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INTRODUCTION OF A WATERLESS ALCOHOL-BASED HAND RUB IN A LONG-TERM-CARE FACILITY

Lona Mody, MD; Shelly A. McNeil, MD; Rongjun Sun, PhD; Suzanne F. Bradley, MD; Carol A. Kauffman, MD

Contamination of the hands of healthcare workers (HCWs) has been recognized to play a role in the transmission of pathogenic bacteria to patients since the observations of Holmes, Semmelweis, and others more than 100 years ago.¹ Hand antisepsis remains the most effective and least expensive measure to prevent transmission of nosocomial infections.²⁻⁴ However, compliance with hand washing recommendations among HCWs averages only 30% to 50% and improves only transiently following educational interventions.⁵⁻¹¹ Skin irritation from frequent washing, too little time due to a high workload, and simply forgetting are frequently reported as reasons for poor compliance with hand hygiene.^{3,6,11,12}

The use of waterless alcohol-based hand rubs as an adjunct to washing with soap and water is becoming increasingly common in acute care facilities. Introduction of alcohol-based hand rubs has been shown to significantly improve compliance with hand hygiene among HCWs in some acute care hospitals and to decrease overall nosocomial infection rates.^{13,14} Transmission of methicillin-resistant *Staphylococcus aureus* (MRSA) infection reportedly decreased in one of these acute care settings,¹⁴ but the hospital had simultaneously implemented a program of active surveillance cultures and contact precautions for MRSA-colonized patients leaving the relative contribu-

tions of the increased compliance and use of the hand rub uncertain.

Nosocomial infection rates in long-term-care facilities (LTCFs) range from 1.8 to 7.1 per 1,000 patient-days and frequently necessitate transferring patients to acute care hospitals with significant associated costs.¹⁵ In a study of compliance in an LTCF, hands were washed only 27% of the time before patient interactions and 63% of the time after interactions.⁵ Multiple factors were cited as contributors to poor compliance with hand hygiene in LTCFs, including perceived time constraints and detrimental effects of hand washing on skin. HCWs in LTCFs are likely to be exposed to fewer infection control programs than HCWs in acute care facilities, and HCWs in LTCFs may perceive their interactions with patients to be at a lower risk for transmission of pathogens when compared with the interactions of nurses in acute care hospitals.

In LTCFs, there have been few studies of the impact of educational interventions or alcohol-based hand rubs on increasing compliance with hand hygiene.^{5,16} This study assessed the effect of the introduction of an alcohol-based hand rub in conjunction with an educational campaign on (1) the knowledge and opinions of HCWs in an LTCF regarding hand hygiene; (2) compliance with hand hygiene of HCWs in an LTCF; (3) transient and persistent

colonization of HCWs' hands with pathogens; and (4) nosocomial infection rates.

METHODS

Study Site

The study was performed in a 162-bed, community-based skilled LTCF in Ann Arbor, Michigan. Two 36-bed nursing units (ward A and ward B) were selected as study wards on the basis of comparable bed utilization, patient acuity, length of stay, and HCW-to-patient ratios. Each unit functions with three 8-hour nursing shifts per day. Three registered nurses and three nurses' aides staff the morning and afternoon shifts and two registered nurses and two to three nurses' aides staff the evening shift. HCWs are assigned to only one of the wards. Following approval of the protocol by the facility's Research Monitoring Committee and the University of Michigan Institutional Review Board, all HCWs employed on wards A and B were invited to participate in the study and to provide written informed consent.

Study Design

This prospective interventional trial was performed in four phases during a 1-year study period. On the basis of a coin toss, ward A was designated the intervention ward (introduction of alcohol-based hand rub) and ward B served as the control ward (hand washing with plain soap and water).

Phase 1: Pre-intervention. Prior to any intervention, all HCWs on both study wards completed a questionnaire. The baseline frequency of hand hygiene was assessed by asking HCWs to report the number of times they had cleansed their hands in the 1-hour period prior to completing the questionnaire. The baseline rate of colonization with pathogenic organisms, including *Staphylococcus aureus*, vancomycin-resistant enterococci, gram-negative bacilli, and *Candida* species, was assessed by sampling the hands of all HCWs on each ward.

