A Novel Technique for Identifying Opportunities to Improve Environmental Hygiene in the Operating Room

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ABSTRACT

Environmental cleaning and disinfection is essential for optimizing safe patient care in the OR; however, perioperative staff members have not had an easy-to-use, objective method for determining whether high-touch, potentially contaminated surfaces have been cleaned during terminal room cleaning. To address this issue, members of the Healthcare Environmental Hygiene Study Group used a transparent, removable, environmentally stable disclosing agent and handheld ultraviolet light to determine whether potentially contaminated surfaces had been contacted by a wet disinfection cleaning cloth during terminal cleaning of ORs. Results from the project showed that 237 of 946 targeted surfaces (25%) had the disclosing agent removed (ie, were cleaned). The use of the disclosing agent for staff education and process monitoring has led to significant improvements in the disinfection cleaning process. *AORN J* 93 (March 2011) 358-364.
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For more than 100 years, the inanimate environment in the OR (eg, equipment surfaces, control panels) has been considered a potential source for bacteria that may cause surgical site infections (SSIs).[1] This is the basis for between-procedure and end-of-day "terminal" room disinfection cleaning, which has been widely accepted as standard practice for more than 50 years.[2]

Operating room cleanliness can help decrease the risk of SSI by providing an environment that minimizes the risk of wound contamination and consequent infection.[3,4] Recent studies have confirmed the frequent contamination of OR equipment with a wide range of bacterial pathogens.[5,6] Mandates from the Joint Commission,[7] the Centers for Medicare and Medicaid Services,[8] and the Centers for Disease Control and Prevention[9] to optimize environmental hygienic practices—particularly in implantation OR suites because of the increased potential for low virulence pathogens from the environment to cause infections during implantation procedures—have been substantially reinforced by an evolving understanding

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of the health care environmental epidemiology of coagulase-negative staphylococci (CoNS). These bacteria (ie, *Staphylococcus epidermidis*, *Staphylococcus haemolyticus*, *Staphylococcus saprophyticus*, *Staphylococcus lugdunensis*) are the most common bacteria found on environmental surfaces; they have traditionally been considered of limited clinical relevance[10] but now are recognized as the most common cause of deep SSIs associated with

- mediastinitis after open heart surgery,[11-16]
- orthopedic implantation surgery,[17-20]
- laminectomies and craniotomies,[21,22]
- vascular implantation procedures,[23,24]
- ventricular assist devices,[25,26] and
- central nervous system ventricular shunts.[27,28]

The most common source of infection from CoNS organisms has been thought to be contamination of the wound site during surgery by CoNS from the patient's own skin; however, recent studies have shown that use of adhesive drapes decreases the concentration of CoNS by 12% during surgical procedures.[29] Thus, understanding that the hospital environment endemically harbors more virulent (ie, slime producing) and antibiotic-resistant CoNS than the nonhospital environment[30] and that most implantable device-associated deep SSIs are caused by these "hypervirulent" strains of CoNS[31] raises the probability that a substantial proportion of such infections develop as a result of CoNS from the OR environment gaining access to the patient's wound during surgery. The probability of such transmission is supported by recent studies of the epidemiology of CoNS that used molecular fingerprinting to identify specific strains in intensive care units.[32] The CoNS bacteria also have been found to survive well in the inanimate environment and even to colonize patients several weeks after the source patients were discharged from the hospital.[32]

In addition, it is widely recognized by the health care community that disinfection cleaning of grossly blood-contaminated surfaces represents a routine part of terminal room cleaning. Unfortunately, most blood-contaminated surfaces do not appear bloody, as documented by a recent study that found only three of 137 (2.2%) blood-contaminated anesthesia equipment surfaces showed visible blood.[33] Previously, the infection risk from such surfaces had been an unsubstantiated concern; however, a recent study shed new light on the issue by identifying two patients on dialysis who acquired a strain of hepatitis C identical to that of another patient on dialysis. An epidemiologic investigation confirmed the presence of the identical strain in seven of 71 blood-contaminated (but not visibly bloody) surfaces in the unit.[34] The authors investigated the incidents further and concluded that transmission from the environment via health care workers' hands was the most probable cause for the patients on dialysis acquiring hepatitis C. A recent study found that a viable hepatitis C virus can survive on dry surfaces in the inanimate environment for up to 30 days.[35] Therefore, it is quite plausible that more thorough environmental hygiene in frequently blood-contaminated environments also may decrease the risk of environmental transmission of the hepatitis C virus to patients and health care workers.

