Impact of alcohol-based, waterless hand antiseptic on the incidence of infection and colonization with methicillin-resistant Staphylococcus aureus and vancomycin-resistant enterococci

ORIGINAL ARTICLE

Impact of Alcohol-Based, Waterless Hand Antiseptic on the Incidence of Infection and Colonization With Methicillin-Resistant *Staphylococcus aureus* and Vancomycin-Resistant Enterococci

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OBJECTIVE. Colonized and infected inpatients are major reservoirs for methicillin-resistant *Staphylococcus aureus* (MRSA) and vancomycin-resistant enterococci (VRE), and transient carriage of these pathogens on the hands of healthcare workers remains the most common mechanism of patient-to-patient transmission. We hypothesized that use of alcohol-based, waterless hand antiseptic would lower the incidence of colonization and/or infection with MRSA and VRE.

METHODS. On June 19, 2001, alcohol hand antiseptic was introduced at the University campus and not the nearby Memorial campus of the University of Massachusetts Medical School (Worcester, MA), allowing us to evaluate the impact of this antiseptic on the incidence of MRSA and VRE colonization and infection. From January 1 through December 31, 2001, the incidence of MRSA colonization or infection was compared between the 2 campuses before and after the hand antiseptic was introduced. Its effect on VRE colonization and infection was only studied in the medical intensive care unit at the University campus.

RESULTS. At the University campus, the incidence of MRSA colonization or infection decreased from 1.26 cases/1,000 patient-days before the intervention to 0.75 cases/1,000 patient-days after the intervention, for a 1.46-fold decrease (95% confidence interval, 1.04-2.58; $P = .037$). At the Memorial campus, the incidence of MRSA colonization or infection remained virtually unchanged, from 0.34 cases/1,000 patient-days to 0.49 cases/1,000 patient-days during the same period. However, a separate analysis of the University campus data that controlled for proximity to prevalent cases did not show a significant improvement in the rates of infection or colonization. The incidence of nosocomial VRE colonization or infection before and after the hand antiseptic decreased from 12.0 cases/1,000 patient-days to 3.0 cases/1,000 patient-days, a 2.25-fold decrease ($P = .018$). Compliance with rectal surveillance for detection of VRE was 86% before and 84% after implementation of the hand antiseptic intervention. The prevalences of VRE cases during these 2 periods were 25% and 29%, respectively ($P = .017$).

CONCLUSIONS. Alcohol hand antiseptic appears to be effective in controlling the transmission of VRE. However, after controlling for proximity to prevalent cases (ie, for clustering), it does not appear to be more effective than standard methods for controlling MRSA. Further controlled studies are needed to evaluate its effectiveness.

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Both vancomycin-resistant enterococci (VRE) and methicillin-resistant *Staphylococcus aureus* (MRSA) are major nosocomial pathogens in the hospitals in the United States. It is well established that colonized and infected inpatients are the major reservoir for these pathogens and that the transient carriage of VRE and MRSA on the hands of healthcare personnel is the most common mechanism of patient-to-patient transmission.[1-5] A recent study found that the proportion of current patients colonized with MRSA was the most important predictor that new patients would acquire MRSA in an intensive care unit (ICU),[6] and similarly colonization pressure was the strongest predictor for VRE acquisition in a detailed study of VRE transmission in one medical ICU.[2]

Control of the spread of VRE and MRSA has remained a challenge for infection control personnel.[7-9] The reservoir of patients colonized or infected with MRSA or VRE (also referred to as MRSA or VRE cases), many of whom are unrecognized, interferes with effective infection control. Handwashing between episodes of patient care remains an important measure in the control of transmission of nosocomial pathogens.[1,10] However, rates of compliance with hand hygiene continue to be unacceptably low among healthcare personnel.[11-17] Alcohol-based hand rub, an alcohol-containing preparation designed for application to the hands to reduce the number of viable microorganisms on the hands, has excellent in vitro activity against gram-positive and gram-negative vegetative bacteria, including multidrug-resistant pathogens such as MRSA and VRE. Alcohol-based products are

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more effective than standard hand hygiene products, such as soap or antimicrobial soap, for hand antisepsis by healthcare workers.[18-25] We hypothesized that the ease of use and the accessibility of alcohol hand hygiene gel or foam in patient care areas in the hospital will result in the reduction of the incidences of VRE and MRSA cases in the ICUs and the wards in which active surveillance for VRE and MRSA and contact precautions for infected and colonized patients are practiced.

