Effect of Antiseptic Handwashing vs Alcohol Sanitizer on Health Care–Associated Infections in Neonatal Intensive Care Units

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Background: The Centers for Disease Control and Prevention, Atlanta, Ga, recommend use of waterless alcohol hand products in lieu of traditional handwashing for patient care, but there are few data demonstrating the impact of this recommendation on health care–associated infections.

Objective: To compare the effect of 2 hand hygiene regimens on infection rates and skin condition and microbial counts of nurses’ hands in neonatal intensive care units.

Design, Setting, and Participants: Clinical trial using a crossover design in 2 neonatal intensive care units in Manhattan, NY, from March 1, 2001, to January 31, 2003, including 2932 neonatal hospital admissions (51760 patient days) and 119 nurse participants.

Intervention: Two hand hygiene products were tested: a traditional antiseptic handwash and an alcohol hand sanitizer. Each product was used for 11 consecutive months in each neonatal intensive care unit in random order.

Results: After adjusting for study site, birth weight, surgery, and follow-up time, there were no significant differences in neonatal infections between the 2 products; odds ratios for alcohol compared with handwashing were 0.98 (95% confidence interval [CI], 0.77-1.25) for any infection, 0.99 (95% CI, 0.77-1.33) for bloodstream infections, 1.61 (95% CI, 0.57-5.54) for pneumonia, 1.78 (95% CI, 0.94-3.37) for skin and soft tissue infections, and 1.26 (95% CI, 0.42-3.76) for central nervous system infections. The skin condition of participating nurses was significantly improved during the alcohol phase (P = .02 and P = .049 for observer and self-assessments, respectively), but there were no significant differences in mean microbial counts on nurses’ hands (3.21 and 3.11 log10 colony-forming units for handwashing and alcohol, respectively; P = .38).

Conclusions: Infection rates and microbial counts on nurses’ hands were equivalent during handwashing and alcohol phases, and nurses’ skin condition was improved using alcohol. However, assessing the impact on infection rates of a single intervention is challenging because of multiple contributory factors such as patient risk, unit design, and staff behavior. Other practices such as frequency and quality of hand hygiene are likely to be as important as product in reducing risk of cross-transmission.

terian Hospital: a 43-bed unit (NICU 1) and a 50-bed unit (NICU 2). Each unit comprised 4 to 6 rooms housing 6 to 10 iso-
lettes. During the study period, NICU 1 had approximately half the square footage per neonate when compared with NICU 2. The 2 units were about 6 miles apart with the only shared staff being 2 neonatal fellows each year. While this was a sample of convenience, the study units were similar to the NICUs in the National Nosocomial Infections Surveillance (NNIS) system da-
tabase in terms of types and rates of infections and distribution of birth weights.2

All neonates hospitalized for more than 24 hours on the study units were eligible for inclusion in the study, and all full-time nurses were eligible to participate. Part-time and agency nurses and nurses from other units who occasionally worked in the NICU were not eligible. Nurses were studied because they touched the neonates most often3 and were the largest group of health care professionals permanently assigned to the study units.

INTERVENTION

Hand Hygiene Products

The 2 tested hand hygiene products were traditional hand-
washing with an antiseptic detergent containing 2% chlorhexi-
dine gluconate (CHG) (Bactoshield; Steris Corporation, St Louis, Mo) or a hand sanitizer containing 61% ethanol and emol-
lients (ALC) (3M Avagard D Instant Antiseptic Hand Sanitizer with Moisturizers; 3M HealthCare, St Paul, Minn). During the ALC phase, a nonantimicrobial liquid soap (Kindsete Body Wash and Shampoo; Steris Corporation) was also provided for use when hands were physically soiled. Hand lotion (Soft Skin Conditioner; Steris Corporation) was provided throughout the study in both NICUs. Other hand hygiene policies and prod-
tucts were standardized across both study units. Prior to the study, a CHG product was used in both study units for traditional hand hygiene, and alcohol hand products were not in use.

