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# Effect of Guideline Implementation on Costs of Hand Hygiene

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Health care associated infections (HAIs) are one of the most serious complications of health care. These infections impose a major cost burden on health care facilities and patients, and are the fifth leading cause of death in acute care hospitals (Jarvis, 1996). At least one-third of such infections are preventable. Because hands of health care personnel frequently serve as vectors for the transmission of organisms between patients and are also a major reservoir for pathogens with antimicrobial resistance, hand hygiene is one effective strategy to reduce HAIs (Aiello & Larson, 2002; Bryan, Cohran, & Larson, 1995; Larson et al., 1992).

Guidelines for hand hygiene were first published by the Centers for Disease Control and Prevention (CDC) in 1981, and were updated and revised by the Association for Professionals in Infection Control and Applied Epidemiology, Inc. (APIC) in 1988 and 1995 (Larson, 1988, 1995). Since that time, innovations have been made in hand hygiene products, which should change practices of health care professionals (Pittet, 2001). Among the various products available (soaps, scrubs, antibacterial formulas, and alcohol hand rubs), alcohol-based products have the most rapid bactericidal action and, when combined with other ingredients, can have sustained activity on the skin. Increased hand hygiene compliance with an alcohol-based rub has been attributed to practical factors such as the ready availability and placement of product dispensers or containers and the minimal time required for use (Voss & Widmer, 1997). In 2002, the CDC Guideline for Hand Hygiene was revised (2002), and recommendations for the use of alcohol hand hygiene products for patient care were made.

The economic implications of changing hand hygiene practices are unclear, although researchers studying the economic impact of guidelines generally confirm that there is a cost saving to standardizing practice (Berild, Ringertz, Lelek, & Fosse, 2001; Mille et al., 2000; Nathwani, Rubinstein, Barlow, & Davey, 2001). For example, two studies demonstrated improvements in antibiotic prescribing and reduced costs when cystitis treatment guidelines were used (Goode et al., 2000; O'Connor, Solberg, Christianson, Amundson, & Mosser, 1996). In addition, researchers have modeled the hypothetical costs and savings related to national adoption of smoking cessation guidelines (Cromwell, Bartosch, Fiore, Hasselblad, & Baker, 1997). The actual costs (and savings) of guideline implementation for hand hygiene, however, has not been assessed. The purposes of this study were to (a) compare the costs of hand hygiene in hospitals with high and low hand hygiene compliance as well as high and low frequency of alcohol hand rub use; and (b) examine associations between hospital characteristics and hand hygiene compliance as well as frequency of alcohol hand rub use.

## Methods

### Sample and setting

This study was part of a larger project designed to investigate dissemination of the Hand Hygiene Guideline and its impact on HAI ("Impact of Hand Hygiene Guideline on Infections and Costs," 1 R01 NR008242-01A23). The sample was obtained from hospitals participating in the CDC's National Nosocomial Infection Surveillance (NNIS) system, which consisted of a reporting network of more than 300 acute care hospitals across the nation. To recruit the sample, CDC staff sent invitations to hospitals describing the study. Interested individuals contacted the principal investigator (EL) and eligibility was determined. Eligibility criteria included being a NNIS hospital or using NNIS methods for 3 years prior to this study, providing data on HAI from one or more intensive care units, and not using alcohol products for hand hygiene prior to the publication of the Hand Hygiene Guideline. Based on an a priori determination of power for the study, a total of 40 hospitals across the United States meeting these criteria were recruited.

### Procedures and variables

The study protocol was reviewed and approved by the institutional review boards of each participating hospital as well as the research team's home institution. Infection control professionals acted as site coordinators and gathered data related to the cost of hand hygiene and implementation of the guideline. During a 2-day site visit, data were reviewed by the study project director (DQ) and observations of staff hand hygiene practices were made. Each site coordinator provided data on hospital characteristics including number of beds, teaching status, and geographic region.

Data regarding the annual cost of hand hygiene products (soap, paper towels, and alcohol hand rubs) were obtained from product purchase orders. Cost data were standardized across hospitals and reported as cost per 100 beds in 2002 U.S. dollars.

To calculate the cost of guideline implementation, the director of infection control at each study hospital and the study project director reviewed a number of data sources including purchase orders and other records available through each hospital's infection control department. Included were costs associated with (a) making posters and/or flyers, (b) mailings, (c) buying new videos, and/or (d) developing and adapting other educational materials. Meeting minutes and attendance records where implementation of the new Hand Hygiene Guideline was discussed with staff were also reviewed to estimate the amount of staff time spent. The data were collected using standardized abstraction forms that were pilot tested prior to use in five local noneligible hospitals.

