Improving environmental hygiene in 27 intensive care units to decrease multidrug-resistant bacterial transmission*

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Objective: **To determine the thoroughness of terminal disinfection and cleaning of patient rooms in hospital intensive care units and to assess the value of a structured intervention program to improve the quality of cleaning as a means of reducing environmental transmission of multidrug-resistant organisms within the intensive care unit.**

Design: **Prospective, multicenter, and pre- and postinterventional study.**

Setting: **Intensive care unit rooms in 27 acute care hospitals. Hospitals ranged in size from 25 beds to 709 beds (mean, 206 beds).**

Interventions: **A fluorescent targeting method was used to objectively evaluate the thoroughness of terminal room cleaning before and after structured educational, procedural, and administrative interventions. Systematic covert monitoring was performed by infection control personnel to assure accuracy and lack of bias.**

Measurements and Main Results: **In total, 3532 environmental surfaces (14 standardized objects) were assessed after terminal cleaning in 260 intensive care unit rooms. Only 49.5% (1748) of surfaces were cleaned at baseline (95% confidence interval, 42% to 57%). Thoroughness of cleaning at baseline did not correlate with hospital size, patient volume, case mix index, geographic location, or teaching status. After intervention and multiple cycles of objective performance feedback to environmental services staff, thoroughness of cleaning improved to 82% (95% confidence interval, 78% to 86%).**

Conclusions: **Significant improvements in intensive care unit room cleaning can be achieved in most hospitals by using a structured approach that incorporates a simple, highly objective surface targeting method and repeated performance feedback to environmental services personnel. Given the documented environmental transmission of a wide range of multidrug-resistant pathogens, our findings identify a substantial opportunity to enhance patient safety by improving the thoroughness of intensive care unit environmental hygiene. (Crit Care Med 2010; 38: 000–000)**

KEY WORDS: healthcare environmental hygiene; multidrug-resistant bacteria; disinfection; cleaning; healthcare-associated infections; quality assurance.

The medical and economic toll of infections with increasingly antibiotic-resistant pathogens in the intensive care setting has continued to escalate, despite many technical advances that have improved patient monitoring and support systems (1, 2). Despite efforts to improve hand hygiene and isolation practices that have been implemented to help mitigate this problem, recent studies have documented the limitation of such interventions (3–6). Although active surveillance protocols and strict isolation may decrease methicillin-resistant *Staphylococcus aureus* (MRSA) transmission (7), such interventions have not decreased overall nosocomial infection rates in several northern European countries, which remain similar to rates in southern European countries and the United States (8). It has now been well documented that pathogens, such as methicillin-sensitive *S. aureus*, MRSA, and vancomycin-resistant enterococci (VRE), *Clostridium difficile*, and *Acinetobacter baumannii*, are readily transmitted from environmental surfaces to healthcare workers' hands (9–13). In addition, it has been shown that patients admitted to rooms previously occupied by individuals infected or colonized with MRSA (14–18), *A. baumannii* (19), and *C. difficile* (20) are at significant risk of acquiring these organisms from environmental sites contaminated by previous occupants. As a result, it has been "highly recommended" that hospitals "ensure compliance by housekeeping staff with cleaning and disinfecting procedures" [9 VI.B.21] (2). Given these considerations and our previous findings, which identified opportunities to improve environmental hygiene in >20 hospitals (22), as well as preliminary studies showing that environmental disinfection cleaning could be objectively evaluated and improved (23), we undertook a systematic analysis of such activities in a group of adult intensive care units (ICUs).

MATERIALS AND METHODS

The thoroughness of environmental cleaning was evaluated in 27 ICUs as part of a larger hospital-wide analysis of terminal disinfection cleaning in a group of acute care hospitals. A transparent, easily cleaned, environmentally stable solution, which dries on surfaces rapidly and fluoresces when exposed to ultraviolet light, was used to evaluate the thoroughness of disinfection cleaning of 14 standardized objects in the near-patient environment. In the absence of removal as part of disinfection cleaning, the target continues to be readily detected by an ultraviolet light but can easily be removed many months after placement. The objects to be cleaned were standardized

*See also p. xxx.