Data collection periods were March 1, 2001, to January 31, 2002, (year 1) and March 1, 2002, to January 31, 2003, (year 2) with a month hiatus (February 2002) during which the product crossover occurred and staff became accustomed to the change. During year 1, NICU 1 used CHG and NICU 2 used ALC, and products were reversed in year 2. All staff and visi-
tors to each NICU used the designated product.

At the onset of the study and during the crossover month, NICU staff members were oriented to the study products and proce-
dures. At least 1 member of the research team visited the study units daily to collect data, monitor use of the hand hygiene prod-
tucts, and respond to questions and concerns. No attempt was made to change any aspects of hand hygiene behavior except to assure that the designated product was available and used. Staff re-
ceived no feedback on their practices. The study was approved
by the institutional review boards of both study institutions, and all nurse participants provided written consent.

Surveillance of Infections

Bloodstream infections, pneumonia, conjunctivitis, skin and soft tissue infections, and central nervous system infections were monitored because these represent more than 80% of all HAI in neonates.24 Surveillance was conducted prospectively by a study nurse epidemiologist who visited the units at least 3 times weekly. Sources of data included laboratory, radiology, and pharmacy records; patient records; information from physician and nursing staff; and direct observation of neonates. Standard-
ized definitions adapted for use in neonates from the NNIS sys-
tem were used.56 The definition of conjunctivitis was broad-
ened from the NNIS definition to include eye drainage with empirical antibiotic treatment. Interrater reliability was first es-

tablished in pilot work and confirmed during year 1 by having
infection data collected simultaneously and independently by
the study nurse epidemiologist and each hospital’s nurse epi-
demiologist. Reliability was monitored throughout the study
during meetings between the nurse epidemiologist and the phy-
sician coinvestigators (a pediatric infectious disease specialist
and a neonatologist). Cases with equivocal data or those that did not fulfill NNIS criteria were reviewed, and discrepancies were resolved by consensus.

Neonatal Data Collection

Neonatal data collected prospectively included demographics (gender, birth date, birth weight, sex, gestational age, Apgar score), surgical procedures, length of stay, types and duration of intravascular therapy, days on ventilator or days of nasal can-
mula continuous positive airway pressure (NC-CPAP), and anti-
microbial therapy.

Assessment of Skin Health of Nurses’ Hands

Two noninvasive assessment tools were used monthly to as-

Observer Assessment

Trained observers used a 6-point scale to examine the hands at magnification × 3. The scale has been shown to correlate well with other physiologic measures of skin condition.7 The scores range from 5 (normal, no observable scale or irritation) to 0 (extensive cracking of skin surface, widespread reddening, or occasional bleeding). In previous studies, including valida-
tion with dermatologist ratings, an interrater agreement of more than 95% within a score ± 1 was consistently obtained across a spectrum of damaged and undamaged hands.810

Self-assessment

Using a self-rating scale, participants gave themselves scores in 4 dimensions: appearance, intactness, moisture content, and sensation. Scores ranged from 4 to 28, with higher scores indi-
cating healthier skin. In previous studies, self-ratings scores significantly correlated with other physiologic measures of skin condition.1113 Observer and participant self-assessments were completed independently.

Microbial Counts on Nurses’ Hands

To assess the impact of the hand regimens on colonizing rather than transient flora, nurses cleansed their hands using the as-
signed product (CHG or ALC) and then a modified glove-
juice technique was used for sampling.10,12 The nurse inserted the dominant hand into a sterile polyethylene bag containing 50 mL of sampling solution (0.075M phosphate buffer, pH 7.9, containing 0.1% polysorbate 80 and 0.1% sodium thiostelan-
fate), and the entire hand was massaged through the wall of the bag for 1 minute. All microbiologic testing was performed by the Clinical Microbiology Service of Columbia University Medical Center, New York, NY. Undiluted and diluted (10-
fold and 100-fold) aliquots of sampling solution were inocu-
lated onto 5% sheep-blood agar plates (BBL; Becton Dickin-
son Microbiology Systems, Cockeysville, Md) to determine total microbial counts.
Assessment of Other Care Practices