During the site visit, the project director also made rounds in one or more intensive care units in the hospital to directly observe hand hygiene using the Hand Hygiene Observation Instrument. This instrument lists indications for hand hygiene based on recommendations from the CDC Guideline that state hand hygiene should be performed: (a) before direct patient contact, (b) before donning sterile gloves when inserting central venous catheters, (c) before inserting invasive devices, (d) before moving from a contaminated to a clean body site in same patient, (e) after touching the patient's intact skin, non-intact skin, body fluids, or wounds, (f) after contact with inanimate objects in patient's vicinity, and (g) after removing gloves. Similar methods of observation have been used in multiple previous studies and inter-rater agreement was 0.95 (Larson, Albrecht, & O'Keefe, 2005; Larson, Cimiotti, et al., 2005). For each hand hygiene indication, whether or not hand hygiene was performed was recorded and, if so, whether the health care worker used soap and water or an alcohol hand rub.

### Data analysis

To measure the rate of compliance with hand hygiene for each hospital, a percentage was calculated by dividing the number of actual hand hygiene episodes by the total indications for hand hygiene. To estimate the ratio of alcohol rub usage for hand hygiene, the number of hand hygiene episodes that occurred with alcohol was divided by the number of episodes that occurred with soap and water.

Descriptive statistics for all variables were examined. Hand hygiene compliance rates were dichotomized into high (above the mean compliance rate) and low (at or below the mean compliance rate). Similarly, the ratio of alcohol use was dichotomized into hospitals using alcohol frequently (defined as at or above the median) and hospitals using alcohol less frequently (defined as below the median). The median rather than the mean was used for calculating the ratio of alcohol use because the data were not normally distributed. Chi-square analyses were calculated to examine the association between the rates of compliance with hand hygiene and the ratio of alcohol use and hospital characteristics (bed size, location, and association with an academic health center). Mann-Whitney tests were used to assess whether there were significant differences in the costs of the hand hygiene products between hospitals with low or high rates of compliance and between hospitals with low and high ratios of alcohol use.

## Results

Among the 40 hospitals that participated, 24 (60%) were affiliated with an academic health center and 30 (75%) were in the eastern region of the United States. The mean number of active beds within the hospitals was 417 (SD 171.8) with 20 (50%) hospitals having 400 beds. In the 40 hospitals, a total of 2,096 hand hygiene indications were observed in 2,100 different staff members. The mean compliance rate was 56.6%, which varied among the hospitals with a range of 24% to 89%. The mean ratio of alcohol use was 2.87 (range: 0 and 22) (see Table 1).

Paper towels were on average the most expensive hand hygiene product with annual costs of almost $10,000 per 100 beds, soap on average cost almost $4,000 per 100 beds and the average cost for the alcohol products was approximately $2,000 per 100 beds. However, while the majority of hospitals were able to provide data on the costs of hand hygiene products, some were not. Half of the hospitals (n=20) provided data on other costs associated with implementation of the guideline (for example, educational materials and staff time spent). The mean implementation cost was $1,062 (range 0-$23,043). Because these cost data were available for only half of the hospitals and due to the wide variation in reported costs, no formal statistical analyses were conducted to compare these costs across hospitals.

There were no significant differences between hospitals with high and low hand hygiene compliance rates by whether they were affiliated with an academic health center, geographic location (East/ West), or bed size. There were no significant differences between hospitals with high and low ratios of alcohol use by whether they were affiliated with an academic health center or by geographic location, but staff in smaller hospitals had a significantly higher ratio of use of alcohol products ($p$=0.03) (see Table 2). Further, there were no significant differences in hand hygiene costs among hospitals with high or low rates of compliance or among those with high or low use of alcohol hand hygiene products (see Table 3).

## Discussion

In this study, no detectable associations between the annual cost of hand hygiene products per 100 beds and overall compliance with hand hygiene practices or rates of alcohol use were found. We did find that smaller hospitals had higher ratios of alcohol-to-soap than large hospitals. While the reason for this finding is not clear, it may be easier for the infection control professional to implement changes, disseminate new information, and/or educate staff in the smaller institutions.

