TABLE 1 (*Continued*)

Patient	Surgery	Surgery duration	No. of times intravenous medications administered	Catheter manifold lumen flush	Catheter stopcock culture	Thioglycolate broth culture results	Gram stain	Identification by Vitek 2	Semi-quantitative colony counts on agar plates	Identification by MALDI-TOF
20	Aortic valve replacement	4h22min	32	NG	20a	NG				
					20b	NG				
					20c	NG				
21	CABG	6h26min	23	NG	21a	NG				
					21b	NG				
					21c	NG				
22	Aortic valve replacement	6h47min	35	NG	22a	NG				
					22b	NG				
					22c	NG				
23	CABG	4h40min	28	*S. epidermidis*	23a	NG				
					23b	NG				
					23c	NG				
24	Aortic valve replacement	5h6min	18	NG	24a	NG				
					24b	NG				
					24c	NG				

NOTE. AHS, α-hemolytic *Streptococcus*; CABG, coronary artery bypass graft; G, growth; GNR, gram-negative rod; GPR, gram-positive rod; MALDI-TOF, matrix-assisted laser desorption/ionization time-of-flight analysis; NG, no growth; STCN, coagulase-negative staphylococci.

ers have utilized comprehensive programs to successfully mitigate the risk of catheter-associated bloodstream infections in the operating room.[8] We hope that our findings will stimulate interest in strategies aimed at minimizing stopcock contamination in the operating room setting.

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Electronic Monitoring of Individual Healthcare Workers' Hand Hygiene Event Rate

Healthcare worker hand hygiene reduces healthcare-associated infections, but compliance is not optimal.[1] Electronic hand hygiene monitoring systems (EMS) provide continuous

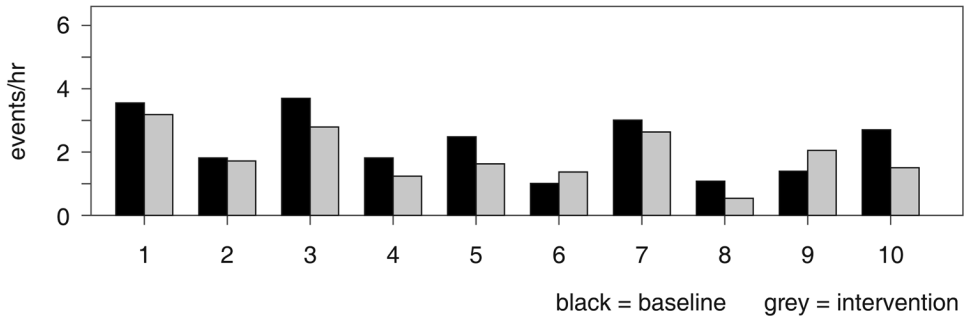

FIGURE 1. Hand hygiene event rate by healthcare worker: baseline versus intervention periods.

monitoring of healthcare workers' hand hygiene and are a potential solution to this problem. EMS may improve compliance by allowing frequent aggregate or individual feedback, providing real-time reminders, or enhancing the Hawthorne effect.[2] However, to estimate healthcare workers' compliance, complex and expensive EMS are required that are capable of tracking the healthcare workers' location or movement and linking this data with hand hygiene events.[3,4] EMS that measure only dispensing events are less expensive but cannot estimate compliance or provide personalized feedback.[3,4]

We tested an EMS that tracked hand hygiene event rate rather than compliance but linked the data to individual healthcare workers. We hypothesized that frequent personalized feedback of event rates would be sufficient to change behavior.

We installed instrumented alcohol-based hand rub dispensers inside and immediately outside all patient rooms on a 10-bed coronary care unit at a 450-bed academic hospital in Toronto, Ontario, Canada. Soap dispensers were not instrumented. Ten of 25 nurses were recruited to test the system and were given wearable monitors that recorded alcohol-based hand rub dispensing events. Data were collected for a 4-week baseline period, followed by a 12-week intervention period during which participants received weekly personalized feedback on their hand hygiene event rate.

The primary outcome was the change in median hand hygiene event rate. Rates were determined by dividing dispensing events for an individual by the hours worked. A secondary outcome was the directly observed hand hygiene compliance of all nurses on the unit measured by trained observers using the 4 Moments for Hand Hygiene.[5]

Statistical analyses were conducted using R (ver. 2.13.0). The Wilcoxon signed rank test was used to compare pre- and postintervention event rates. Informed consent was obtained, and the study was approved by the hospital's institutional review board.

