ORIGINAL ARTICLE

Improving Cleaning of the Environment Surrounding Patients in 36 Acute Care Hospitals

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OBJECTIVE. The prevalence of serious infections caused by multidrug-resistant pathogens transmitted in the hospital setting has reached alarming levels, despite intensified interventions. In the context of mandates that hospitals ensure compliance with disinfection procedures of surfaces in the environment surrounding the patient, we implemented a multihospital project to both evaluate and improve current cleaning practices.

DESIGN. Prospective quasi-experimental, before-after, study.

SETTING. Thirty-six acute care hospitals in the United States ranging in size from 25 to 721 beds.

METHODS. We used a fluorescent targeting method to objectively evaluate the thoroughness of terminal room disinfection cleaning before and after structured educational and procedural interventions.

RESULTS. Of 20,646 standardized environmental surfaces (14 types of objects), only 9,910 (48%) were cleaned at baseline (95% confidence interval, 43.4–51.8). Thoroughness of cleaning at baseline correlated only with hospital expenditures for environmental services personnel ($P = .02$). After implementation of interventions and provision of objective performance feedback to the environmental services staff, it was determined that 7,287 (77%) of 9,464 standardized environmental surfaces were cleaned ($P < .001$). Improvement was unrelated to any demographic, fiscal, or staffing parameter but was related to the degree to which cleaning was suboptimal at baseline ($P < .001$).

CONCLUSIONS. Significant improvements in disinfection cleaning can be achieved in most hospitals, without a substantial added fiscal commitment, by the use of a structured approach that incorporates a simple, highly objective surface targeting method, repeated performance feedback to environmental services personnel, and administrative interventions. However, administrative leadership and institutional flexibility are necessary to achieve success, and sustainability requires an ongoing programmatic commitment from each institution.

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The impact of healthcare-associated infections (HAIs), particularly those caused by multidrug-resistant organisms, is substantial. Although there have been many examples of "successful small-scale interventions to eliminate adverse events, including HAIs, in hospitals, the rate of overall improvement has been slow."[1(p261)] Hand hygiene and isolation practices are traditionally recognized as critical interventions in limiting the spread of hospital-associated pathogens.[2] However, although some reports have recently documented sporadically improved rates of compliance with hand hygiene guidelines,[3] the logistics of optimizing hand hygiene while providing direct patient care in the environment surrounding the patient (the "patient zone"),[2,4] as well as the potential for both gloved and ungloved hands to transmit pathogens between environmental surfaces and patients, may limit the impact of even optimal hand hygiene practices. In addition, the optimization of isolation practices has both programmatic and logistical limitations.[5] Although numerous studies prior to 2005 programmatically evaluated contamination of patient care surfaces with *Clostridium difficile,* methicillin-resistant *Staphylococcus aureus* (MRSA), and vancomycin-resistant enterococci (VRE),[6] recent reports have more rigorously clarified the magnitude of such contamination[7,8] with these "hardy hospital pathogens."[9]

It has now been well documented that pathogens such as methicillin-susceptible *S. aureus,*[10] MRSA,[11,12] and VRE,[12-14] are readily transmitted from environmental surfaces to healthcare workers' hands. Recently, the link between environmental contamination and patient acquisition has been more convincingly

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demonstrated. Epidemiologic studies have shown that patients admitted to rooms previously occupied by individuals infected or colonized with MRSA,[15-19] VRE,[15,18-20] or *Acinetobacter baumanii*[21] are at significant risk of acquiring these organisms from previously contaminated environmental sites. In the context of a broader understanding of the role the environment plays in the transmission of hospital-associated pathogens, the Centers for Disease Control and Prevention recommended in 2003 that environmental services personnel "pay close attention to cleaning and disinfection of high-touch surfaces in patient-care areas"[22(sec.VI.B.1)] and that hospitals must "ensure compliance by housekeeping staff with cleaning and disinfecting procedures."[22(sec.VI.B.2)] On the basis of the preceding considerations, as well as preliminary studies showing that environmental disinfection cleaning carried out as part of discharge or terminal room cleaning could be objectively evaluated and improved,[23] we undertook a systematic analysis of such activities in a range of acute care hospitals.