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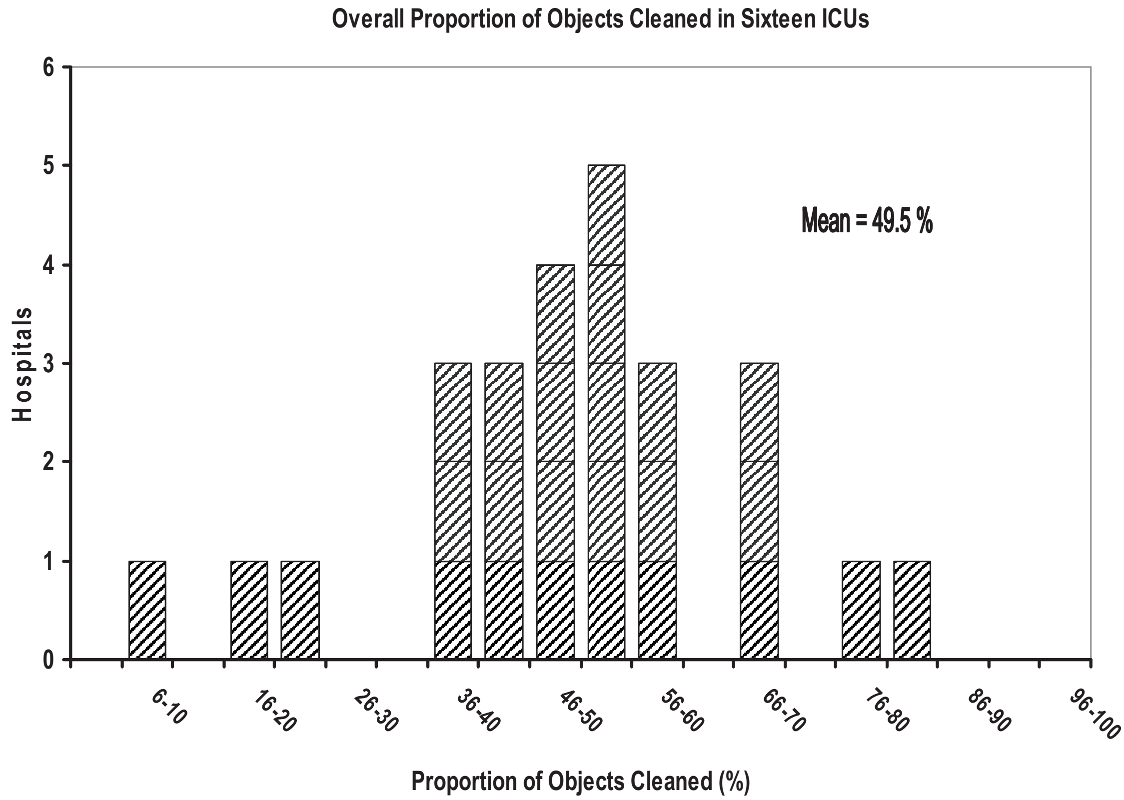

Figure 1. The overall proportion (%) of high-risk objects cleaned in 16 intensive care units (*ICUs*) (mean, 49.5%; 95% confidence interval, 42–57).

on the basis of published reports over the past 17 yrs (8). The objects represented an expansion of the sites previously recommended to be cleaned on a more frequent schedule than "minimal-touch housekeeping surfaces" (i.e., floors and walls) by the Centers for Disease Control and Prevention (8, 21). For this reason, these objects are referred to as "high-risk objects" (HROs). Evaluated rooms were chosen randomly as they became available for targeting and were reevaluated after terminal cleaning. Documentation of the specific objects targeted in each room at the time of marking permitted accurate assessment of the thoroughness of cleaning when the room was later evaluated. After initial analysis of the thoroughness of cleaning, identical structured educational programs were developed for the environmental services staff of each hospital. Subsequently, the thoroughness of cleaning was reevaluated and the results were used to direct further programmatic and educational interventions (referred to as a feedback cycle). Statistical data analysis was performed using two-tailed Fisher's exact test, paired *t* tests, and correlation coefficients, which were calculated using GraphPad Instat 3.0. The protocol for this study was reviewed and exempted from Institutional Review Board approval by all of the participating institutions, which requested such an assessment.