Nurse participants were asked to keep a diary 1 shift per month noting the frequency of hand hygiene, lotion and glove use, and number of patients contacted. To assess the quality of hand hygiene, research assistants made 440 observations (220 with each product) of hand hygiene using a previously validated 5-item scale. For traditional handwashing, the items included thoroughly wetting, rinsing, and drying hands; covering all surfaces; and avoiding recontamination. For alcohol, items included hands free of soil before using the product, applying alcohol to faces; and avoiding recontamination. For alcohol, items included hands free of soil before using the product, applying alcohol to faces; and avoiding recontamination.

DATA ANALYSIS

Incidence rates were calculated as the number of incident infections per 1000 patient days for all infections combined, skin and soft tissue infections, central nervous system infections, and conjunctivitis. Consistent with NNIS protocols, incidence rates for bloodstream infections and pneumonia used central venous–catheter days and ventilator days as respective denominators, thereby providing infection rates controlled for variations in device use. Differences between treatment groups and study sites were assessed using t tests and Mann-Whitney U tests for continuous measures and χ2 tests for categorical measures. Logistic regression was used to test the null hypothesis of no difference in the risk of any infection between the 2 treatment groups (ALC and CHG). The outcome variable in the model was the presence or absence of any infection in each neonate. In addition to the dichotomous indicator of product used, the model included several potential confounders: study site (NICU 1 or 2), birth weight measured in grams, days of follow-up, and whether a surgical procedure was performed on the neonate. Days of follow-up was defined as the length of stay for neonates without infection and time from hospital admission to first infection for infected neonates. Analogous models were fit for each type of infection. Confidence intervals for incidence rates were computed based on the Poisson distribution.

Measurements of nurses’ skin condition and microbial density on hands were compared using t tests for data obtained via crossover studies as described in Fleiss. These analyses compared the final measurements for each product period. To normalize data, microbial counts were converted to log_{10} colony-forming units. Hand hygiene practices as reported on nurse diary cards and quality scores from direct observation were compared between products (ALC or CHG) for both units combined using the Mann-Whitney U test.

The statistical power of the study was calculated as follows: for all infections, with 10000 patient days of follow-up and an overall infection rate of 14 per 1000 patient days, the study had more than 90% power to detect a risk ratio between the 2 treatment groups of 1.6. For bloodstream infections with 5500 catheter days of follow-up and a rate of 17.5 per 1000 catheter days, we had 90% power to detect a risk ratio of 1.5. Additionally, with 1500 infants, the study had 90% power to detect an odds ratio of 1.4 assuming a reference proportion infected of 12%

Table 1. Characteristics of Neonates by Product Phase

<table>
<thead>
<tr>
<th>Variable</th>
<th>CHG</th>
<th>ALC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gestational age, wk, mean (range)</td>
<td>35.1 (23-42)</td>
<td>34.6 (23-49)</td>
</tr>
<tr>
<td>Birth weight, g, mean (SD)</td>
<td>2456 (1015)</td>
<td>2380 (1047)</td>
</tr>
<tr>
<td>Birth weight categories, g, %*&lt;1000</td>
<td>136 (9.0)</td>
<td>188 (13.3)</td>
</tr>
<tr>
<td>1000-1500</td>
<td>180 (11.9)</td>
<td>153 (10.8)</td>
</tr>
<tr>
<td>1501-2500</td>
<td>462 (30.5)</td>
<td>406 (28.7)</td>
</tr>
<tr>
<td>&gt;2500</td>
<td>738 (48.7)</td>
<td>669 (47.2)</td>
</tr>
<tr>
<td>Girls, %</td>
<td>44.9</td>
<td>43.2</td>
</tr>
<tr>
<td>Device use ratios†</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Central venous catheter</td>
<td>0.34 (8830/25 735)</td>
<td>0.35 (9162/26 025)</td>
</tr>
<tr>
<td>Ventilator</td>
<td>0.16 (4049/25 735)</td>
<td>0.17 (4460/26 025)</td>
</tr>
<tr>
<td>NC-CPAP†</td>
<td>0.21 (15372/25 735)</td>
<td>0.28 (7429/26 025)</td>
</tr>
<tr>
<td>Surgical procedure*</td>
<td>0.16 (244/1516)</td>
<td>0.20 (283/1416)</td>
</tr>
</tbody>
</table>