METHODS

Participating Institutions

Thirty-six acute care hospitals with 25–721 beds (mean number of beds, 257) that were geographically dispersed throughout the United States participated in our study.[24]

Study Method

Our study consisted of a prospective, quasi-experimental, before-and-after, interventional trial to compare the thoroughness of terminal room disinfection cleaning. To evaluate room cleaning, personnel trained to mark and evaluate targets in a consistent manner utilized a transparent, easily cleaned, environmentally stable marking solution that fluoresces when exposed to an ultraviolet light, as described elsewhere.[25,26] Objects were marked in each patient area when the room was empty, and were evaluated after 1 or 2 patients had been discharged and after the room had been terminally cleaned on at least 1 occasion. A standardized group of 14 types of objects were chosen for evaluation on the basis of 21 studies conducted prior to 2005 that documented an overall average contamination rate of 33% for these objects with respect to hospital-associated pathogens such as *C. difficile,* MRSA, and VRE.[6] The standardized group of types of objects included an expansion of the "high-touch housekeeping surfaces" recommended by the Centers for Disease Control and Prevention for more frequent cleaning,[22] and they are referred to here as high-risk objects (HROs).

Phase I: preintervention analysis. To evaluate the preintervention thoroughness of terminal cleaning, each hospital undertook a covert assessment of a representative sample of HROs from a convenience sample of patient rooms and adjoining bathrooms in adult general medical and surgical units and in special care areas. Variations in room equipment resulted in the evaluation of a median of 13 objects per room. All results were collated by the authors and provided to the participanting hospitals in a standardized graphic format.

Phase II: programmatic analysis and educational interventions. After analyzing the results of phase I, the project directors at each hospital met with relevant administrative personnel to review the findings and develop intervention plans. The project directors were provided with a standardized educational software program (PowerPoint; Microsoft) to present the findings to both line and supervisory environmental services personnel. Although participating hospitals were encouraged to expand and customize the presentation to reflect their individual hospital's particular environment, both the basic structure of the presentation and the basic educational presentation were carried out in a standardized manner. The program reviewed the importance of disinfection and cleaning for the safety of patients, environmental services personnel, and healthcare workers; it clarified the importance of cleaning HROs; and it provided a hands-on demonstration of the evaluation system while emphasizing the importance of this work in the overall infection prevention activity of the institution. Subsequently, reevaluation of terminal cleaning in the 15–50 rooms was carried out in a manner identical to that described in phase I. Results of the evaluation, presented in a standardized graphic format, were reviewed with environmental services management staff by the hospital directors and were subsequently presented to the line personnel.

Phase III: performance feedback and programmatic analysis. After feedback of phase II results was provided to the environmental services staff and after the development of further hospital-specific interventions, an evaluation of the thoroughness of terminal cleaning was again performed, as during phase II. Most hospitals used the findings of several performance-assessment and feedback cycles, group one-on-one teaching interventions, and further administrative process changes to optimize terminal cleaning activities. Such activities during phase III were complemented by active interhospital networking, as well as consultation and ongoing analysis of results, with advice from the authors on process improvement interventions.

Data and Statistical Analysis

Data collection and analysis were carried out in an identical manner for all hospitals. Statistical data analysis was performed using the 2-tailed Fisher exact test, the unpaired Student *t* test, and a correlation coefficient, which were calculated using Instant software, version 03.0 (GraphPad).

RESULTS

Characteristics of Study Institutions

A total of 42 hospitals completed all or most of phase I data collection, but 6 hospitals withdrew thereafter for various reasons; hereafter, all data refer only to the 36 hospitals that fully participated in this entire study. During 2006, the 36 hospitals provided data on 4,995–243,268 days of acute pa-

TABLE. Comparison of Rates of Cleaning for 14 Types of High-Risk Object (HRO) in 36 Acute Care Hospitals, Before and After Intervention