RESULTS

The voluntary, self-selected 27 ICU study hospitals ranged in size from 25 beds to 709 beds (mean, 206 beds) with 5000 to 247,000 inpatient days per year (mean, 51,500 inpatient days). Twenty of the hospitals had either one or two mixed purpose ICUs, whereas the three largest institutions had between four and six ICUs, at least several of which were dedicated units by medical or surgical specialty.

The thoroughness with which 3532 HROs were cleaned as part of discharge disinfection cleaning was covertly evaluated as baseline performance data in a total of 260 ICU rooms/bathrooms in the study hospitals (median, 11 rooms per ICU). Although all 14 of the identified HROs in the protocol were evaluated when present, there were variations in room equipment (such as patient chairs and frequently the lack of individual bathrooms in many ICUs); as a result, on average 9.4 objects per room were actually evaluated. The overall thoroughness of baseline, expressed as a portion of objects evaluated, was 49.5% (SEM, 3.5; 95% confidence interval, 42–57). Although two thirds of hospitals were within ±10% of the mean, overall thoroughness of cleaning ranged widely between 9% and 85% (Fig. 1). The overall thoroughness of baseline preintervention cleaning of individual HROs in the near-patient environment was 48.1% (SEM, 4.7; 95% confidence interval, 38–58). Despite a relatively narrow range in the overall thoroughness of cleaning for most of the 27 ICUs, there was a wide range of results with respect to how well different HROs were cleaned (Table 1). This finding was particularly notable with respect to the cleaning of the three least-well-cleaned objects, bathroom light switches (26%) and room door knobs (25%), as well as bedpan cleaners (21%), for which results ranged from 0% to 100% in the study ICUs at baseline (Fig. 2*A*).

After a structured and standardized educational intervention with the environmental services staff as well as between one and three performance feedback cycles, during which managers used monitoring results to reinforce the education and further educate the staff with performance expectations, the overall thoroughness of cleaning improved to 82% (range, 70% to 94%; SEM, 2.0; 95% confidence interval, 78–86) for the study group ICUs ($p < .0001$). Although cleaning improved significantly in all but the two ICUs in which the thoroughness of cleaning was >80% before intervention, the actual improvement ranged from <15% for these two ICUs to >8-fold for the least-well-cleaned ICUs above baseline. The individual rate of discharge cleaning of the 14 monitored objects improved significantly ($p < .0001$) (Table 1). Improvement was particularly notable for the three least-well-cleaned HROs, bathroom light switches, room doorknobs, and bedpan cleaners, which improved from an average of 24% to 73% (Fig. 2*B*). Sustainability of the results was evaluated in six hospitals that had participated in the program for >2 yrs. Among these hospitals, the thoroughness of cleaning deteriorated between 10% and 20% over intervals varying from 6 months to 18 months.

Table 1. Summary of the mean proportion cleaned (%) range and 95% confidence interval (CI) for the 14 high-risk objects documented before and after interventions ($p < .001$ for all)

	Before Intervention (Phase I)			All Hospitals After Intervention (Final Results)		
Object	Mean Proportion Cleaned (%)	Range (%)	95% CI	Mean Proportion Cleaned (%)	Range (%)	95% CI
Sink	79	0–100	68–89	90	50–100	83–97
Tray table	72	0–100	60–84	94	60–100	89–98
Toilet seat	67	0–100	55–81	93	43–100	87–99
Flush handle	51	0–100	38–63	90	0–100	82–99
Bedside table	59	0–100	44–75	81	17–100	71–92
Side rail	51	0–100	39–64	80	0–100	70–90
Call box	51	0–100	37–64	81	33–100	72–90
Chair	50	0–100	36–64	81	25–100	70–92
Telephone	42	0–100	26–59	77	0–100	68–88
Bathroom hand hold	42	0–100	27–56	78	0–100	67–90
Bathroom door knobs	37	0–100	23–52	81	25–100	72–91
Bathroom light switch	26	0–100	Oct–42	77	0–100	64–90
Room door knobs	25	0–100	Apr–37	70	25–100	61–79
Bedpan cleaner	21	0–80	Aug–34	73	33–100	62–83
Mean for all objects	48.1	21–79	38–58	82	70–94	78–86

DISCUSSION

The risk of acquiring hospital-associated infections has been a recognized problem for ICUs since their use became widely established >20 yrs ago (24). Unfortunately, the medical and economic toll of these infections resulting from the escalating number of hospital-associated infections in recent years has created a new urgency to implement enhanced prevention strategies (2).