Abbreviations: ALC, hand sanitizer containing 61% ethanol and emollients; CHG, antiseptic detergent containing 2% chlorhexidine gluconate; NC-CPAP, nasal cannula continuous positive airway pressure.

*The following proportions were significantly greater during the ALC periods: neonates less than 1000 g (P <.001), neonates receiving NC-CPAP (P <.001), and neonates undergoing surgical procedures (P = .006).†Device use ratios = number of device days/total number of patient days.

RESULTS

CHARACTERISTICS OF NEONATES AND NURSES

During the 2-year study period, 2829 neonates with 2932 hospital admissions (51 760 patient days) of more than 24 hours were included: 1692 (57.7%) and 1240 (42.3%) admissions in NICU 1 and NICU 2, respectively. Mean gestational ages were 34.7 and 35.1 weeks in NICU 1 and NICU 2, respectively (P = .09). Mean birth weights were 2389 and 2447 g, respectively (P = .08); significantly more neonates weighed less than 1000 g in NICU 1 than in NICU 2 (12.8% vs 8.7%; P < .01). The NICU 1 had significantly higher device use ratios for central venous catheters (0.41 vs 0.27; P < .001) and NC-CPAP (0.37 vs 0.08; P < .001) and more neonates who underwent surgical procedures (0.24 and 0.10, respectively; P < .001). There were significantly larger proportions of neonates weighing less than 1000 g, receiving NC-CPAP, and undergoing a surgical procedure during the ALC phase (Table 1).

Overall, 76.8% (119/155) of eligible nurses agreed to participate in the study and had 1 or more hand cultures performed. The primary stated reason that nurses refused to participate was unwillingness to perform study procedures, such as completing the diary cards. Over the course of the study, 12 nurses withdrew, 9 because they left the study NICU and 3 because they no longer wanted to participate. The mean age of participants was 41.1 years, and the majority (97.5%) were women. There were no significant differences in baseline observations of hand hygiene behavior or microbial counts on hands between sites, but nurses in NICU 2 self-reported significantly healthier baseline skin condition (Table 2).

Nurses completed 1070 daily diary cards (528 and 542 for CHG and ALC phases, respectively). Total hand hygiene episodes were significantly more frequent during the ALC phase (2.73 and 1.93 times per hour in the ALC and CHG phases, respectively; P < .001). During the ALC phase, plain soap was used a mean of once per hour per nurse. During the ALC phase, nurses reported significantly less gloving and more patient contacts. No other practices were significantly different (Table 3). The mean hand hygiene quality scores (n = 440 direct observa-
tions) were significantly higher with ALC than with traditional handwashing (4.70 and 4.07 of 5; \( P < .001 \)).

**EFFECT OF HAND HYGIENE REGIMEN ON HAI RATES**

The numbers of neonates infected, total exposure days, and unadjusted incidence density of infections by treatment group are summarized in Table 4. After adjusting for birth weight, study site, surgery, and follow-up time, there were no significant differences in infection risk during the CHG and ALC periods for any type of infection (Table 5).