Phase 2: Educational Intervention (3 Weeks). During the first 3 weeks of the study, an educational campaign was conducted on both study wards and continued for the remainder of the study period. The educational intervention consisted of nursing in-services and posters over sinks and in hallways, staff washrooms, and break rooms reminding HCWs to cleanse their hands. Registered nurses were educated about hand hygiene guidelines in separate in-services and were encouraged to reinforce the guidelines on a daily basis with their staff. At the end of the 3-week educational intervention, all HCWs on both wards completed the same questionnaire as in phase 1 to evaluate the effect of the educational intervention on self-reported hand hygiene practices, knowledge, and opinions. The hands of HCWs on both wards were sampled again to assess the impact of the educational intervention on hand colonization.

Phase 3: Introduction of an Alcohol-Based Hand Rub (12 Weeks). HCWs on ward A attended one of several in-services designed to introduce them to the

concept of hand hygiene with a waterless alcohol-based hand rub as an adjunct to washing with soap and water. All HCWs on ward A were supplied with a pocket-sized container of an alcohol-based antimicrobial hand rub (Prevacare Antimicrobial Hand Gel, Johnson & Johnson, Somerville, NJ), which was replaced as necessary. Larger pump dispensers of the hand rub were placed by sinks in all patient rooms, break rooms, and staff washrooms and on medication carts and nursing desks on ward A. The effect of the alcohol-based hand rub on colonization was assessed by sampling the hands of all HCWs on ward A 4, 8, and 12 weeks after its introduction. HCWs on ward B continued their regular soap and water hand washing practices and were asked not to use any alcohol-based hand rub at work or home during the study period. The hands of HCWs on ward B were also sampled every 4 weeks. At the end of phase 3, all HCWs on both wards again completed the same questionnaire to evaluate changes in self-reported hand hygiene practices, knowledge, and opinions following this phase of the intervention. HCWs on ward A were also asked to complete a second questionnaire examining acceptability and tolerability of the alcohol-based hand rub used in the study.

Phase 4: Long-term Follow-up (8 Months).

The use of the alcohol-based hand rub was maintained on ward A for a total of 11 months to assess its impact on nosocomial infection rates on that ward. Infection control surveillance data and patient charts were reviewed on a regular basis. With the use of the criteria of McGeer et al., monthly nosocomial infection rates (infections per 1,000 resident-days) were calculated and compared between the two study wards.¹⁷

Microbiological Methods

The hands of HCWs were sampled before and after cleansing with either the alcohol-based hand rub (ward A) or soap and water (ward B). HCWs were not made aware of sampling schedules. A modified broth-bag technique was employed.¹⁸ Each hand was sequentially immersed in 50 mL of brain-heart infusion broth in a sterile plastic bag and kneaded for 30 seconds. After removal of the hands from the bag, the broth was transferred to a sterile container and incubated at 35°C for 24 hours. Following incubation, the broth was gently agitated for 60 seconds and serial 10-fold dilutions were made in sterile saline. An aliquot of 0.1 mL from each dilution was plated on bile esculin agar (Difco Laboratories, Detroit, MI) with 6 µg/mL of vancomycin, mannitol salt agar (BBL, Sparks, MA), MacConkey agar (Difco Laboratories), and Sabouraud's dextrose agar (Difco Laboratories) with 10 µg/mL of gentamicin and 10 µg/mL of vancomycin. All phenotypically different colonies were identified by standard methods.

