Alcohol-Based Handrub Improves Compliance With Hand Hygiene in Intensive Care Units

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Background: Nosocomial infection is a leading complication in intensive care units. Although hand hygiene is the single most efficient preventive measure, compliance with this simple action remains low.

Objectives: To assess the effect of an intervention to promote hand hygiene and to investigate risk factors for noncompliance in intensive care units.

Methods: We performed 7 observational surveys and implemented a promotional campaign after baseline in medical, surgical, and pediatric intensive care units of a teaching hospital. Health care workers were observed during routine patient care. The intervention consisted of a hospitalwide promotional campaign, including observation and performance feedback, posters display, and distribution of individual bottles of alcohol-based handrub. The main outcome measure was compliance with hand hygiene through handwashing or handrubbing.

Results: We observed 2743 opportunities for hand hygiene distributed over 248 periods. Overall compliance increased from 38.4% to 54.5% during the study (P<.001). Although recourse to handwashing remained stable at around 30%, handrubbing increased from 5.4% at baseline to 21.7% at the last survey (P<.001). Compliance increased among nurses and nursing assistants, but remained stable among physicians. Handwashing compliance decreased, on average, by 4.7% for an increase of 10 opportunities for hand hygiene per hour of patient care (P<.001), whereas no such association existed for handrubbing.

Conclusions: Our intervention induced a marked and sustained increase in compliance with hand hygiene. In intensive care units, less time-consuming handrubbing might replace standard handwashing and overcome the barrier of time constraints.

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Hand Hygiene is the single most important measure to prevent cross-transmission of microorganisms from one patient to another,1 and several studies2-8 have demonstrated a reduction in infection rates after improvement in hand-hygiene practices. In intensive care units (ICUs), most endemic infections are due to the carriage of microorganisms on health care workers’ hands,9 and outbreaks of infections resulting from cross-transmission are frequent.10 Critically ill patients are more likely to be colonized or infected with harmful and multi-resistant pathogens. The intensity of patient care and number of contacts between health care workers and patients in ICUs are high, and procedures with a high risk of cross-transmission are common. However, compliance with hand hygiene has been documented as being low, usually below 50%. Although it has been a challenge for infection control teams to design and implement interventions to improve compliance in ICUs, few have had sustained success.6,11-14

Following a baseline survey of hand-hygiene practices conducted in 1994,15 we implemented a hospitalwide campaign to promote hand hygiene. The overall evaluation of this campaign has been published recently.16 Most important, we showed that workloads were highest in the ICUs, but compliance there was lowest. The present study focuses on the specific setting of ICUs and on an alternative way to achieve hand hygiene, using an alcohol-based handrub. Because high workload is a barrier to good compliance in ICUs13,17 and because frequent handwashing requires time,18 we hypothesized that the use of less time-consuming alcohol-based handrub might improve overall compliance. The aim of this study was to assess the effect of the alcohol-based handrub promotion in the ICU setting and to investigate risk factors for noncompliance.
SUBJECTS AND METHODS

SETTING

The study was conducted in the medical (18 beds), surgical (22 beds), and neonatal and pediatric (30 beds) ICUs of the University of Geneva Hospitals, a 2300-bed tertiary care institution covering a population of about 500000.

Several hospitalwide or ICU-specific infection control policies were in place at the time of the study. These included contact isolation (geographical isolation and wearing of gloves, gown, and mask when indicated) for suspected or known methicillin-resistant Staphylococcus aureus-colonized or -infected patients, as described elsewhere. In the medical ICU, an intervention to reduce catheter-related infections was implemented in March 1997, including detailed information to all clinical staff about pathogenesis of these infections and guidelines on device insertion, maintenance, and use. Included in the guidelines were maximum barrier precautions (sterile gloves, gown, cap, mask, and a large sheet) for all but peripheral lines.

DESIGN

After a baseline survey, we implemented a hospitalwide campaign to promote hand hygiene from January 1995 onward. The intervention has been described previously. Briefly, we displayed posters (29.5 × 42 cm) in strategic areas throughout the institution concerning nosocomial infection, cross-transmission, and the importance of hand hygiene in general. Individual bottles of alcohol-based handrub solution were made available, and all staff were encouraged to carry them in their pockets. The alcohol-based solution was prepared by the central pharmacy of the hospital and was ordered by each ward as with any other drug or pharmaceutical preparation. Consequently, the bottles were available in each ward for all persons working there or consultants. These bottles are made for pocket carriage, are equipped with a flip-top lid (easily opened and closed with one finger), are usually emptied within 3 days, and are not reused. Handrubbing is performed after closing and reintroducing the bottle into the pocket, thus preventing hand contamination after handrubbing. Clips were installed on all beds to hold additional bottles to promote bedside use.