	Preintervention (phase I)		All hospitals postintervention (final results)	
Type of HRO	Mean % of HROs cleaned (range)	95% CI	Mean % of HROs cleaned (range)	95% CI
Sink	79 (38–97)	72.4–84	89 (47–100)	84.5–94
Tray table	74 (35–100)	68.7–79.8	87 (31–100)	81.8–92.2
Toilet seat	71 (3–100)	62.9–80.2	87 (38–100)	81.4–92.4
Flush handle	58 (6–88)	50.6–64.9	85 (40–100)	80.1–90.7
Side rail	57 (10–93)	49.1–64.3	81 (20–100)	73.9–88.6
Bedside table	55 (0–100)	45.7–63.5	76 (29–100)	68.5–83.7
Call box	52 (6–90)	44–60.8	81 (38–100)	73.9–87.5
Chair	53 (11–100)	42.4–62.8	78 (33–100)	70.5–85
Telephone	49 (12–86)	43.3–55	78 (20–100)	72.4–83.6
Bathroom door knobs	29 (0–82)	22.1–36.2	71 (19–95)	64.1–78.1
Bathroom handhold	28 (0–90)	20.9–35.8	74 (15–100)	66.1–81.6
Bathroom light switch	25 (0–84)	17.1–33.1	64 (8–100)	55.9–72.9
Room door knobs	22 (0–73)	15.9–28.4	66 (25–100)	59.7–73.2
Bedpan cleaner	22 (0–79)	15.9–28.3	62 (0–100)	51.7–71.4

NOTE. All P values are <.001; CI, confidence interval.

tient care.[24] Five of the hospitals were rural critical access hospitals, 23 were urban or suburban community hospitals ranging in size from 70 to 499 beds, and 8 were regional referral hospitals with an average size of 525 acute care beds. The mean Medicare case-mix index (± standard deviation [SD]) for the group was 1.41 ± 0.3 (range, 0.96–2.05).[24] The 36 hospitals were located in 15 states and in the District of Columbia as well as in 7 of the 9 standard geographic regions of the United States.[27] The number of environmental services personnel ranged from 0.78 to 3.0 full-time equivalent staff per 1,000 patient-days (mean ± SD, 1.37 ± 0.44). The cost of environmental services per patient-day varied from $35.10 to $96.70 (mean ± SD, $57.19 ± $16.41).[24] Fiscal performance, as reflected by each hospital's reported excess financial margin (ie, the total operating revenue minus the total operating expense plus the nonoperating revenue, divided by the total operating revenue minus the total operating expense, multipled by 100), ranged substantially from −0.37% to 26.7% (mean ± SD, 7.8% ± 7.2%).[24]

Phase I

Of 20,646 HROs evaluated (belonging to 14 types of HRO), only 9,910 (48%) were cleaned at baseline (ie, during terminal room cleaning; 95% confidence interval [CI], 43.4–51.8) in 1,605 patient rooms of the 36 study hospitals (Table). A larger number of rooms were evaluated in the tertiary care hospitals (mean of 56 rooms) than in the community (mean of 44 rooms) or critical access hospitals (mean of 24 rooms). Although the thoroughness of cleaning varied widely among the hospitals (24%–81% of HROs cleaned), half of the hospitals had values that clustered between 4.1% below and 7.4% above the mean in our study (Figure 1). Overall, thoroughness of cleaning correlated with hospital expenditures for environmental services personnel (cost per 1,000 patient-days; $P = .02$; $r = 0.4$) but did not correlate with the total number of patient-days, the Medicare case mix index, the number of environmental services staff (number of personnel per 1,000 patient-days), or the hospital's fiscal standing as reflected by its excess finanical margin.

Despite a relatively narrow range in the overall value for thoroughness of cleaning for most hospitals, there was a wide range of results with respect to how well many types of HRO were cleaned (Table). This finding was particularly notable for the 5 types of HRO with the lowest cleaning rates. Rates were low for bathroom doorknobs (mean percentage of HROs

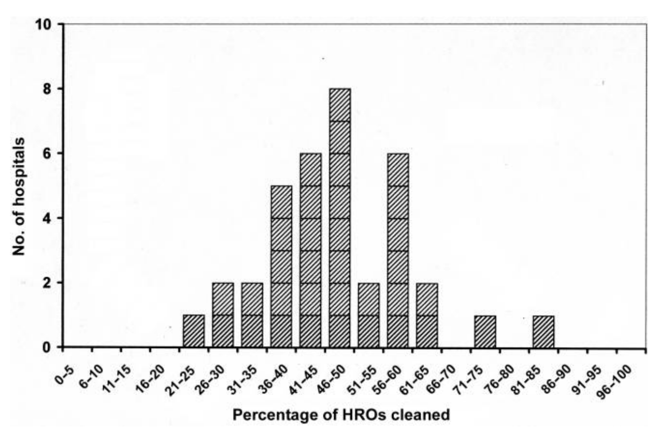

FIGURE 1. Baseline rates of environmental cleaning at the 36 acute care hospitals in the study. The mean percentage of high-risk objects (HROs) determined to have been cleaned in each of the 36 acute care hospitals was 48% (95% confidence interval, 43.4%–51.8%).