Hand Washing Questionnaire

Self-reported practices, knowledge, and opinions regarding hand hygiene were measured using the Handwashing Practices Inventory (HPI).¹⁹ The HPI

TABLE 1

SELECTED SELF-REPORTED HAND HYGIENE PRACTICES, KNOWLEDGE, AND OPINIONS OF HEALTHCARE WORKERS ON THE INTERVENTION WARD (WARD A) AND THE CONTROL WARD (WARD B) AT BASELINE (PRIOR TO THE INTERVENTION)*

Survey Item	Ward A	Ward B	P
	Mean (SEM)	Mean (SEM)	
I wash my hands before eating	4.4 (.18)	4.5 (.16)	.48
I wash my hands before caring for a wound	4.3 (.19)	4.7 (.15)	.13
I wash my hands after caring for a wound	4.7 (.14)	4.9 (.10)	.67
I wash my hands if a poster reminds me	3.4 (.28)	3.9 (.23)	.61
I wash my hands when others are watching	4.2 (.25)	4.0 (.21)	.26
I wash my hands after minimum patient contact	4.2 (.19)	4.1 (.22)	.28
I wash my hands after touching office objects	2.4 (.23)	2.8 (.26)	.08
Washing hands can cause skin to be dry and cracked	3.5 (.29)	3.8 (.43)	.68
Washing hands is inconvenient	2.1 (.32)	1.6 (.28)	.72
Washing hands takes too much time	1.8 (.31)	1.7 (.28)	.68
Lack of a nearby sink can be a reason for not washing hands	2.1 (.31)	2.6 (.32)	.32
Lack of an acceptable soap product can be a reason for not washing hands	2.0 (.29)	2.8 (.32)	.81
If I wear gloves, hand washing is not necessary	2.0 (.38)	1.2 (.01)	.04
Alcohol rub is more convenient than soap	3.7 (.29)	3.5 (.31)	.58
Alcohol rub is faster to use than soap	3.7 (.36)	3.5 (.32)	.74
Alcohol rub is as effective as soap in preventing infection	3.2 (.35)	3.0 (.30)	.61
Alcohol rub is more drying to the skin than soap	3.4 (.34)	3.2 (.30)	.71

SEM = standard error of the mean.

*Results are expressed as the mean response score on a scale of 1 to 5: 1 = strongly disagree (opinion items) or never (practice items) and 5 = strongly agree (opinion items) or always (practice items).

includes 26 items regarding hand hygiene practices and 22 items regarding hand hygiene opinions and has been validated in an LTCF.²⁰ We also asked questions pertaining to the use of alcohol-based hand rubs, nail polish, and artificial fingernails. A separate questionnaire was completed by HCWs on ward A to assess their opinions about the use of the alcohol-based hand rub. Each question on both self-administered questionnaires was scored on a 1 to 5 Likert scale. Questions regarding hand hygiene practices were scored from 1, meaning never, to 5, meaning always, whereas questions regarding hand hygiene opinions were scored from 1, meaning strongly disagree, to 5, meaning strongly agree.

Statistical Methods

The mean scores on each question were compared between HCWs on ward A and ward B using a standard *t* test at baseline, and following each intervention phase. The mean scores were compared within the group of HCWs on ward A and ward B using a paired *t* test to examine any differences in HCWs' practices, knowledge, and opinions at baseline, after the educational intervention, and after introduction of the alcohol-based rub. Differences in the self-reported mean frequency of hand hygiene were compared using the standard *t* test. The proportions of HCWs on ward A and ward B reporting increased frequency of hand hygiene were compared using the chi-square test. The frequency of isolation of pathogens was compared between HCWs on ward A and

ward B, and before and after hand hygiene with the alcohol-based rub (ward A) and soap and water (ward B). The frequency of isolation of pathogens was compared using the chi-square test; the GENMOD model with repeated measures (version 6.12; SAS Institute, Inc., Cary, NC) was used to examine differences in the quantity of various organisms isolated from HCWs during the study period. Significance was defined as a *P* value of .05 or less.