In a previous study conducted in one 450-bed community teaching hospital, $22,000 was spent annually on hand hygiene products at a cost of $0.72 per patient per day (Boyce, 2001). It was reported that 2% chlorhexidine gluconate was 1.7 times as expensive as the plain soap and the alcohol-based gel twice as expensive. Similar results were found by others (Cimiotti, Stone, & Larson, 2004). Despite the higher costs for products, however, use of alcohol products was overall less costly than traditional handwashing because of the longer time required for handwashing as well as the added costs of paper towels and water. Similarly, in this study, there was a trend for decreased paper towel costs in hospitals where providers had a higher ratio of alcohol use ($p$=0.06).

Increased accessibility of alcohol-based hand rubs has been associated with significantly higher rates of hand hygiene (Bischoff, Reynolds, Sessler, Edmond, & Wenzel, 2000; Harbarth et al., 2002). If a waterless alcohol-based hand rub increases the frequency of hand hygiene, one would expect that the direct cost of hand hygiene would also increase as more products are used. In terms of product use alone, however, the alcohol hand hygiene regimen may become more cost effective as it is increasingly substituted for traditional washing (use of soap, water, and paper towels) in accordance with the new CDC Guideline. Indeed, others have reported cost savings when alcohol hand hygiene is implemented (Pittet, Sax, Hugonnet, & Harbarth, 2004). It is surprising that we did not detect any impact of hand hygiene regimens on costs in this study. This is likely due to the fact that even though alcohol products were used more than twice as often as soap and water, the overall compliance with hand hygiene was, on average, just over 50%. Hence, the low frequency of hand hygiene overall may have made it difficult to detect any changes in costs. Further, many hospitals were unable to provide cost data.

The total hospital-related financial burden of HAIs in the United States was estimated to exceed $4.5 billion in 1992 (CDC, 1992). Using the Consumer Price Inflator this converts to $6.5 billion in 2006 dollars. However, this estimate is based on infection rates measured in the mid 1970s. Because of higher morbidity related to more serious infections in high-risk patients and increased antibiotic resistance, the actual cost attributable to HAIs is likely to be much higher (Cosgrove, 2006; Nixon, Jackson, Varghese, Jenkins, & Taylor, 2006). Researchers have used matched case control studies to estimate increased length of stay and hospital costs of HAIs in specific settings (CDC, 1992; Girou, Stephan, Novara, Safar, & Fagon, 1998; Pittet, Tarara, & Wenzel, 1994). While there is wide variation in the cost estimates of specific HAIs (for example, $3,500 to $40,000 per survivor of bloodstream infection) (Stone, Braccia, & Larson, 2005; Stone, Larson, & Kawar, 2002), clearly these costs exceed those related to hand hygiene and hand hygiene is a cost-effective strategy to reduce HAIs.

This study had several strengths and limitations. While the sample of 40 hospitals was geographically dispersed, they were not likely representative of all U.S. hospitals because they volunteered to participate in the study and were also members of the NNIS surveillance system. Hospitals in the NNIS system tend to be larger, more frequently affiliated with academic health centers, and have larger ICUs when compared with all U.S. hospitals. On

the other hand, an advantage to this sample is that surveillance practices and definitions of HAIs are standardized in NNIS hospitals and are reliable and valid (Emori et al., 1998; Richards et al., 2001). A major strength of this study was that hand hygiene practices were measured directly by a single, well-trained observer rather than by staff self-report. The presence of an observer, however, also increases the potential that staff will change their behavior when they know they are being observed.

The major limitations of this study relate to the quality and availability of data regarding the costs of hand hygiene. First, not all cost data were available in all hospitals. Second, we had no way to confirm the accuracy of cost data (some hospitals purchase products in bulk and it might not be possible to identify exactly when products were used). Clearly, it will be important in future economic studies to assure that the quality of the cost data is improved, and advances in record keeping for purchasing will greatly enhance cost-effectiveness research.