We performed 7 biannual observational surveys, from December 1994 to December 1997, as described elsewhere. Each survey lasted 2 to 3 weeks. We scheduled 20-minute observation periods, randomly distributed throughout the study. Infection control nurses observed health care workers during routine patient care and recorded opportunities for hand hygiene according to established criteria, as well as the number and type of hand cleansings. Observers were visible but as unobtrusive as possible. Handwashing referred to washing hands with water alone or with unmedicated soap, and handrubbing referred to the use of an alcohol-based handrub solution (75% isopropyl alcohol, weight-to-weight ratio) containing 0.5% chlorhexidine gluconate and skin emollients. No judgment on the quality of hand hygiene was made.

Concordance among observers and sensitivity to detect opportunities for hand hygiene were excellent.

Table 1. Distribution of Opportunities for Hand Hygiene According to Level of Risk for Cross-transmission in Critical Care, 1994 to 1997*

<table>
<thead>
<tr>
<th>Opportunity</th>
<th>Low Risk</th>
<th>Medium Risk</th>
<th>High Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Opportunities</td>
<td>781 (28)</td>
<td>1382 (50)</td>
<td>580 (21)</td>
</tr>
<tr>
<td>Before intravenous or arterial care</td>
<td>...</td>
<td>...</td>
<td>307 (53)</td>
</tr>
<tr>
<td>After intravenous or arterial care</td>
<td>...</td>
<td>257 (19)</td>
<td>...</td>
</tr>
<tr>
<td>Before respiratory care</td>
<td>...</td>
<td>70 (12)</td>
<td>...</td>
</tr>
<tr>
<td>After respiratory care</td>
<td>99 (7)</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>Before urinary care</td>
<td>...</td>
<td>24 (4)</td>
<td>...</td>
</tr>
<tr>
<td>After urinary care</td>
<td>...</td>
<td>31 (2)</td>
<td>...</td>
</tr>
<tr>
<td>Before wound care</td>
<td>...</td>
<td>61 (11)</td>
<td>...</td>
</tr>
<tr>
<td>After wound care</td>
<td>56 (4)</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>Between shifts</td>
<td>...</td>
<td>118 (20)</td>
<td>...</td>
</tr>
<tr>
<td>After contact with body fluid</td>
<td>...</td>
<td>126 (9)</td>
<td>...</td>
</tr>
<tr>
<td>After patient contact</td>
<td>813 (59)</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>Indirect patient contact</td>
<td>...</td>
<td>695 (89)</td>
<td>...</td>
</tr>
<tr>
<td>Hospital maintenance</td>
<td>86 (11)</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

*Data are given as number (percentage). Not all percentages sum to 100 because of rounding. Ellipses indicate not applicable.

RESULTS

STUDY SAMPLE

We performed 7 surveys on a biannual basis from December 1994 to December 1997. We observed 2743 opportunities for hand hygiene, distributed over 248 scheduled observation periods. Most (98%) of these periods lasted about 20 minutes (range, 15-45 minutes), totaling 84 hours of observation. The periods were spread throughout all times of the day (47% of the opportunities in the morning, 33% in the evening, and 20% during the night) and week.

Nurses contributed 82% of the opportunities; physicians, 9%; nursing assistants, 6%; and other health care workers, 3%.

The overall median activity index and patient-staff ratio were 30 (range, 3-144) opportunities per hour and 1.12 (range, 0.13-6.25) patients per nurse. Both remained stable throughout the study (linear regression, P = .97 and P = .63, respectively). For nurses, the median number of opportunities for hand hygiene was 21 (range, 3-144) per hour of patient care.

Table 1 shows the distribution of the observed opportunities for hand hygiene stratified by the level of risk of cross-transmission. More than 50% (1382/2743) were of medium risk and 21% (580/2743) were of high risk of cross-transmission, with the dominant group being “before intravenous or arterial care.” The distribution of the opportunities according to the level of risk did not change over time (P = .45).

IMPROVEMENT OF COMPLIANCE OVER TIME

The overall compliance with hand hygiene increased from 38.4% at baseline to 54.5% at the last survey (score test...
Performance feedback was provided shortly after each survey. In brief, it was performed 2 months after each survey through a hospital newsletter that is distributed with employee paychecks. In addition, regular informal discussions about the results were held between ICU staff and infection control nurses.