RESULTS

Forty-four HCWs were enrolled (22 on ward A and 22 on ward B). Thirty-eight HCWs completed all three questionnaires; 6 HCWs left the facility prior to the end of phase 3 and were not included in the subsequent analysis. There were 6 registered nurses and 16 nursing aides on ward A and 7 registered nurses and 15 nursing aides on ward B. Five HCWs on ward A and 6 HCWs on ward B reported routine use of nail polish. Moreover, 5 HCWs on ward A and 3 on ward B reported wearing artificial nails.

Practices, Knowledge, and Opinions Regarding Hand Hygiene

At baseline, self-reported practices, knowledge, and opinions regarding hand hygiene did not differ between HCWs on ward A and HCWs on ward B, except that HCWs on ward B were more likely to say that wearing gloves did not preclude the need for hand hygiene (Table 1). Following the educational intervention, few changes in

TABLE 2

SELECTED SELF-REPORTED HAND HYGIENE PRACTICES AND OPINIONS OF HEALTHCARE WORKERS ON THE INTERVENTION WARD (WARD A) AND THE CONTROL WARD (WARD B) FOLLOWING THE EDUCATIONAL INTERVENTION AND THE INTRODUCTION OF AN ALCOHOL-BASED HAND RUB

Survey Item	Baseline	After	P*	After	P†
	Mean (SEM)	Education		Intervention	
Ward A					
I wash my hands before caring for wounds	4.33 (.19)	4.67 (.13)	.02	4.84 (.13)	.08
I wash my hands after touching office objects	2.43 (.23)	2.57 (.25)	.38	3.11 (.25)	.03
Lack of a nearby sink can be a reason for not washing hands	2.10 (.31)	2.76 (.32)	.05	2.79 (.37)	.55
Lack of an acceptable soap product can be a reason for not washing hands	2.00 (.29)	3.05 (.32)	.009	2.47 (.3)	.19
Ward B					
I wash my hands before caring for wounds	4.68 (.15)	4.84 (.09)	.08	4.89 (.11)	.58
I wash my hands after touching office objects	2.79 (.26)	3.11 (.25)	.03	3.72 (.29)	.6
Lack of nearby sink can be a reason for not washing hands	2.63 (.32)	2.79 (.37)	.55	2.12 (.31)	.86
Lack of an acceptable soap product can be a reason for not washing hands	2.48 (.32)	2.47 (.32)	.19	2.18 (.3)	.74

SEM = standard error of the mean.

*P for comparison of mean scores following the educational intervention compared with baseline.

†P for comparison of mean scores following the introduction of the alcohol-based hand rub compared with scores following the educational intervention.

HCWs' practices, knowledge, or opinions were noted (Table 2). When compared with baseline, HCWs on ward A were more likely to report hand cleansing prior to wound care and agreed more strongly that the lack of nearby sinks or of acceptable soap products could be a reason not to wash hands. HCWs on ward B were more likely to report hand hygiene after touching office objects. Mean scores did not differ between the wards for the remaining 44 questions.

Following the introduction of the alcohol-based rub, few HCWs reported a change in hand hygiene practices, knowledge, and opinions (Table 2). When mean scores were compared with those reported following the educational intervention, HCWs on ward A were more likely to report hand cleansing after touching office objects following the introduction of the rub. Mean scores did not differ from baseline for the remaining 47 questions on either ward. HCWs on ward A were more likely than those on ward B to agree that the alcohol-based rub was more convenient (4.30 ± 0.32 vs 3.33 ± 0.34 ; $P = .05$) and faster (4.58 ± 0.16 vs 3.39 ± 0.32 ; $P = .002$) than washing with soap and water and more likely to disagree that the rub was more drying to the skin than soap and water (2.04 ± 0.30 vs 3.82 ± 0.26 ; $P = .04$).

At the end of the intervention period, most HCWs on ward A thought that the alcohol-based rub saved them time (88%) and made their hands feel moisturized (81%) and reported that they were comfortable using the alcohol-based rub to protect themselves and their patients (71%). A significant proportion (80%) stated that they would like to have the alcohol-based hand rub routinely available at work and 63% of them thought that their hands were less dry and cracked than at the beginning of the study.