METHODS

Study Sites

The University of Massachusetts Medical Center (Worcester, MA) is a 388-bed teaching and tertiary care hospital with 6 ICUs, and Memorial Hospital (Worcester, MA) is a 275-bed community teaching hospital with 3 ICUs. These 2 institutions merged in 1998 and began sharing the same infection control program. Prospective surveillance for VRE and MRSA has been part of the infection control program for both hospitals. Patients who are identified as colonized or infected with MRSA or VRE are placed in contact isolation. The 16-bed medical ICUs at the University campus housed the majority of patients receiving mechanical ventilation at the hospital, including patients who were transferred from other units because of failure to be weaned from the ventilator and who, therefore, had a prolonged length of stay. VRE was first detected at the University campus in 1993, and since then it has become endemic, especially in the medical ICU. Therefore, this unit was chosen to study the effect of alcohol hand antiseptic on the incidence of VRE.

Study Design

University campus was chosen for use of alcohol hand antiseptic, and healthcare workers were provided with this antiseptic in conjunction with plain soap and/or antimicrobial soap. The Memorial campus continued to use plain and antimicrobial soap for hand hygiene. Since the incidence of VRE cases was low at the Memorial campus and the medical ICU at the University campus has the majority of the VRE cases in the hospital, the medical ICU was chosen as the site to study the impact of provision of alcohol hand antiseptic on the incidence of VRE cases. We chose to study the impact of alcohol hand antiseptic on the overall rates of MRSA cases at both campuses, because MRSA cases were more prevalent than VRE cases at the Memorial campus.

Impact of alcohol-based, waterless hand antiseptic on the incidence of MRSA cases at both campuses. The study period extended from January 1, 2001 through December 31, 2001. Alcohol hand antiseptic foam (Alcare; Steris Corporation) was made available on June 19, 2001, and dispensers were installed in and right outside each patient's room, near the medication preparation area, and inside patients' bathrooms at the University campus; plain soap and/or antimicrobial soap continued to be available for hand hygiene. The Memorial campus continued to be provided with plain and/or antimicrobial soap only. Steris Corporation provided in-service education for all healthcare personnel at the University campus around the time that the waterless, alcohol-based hand antiseptic was first made available. Prospective surveillance for MRSA continued at both campuses throughout the study period. This consisted of weekly collection of nasal and perineal swab specimens from patients in wards or units in which 2 or more patients were colonized or infection with MRSA. Patients with MRSA cases were placed in contact isolation. The incidence of MRSA colonization or infection at the 2 campuses was compared before and after introduction of the alcohol-based antiseptic.

To adjust for clustering of colonization events (the presence of a colonized patient in a unit increased the risk of colonization of other patients in the same unit), we looked at the impact of the prevalent MRSA cases in the ICUs on the incidence of nosocomial MRSA cases before and after the intervention. This was done at the University campus only, because no such data were available for the Memorial campus.

Impact of alcohol-based, waterless hand antiseptic on the incidence of VRE cases in the medical ICU at the University campus. The study period extended from January 1, 2001, through November 30, 2001. Prospective surveillance for VRE in the medical ICU continued throughout the study period. On June 19, 2001, alcohol hand antiseptic foam dispensers were installed in and right outside each patient's room, near the medication preparation area and inside the bathroom in the medical ICU. Throughout the study period, compliance with weekly surveillance for VRE was monitored only in the medical ICU. The infection control department has a policy whereby patients newly admitted to the medical ICU routinely undergo culture of a rectal specimen for detection of VRE, and prospective weekly surveillance cultures of rectal swab specimens are performed for all patients in the medical ICU whenever there are 2 or more patients residing in the unit who have a VRE case. The staff of the infection control department reminded the nursing personnel throughout the week to perform surveillance cultures of rectal swab specimens for patients for whom culture had not been performed. Patients colonized or infected with VRE were placed in contact isolation. The incidence of VRE cases was monitored before and after introduction of the alcohol hand antiseptic. The difference in the incidence of cases per 1,000 patient-days was compared.