**STATISTICAL ANALYSIS**

The dependent variable was compliance with hand hygiene, through either handwashing or handrubbing. Independent variables included the category of staff (nurses, physicians, nursing assistants, and other health care workers), time of day and week when the observation was performed, number of patients and staff in the unit, patient-staff ratio at the time of observation, activity index (defined as the number of opportunities for hand hygiene during each observation period per hour of care), and type of care that generated the opportunity. Opportunities were categorized into low to medium risk of cross-transmission (after direct patient contact, intravenous or arterial care, urinary care, respiratory care, wound care, contact with biological fluid, indirect patient contact, and hospital maintenance) or high risk of cross-transmission (between care of a dirty and care of a clean body site and before intravenous or arterial care, urinary care, respiratory care, and wound care). Indirect patient contact was defined as a contact with inanimate objects (including medical equipment) in the immediate vicinity of the patient.

We first investigated the effect of the campaign, then assessed factors predicting noncompliance, and finally investigated factors associated with the use of handrubbing vs handwashing. In the latter, we considered only opportunities followed by a hand-hygiene action. The dependent variable was the hand-hygiene technique (handwashing or handrubbing).

We compared categorical variables by the χ² test or Fisher exact test, and continuous variables by the t test or by nonparametric methods when departure from normality was observed. The association between continuous variables was graphically explored by nonparametric regression analysis and summarized by linear regression if appropriate. This method was used to investigate the association between compliance and workload.

All independent variables were first examined in a univariate analysis using the Mantel-Haenszel method and logistic regression. Variables associated with the dependent variable with a probability of 0.1 or less were further investigated in a multivariate logistic regression model. In the final multivariate models, we investigated whether the effect of the variables changed over time by adding an interaction term between the variable “study” and all the other independent variables. Measures of association are summarized by odds ratios (ORs), displayed with their 95% confidence intervals (CIs). We used a generalized estimating equation because of independence of observations within an observation period.

All tests were 2-tailed, and P < .05 was considered statistically significant. We used commercially available statistical software (Stata, version 6; Stata Corp, College Station, Tex) for all analyses.

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**RISK FACTORS FOR NONCOMPLIANCE**

Factors associated with noncompliance are displayed in Table 2. Even after adjustment for potential confounders, compliance improved over time. The level of risk and activity index remained independent predictors of noncompliance. The odds of noncompliance among physicians and other health care worker categories remained significantly higher than among nurses. No interaction was found.

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**HANDBRUBBING VS HANDBASHING**

The frequency of handwashing decreased, on average, by 4.7% for an increase of 10 opportunities per hour (95% CI, 3.2%-6.1%; P < .001), whereas no such association existed for the frequency of handrubbing (P = .12) (Figure 2).
We examined the tendency over time to use handrubbing compared with handwashing among opportunities that generated a hand-hygiene action. Recourse to handrubbing among nurses increased considerably from one survey to the next (OR, 1.28; \( P < .001 \)), more so than among physicians (OR, 1.16; \( P = .33 \)). Similarly, recourse to handrubbing increased during activities associated with a low to medium risk of cross-transmission (OR, 1.28; \( P < .001 \)), with a high risk of cross-transmission (OR, 1.24; \( P = .02 \)), and among most strata of the activity index. We did not find any interaction between time and these variables.

Factors associated with preferential recourse to handrubbing are displayed in Table 3. Physicians tended to use handrubbing more often than nurses, and nursing assistants less often. As expected, handrubbing was used more often than handwashing in high-risk situations. Interestingly, we found an association between recourse to handrubbing and workload, as health care workers tended to perform handrubbing more often when the activity index was high (>60 opportunities per hour) compared with when it was low (0-20 opportunities per hour).

**COMMENT**

Compliance with hand-hygiene recommendations at baseline was low (38%) and fell in the range of that found in other studies.\(^6,11,23-25\) This study is the first to show a marked and sustained improvement in compliance with hand hygiene. The effect was mostly attributable to the increased recourse to handrubbing.\(^16\) Improvement was observed most among nurses and nursing assistants and was absent among physicians and other health care workers. Furthermore, a high level of activity and high-risk opportunities were associated with noncompliance in all surveys.