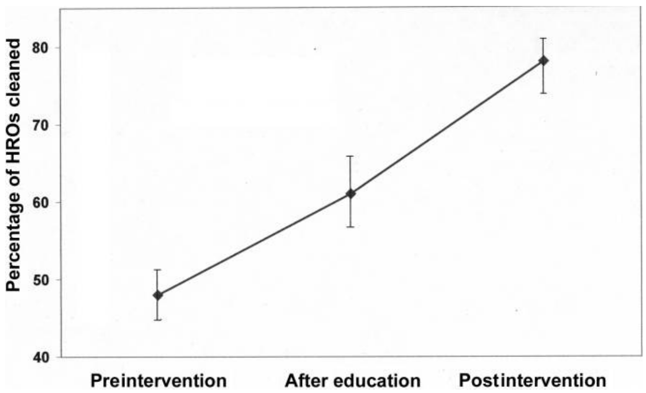

FIGURE 2. Change in the mean rate of environmental cleaning in the 36 study hospitals during the 3 phases of the study. HROs, high-risk objects; *whiskers,* 95% confidence intervals.

cleaned, 29%; range, 0%–82%), bathroom handholds (mean, 28%; range, 0%–90%), bathroom light switches (mean, 25%; range, 0%–84%), room doorknobs (mean, 22%; range, 0%–73%), and bedpan cleaners (mean, 22%; range, 0%–79%), and 1 or more of these types of HRO was not cleaned at all in 578 (36%) of the 1,605 patient rooms evaluated.

Phase II

Six hospitals withdrew from the study after preintervention data collection, leaving 36 that participated fully. For 4 of these 6 hospitals, other administrative responsibilities precluded further participation in our study by the hospital coordinators; for the other 2 hospitals, the administrations were concerned that their hospitals' results might not remain anonymous. After administrative analysis, development and implementation of a hospital-specific intervention plan, and use of a structured educational program for the environmental services line staff, the thoroughness of terminal cleaning improved significantly for the remaining 36 hospitals: from 9,910 (48%) of 20,646 HROs before the intervention to 7,674 (61%) of 12,580 HROs after the intervention ($P < .001$). It should be noted that, in each phase of our study, relatively fewer HROs were evaluated, because it was found that an accurate analysis of the thoroughness of cleaning could be determined without assessing as many rooms as we thought would be necessary when the project was designed.

Phase III

After evaluation of the impact of phase II activities, the hospitals provided further performance feedback to environmental services personnel. As a result, the overall thoroughness of cleaning improved significantly for the whole group of 36 hospitals (from 9,910 [48%] to 15,897 [77%] of 20,646 HROs; $P < .001$ [95% CI, 72.4–80.9]) but varied widely between hospitals (increases of 0.6%–288% from baseline) (Figure 2). Although 29 (81%) of the 36 study hospitals improved the thoroughness of their cleaning from 45% of HROs at baseline to 81% of HROs, 7 hospitals (19%) realized only limited improvement, from a mean of 61% of HROs at baseline to 67% of HROs after educational and performance feedback to the environmental services staff. Improvement relative to baseline did not correlate with the number of hospital beds, the number of patient-days, Medicare case-mix index, environmental services staffing level (number of full-time equivalent staff per 1,000 patient-days), hospital expenditures for environmental services personnel, or the excess financial margin. Improvement was also not correlated with other institutional characteristics, including type of hospital (ie, community or tertiary care), geographic location, or type of ownership. In contrast, improvement was strongly correlated with the degree to which rooms were not cleaned before intervention; the least well-cleaned hospitals consistently improved more than the better-cleaned hospitals ($P < .001$; $r = 0.8$). The overall rate of cleaning of the 14 HROs improved significantly ($P < .001$ for each) (Table). Improvement was particularly notable for the 5 types of HRO with the lowest cleaning rates prior to intervention; the mean cleaning rate improved from 25.2% to 67.4% of HROs (Figure 3). Sustainability of results was evaluated in 8 hospitals that had participated in the program for more than 2 years. Among these hospitals, the thoroughness of cleaning of HROs deteriorated by 10%–20% over intervals varying from 6 to 18 months following the last performance feedback cycle.