Alcohol-based, waterless hand antiseptic use. Data on the quantity of hand antiseptic used were obtained from the materials management department.

Microbiologic Analysis

Culture for detection of MRSA was performed on specimens obtained by means of culturette swab specimens from patients' nares, axillae, perineum, and open wounds, such as tracheal stomata and abdominal wounds. Culture for detection of VRE was performed on rectal and open-wound swab

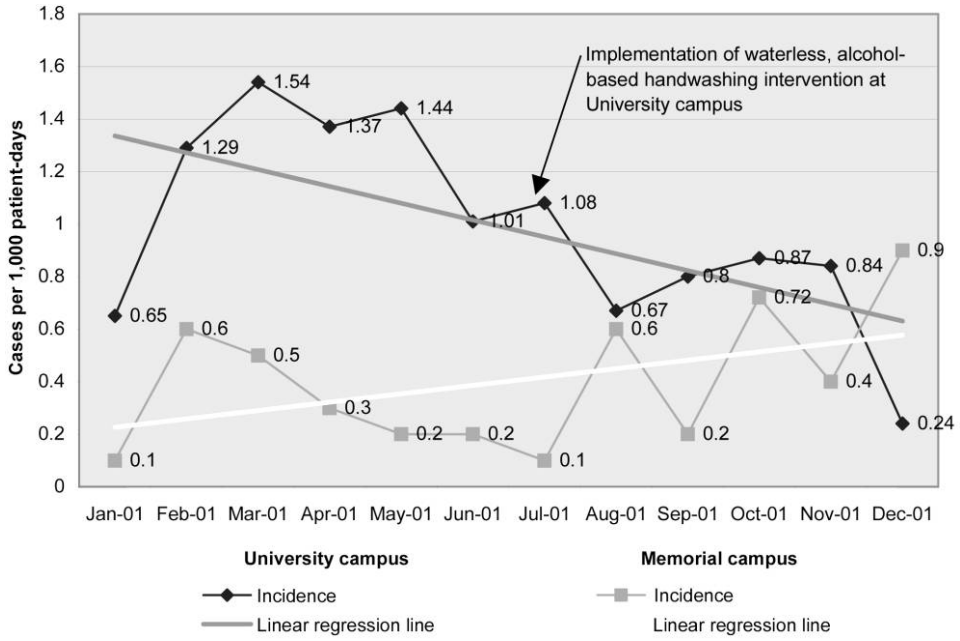

FIGURE 1. Incidence of cases of methicillin-resistant *Staphylococcus aureus* (MRSA) colonization or infection before and after introduction of alcohol-based, waterless hand antiseptic at the University and Memorial campuses of the University of Massachusetts Medical School (Worcester, MA), January through December, 2001.

specimens. Swabs were plated onto blood agar and incubated at 35°C for 24 hours. Single colonies with morphologic characteristics typical of *Staphylococcus* and *Enterococcus* organisms were picked and subcultured onto brain heart infusion agar. For *Staphylococcus* species, a tube coagulase test was performed on selected colonies and was read after 4 and 24 hours to determine the presence or absence of coagulase. A positive result of the coagulase test identified the organism as *S. aureus*. Isolates were screened for methicillin resistance by incubation with 6 μg/mL of oxacillin at 35°C for 24 hours. Cocci from colonies that had typical morphologic characteristics, were catalase-negative and gram-positive, and grew in pairs and chains were examined using the pyrrolidonyl arylamidase test. A positive result of this test identified the organism as a species of *Enterococcus*. Organisms were grown on plates containing colistin–nalidixic acid agar, 5% sheep blood agar, and either 8 μg/mL vancomycin alone or 8 μg/mL vancomycin plus bile esculin azide agar, to screen for vancomycin resistance. Susceptibility tests were performed for *Enterococcus* and *Staphylococcus* organisms by means of the Vitek system.