We recorded 6,941 hand hygiene events over 344 12-hour shifts. This is more than 2-fold higher than the number of events recorded by our hospital's hand hygiene auditors on all inpatient units over 2 years.[5]

The median (range) hand hygiene event rate for participants was 2.1 (1.0–3.7) during the baseline phase and 1.7 (0.5–3.2) during the intervention phase. Although hand hygiene event rates varied from 3- to 6-fold between participants, each participant's own event rate was relatively consistent over the course of the study, with a median (range) change in event rate of −25% (−100% to +32%; Figure 1).

Directly observed hand hygiene compliance did not change during the study. Compliance was 66% (49/74) during the 12 weeks prior to installation, 57% (39/69) during the baseline period, and 68% (132/193) during the intervention (Figure 2).

Despite implementation of an EMS capable of providing individual feedback to healthcare workers, we failed to observe any increase in hand hygiene event rates or improvement in hand hygiene compliance.

Our study is the first to test an EMS configured to track individual hand hygiene event rates. Additionally, few studies have assessed the impact of an EMS using directly observed compliance data collected before EMS installation and throughout the intervention. It is limited, however, since it was conducted on a single unit using volunteers, and the results may not be generalizable. Nevertheless, our results provide evidence that feedback of individual event rates alone may not be an effective strategy to improve hand hygiene performance. Potential reasons for our failure to change performance include (1) participants' concerns that event rates may not accurately reflect hand hygiene performance, (2) challenges in understanding results in terms of rates, and (3) lack of real-time reminders.

During the study, participants raised concerns regarding the interpretation of their individual results. Participants believed that their event rates were underestimated because we failed to instrument the soap dispensers and because participants had variable amounts of nonclinical responsibilities not accounted for in our estimates, which assumed that participants provided hands-on clinical care for a full shift. These concerns may have undermined participant's confidence in the data. Boyce et al[6] described a reduction in hand hygiene compliance after introduction of an EMS with only 60% accuracy. In another study on perceptions of EMS, accuracy was found to be healthcare workers' primary concern.[7]

Participants had an intuitive understanding of compliance but were unsure of how to interpret and respond to event

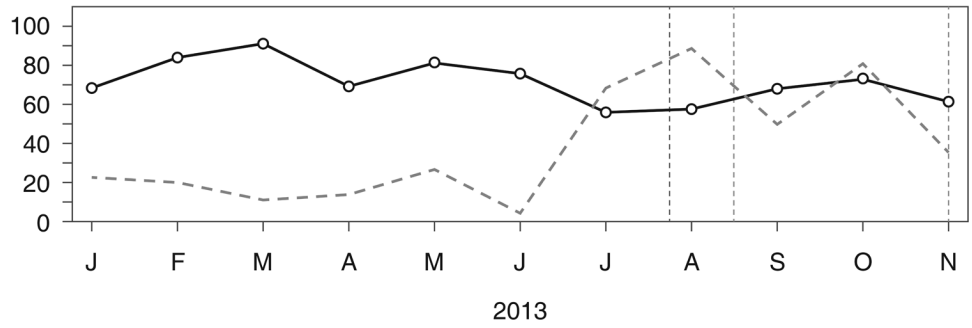

FIGURE 2. Directly observed hand hygiene compliance in the coronary care unit for nurses. Solid line = hand hygiene compliance. Dashed line = hand hygiene opportunities observed. Vertical dashed lines = beginning of baseline period, beginning of intervention period, and end of intervention period.

rates, particularly since we did not set a specific target for improvement but only suggested that participants attempt to increase their hand hygiene event rate. It may be that setting clearer targets and/or having both the targets and feedback come from a clinical leader rather than the research team may have been more effective.

Finally, it appears that the majority of studies of effective EMS provide real-time reminders to participants.[3,4] Swoboda et al[8] used a voice message triggered by room exit as a hand hygiene reminder and demonstrated an increase in hand hygiene events, while Levchenko et al[9] noted an increase in compliance with use of an audible reminder triggered by room entry or exit.

In summary, we demonstrated that the use of an EMS capable of providing individual feedback on hand hygiene event rates did not change healthcare workers' hand hygiene behavior. We believe that improvements in hand hygiene will require EMS capable of providing feedback in terms of compliance and/or real-time reminders.

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Potential conflicts of interest. The authors report that there is a potential conflict of interest because of the anticipated commercialization of the hand hygiene monitoring system. This intellectual property is patent protected. Any future royalties generated will be distributed according to the policy at Toronto Rehabilitation Institute. A.I.L. and G.R.F. report that they are inventors of the technology who may benefit from royalties in the future. All other 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.

