model, patients with a flag on admission experienced an excess length of stay of 2 days and 22 hours (2.86 days; 6.99 days [95% CI, 6.84–7.15] vs 4.13 days [95% CI, 4.10–4.16]). In the multivariate model, flagged patients had an excess mean length of stay 1 day and 18 hours longer (1.76 days, 7.03 days [95% CI, 6.82–7.24] vs 5.27 days [95% CI, 5.15–5.38]) compared with patients with no flag for MRSA/VRE after (Table 4). This excess attributable length of stay was greater than that attributable to age, residence, prior hospitalization, and clinical service. The greatest impacts were patient severity of illness on admission and discharge

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TABLE 3. Factors Influencing Acuity-Unrelated Within-Hospital Transfers

Factors	Adjusted Odds Ratio[a]	95% CI	*P* Value
MRSA/VRE Flag Status			
MRSA/VRE flag[b]	1.19	1.13–1.26	<.0001
No flag for MRSA/VRE	Reference		
Severity of illness (acuity) on admission			
Observation unit	0.68	0.64–0.72	<.0001
General care unit	Reference		
Step-down unit	1.41	1.32–1.50	<.0001
Intensive care unit	1.24	1.16–1.31	<.0001
Clinical service			
Surgical	Reference		<.0001
Medical	1.08	1.04–1.12	
Discharge destination			
Home	Reference		
Facility	2.23	2.13–2.33	<.0001
Death	1.62	1.45–1.82	.1422

NOTE. MRSA, methicillin-resistant *Staphylococcus aureus*; vancomycin-resistant Enterococcus; OR, odds ratio; CI, confidenc interval.

[a]Adjusted ORs were also controlled for gender, age, admission day of week, residence prior to admission and hospitalization within the previous 30 days (data not shown). Unadjusted OR for MRSA/VRE flag status of flag vs no flag was 1.55 [95% CI: 1.47–1.63] (data not shown).

[b]The odds of experiencing acuity-unrelated transfers for patients with a MRSA flag, VRE flag, and both MRSA and VRE flag were 1.24, 1.27, and 0.98, compared with patients with no flag, respectively.

destination. Considering observation unit patients as the referent population, patients requiring a general care unit, step-down unit, or ICU level care on admission had extended hospitalizations of 5 days 4 hours, 5 days 7 hours, and 10 days 17 hours, respectively. Similarly, considering discharge to home as the referent category, patients discharged to facilities or who died during the admission had excess length of stay of 4 days 7 hours and 3 days 16 hours, respectively.

DISCUSSION

We used a large retrospective cohort of admissions to examine the relationship between MRSA/VRE designation and selected operational outcomes and found that patients admitted with MRSA/VRE flag compared with those without a MRSA/VRE flag experienced a longer time to bed arrival, increased likelihood of acuity-unrelated within-hospital transfers, and extended length of stay. These analyses quantify what clinicians and hospital administrators have understood intuitively: MRSA/VRE designation affects operational efficiency.

The excess time to bed arrival of 1 hour associated with the MRSA/VRE flag is operationally notable and potentially clinically significant. This delay may be explained by the additional time required to match such patients based on colonization status[5] and is consistent with the results of at least 1 other study.[6] Some studies have demonstrated an association between length of emergency department boarding of patients and mortality, increased overall length of stay,[14] medication delays, and adverse events.[15,16]

The nearly 20% increase in odds for MRSA/VRE flagged patients experiencing an acuity-unrelated within-hospital transfer may be the result of the practice of "bed moves," or transfers of patients to optimize use of available beds, particularly for double-occupancy accommodations. Because such transfers are attributed only to the patient who experienced the event and not to the patient triggering the transfer or series of transfers, it is possible that this finding underestimates the impact of the flag designation. Within-hospital transfers are burdensome to both patients and staff and may represent an inefficient use of resources and potentially may contribute to patient harm[17] and excess costs.[18] At times during which hospitals are operating at very high occupancy, such potentially avoidable transfers may further affect the flow of patients. The frequency and operational impact of acuity-unrelated transfers, however, will depend on the specific combination of bedding arrangements across varying levels of acuity and services, an analysis that is beyond the scope of this study and that is better suited to simulation approaches.

Our findings regarding length of stay highlight the need for mechanisms to mitigate the impact of the MRSA/VRE designation to improve patient flow in the hospital. The factors that result in this extended length of stay are not known with certainty, but it is possible that the flag, through delays in delivery of care, adverse events, or other sequellae, results in less efficient care overall. Over the past several decades, length of stay for large nonfederal community hospitals has declined from 9.1 to 5.7 days.[10] To the extent that a substantial portion of a patient's length of stay is associated with MRSA/VRE flag status, this represents a need for focused efforts to limit the operational impact of the flag, such as programs to document clearance of colonization and removal of the MRSA/VRE designation. We have previously demonstrated the efficacy[12] and effectiveness[19] of this approach for MRSA. Assuming that half of the cohort had cleared colonization at the time of admission[20] and the excess length of stay predicted by the model, a substantial increase in available patient days could be realized. Furthermore, it is possible that administrative delays due to lack of single-occupancy accomodations at post-acute care facilities contribute to observed length of stay among flagged patients.