Statistical Analysis

The effect of the intervention on incidence rates and the effect of clustering on incidence rates were evaluated by fitting incidence case rates using generalized linear mixed models,[26,27] longitudinal Poisson and negative binomial regression models. The fitness of the model was evaluated using the Akaike information criteria.[28] The effect of the intervention on rates of infection and colonization was estimated by exponentiating the coefficient of the effect during the study period from the fitted model. If the estimated effect was less than 1.0, the reciprocal of the exponentiated coefficient is reported as a "fold reduction" in the incidence rate. Incidence rates with *P* values of less than .05 were considered to be statistically significant. The statistical software packages used were LogXact (Cytel Software) and SAS, version 9.13 (SAS Institute).

RESULTS

Impact of Alcohol-Based, Waterless Hand Antiseptic on the Incidence of MRSA

At the University campus, there were 56 cases of nosocomial MRSA colonization or infection over a 5-month period (from January 1 through May 31, 2001) before introduction of the alcohol hand antiseptic, for a mean rate of 11.2 cases/month. There were 40 cases of nosocomial MRSA colonization or infection over a 6-month period (from July 1 through December 31, 2001) after introduction of the intervention, for a mean rate of 6.7 cases/month. The mean number of patients admitted was 1,529 per month before the intervention and 1,522 per month after the intervention. The hospital-wide incidence of nosocomial MRSA cases decreased from 1.26 cases/1,000 patient-days before the introduction of alcohol hand antiseptic to 0.75 cases/1,000 patient-days after the intervention (Figure 1).

At the Memorial campus, because the alcohol hand antiseptic was not introduced, we compared the number of cases of nosocomial MRSA colonization or infection before with the number of cases after June 19, 2001. There were 14 nosocomial cases of MRSA colonization or infection during the 5-month period before June 19, 2001 (from January 1 through May 31, 2001), for a mean rate of 2.8 cases/month, and 24 nosocomial cases during the 6-month period after June 19, 2001 (from July 1 through December 31, 2001), for a mean rate of 4 cases/month. The total number of patient admissions was 1,917 per month before and 1,957 per month after June 19, 2001. The incidence of nosocomial MRSA cases increased from 0.34 cases/1,000 patient-days before to 0.49 cases/1,000 patient-days after June 19, 2001 (Figure 1). An analysis that controlled for patient-days of hospital stay found a slight (1.45-fold) but nonsignificant increase in the incidence of colonization or infection.

At the University campus, the incidence of MRSA cases was significantly higher than that at the Memorial campus before the introduction of alcohol hand antiseptic ($P < .001$). However, after the intervention, the difference in the incidence of MRSA cases between campuses was not statistically significant ($P = .202$), because of a significant 1.64-fold decrease (95% CI, 1.04-2.58; $P = .037$) in the incidence rate for MRSA cases at the University campus after the intervention.

Analysis of Clustering of Prevalent Cases of MRSA Colonization and Infection at the University Campus

In the generalized linear mixed model analysis, the effect of the intervention on the reduction of nosocomial MRSA cases was significant when prevalent cases were not factored into the analysis ($P = .037$). The number of nosocomial cases in the unit in the prior month had no significant effect on the incidence of cases among newly admitted patients. There was no significant general trend over time. When the number of prevalent cases was modeled, the impact of the intervention was nonsignificant.

Impact of Alcohol-Based, Waterless Hand Antiseptic on the Incidence of VRE Cases

From January 1, 2001, through June 18, 2001, the number of VRE cases identified among patients at admission to the medical ICU at the University campus was 10, compared with 14 cases from June 19 through November 30, 2001. The number of VRE cases identified among patients more than 72 hours after admission to the medical ICU was 29 before the intervention, compared with 19 after the intervention. There were 80 admissions before introduction of hand antiseptic, for a mean rate of 16 admissions/month and a mean hospitalization duration of 465 patient-days/month. After the intervention, there were 79 admissions, for a mean rate of 16 admissions/month and a mean hospitalization duration of 469 patient-days/month.