In the context of our preliminary studies, which showed that disinfection cleaning in acute care hospitals can be improved using an objective evaluation process, environmental services staff education, and programmatic feedback (25), we undertook a similar evaluation and intervention in 27 ICUs as part of a study in 36 acute care hospitals (23). Before educational and programmatic interventions, an objective testing method was

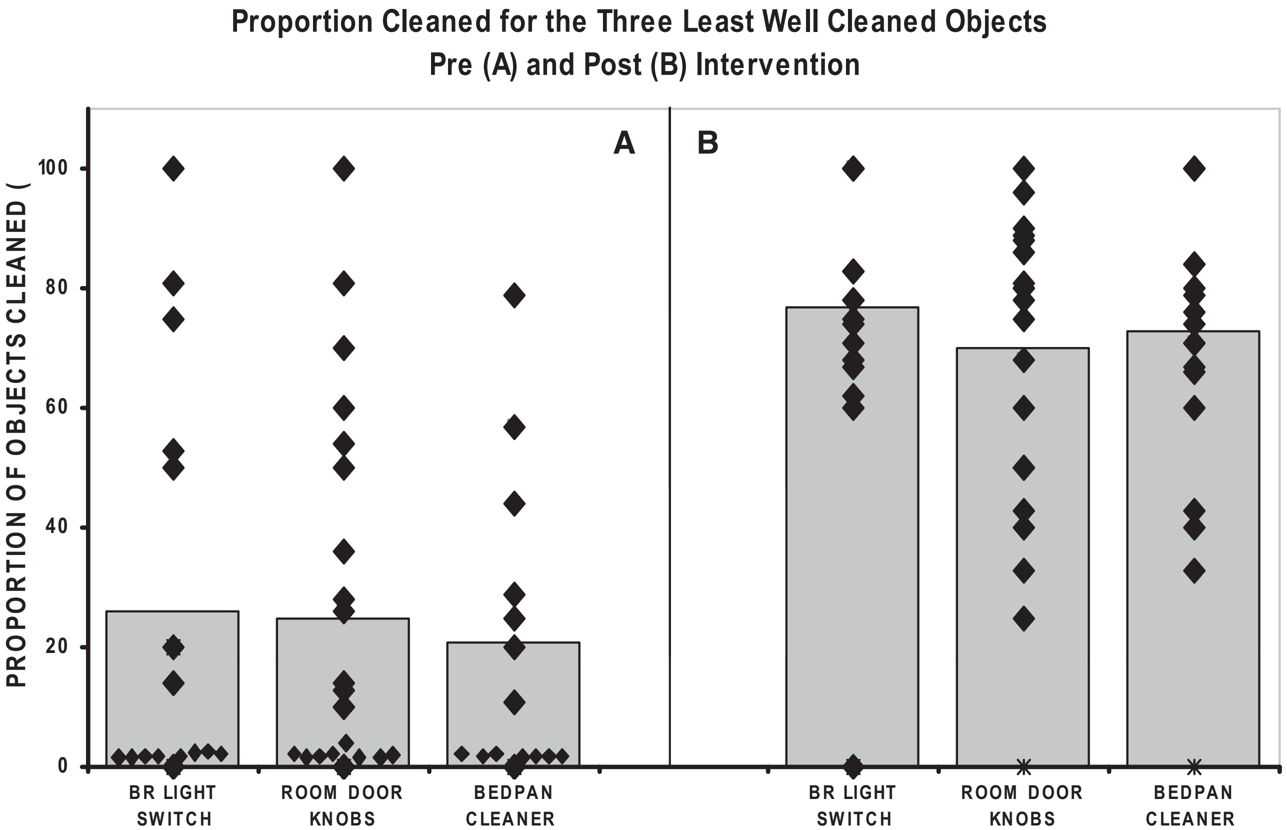

Figure 2. The proportion (%) of high-risk objects cleaned in 36 hospitals before interventions, after education, and after interventions, ±95% confidence interval.