The rationale underlying the promotional campaign was that a wider use of handrubbing would shorten the time required to perform hand hygiene, thus increas-

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**Table 2. Factors Predicting Noncompliance With Hand Hygiene in Intensive Care Units, 1994 to 1997**

<table>
<thead>
<tr>
<th>Factor</th>
<th>Univariate Analysis</th>
<th>( P ) Value</th>
<th>Multivariate Analysis</th>
<th>( P ) Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Study†</td>
<td>0.91 (0.85-0.98)</td>
<td>.01</td>
<td>0.90 (0.85-0.96)</td>
<td>.002</td>
</tr>
<tr>
<td>Health care worker</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nurses</td>
<td>1</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Physicians</td>
<td>1.78 (1.38-2.31)</td>
<td>&lt;.001</td>
<td>2.07 (1.54-2.77)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Nursing assistants</td>
<td>1.25 (0.93-1.69)</td>
<td>.14</td>
<td>1.43 (1.03-1.98)</td>
<td>.03</td>
</tr>
<tr>
<td>Other</td>
<td>2.04 (1.26-3.31)</td>
<td>.004</td>
<td>2.16 (1.24-3.82)</td>
<td>.007</td>
</tr>
<tr>
<td>Level of risk</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low to medium</td>
<td>1</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>2.73 (2.29-3.27)</td>
<td>&lt;.001</td>
<td>3.14 (2.56-3.84)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Activity index, opportunities per hour</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-20</td>
<td>1</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>21-40</td>
<td>1.67 (1.19-2.36)</td>
<td>.003</td>
<td>1.64 (1.15-2.34)</td>
<td>.006</td>
</tr>
<tr>
<td>41-60</td>
<td>2.40 (1.63-3.54)</td>
<td>&lt;.001</td>
<td>2.18 (1.46-3.28)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>&gt;60</td>
<td>5.11 (3.09-8.81)</td>
<td>&lt;.001</td>
<td>4.89 (2.84-8.14)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Time of the week</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weekdays</td>
<td>1</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Weekend</td>
<td>0.84 (0.58-1.23)</td>
<td>.37</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time of day</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Morning</td>
<td>1</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Afternoon</td>
<td>1.14 (0.82-1.58)</td>
<td>.42</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Night</td>
<td>0.75 (0.53-1.07)</td>
<td>.11</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Data are given as odds ratio (OR) (95% confidence interval) unless otherwise indicated. Ellipses indicate not applicable.
†Refers to the average modification of the OR between 2 consecutive surveys.
ing compliance. Waterless hand disinfection is fast-acting and can be performed at the bedside, using individual bottles or dispensers made available.

Current guidelines recommend that handwashing be performed for at least 20 seconds, but this figure does not include the time required to walk to the sink, rinse and dry the hands, and walk back to the patient. The whole procedure takes 1 to 2 minutes. Proper adherence to these recommendations is impossible in ICUs, where the number of contacts with patients is high. In this study, the median number of opportunities per hour (reflecting workload) for hand hygiene was 30, requiring 30 to 60 minutes per hour for hand hygiene, assuming 100% compliance. This time constraint is not compatible with adequate patient care. In contrast, 20 seconds are sufficient to perform handrubbing. In a hypothetical model, Voss and Widmer calculated that in a 14-bed ICU, the time required to perform handwashing would be 16 hours of nursing time per day shift, but only 3 hours for handrubbing. This is a conservative estimate, because they assumed 2 to 3 opportunities for hand hygiene per health care worker and per hour, which is much fewer than what we and others measured. Recourse to the less time-consuming handrubbing might be the solution to bypass the time constraint, as illustrated by our data. Compliance with handwashing was inversely associated with a high workload, decreasing, on average, by almost 5% for an increase of 10 opportunities per hour, whereas no such association existed with handrubbing.

More than 20% of the opportunities for hand hygiene in our ICUs carried a high risk of cross-transmission. Compliance in this group was low (26%), lower than in the group of low- to medium-risk opportunities, as previously reported by others, but it significantly increased during our study. This is consistent with our policy that high-risk opportunities are an indication for the use of an alcohol-based handrub solution, as opposed to standard handwashing.