The incidence of nosocomial colonization or infection with VRE was 12.0 cases/1,000 patient-days before the use of waterless, alcohol-based hand antiseptic, compared with 3.0 cases/1,000 patient-days after the intervention ($P < .001$) (Figure 2). The incidence of VRE infection (rather than VRE infection and colonization) decreased from 0.4 cases/1,000 patient-days before the intervention to 0 cases/1,000 patient-days after the intervention ($P = 1.0$). The model-based estimate of the effect of the intervention showed a significant 2.25-fold reduction in the incidence of VRE (95% CI, 1.13-4.71; $P = .018$), based on an incidence ratio estimate of 0.445 (95% CI, 0.212-0.883). The incidence of VRE colonization or infection among patients originating from outside the institution was 3 cases/1,000 patient-days before the intervention and 2/1,000 patient-days after the intervention. The prevalence of VRE cases was 25% before the intervention and 26% after the intervention, and

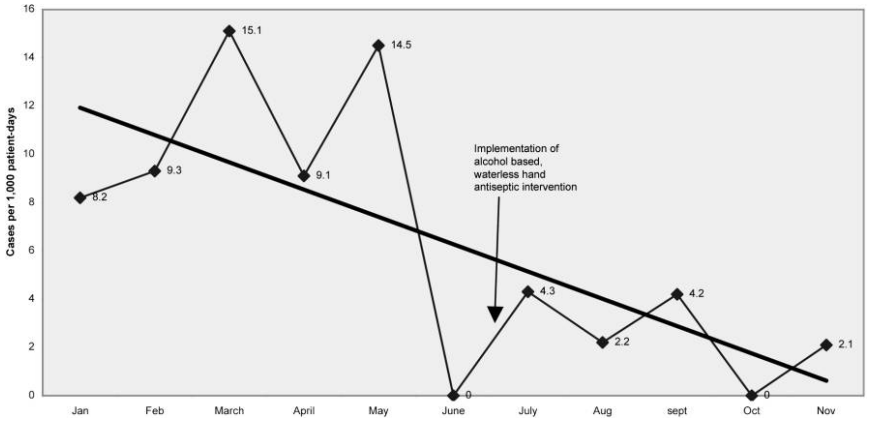

FIGURE 2. Incidence of cases of vancomycin-resistant *Enterococcus* (VRE) colonization or infection before and after initiation of use of alcohol-based, waterless hand antiseptic at the University campus of the University of Massachusetts Medical School (Worcester, MA), January through November, 2001.

compliance with weekly surveillance cultures of rectal swab specimens was 86% and 85%, respectively.

Quantity of Waterless, Alcohol-Based Hand Antiseptic Used

The number of boxes of waterless, alcohol-based hand antiseptic provided to the University campus ICUs at the beginning of the intervention was not recorded. However, data on the overall quantity used showed an increase from 195 boxes during October 2001 to 312 boxes during December 2001, with an increase from 24 boxes to 30 boxes for the medical ICU over the same period.

DISCUSSION

The benefit of improved infection control practices, including hand hygiene practices, in reducing nosocomial infection rates has been demonstrated.[16,29] The incidence of MRSA cases at the University campus, where the alcohol hand antiseptic was made available, decreased significantly, compared with the incidence at Memorial campus, where the alcohol-based waterless hand antiseptic was not introduced. However, the analysis of the clustering effect at the University campus suggests that the effect of the intervention may have been at least partially confounded with a general decrease in prevalent cases at this campus. Because the analysis was adjusted for the effect of the prevalent cases, the impact of the intervention disappeared

The incidence of VRE colonization or infection at the medical ICU at the University campus decreased significantly with the introduction of alcohol-based hand antiseptic. This could not be explained by an increased incidence of VRE cases among patients admitted from outside the institution, because there was no significant increase in the number of patients with VRE colonization or infection admitted to the medical ICU, nor could it be explained by an increase in surveillance of rectal swab specimens for detection of VRE, because the compliance with weekly rectal surveillance was similar between the 2 periods. The decrease was seen despite a higher prevalence of VRE cases after the alcohol hand antiseptic was made available. Use of alcohol hand antiseptic was the only new intervention that was introduced during the study period.