DISCUSSION

Healthcare-associated pathogens are readily transmitted from environmental surfaces to healthcare workers' hands.[10-14] It has also been shown that patients are at risk of acquiring MRSA and VRE from rooms that are suboptimally cleaned.[15-21] In addition, in a number of hospital settings,

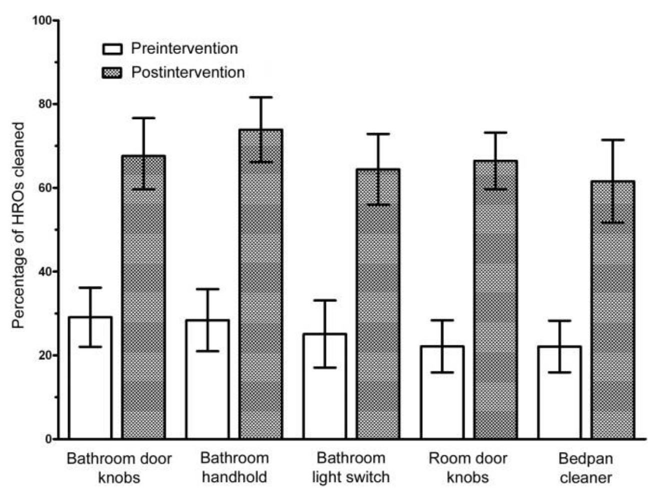

FIGURE 3. Comparison of pre- and postintervention rates of cleaning for 5 types of high-risk object (HRO) with the lowest cleaning rate prior to the intervention in the 36 study hospitals. *Bars,* mean values; *whiskers,* mean 95% confidence intervals.

improved environmental disinfection cleaning has been important in controlling the transmission of methicillin-susceptible *S. aureus*,[5,28] MRSA,[11,29] glycopeptide-intermediate *S. aureus*,[30] *C. difficile*,[31,32] extended-spectrum β-lactase gram-negative rods,[33] VRE,[34-36] and *A. baummanni*.[37,38] The initial report documenting improvement in environmental hygiene in 3 hospitals using the program presented here,[23] along with our study's observations, led to the formation of the Healthcare Environmental Hygiene Study Group, a broad-based voluntary consortium of infection control practitioners and hospital epidemiologists that currently involves 64 institutions in the United States and Canada, whose initial multihospital project was to develop and evaluate interventions to improve environmental hygiene related to terminal room disinfection cleaning.

Before the educational and programmatic interventions, an objective, indirect testing method was used to covertly evaluate the thoroughness with which 20,646 HROs were cleaned as part of the terminal room cleaning process in the 36 hospitals. Opportunities to improve cleaning were found in all hospitals at baseline: a mean of 48% of HROs were being cleaned. The 3 best-cleaned types of HRO (ie, sinks, tray tables, and toilet seats) had a relatively high cleaning rate (mean, 74.6% of HROs), which suggests that the environmental services staff routinely paid close attention to areas where lack of cosmetic cleanliness might be most evident. In contrast, fewer than 30% of bedpan cleaners, bathroom handholds, light switches, and bathroom and room doorknobs were cleaned. This finding is of particular concern in view of the fact that these types of HRO, because of the nature of their use (bedpan cleaners and bathroom handholds) or as a result of suboptimal hand hygiene after toileting (bathroom light switches and bathroom and room doorknobs), pose a particularly high risk of being contaminated by healthcare-associated pathogens, which can then colonize the gastrointestinal tract of a patient. The only demographic or hospital-specific parameter that correlated with the thoroughness of cleaning before intervention was that hospitals with larger environmental services personnel expenditures were more thoroughly cleaned ($P = .02$; $r = 0.4$).