## Implications for Nurse Leaders

Nursing and health care policy leaders should look for ways to promote sustained adherence to hand hygiene recommendations. One initiative to boost hand hygiene compliance using behavior modification techniques, guidelines, and rigorous program compliance was launched by the CDC in collaboration with the Institute for Healthcare Improvement, APIC, and the Society for Healthcare Epidemiology of America. As part of this initiative, these organizations collaborated on the “How-to Guide: Improving Hand Hygiene,” which provides organizations with a detailed free guide available on the Internet (http://www.ihi.org/IHI/Topics/CriticalCare/IntensiveCare/Tools/HowtoGuideImprovingHandHygiene.htm). In this guide, suggestions on how to improve four critical components of a multidimensional hand hygiene program are discussed: (a) clinical staff, including new hire and trainees, understand key elements of hand hygiene practice (demonstrate knowledge); (b) clinical staff, including new hire and trainees, use appropriate technique when cleansing their hands (demonstrate competence); (c) alcohol-based hand rub and gloves are available at the point of care (enable staff); and (d) hand hygiene is performed at the right time and in the right ways (verify competency, monitor compliance, and provide feedback). Hand hygiene is a simple and inexpensive intervention that can save lives by preventing the transmission of infections pathogens, yet health care providers’ adherence remains poor. Implementing a bundled approach to improving hand hygiene should result in substantially greater reduction in HAI by improving hand hygiene practices.$

### Executive Summary

- Hands of health care personnel frequently serve as vectors for the transmission of organisms between patients and are also a major reservoir for pathogens with antimicrobial resistance.
- Hand hygiene is one effective strategy to reduce health care associated infections.
- The purposes of this study were to (a) compare the costs of hand hygiene in hospitals with high and low hand hygiene compliance as well as high and low frequency of alcohol hand rub use; and (b) examine associations between hospital characteristics and hand hygiene compliance as well as frequency of alcohol hand rub use.

- Nursing and health care policy leaders should look for ways to promote sustained adherence to hand hygiene recommendations.

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## Table 1

Hospital Characteristics, Hand Hygiene Practices, and Costs of Hand Hygiene Products in Study Hospitals (n=40)

| Hospitals Characteristics | Summary Statistics |
|---|---|
| Number of active beds | |
| 100–199 | 4 (10%) |
| 200–399 | 16 (40%) |
| 400–599 | 14 (35%) |
| 600–900 | 6 (15%) |
| Geographic region | |
| Eastern | 30 (75%) |
| Western | 10 (25%) |
| Academic health center affiliation | 24 (60%) |
| Hand Hygiene Practices | |
| Mean hand hygiene compliance rate | 57% (24%–89%) |
| Mean ratio of alcohol hand hygiene product usage (alcohol/soap and water) | 2.87 (0–22) |
| Hand Hygiene Product Costs | |
| Paper towels (n=30) | $9,537 (4,678) |
| Soap (n=34) | $3,644 (2640) |
| Alcohol (n=36) | $1,766 (1,595) |

Summary statistics are reported as means and standard deviations for continuous variables and sample size and percentages for categorical variables.

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**Table 2**

Association Between Hospital Characteristics and Hand Hygiene Compliance Rates and Frequency of Alcohol Rubs for Hand Hygiene

| Hospital Characteristics | High Compliance Rate | n | *P* | High Ratio of Alcohol Use | n | *P* |
|---|---|---|---|---|---|---|
| Academic health center | | | 0.12 | | | 1.0 |
| Yes | 41.7% | 10 | | 50.0% | 12 | |
| No | 68.8% | 11 | | 50.0% | 8 | |
| Geographic region | | | 0.47 | | | 0.72 |
| Eastern | 56.7% | 17 | | 46.7% | 14 | |
| Western | 40.0% | 4 | | 60.0% | 6 | |
| Number of active beds | | | 0.08 | | | 0.03 |
| 100–199 | 100% | 4 | | 100% | 4 | |
| 200–399 | 56.3% | 9 | | 62.5% | 10 | |
| 400–599 | 50.0% | 7 | | 35.7% | 5 | |
| 600–900 | 16.7% | 1 | | 16.7% | 1 | |

*P* values are results from Chi-square analyses

**Table 3**

Differences in Costs of Hand Hygiene by Compliance and Alcohol Use

| | Compliance Rate | | | Alcohol Use | | |
|---|---|---|---|---|---|---|
| **Products** | **High** | **Low** | ***P*** | **Frequent** | **Less Frequent** | ***P*** |
| Towel | $11,131 | $8,318 | 0.69 | $10,455 | $8,159 | 0.06 |
| Soap | $4,230 | $3,058 | 0.28 | $4,120 | $3,168 | 0.25 |
| Alcohol | $1,651 | $1,881 | 0.16 | $2,131 | $1,401 | 0.19 |

*P* values are results from Mann Whitney tests.