Sink-based antiseptic detergents are commonly used in adult and pediatric critical care units.[30] Kaplan and McGuckin[31] demonstrated that hand hygiene compliance could be improved by providing easier access to sinks. However, studies of sink-based hand hygiene showed that rates of compliance with hand hygiene among healthcare workers were unacceptably low, ranging from 32% to 60% in non–ICU settings[32,33] and from 5%-81% in ICUs,[34,35] especially during periods of increased workload.[36] Easy access to hand hygiene supplies (eg, sinks, soaps, medicated detergent, and alcohol-based hand antiseptic) is essential for optimal adherence to hand hygiene recommendations.[37] It takes time for a healthcare worker to go to a sink and wash and dry their hands between patient-care episodes, and easy access to an alcohol-based hand rub will improve adherence. Bischoff et al.[36] reported that hand hygiene compliance failed to improve after introduction of an education and feedback intervention program for healthcare workers and handwashing awareness programs for patients. The rates of hand hygiene practices only improved with the introduction of alcohol hand antiseptic, with an association between the rate of improvement and accessibility to the antiseptic. Hand hygiene compliance among healthcare workers increased from 19% before to 41% after installation of 1 dispenser of alcohol-based antiseptic per 4 beds and from 23% before to 48% after installation of 1 dispenser for each bed. On the other hand, McGuckin et al.[38] showed that a hand hygiene–education program that empowered patients to monitor the hand hygiene activity of healthcare workers could improve compliance with hand hygiene. Use of alcohol has been shown to prevent the transfer of pathogens more effectively than use of plain soap and water. Ehrenkranz et al.[21] demonstrated that transfer of gram-negative bacilli occurred after 17% of hygiene episodes involving an alcohol-based hand rub, compared with 92% of hygiene episodes involving plain soap and water. We suggest that the provision of a hand antiseptic inside and immediately outside each patient room that is easily accessible and has a low rate of reaction with users' hands can improve adherence to hand hygiene and reduce the incidences of MRSA and VRE cases. Several recent prospective, randomized trials have shown that healthcare personnel tolerated alcohol-based hand rubs containing emollients much better than they tolerated nonantimicrobial soaps or antimicrobial soaps.[11,20,35,36,39] In addition to easy access to hand antiseptic, a low rate of reaction to hand antiseptic plays a role in the adherence to hand hygiene protocol.

There are limitations to this study. First, this study did not involve randomization or blinding and, therefore, lacked protection from possible confounding factors, which would have been obviated by a randomized clinical trial. We do not know whether patient characteristics, compliance with isolation practices, and nursing workload were similar between the 2 periods. Pittet et al.[11] showed an association between intensity of care and noncompliance with hand hygiene recommendations. In the VRE study, we presented data to show that compliance with rectal culture surveillance for VRE was unchanged between the 2 study periods. We did not monitor hand hygiene compliance among healthcare personnel before and after the intervention to see whether, in fact, the frequency of hand hygiene practice increased. However, the quantity of hand antiseptic that was used increased over a 4-month period, implying that healthcare personnel were indeed using this product. Hand hygiene monitoring would have given stronger credence to the premise that introduction of this alcohol-based hand antiseptic produced a change in behavior and resulted in a reduction in the rates of MRSA and VRE cases, but increased use could be a surrogate marker for increased hand hygiene adherence. In addition, because

of the favorable feedback received from healthcare personnel regarding this product, we believe that its accessibility and the lack of skin reactions encouraged more-frequent hand hygiene practices.

We conclude that the introduction of an easily accessible alcohol hand antiseptic appeared to contribute to a decrease in the incidence of VRE cases in our institution. The reduction in MRSA cases can be better explained by a change in the prevalence of MRSA colonization and infection in the units. However, further controlled studies in which existing cases are controlled are needed to determine whether frequent use of waterless, alcohol-based hand antiseptic by healthcare personnel will lead to decreased rates of healthcare-associated colonization and infection.

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