The thoroughness of cleaning after interventions (during phase III) improved for the entire group of hospitals (absolute increase of 63% from baseline) but ranged widely among individual institutions (absolute increase of 0.6%–287%). Although cleaning rates in 29 (80%) of 36 of hospitals improved substantially, several relied on interventions in addition to education and performance feedback, including personnel resource reallocation (4 hospitals), the addition of 2–4 full-time equivalent housekeepers (3 hospitals), increased education of the environmental services supervisory staff (7 hospitals), and clarification of commitment to improvement from the hospital administration (7 hospitals). Although the small number of the hospitals that realized only limited improvement limits objective analysis, 4 of the hospitals had participated in the project for less than 6 months, and 3 were the best-cleaned hospitals in the study prior to intervention. The latter observation suggests that these hospitals may have been less motivated to improve because they believed themselves to be already well cleaned. This possibility is supported by the finding that the only factor that significantly correlated with postintervention improvement was the lack of thoroughness with which cleaning was done prior to intervention ($P < .001$; $r = 0.8$).

Interventions led to a significant ($P < .001$) improvement in cleaning of all 14 types of HRO by the end of phase III. This improvement was particularly notable for the 5 types of HRO with the lowest cleaning rates prior to intervention; for this group, the mean cleaning rate improved from 25.2% to 67.4% of HROs (Figure 3). Although the overall level of cleaning for these types of HRO during our study remained below the other 9 types of HRO, it is of note that the overall rate of cleaning of these types of HRO improved to 63% of HROs in the 11 hospitals in which 1 or more of these types of HRO had not previously been cleaned at all.

Although the current report represents the first large multihospital study to evaluate and improve environmental cleaning, 2 studies that have used environmental cultures to evaluate the impact of small-scale educational and programmatic interventions also demonstrated favorable results.[7,36] A quantitative analysis of the thoroughness of environmental cleaning in a single intensive care unit was carried out by Hayden et al.[36] In their study, trained observers covertly evaluated the thoroughness of cleaning of specific HROs over a 9-month period and noted a cleaning rate of 48%, an observation essentially identical to our finding of a cleaning rate of 47.3% prior to the intervention. After the educational interventions, we found that enforcement of routine environmental cleaning measures was the only intervention significantly associated with decreased surface contamination with VRE, a lower rate of VRE contamination of healthcare worker hands, and significant reduction in the rate of VRE cross-transmission. Eckstein et al.[7] found that the overall rate of environmental contamination of 6 types of HRO with VRE and *C. difficile* fell from 71% to 57% of HROs after routine disinfection cleaning, and, after educational and programmatic interventions, the rates of environmental contamination with VRE and *C. difficile* fell to 0% and 20%, respectively, after routine disinfection cleaning.

A unique feature of our study is that it both objectively documents a major deficiency in conditions at participating institutions and demonstrates the effectiveness of basic interventions in improving cleaning practices. However, our findings should be viewed in the light of several potential limitations. The primary limitation of our study was that its design precluded an assessment of the potential impact of improved cleaning on either environmental contamination with hospital-associated pathogens or its possible impact on their transmission. However, the 2 but in-depth prospective culture-based studies[7,36] discussed above clearly support the conclusion that a rigorous enhancement of environmental disinfection cleaning procedures can decrease rates of environmental contamination with *C. difficile* and VRE and can have a favorable impact on VRE transmission.[36] Given the need to better understand how optimizing environmental hygiene practices effects the rate of transmission of hospital-associated pathogens, there is clearly a need for further research related to the epidemiology of these pathogens in healthcare settings.