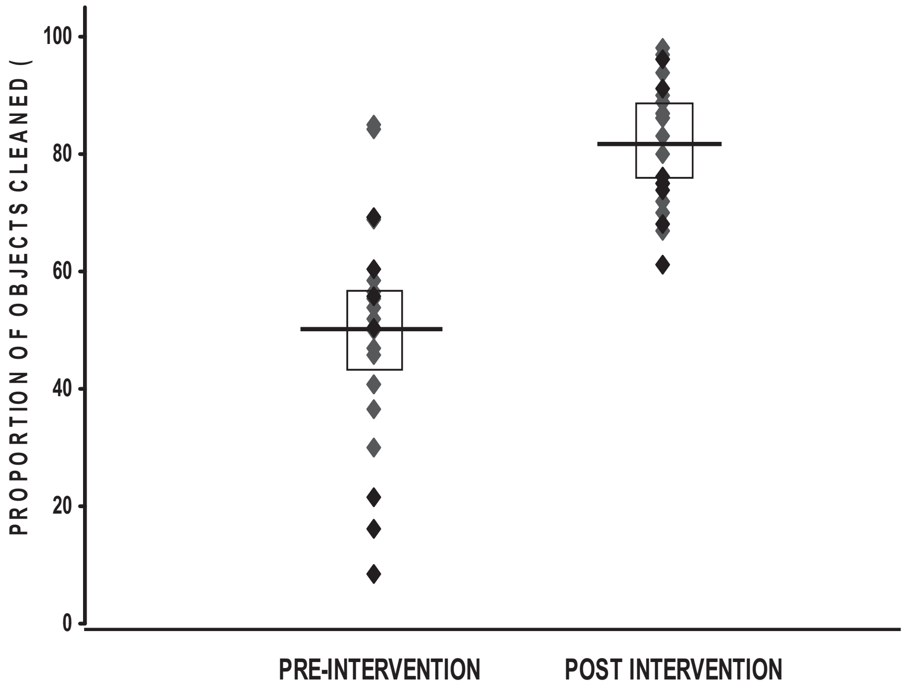

Figure 3. The proportion (%) of the three least-well-cleaned objects before intervention (*gray bars*) compared with the proportion cleaned after intervention (*black bars*), ±95% confidence interval in the 27 study intensive care units.

used to covertly evaluate the thoroughness with which 3532 standardized HROs were cleaned as part of the terminal room cleaning process in the ICUs. Opportunities to improve cleaning were identified in all ICUs at baseline. Before the intervention, there was a ten-fold difference in the thoroughness of cleaning, which ranged from 9% to 85%, although two thirds of the hospitals clustered narrowly around the mean of 48% (Fig. 1). Several objects, including sinks, tray tables, and toilet seats, were cleaned relatively well (average 73%), suggesting that the environmental services staff routinely gave fairly close attention to areas where lack of cosmetic cleanliness might be most evident. In contrast, bathroom light switches, bedpan cleaners, and room doorknobs were cleaned <26% of the time. This finding is of particular concern in view of the fact that two of these objects, bedpan cleaners and bathroom light switches, pose a particularly high risk of being contaminated by healthcare-associated pathogens colonizing the gastrointestinal tract as a result of suboptimal hand hygiene after toileting.

The thoroughness of cleaning after interventions improved 71% from baseline for the entire group but ranged widely among individual institutions from <15% for the two previously best cleaned ICUs to 844% for the least-well-cleaned ICU. Although cleaning improved substantially in all ICUs in which preintervention thoroughness of cleaning was <80%, further interventions were often undertaken in addition to education and performance feedback. Additional enhancements included personnel resource reallocation (n = 3 hospitals), the addition of between two and four full-time equivalent housekeepers (n = 2 hospitals), increased education of environmental services supervisory staff (n = 5 hospitals), and clarification of commitment for improvement from the hospital administration (n = 5 hospitals) to achieve these results.