Compliance With Hand Hygiene

The self-reported frequency of hand hygiene did not increase significantly from baseline on either ward following the educational intervention and did not differ between the two wards following the educational intervention ($P = .48$) (Fig. 1). However, at the end of the intervention period, the frequency of hand hygiene (number of times hands were cleansed per hour) had increased significantly on ward A when compared with baseline (14.55 ± 5.32 vs 7.91 ± 1.92 ; $P = .04$) and when ward A was compared with ward B (15.81 ± 4.08 vs 7.11 ± 1.05 ; $P = .04$) (Fig. 1). At the end of the study period, 74% of HCWs on ward A believed that they cleansed their hands more frequently than at baseline compared with only 39% of HCWs on ward B ($P = .04$).

Hand Colonization

At baseline, 29 (66%) of the HCWs were colonized with one or more gram-negative bacilli, 18 (41%) with *Candida* species, 9 (20%) with *S. aureus*, and 4 (9%) with vancomycin-resistant enterococci (Fig. 2). Predominant gram-negative bacilli isolated included *Enterobacter* species (12), *Klebsiella* species (11), *Serratia* species (6), and *Proteus* species (3). Baseline colonization rates with specific pathogens did not differ between the two wards (Fig. 2). Similarly, there was no statistically significant difference in colonization rates after the educational intervention and after the alcohol-based hand rub intervention on either ward A or ward B (Fig. 2).

To compare the efficacies of the alcohol-based rub and soap and water, the hands of HCWs were sampled before and after cleansing on three occasions 1 month apart during the alcohol-based hand rub intervention phase. The alcohol-based rub was more efficacious than

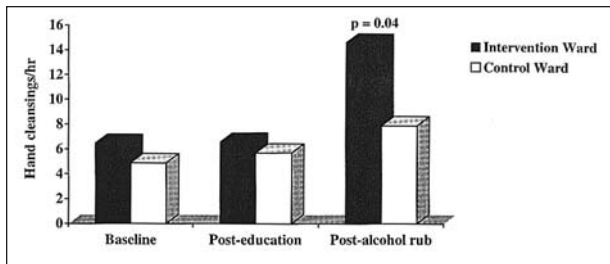


FIGURE 1. Self-reported frequency of hand hygiene among healthcare workers (HCWs) on the intervention ward (ward A) and the control ward (ward B) at baseline, following an educational intervention, and after introduction of an alcohol-based hand rub. A significant increase in the frequency of hand hygiene was seen among HCWs on ward A following introduction of the alcohol-based rub when compared with baseline ($P = .04$). Hand hygiene was more frequent on ward A than on ward B at the end of the intervention period ($P = .04$).

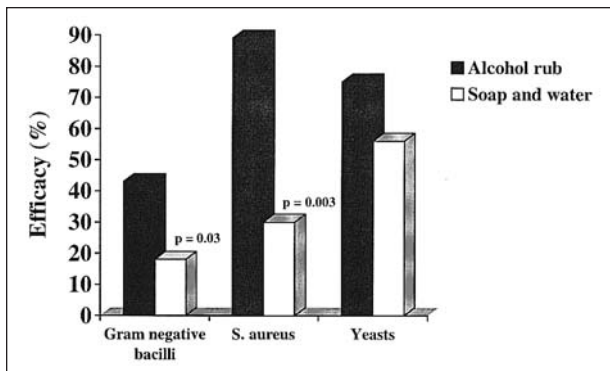


FIGURE 3. The efficacy of soap and water hand washing on the control ward (ward B) compared with the efficacy of the alcohol-based hand rub on the intervention ward (ward A) in eliminating pathogens from the hands of healthcare workers. The alcohol-based hand rub was more effective than soap and water in eliminating gram-negative bacilli ($P = .03$) and *Staphylococcus aureus* ($P = .003$).

soap and water in removing pathogens already present on the hands of HCWs. Of 47 cultures from HCWs on ward A from which gram-negative bacilli were isolated prior to hand cleansing, 20 (43%) cleared following use of the alcohol-based rub, whereas only 7 (18%) of 39 cleared following the use of soap and water on ward B ($P = .03$) (Fig. 3). Similarly, the alcohol-based rub was more efficacious than soap and water in removing *S. aureus* (16 of 18 vs 3 of 10; $P = .003$). No significant difference in efficacy was noted for yeast (18 of 24 vs 10 of 18; $P = .19$).