A further limitation of our study is that, because it did not employ a nonintervention control group, one or more unrecognized confounders may have impacted the substantial improvement in cleaning observed in more than 80% of the hospitals. However, the rapidity with which improvement was documented after intervention and the large number of participating hospitals where this observation was replicated suggest that the program itself led to the improvements that occurred. In addition, the fact that less than 1% of the hospitals in the United States participated in our study may make it difficult to predict to what degree the results may be generalized. However, the wide geographic distribution of study hospitals (as well as their diversity in size) and the fact that the mean Medicare case-mix index of 1.42 for the group of hospitals was quite similar to that of all US acute care hospitals in 2006[39](ie, 1.47) all support the generalizability of both our pre- and postintervention results. Finally, it should be noted that the sustainability of improved cleaning was not able to be fully evaluated. Although some decrease in performance (absolute decrease of 10%–20% in cleaning rate for HROs) was found in 8 hospitals evaluated 6–18 months after the study ended at those hospitals (all of which responded rapidly to further feedback), it is likely that the improved levels of disinfection cleaning documented here will not be sustainable without an ongoing programmatic commitment by each institution. Further investigation should be directed at defining what measures are most cost-effective at reinforcing and maintaining improved environmental hygiene and at unambiguously linking improved hygiene to patient outcomes.

The overall favorable impact on environmental cleaning documented by the 36 hospitals that fully participated in our study provides further evidence of the value of collaborative quality-improvement initiatives such as the recently reported work by the Keystone Project, the Pittsburgh Regional Health Initiative, and the Institute for Healthcare Improvement's 100,000 Lives Campaign.[1] Despite the challenges in effecting behavioral change in healthcare settings,[40] our large multihospital study not only documented a widespread deficiency in a fundamental aspect of infection prevention but also demonstrated the means to achieve improvement in environmental hygiene by the use of an objective monitoring system, educational and administrative interventions, and ongoing performance feedback to environmental services personnel.

THE HEALTHCARE ENVIRONMENTAL HYGIENE STUDY GROUP

In addition to the authors, the following members of the Healthcare Environmental Hygiene Study Group participated in this project: S. Hansen (Altru Medical Center; Grand Forks, ND); J. Lamphron and A. Assimacopoulous (Avera McKennan Hospital and University Health Center; Sioux Falls, SD); D. Clutts (Bay Park Community Hospital, Oregon, Flower Hospital, Sylvania, and The Toledo Hospital, Toledo, OH); C. Sulis (Boston Medical Center; Boston, MA); J. Briggs (Caritas Carney Hospital; Boston, MA); B Rettig (Defiance Hospital; Defiance, OH); L. Emerine (Fostoria Hospital; Fostoria, OH); C. Johnson (Hamilton Hospital; Webster City, IA); E. Berry (Kaiser Permanante Medical Center; Sacramento, CA); B. Shephard (Kaiser Permanante Santa Rosa Medical Center; Santa Rosa, CA); D. Barron (Kaiser Sunnyside Medical Center; Clackamas, OR); J. Eyer-Kelley and S. Willey (Lahey Clinic Medical Center; Burlington, MA); P. Harrison (Mercy Medical Center; Merced, CA); D. Laughlin (Memorial Hospital; Pawtucket, RI); E. Mello (MetroWest Medical Center; Natick, MA); S. Mauzey (Methodist Hospital; Henderson, KY); C. Chenvert (Miriam Hospital; Providence, RI); L. Sholtz (Nebraska Medical Center; Omaha, NB); G. Jackson (Newport Hospital; Newport, RI); M. Post (Oregon Health Sciences University Medical Center; Portland, OR); N. Church and M. Shanks (Providence Saint Vincent Medical Center; Portland, OR); C. Koal (Pullman Regional Hospital; Pullman, WA); D. Hylander (Quincy Medical Center; Quincy, MA); D. Applegate (Saint Vincent Healthcare; Billings, MT); K. Stauffer (Shands at AGH; Gainsville, FL); B. Sullivan and L. A. Bruno-Murtha (Somerville Hospital; Somerville, MA); L. A. Quinn (South County Hospital; Wakefield, RI); B. Grant, J. Joyce, M. Sestovick, and D. Baranowsky (Stamford Hospital; Stamford, CT); M. Freeman and L. Herwalt (University of Iowa Hospitals and Clinics; Iowa City, IA); P. Kim and C. Woods (Washington Hospital Center; Washington, DC); D. Harkness and L. A. Bruno-Murtha (Whidden Hospital; Everett, MA); L. Grubb (Union Memorial Hospital; Baltimore, MD); and D. Johnson (Westerly Hospital; Westerly, RI).

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Potential conflicts of interest. P.C.C. reports that patents related to the targeting solution and the method of its use have been applied for. All other authors report no potential conflicts of interest relevant to this article.

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