**SKIN CONDITION AND MICROBIOLOGY OF NURSES’ HANDS**

A total of 2328 self-assessments and 2313 observer assessments of skin condition were made, about 19 per

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**Table 2. Baseline Characteristics of 119 Participating NICU Nurses**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>NICU 1</th>
<th>NICU 2</th>
<th>Total</th>
<th>( P ) Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Years in nursing, mean</td>
<td>19.0</td>
<td>13.8</td>
<td>16.5</td>
<td>.01*</td>
</tr>
<tr>
<td>Years in study unit, mean</td>
<td>10.7</td>
<td>9.4</td>
<td>10.5</td>
<td>.80*</td>
</tr>
<tr>
<td>History of skin problems, %</td>
<td>49.1</td>
<td>38.9</td>
<td>44.3</td>
<td>.27†</td>
</tr>
<tr>
<td>Baseline skin condition</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean observer rating (5 maximum)</td>
<td>3.90</td>
<td>4.53</td>
<td>4.19</td>
<td>.001‡</td>
</tr>
<tr>
<td>Mean self-rating (24 maximum)</td>
<td>22.2</td>
<td>23.7</td>
<td>22.9</td>
<td>.06‡</td>
</tr>
<tr>
<td>Mean hand microbial count, ( \log_{10} )</td>
<td>3.53</td>
<td>3.42</td>
<td>3.47</td>
<td>.12*</td>
</tr>
<tr>
<td>Observed hand hygiene behaviors, mean/h§</td>
<td>2.48</td>
<td>2.62</td>
<td>2.54</td>
<td>.32‡</td>
</tr>
<tr>
<td>Hand hygiene</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alcohol uses</td>
<td>0.95</td>
<td>1.10</td>
<td>1.00</td>
<td>.62</td>
</tr>
<tr>
<td>Lotion use</td>
<td>0.07</td>
<td>0.18</td>
<td>0.11</td>
<td>.23</td>
</tr>
<tr>
<td>Glovings</td>
<td>2.59</td>
<td>2.50</td>
<td>2.55</td>
<td>.57</td>
</tr>
<tr>
<td>Minutes in gloves</td>
<td>17.3</td>
<td>17.0</td>
<td>17.2</td>
<td>.98</td>
</tr>
<tr>
<td>Patients contacted</td>
<td>2.6</td>
<td>2.4</td>
<td>2.5</td>
<td>.08</td>
</tr>
</tbody>
</table>

Abbreviation: NICU, neonatal intensive care unit.

* Determined using \( t \) test.
† Determined using \( \chi^2 \) test.
‡ Determined using Mann-Whitney \( U \) test.
§ Hand hygiene = handwashing or application of alcohol product.

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**Table 3. Self-reported Hand Hygiene Practices During Each Study Phase (Both NICUs Combined) From 1070 Diary Cards**

<table>
<thead>
<tr>
<th>Practice</th>
<th>CHG (n = 528 cards)</th>
<th>ALC (n = 542 cards)</th>
<th>( P ) Value*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. of Recorded</td>
<td>Mean/h (SD)</td>
<td>No. of Recorded</td>
</tr>
<tr>
<td></td>
<td>Observations</td>
<td></td>
<td>Observations</td>
</tr>
<tr>
<td>Lotion uses</td>
<td>474</td>
<td>0.39 (0.48)</td>
<td>317</td>
</tr>
<tr>
<td>Glovings</td>
<td>665</td>
<td>1.56 (1.18)</td>
<td>592</td>
</tr>
<tr>
<td>Min/h gloved</td>
<td>581</td>
<td>17.2 (11.7)</td>
<td>477</td>
</tr>
<tr>
<td>Patient contacts</td>
<td>129</td>
<td>2.22 (1.66)</td>
<td>65</td>
</tr>
</tbody>
</table>

Abbreviations: ALC, hand sanitizer containing 61% ethanol and emollients; CHG, antiseptic detergent containing 2% chlorhexidine gluconate; NICU, neonatal intensive care unit.

* Determined using Mann-Whitney \( U \) test.