Nosocomial Infection Rates

During the 12-month study period, monthly infection rates ranged from 1.7 to 9.8 per 1,000 resident-days on ward A and 2.2 to 9.6 per 1,000 resident-days on ward B (Fig. 4). There were no differences between the two wards regarding total or specific organism infection rates during the study period.

DISCUSSION

Little is known about the impact of infection control interventions on compliance with hand hygiene or noso-

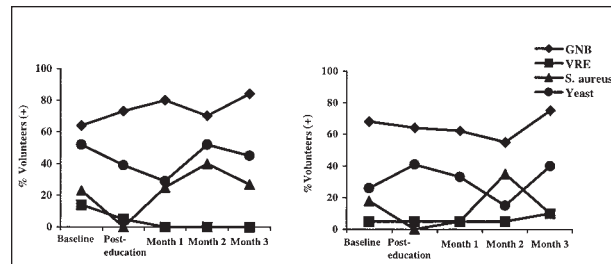


FIGURE 2. Percentage of volunteer healthcare workers on (left) the intervention ward (ward A) and (right) the control ward (ward B) from whom potential pathogens were isolated prior to hand hygiene. GNB = gram-negative bacilli; VRE = vancomycin-resistant enterococci.

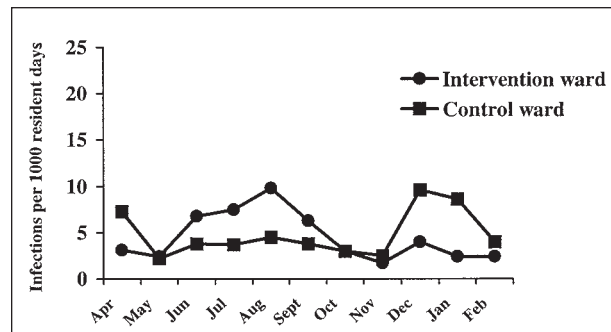


FIGURE 4. Nosocomial infection rates, expressed as the number of infections per 1,000 resident-days, on the intervention ward (ward A) and the control ward (ward B) during the 11-month observation period following the introduction of the alcohol-based hand rub.

comial infection rates in LTCFs. Although baseline compliance with hand hygiene is known to be low,⁵ few studies have prospectively examined the effect of targeted infection control interventions in this setting. A recent report demonstrated an increase in compliance with hand hygiene and a concomitant decrease in clinical isolates of MRSA and vancomycin-resistant enterococci following introduction of a waterless alcohol-based hand rub to a large, combined acute and long-term-care facility.¹⁶ This study was performed in an LTCF in which the residents were considerably younger and the acuity of illness and baseline nosocomial infection rates were considerably higher than in a typical community-based geriatric LTCF; therefore, it is unclear to what degree the results can be generalized to typical LTCFs.

We used the HPI, a survey instrument developed by Larson et al. and validated in an LTCF,^{19,20} as a tool to examine the effect of an educational intervention and the introduction of an alcohol-based hand rub on the knowledge, opinions, and self-reported hand hygiene behavior of HCWs in a community-based LTCF. As the prior studies predicted, education alone had little effect on HCWs' self-reported practices. HCWs on ward A were more likely to report hand cleansing prior to wound care, whereas HCWs on ward B were more likely to report hand cleansing after touching office objects; no other changes in self-reported practices were noted. Similarly, HCWs' knowl-

edge and opinions changed little following education alone. HCWs on ward A learned that lack of a nearby sink or of access to an acceptable soap product is one reason HCWs do not cleanse their hands; this belief may have contributed to the high level of acceptance and satisfaction seen among these HCWs for the alcohol-based hand rub. Following the introduction of the alcohol-based hand rub, HCWs on ward A were more likely to report cleansing their hands after touching office objects, perhaps because of the increased convenience of the alcohol-based hand rub over soap and water in this setting. No difference was seen on either ward in other items of knowledge or opinion following the alcohol-based hand rub intervention.