Good accessibility to hand-hygiene supplies is a prerequisite to adequate compliance. Inconveniently located facilities increase the time spent by health care workers to achieve hand hygiene and jeopardize compliance. Bischoff et al illustrated this by measuring compliance with hand hygiene at baseline and after providing alcohol-based waterless handrub dispensers, initially at a ratio of 1 dispenser per 4 beds and, later, 1 dispenser per bed. Compliance significantly increased with the better availability of the dispensers. Similarly, Maury et al observed a marked improvement in compliance with hand hygiene after providing individual bottles and dispensers of an alcohol-based solution. The present study extends the observation in these reports by demonstrating amelioration of noncompliance due to time constraint and by reporting sustained effect of the waterless hand-disinfection strategy. Before this study, the standard for hand hygiene at our institution was handwashing. We promoted the use of handrub solution at the bedside by distributing individual bottles for pocket carriage and by installing dispensers in patient rooms, thus optimizing accessibility.

Adverse effects of hand-hygiene agents are reported as a reason for noncompliance. This issue is of particular relevance in ICUs, where the frequency of opportunities for hand hygiene is high and much higher than in other wards. The handrub solution used in our institution contains skin emollients, and hand-care lotion was provided throughout the intervention, possibly contributing to the absence of any major skin reaction in our experience.

For many decades, handwashing has been the standard technique for hand hygiene, and the introduction of a new method raises the question of its efficacy. The effectiveness of handwashing in reducing the bacterial count on hands is a function of the time spent to wash hands, a 0.6 log10 reduction after 15 seconds to 3.3 after 2 minutes. In contrast, a solution containing 50% of n-propanol alcohol achieves a 3.7 log10 reduction after 30 seconds. Time spent washing hands has been measured in several studies and usually does not exceed 25 seconds. Alcohol not only achieves a greater reduction in bacterial count but also acts much quicker. Moreover, the hand-cleansing method before patient care could affect the degree of bacterial contamination during care. Compared with those who used an alcohol-based handrub solution, health care workers who washed their hands with soap and water had an excess of 52 colony-forming units on their fingertips. Similarly, Zaragoza et al demonstrated in a randomized clinical trial the better efficacy of alcohol-based solutions vs soap in reducing hand contamination.

Therefore, the use of an alcohol-based handrub solution is an alternative to standard handwashing, is less time-consuming, is at least as efficient, and has fewer adverse effects on the skin than soap. In our view, it should
replace handwashing in all indications, except when hands are macroscopically soiled.

Compliance among physicians was low, as previously documented,11,37,38 although during the study they indicated a preference for the handrub. We are investigating reasons for the lack of compliance among physicians and are implementing an intervention targeting ICU physicians.

It has been a challenge for infection control practitioners to improve compliance with hand hygiene. Many interventions have been implemented, although none have had a lasting effect, if any at all.6,13,23,24,27,39-41 The most successful strategies were those aiming to improve accessibility to hand-hygiene agents11,25 or those providing performance feedback.12,24 Monocompound strategies had limited effects.14,28 To be successful, interventions must address individual factors, interactions within a group, and institutional constraints and climate.14,28,42 Our intervention, which addressed system modification and behavioral change, was successful because it was inspired by these concepts. The program was multimodal, was fully supported by the institution, and involved every level of the organization.16

Because attitude and compliance with hand hygiene are behavioral in essence, several other strategies to induce behavioral changes have been proposed, such as patient education,25,41 administrative sanction or reward,43,44 enhancement of role modeling by superiors, and establishment of an institutional safety climate.14 Larson and colleagues15 implemented an intervention based on creating an organizational culture in which hand hygiene was a definitive administrative expectation.

Our study has several limitations. We did not have a control group because hand hygiene was an institutional priority and was therefore implemented hospital-wide. Having a control group in another hospital would have been logistically demanding and would have introduced some uncontrollable confounding factors. We are unable to estimate the relative efficacy of the different components of our intervention. Interventions need to be multifactorial to be effective.14,16,28 Therefore, we would not have wanted to dissect the campaign. We cannot rule out a Hawthorne effect to explain the improvement in compliance. However, this seems unlikely because of the steady and regular increase in compliance during the study and the reported increase in the overall consumption of the alcohol-based handrub solution.16 Finally, we are unable to estimate the effect of our campaign on nosocomial infection rates, as we did not measure these throughout the study. However, the prevalence of nosocomial infection and the attack rate of methicillin-resistant \textit{Staphylococcus aureus} decreased throughout the institution.16 This issue needs further assessment by controlled trials in critical care settings.

In summary, increased recourse to an alcohol-based handrub solution induced a marked and sustained improvement in compliance with hand-hygiene recommendations among ICU staff. Handrubbing is an alternative to standard handwashing, is less time-consuming, and is at least as efficient.

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