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**Table 4. Unadjusted Health Care–Associated Infection Rates for Both Study Units by Product (CHG or ALC)**

<table>
<thead>
<tr>
<th>Infection</th>
<th>CHG (1516 Admissions)</th>
<th>ALC (1416 Admissions)</th>
<th>( P ) Value*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. of Neonates Infected</td>
<td>Total Infections</td>
<td>No. of Exposure Days</td>
</tr>
<tr>
<td>Bloodstream</td>
<td>106</td>
<td>131</td>
<td>8830</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>6</td>
<td>7</td>
<td>4049</td>
</tr>
<tr>
<td>Skin</td>
<td>15</td>
<td>16</td>
<td>25735</td>
</tr>
<tr>
<td>CNS</td>
<td>5</td>
<td>7</td>
<td>25735</td>
</tr>
<tr>
<td>Conjunctivitis</td>
<td>75</td>
<td>85</td>
<td>25735</td>
</tr>
<tr>
<td>All</td>
<td>181</td>
<td>245</td>
<td>25735</td>
</tr>
</tbody>
</table>

Abbreviations: ALC, hand sanitizer containing 61% ethanol and emollients; CHG, antiseptic detergent containing 2% chlorhexidine gluconate; CNS, central nervous system.

* For all infections, skin, CNS, and conjunctivitis, the denominator is 1000 patient days. For bloodstream infection, the denominator is 1000 central venous–catheter days. For pneumonia, the denominator is 1000 ventilator days.
COMMENT

To our knowledge, this is the first study to assess the effects of CHG or ALC on HAI in a high-risk neonatal setting. Because there were significantly more low-birth-weight neonates, NC-CPAP, and surgical procedures during the ALC phase, bloodstream infection and pneumonia rates were controlled for device days and the regression analyses controlled for study unit, surgery, and birth weight. After adjustment for these factors, infection rates among high-risk neonates were equivalent when staff used either a traditional antiseptic handwash product or an alcohol hand sanitizer.

CONSISTENCY OF STUDY RESULTS WITH OTHER RESEARCH

Numerous studies have confirmed the efficacy of alcohol-based products, reporting microbialic effects of ALC as good or superior to those of other antiseptics. Several studies have demonstrated significantly better removal of methicillin-resistant *Staphylococcus aureus* or vancomycin-resistant enterococci from the hands of health care workers by ALC when compared with CHG. Pittet et al showed over a period of 3 years that when the use of alcohol hand rubs increased from 3.5 to 16.4 L per 1000 patient days, there was a significant reduction of HAI from 16.9% to 9.9%. Several others have demonstrated reductions in infection rates associated with use of alcohol hand sanitizers in descriptive studies. A recent study of more than 4300 patients demonstrated that the 30-day surgical site infection rates were equivalent with the alcohol and the traditional surgical scrub protocols (2.44% and 2.48%, respectively). Our study is consistent with these findings; alcohol is at least equivalent to traditional antiseptic handwashing in terms of impact on infection rates.

The skin condition of participating nurses improved significantly during the alcohol period, as did the quality of the hand hygiene procedure. These findings are consistent with other studies that have also demonstrated that alcohol-based products are associated with less skin irritation and dryness and improved hand hygiene quality when compared with traditional handwashing.

OTHER FACTORS ASSOCIATED WITH INFECTION RATES

There are multiple factors associated with HAI, making it difficult to sort out the independent effects of specific variables, including hand hygiene. In this study, despite our efforts to control or measure variables that could affect infection rates, it is likely that there were unmeasured or uncontrolled factors that had an impact on the risk of infection.

During the study, there were 7 clusters of bacterial infection detected. In NICU 1, an outbreak of *Klebsiella pneumoniae* occurred during the CHG phase, and a cluster of *Serratia marcescens* occurred during the ALC phase. In NICU 2, 4 clusters occurred during the CHG phase (2 with methicillin-resistant *S aureus*, 1 with *S marcescens*, and 1 with vancomycin-resistant enterococci) and 1 cluster of *K pneumoniae* occurred during the ALC phase. Hence, the majority (71.4%) of clusters occurred during the CHG phase. These outbreaks could have been an effect of the hand hygiene product. Alternatively, the outbreaks may have been unrelated to the hand hygiene product but resulted in changed hand hygiene behavior. Because of these uncertainties, we could not control for these clusters in the analysis.