As noted in Table 1, interventions led to a significant ($p < .001$) improvement in cleaning of all 14 individual HROs as a result of the process improvement program. This improvement was particularly notable for the three least-well-cleaned objects before intervention, which as a group improved from an average of 24 to 73 (Fig. 2). Although the overall level of cleaning realized during the study for these HROs remained below the other 11 objects, it is of note that the cleaning of these objects improved overall to 68% in the 13 ICUs in which one or more of these objects had not previously been cleaned at all as part of the discharge disinfection cleaning process.

Although the current report represents the first large multi-institutional project to evaluate and improve environmental cleaning in ICUs, two studies that used environmental cultures to evaluate the impact of educational and programmatic interventions also documented favorable results (26, 27). A quantitative analysis of the thoroughness of environmental cleaning in a single ICU was carried out by Hayden et al (26). Trained observers covertly evaluated the thoroughness of cleaning of specific HROs over a 9-month period and reported that 48% of the sites were cleaned, an observation that was identical to our finding that 48% of objects were cleaned before interventions in the 27 ICUs we studied. After educational interventions, the authors found that enforcement of routine environmental cleaning measures was the only intervention significantly associated with VRE cross-transmission. Of note was the finding that postintervention cleaning improved to 84%, a level essentially identical to the 82% documented in this report. Recently, Goodman and associates demonstrated that a programmatic approach identical to that used by our group significantly reduced environmental contamination with MRSA and VRE in ten ICUs of a tertiary care referral hospital (27). Further analysis of this study has confirmed that improved environmental hygiene was significantly associated with decreased MRSA acquisition and, to a lesser degree, VRE transmission (28).

A unique feature of the present study is that not only did it objectively document a major deficiency in evaluated hygiene in most participating ICUs but it demonstrated the effectiveness of basic interventions in improving practice. Our findings should be viewed in the light of several potential limitations. The primary limitation of this study was that its design precluded an assessment of the actual impact of improved cleaning on environmental contamination with hospital-associated pathogens on their transmission. However, the two prospective culture-based interventional process improvement ICU studies discussed above (27, 28) as well as studies in non-ICU settings with *C. difficile* (29, 30), VRE (29), and MRSA (31) support the ability of programmatic enhancement of environmental disinfection cleaning to decrease environmental contamination with *C. difficile*, MRSA, and VRE as well as to favorably affect MRSA and VRE transmission to patients (26, 28). Although the fact that <1% of the hospitals in the United States participated in our project makes it difficult to predict to what degree the results may be generalized, the fact that the average Medicare Case Mix Index of 1.40 for the group was similar to that of all U.S. acute care hospitals (1.47) in 2006 (32), as well as the wide geographic distribution and size diversity of participating ICUs, support the generalizability of both our pre- and postintervention findings.

The overall favorable impact on environmental cleaning documented in the ICUs of the 27 hospitals that participated in the project provides further evidence of the value of collaborative quality improvement initiatives, such as the recently reported work of the Keystone Project, the Pittsburgh Regional Health Initiative, and the Institute for Healthcare Improvements 100,000 Lives Campaign (33). Despite the challenges in effecting behavioral change in healthcare settings (34), our large multicentered study not only documented a widespread deficiency in a fundamental aspect of infection prevention in the ICU setting, but also demonstrated the means to achieve improvement in environmental hygiene through the use of an objective monitoring system, educational and administrative interventions, and ongoing performance feedback to environmental services personnel.

Finally, it should be noted that the use of a simple objective evaluation system, such as described in this report, supports the Department of Health and Human Services Action Plan to Prevent Healthcare-Associated Infections (January 9, 2009) recommended use of "standardized methods (i.e., performance methods) that are feasible, valid, and reliable for measuring and reporting compliance with broad-based HAI prevention practices that must be practiced consistently by a large number of healthcare personnel" [Section D.1.c.] (35).

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