A growing body of evidence demonstrates that the duration of colonization with MRSA and VRE is not life-long,[21–26] and is possibly much shorter than previously believed, even in the setting of recent infection.[20,27–29] There are no consensus guidelines to inform the appropriate time interval to wait prior to screening, the anatomical sites to screen, specific screening assay, number of screens, and interpretation of the results in the presence of antibiotics with activity against MRSA or

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TABLE 4. Factors Influencing Length of Stay

Factors	LS Mean Length of Stay, d (95% CI)[a]	Adjusted Increase in Length of Stay Compared With Referent Group[b]	*P* Value
MRSA/VRE Flag Status			
MRSA/VRE Flag[c]	7.03 (6.83–7.24)	1 d 18 h	<.0001
No flag for MRSA/VRE	5.27 (5.15–5.38)	Reference	
Age			
<65 y	6.00 (5.85–6.14)	Reference	<.0001
≥65 y	6.17 (6.03–6.32)	4 h	
Severity of illness (acuity) on admission			
Observation unit	2.04 (1.98–2.10)	Reference	<.0001
General care unit	7.22 (7.06–7.39)	5 d 4 h	
Step-down unit	7.31 (7.08–7.55)	5 d 7 h	
Intensive care unit	12.73 (12.35–13.11)	10 d 17 h	
Residence prior to admission, home			
No	6.31 (6.13–6.49)	11 h	<.0001
Yes	5.86 (5.73–6.00)	Reference	
Hospitalization within previous 30 d			
No	5.72 (5.59–5.85)	Reference	<.0001
Yes	6.47 (6.30–6.64)	18 h	
Clinical service			
Surgical	5.46 (5.33–5.60)	Reference	<.0001
Medical	6.77 (6.62–6.93)	1 d 7 h	
Discharge destination			
Home	3.77 (3.70–3.84)	Reference	<.0001
Facility	8.05 (7.87–8.23)	4 d 7 h	
Death	7.43 (7.06–7.82)	3 d 16 h	

NOTE. LS, Least-Square; MRSA, methicillin-resistant *Staphylococcus aureus*; vancomycin-resistant Enterococcus; CI, confidence interval.

[a]LS mean length of stay: multivariate model based predicted mean, the average of predicted marginal mean over the classes of the simultaneously controlled covariates. The multivariate model also controlled for gender and admission day of week. Unadjusted observed means for MRSA/VRE flag status were 6.99 days [95% CI, 6.84–7.15] for patients with a flag and 4.13 days [95% CI, 4.10–4.16] for patients with no flag, which is an adjusted increase of 2 days and 21 hours for patients with a flag on admission (data not shown).

[b]Length of increase in length of stay was rounded to the nearest integer.

[c]MRSA flag, VRE flag, and both MRSA and VRE flag were associated with an excess length of stay of 17 hours, 2 days and 3 hours, and 1 day and 14 hours, respectively, compared with patients with no flag.

VRE.[30] In the absence of clear guidance, we have previously demonstrated widespread variation in contact precautions discontinuation protocols, although the majority rely on passive surveillance, effectively resulting in a persistent MRSA/VRE designation for patients previously identified as infected or colonized with MRSA or VRE.[5] Thus, the persistence of the MRSA/VRE flag represents a potential target to reduce barriers to patient flow throughout the hospital. In fact, de-flagged patients have been associated with fewer idle beds.[19]

This study was conducted at a large tertiary care medical center with long-standing use of the EHR to document MRSA/VRE flag status. Thus, in settings in which MRSA/VRE flag status is not as prominently displayed or is not displayed at all, our findings may not be as compelling. Our institution additionally includes flags for multidrug-resistant Gram-negative organisms and *Clostridium difficile* infection, which were not evaluated in the current study. Patients with these flags were grouped in the no-flag group, which would be expected to bias findings toward the null. The outcomes addressed—time to bed arrival, acuity-unrelated within hospital transfers, and length of stay—are influenced by hospital structure, including the number, acuity levels, and types of beds, as well as the proportions of beds with specific characteristics. Despite a lack of consensus in the literature regarding the economic, operational, and clinical tradeoffs between single- and double-occupancy accommodations,[17,31,32] there is no doubt that double-occupancy accommodations introduce inefficiencies through matching requirements, ie, inefficiencies that may manifest in delays to bed assignment, patient transfers, and prolonged hospital stays. The findings reported here are not immediately transferrable to any individual hospital. In addition to hospital structure, the patient population analyzed likely influenced our findings. Although this factor may limit generalizability of the findings, the proportion of patients identified as MRSA/VRE on

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admission is within the range of prevalence reported previously.[2,33,34] MGH operates at a consistently high patient census; thus, the impact of flag prevalence, combined with hospital structure, may be more pronounced. This study relied on a proxy measures for patient acuity, which are likely to incompletely characterize patient severity of illness. These data are, however, often those most readily available in administrative sources used for large cohort analyses.

We found that MRSA/VRE designation was associated with operational consequences and that additional mechanisms to efficiently identify patients no longer colonized with MRSA/VRE are warranted. This need is especially important as EHRs begin to improve the exchange of administrative and clinical information across the care continuum, thus raising the stakes for ensuring the validity of that information.

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Address correspondence to Erica S. Shenoy, MD, PhD, 55 Fruit Street, Bulfinch 334, Infection Control Unit, Massachusetts General Hospital, Boston, MA 02114 (eshenoy@partners.org).

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