The effect of the introduction of a waterless alcohol-based hand rub on compliance with hand hygiene was assessed by HCWs' self-report. Direct observation of HCWs' hand hygiene practices is the most accurate means of assessing compliance, but this method can be logistically difficult in LTCFs. Our study was performed in an LTCF in which residents lived in private rooms and sinks were located in their bathrooms. Thus, direct observation of hand hygiene by HCWs would have been intrusive and difficult.

The number of hand cleansings in 1 hour reported by HCWs was not different between the two wards either at baseline or following the educational intervention. However, following the introduction of the hand rub, there was a significant increase in the frequency of hand hygiene in the intervention group (ward A). The improved compliance noted on the intervention ward was possibly related to HCWs' satisfaction with the alcohol-based rub. HCWs thought that it was faster, less drying, and more convenient than soap and water.

Our assessment of compliance by self-report is a limitation of this study. Few studies have been done to evaluate the correlation between self-reported and observed frequency of hand hygiene. Broughall et al. found that the observed frequency of hand hygiene during a nursing shift was lower than that reported by the nurses.²¹ Although we recognize the limitations of self-reporting, the frequency of hand cleansing per hour reported by HCWs in our study was similar on the two floors at baseline and after the educational intervention. We think that the accuracy of self-reporting was optimized in our study by asking HCWs to estimate their frequency of hand hygiene only during the 1 hour prior to completing the questionnaire, rather than for the entire shift.

The hands of HCWs in LTCFs are at a high risk of colonization with pathogens. In a study evaluating modes of transmission of trimethoprim-resistant gram-negative pathogens, 16 of 21 staff members were colonized and a significant proportion of colonizing strains were identical to patient isolates.²² In our study, HCWs were frequently colonized with gram-negative bacilli, yeasts, and *S. aureus*, but less often with vancomycin-resistant enterococci. The increased compliance with hand hygiene seen was not associated with a reduction of hand colonization

with pathogens. It is likely that we were unable to demonstrate a difference in colonization rates between HCWs on the two wards because the sampling method used was sensitive, making it difficult to measure efficacy using log reduction. Various methods have been used to culture the hands of HCWs. These have included selective¹⁸ and non-selective broth immersion of hands,²² the finger impression method, and the use of swabs to culture fingertips and web spaces. With the addition of an overnight incubation step prior to plating of the broth, colonization with few organisms that would not have been discovered by other techniques was documented. This made detection of differences between the groups difficult.

Ultimately, it is important to know whether educational efforts and the introduction of an alcohol-based hand rub lead to fewer infections among residents of LTCFs. Few prior studies have assessed rates of nosocomial infections following introduction of an alcohol-based rub.^{14,18} In the acute care setting, one study reported that the use of an alcohol-based hand rub in conjunction with an ongoing hand hygiene education campaign was associated with reductions in both MRSA infection and overall nosocomial infection rates¹⁴; the reduction in MRSA infection could have been related to the simultaneous implementation of a program of active surveillance cultures and contact precautions for all colonized patients, however. Whether a similar impact can be realized in the LTCF setting has yet to be determined. We monitored nosocomial infection rates on the two study wards for 1 year and did not see any significant changes in total or specific nosocomial infections. A larger trial involving more facilities is required to address this issue.

The alcohol-based hand rub was well accepted and tolerated by HCWs in an LTCF, and its introduction led to a significant increase in the self-reported frequency of hand hygiene. Further studies are necessary to evaluate the effectiveness of the alcohol-based rub in reducing infection rates and its economic impact in this setting.

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