Conounding associated with behavior changes was also possible. In a previous trial comparing ALC and CHG products, infection rates were significantly lower when CHG was used. However, during the alcohol phase, staff members were more likely to use plain soap, and this behavior likely confounded results. During the CHG phase of our study, nurses were significantly more likely to don gloves and reported touching fewer patients. Both of these practices could reduce the risk of microbial transmission. Despite this, no differences in adjusted infection rates occurred during the ALC phase, further confirming that alcohol was at least equivalent to CHG.

As in this study, alcohol hand rubs have been associated with improved hand hygiene compliance. Nevertheless, even during the ALC period in our study, the hand hygiene frequency, although increased, was still low. Similar low rates have been reported in other adult and neonatal intensive care units. Hence, despite increased frequency of hand hygiene observed with ALC, the overall low rate of hand hygiene probably limited the clinical impact.

There were several limitations to this trial. Differences existed between the 2 study sites in terms of patient demographics and unit design. However, we attempted to control for these differences in the analysis.
Hand hygiene practices were self-reported. The study results may not be generalizable to other units or patient populations.

Because it was not possible to blind the users or research team to the study products, the potential for investigator bias cannot be ruled out. We attempted to minimize this by use of validated instruments to diagnose infections and assess skin condition and quality control measures (eg, confirmation of infections by neonatologist or pediatric infectious disease specialist). Only volunteer nursing staff members were included in the microbiologic and behavioral components of the study; the practices of other health care personnel and nonparticipating nurses were not assessed.

Results from this study cannot be construed to be an assessment of the Centers for Disease Control and Prevention guideline. The guideline was not yet published when this study began, so other recommendations of the guideline, such as strategies to promote or monitor hand hygiene, were not included in our study. Our goal was to assess the tested products in the context of usual practices. We believe that this approach was realistic, since studies to change other hand hygiene behaviors have been discouraging to date.47,50-55

In conclusion, there were no significant differences in HAI among neonates during a 2-year period when staff used a traditional antiseptic handwash or an alcohol hand sanitizer. However, ALC was associated with improved skin condition and quality of hand hygiene and, as we have reported elsewhere, was less time-consuming and costly.36 Thus, we confirm that the Centers for Disease Control and Prevention recommendation for use of alcohol in lieu of traditional handwashing warrants widespread application. Despite the fact that hand hygiene frequency increased during the alcohol phase, the frequency was still low. Hence, results of this study add to the overwhelming evidence that systems-level interventions are needed to improve the quality of hand hygiene practices.

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Table 6. Final Mean Skin Condition Ratings and Microbial Counts of Nurses’ Hands by Hand Hygiene Product Phase

<table>
<thead>
<tr>
<th>Test</th>
<th>NICU 1</th>
<th>NICU 2</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ALC</td>
<td>CHG</td>
<td>ALC</td>
</tr>
<tr>
<td>Mean observer assessment</td>
<td>4.07</td>
<td>3.28</td>
<td>4.44</td>
</tr>
<tr>
<td>(score range, 0-5)†</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean self-assessment</td>
<td>21.3</td>
<td>21.1</td>
<td>23.4</td>
</tr>
<tr>
<td>(score range, 4-28)†</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean log10 counts</td>
<td>2.98</td>
<td>3.41</td>
<td>3.25</td>
</tr>
</tbody>
</table>
| *Abbreviations: ALC, hand sanitizer containing 61% ethanol and emollients; CHG, antiseptic detergent containing 2% chlorhexidine gluconate; NICU, neonatal intensive care unit.

†Determined by t test comparing crossed-over treatments.

‡Higher scores = healthier skin.