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Anatomic Sites of Colonization with Community-Associated Methicillin-Resistant *Staphylococcus aureus*

Methicillin-resistant *Staphylococcus aureus* (MRSA) has emerged over the past 20 years as a cause of infections in community populations, so-called community-associated MRSA (CA-MRSA). By pulsed-field gel electrophoresis (PFGE) subtyping, USA300 is the most common CA-MRSA strain in the United States. It has been suggested that the colonization dynamics for CA-MRSA may be different than those for traditional MRSA strains,[1] with extranasal colonization potentially playing a role in CA-MRSA transmission and infection.[1]

Another distinguishing characteristic of USA300 MRSA strains is greater susceptibility to non-β-lactam antibiotics compared with healthcare-associated MRSA strains. However, multidrug-resistant (MDR) USA300 strains have been described, largely among patients infected with human immunodeficiency virus (HIV) and men who have sex with men (MSM).[2] Also of concern, resistance to common decolonizing agents, such as mupirocin[2] and chlorhexidine gluconate (CHG),[3] has been reported in CA-MRSA.

The objectives of this study were to examine the phenotype of USA300 MRSA strains, the prevalence of the *qac*A/B gene in this population, and the anatomic sites of colonization by PFGE pattern.

We previously reported on the prevalence of nasal and extranasal CA-MRSA colonization among inpatients (374 HIV infected and 371 HIV negative) at Stroger Hospital of Cook County (CCH), the major safety net hospital in Chicago.[4] As described elsewhere, nasal and extranasal (throat, axilla, inguinal, perirectal, and chronic wound, if present) surveillance swab specimens were collected from patients within 72 hours of admission from March 2011 to April 2012; cultures were processed with broth enrichment.[4] Sex was recorded, and enrolled men were asked whether they identified themselves as MSM. Genotypic analysis with PFGE was performed on all identified MRSA isolates. Results were interpreted as described by McDougal et al.[5]

Confirmed MRSA isolates had antibiotic susceptibility determined (MicroScan Walkaway System, Siemens Healthcare Diagnostics). For USA300 MRSA strains, MDR was defined as resistance to 4 or more non-β-lactam antibiotic classes. High-level mupirocin resistance was assessed using disk diffusion.[6]

Carriage of *qac*A and *qac*B genes, which code for efflux pumps associated with increased minimum inhibitory concentrations of CHG,[7] was assessed using real-time polymerase chain reaction, as described previously.[8]

A χ^2 test was used to examine the association of PFGE patterns and colonization sites, with Fisher exact test used for small samples. SAS software (ver. 9.2; SAS Institute) was used for statistical analysis. The study was approved by the institutional review board of CCH and Rush University Medical Center.

We observed that following the nares, the perirectal area was the second most common site of colonization (58% of colonized individuals). Prevalence of extranasal and exclusive extranasal colonization was not significantly different between patients colonized with USA300 or non-USA300 strains (Table 1). However, the average number of sites colonized was significantly higher for USA300 versus non-USA300 strains (2.8 [standard deviation (SD), 1.51] and 2.2 [SD, 1.48], respectively; $P = .049$). Inguinal, perirectal, and concomitant inguinal and perirectal colonization were all significantly associated with colonization with the USA300 strain type in comparison to non-USA300 MRSA strains (Table 1). Inguinal or perirectal MRSA colonization was found more often in men (63/480; 13%)—MSM (odds ratio [OR], 2.2 [95% confidence interval (CI), 1.1–4.2]; $P = .02$) and heterosexual men (OR, 1.8 [95% CI, 1.02–3.2]; $P = .04$)—than in women (20/265; 8%; OR, 1.9 [95% CI, 1.1–3.1]; $P = .02$).

There were 5 individuals who had an MRSA infection at the time of enrollment, and they were all found to have colonization with MRSA. Four of these individuals had skin and soft tissue infections and were colonized with the USA300 strain type, and 1 individual had a bloodstream infection and was colonized with a non-USA300 strain type. Excluding chronic wound cultures, each of these individuals had 3–5 sites of MRSA colonization, suggesting a significant level of extranasal colonization and colonization burden for individuals infected with MRSA.

Of the colonized individuals, 3.4% carried high-level mupirocin-resistant strains (1 USA100, 2 USA500, 1 USA300). Of the individuals colonized with USA300 MRSA strains, 4 (5%) carried MDR strains. There were 117 MRSA isolates evaluated for the presence of the *qac*A/B genes; all were negative.

We examined colonization and molecular characteristics of CA-MRSA isolates collected from patients seeking care at the major safety net hospital in Chicago. We found that inguinal and perirectal colonization was more common with the USA300 strain type than with non-USA300 MRSA strains. In addition, highly antibiotic-resistant USA300 MRSA strains were rare, and none of the MRSA isolates collected over a 14-month study period were found to harbor the *qac*A/B genes.

We observed that males—both heterosexual males and MSM—had a higher prevalence of inguinal and perirectal MRSA colonization in comparison to females. Similarities observed in colonization patterns between MSM and heterosexual males suggest that perhaps social, hormonal, skin