Given the expectation that "patients having an invasive procedure should be ensured a clean environment,"[36(p455)] AORN developed recommended practices for environmental cleaning in the OR that address a broad range of issues, including expectations related to daily terminal cleaning of the OR[37] that are "intended to be attainable recommendations for an optimal level of environmental cleaning practice."[38(p32)] These standards specifically include cleaning with a "clean, lint-free cloth moistened with an Environmental Protection Agency (EPA)-registered hospital detergent/disinfectant."[37(p242)]

Two reports[39,40] have suggested that terminal cleaning in individual institutions could be improved; however, only one objectively evaluated terminal cleaning on a limited basis. In 1999, Griffith et al found relatively low levels of bacterial contamination on stretcher handles and OR door push plates in nine ORs in a single hospital; however, the relationship of the cultures to cleaning was not discussed.[39] In 2005, Neil et al evaluated OR suites on a daily basis before the first procedure of the day and documented the presence of dust, blood, suture material, or paper trash but did not calculate actual rates of contamination as part of the study.[40] Given the information in these reports and the findings of the Healthcare Environmental Hygiene Study Group (HEHSG) from a review of suboptimal patient room disinfection cleaning at the time of discharge that identified multiple opportunities for improvement in more than 20 hospitals,[41] several members of the HEHSG initiated a standardized evaluation of terminal cleaning practice in the OR setting.

METHODS

Between July 2007 and August 2008, the ORs of six hospitals representing a convenience sample and ranging in size from 138 to 719 acute care beds (average, 225) were evaluated for the thoroughness of terminal cleaning in rooms used for procedures involving bioprosthetic material implantation. Rooms were cleaned at the end of the day by trained OR environmental services staff members according to published standards.[37] Infection preventionists at each participating hospital evaluated the cleaning by using a transparent, easily removable, environmentally stable solution (ie, disclosing agent) that dries rapidly on surfaces and fluoresces when exposed to ultraviolet light. The disclosing agent consists of a mixture of several natural gluten-derived glues with mild detergents, similar to those found in personal hygiene liquid soaps, to which a small amount of clear natural fluorescent dye is added. The material, which has the consistency of thick syrup, is dispensed on the targeted object using a nipple-tipped 30-mL plastic reagent bottle.

We chose 10 standardized objects based on recommendations from AORN and commonly used textbooks as well as their inherent risk for contaminating health care workers' hands in the perioperative setting (Table 1).[36,37,42,43] The same items were chosen at each facility and were used to evaluate the removal of the disclosing agent. Other surfaces that are recommended to be included during terminal cleaning (eg, floors, kick buckets, external light racks, foot pedals, scrub sinks) were not evaluated because they have a relatively low risk of contaminating health care workers' hands in the perioperative setting. The infection preventionist at each site conducted assessments of a minimum of 10 ORs at each of the six hospitals.

Approximately 0.03 mL of material was applied to each test object, creating approximately a 1-cm "target" that became inconspicuous as it dried after several minutes. The target resisted dry abrasion but was easily removed with light abrasion from a wet cloth. The target was made

TABLE 1. Basis for Choosing OR Surfaces to Evaluate

Recommended objects	Chosen study objects
Overhead lights[1-3]	Main and second overtable lights
Doors (ie, push plates)[1-3]	Main and second OR doors
Furniture, room equipment, horizontal equipment[1-3]	Bovie control panel and radiology equipment
Anesthesia equipment surfaces[4]	Anesthesia machine and anesthesia cart
Light switches[4]	Main OR light switch
Handles on cabinets[1-3]	Storage cabinet handle
Other surfaces that have been touched during patient care[4]	All of the above

1. Lister J. *On the antiseptic principle in the practice of surgery.* Lancet. *1867;90(2299):353-356.*
2. Ginsberg F. *There is no time to let down an infection control program.* Mod Hosp. *1962;98:116-118.*
3. Blanchard J. *Terminal cleaning [Clinical Issues].* AORN J. *2009;89(2):409-411.*
4. Yavuz SS, Bicer Y, Yapici N, et al. *Analysis of risk factors for sternal surgical site infection: emphasizing the appropriate ventilation of the operating theaters.* Infect Control Hosp Epidmiol. *2006;27(9):958-963.*

Figure 1. OR light with ultraviolet-light illuminated target.

visible by using a handheld ultraviolet light and remained easily removable for several months (Figure 1). Each high-touch or potentially contaminated piece of equipment was marked on an easily accessible surface for cleaning after the last procedure of the day. After the room had been terminally cleaned two to three times, each object was evaluated to determine whether the target had been removed or substantially disrupted. If the targets were removed, the object was considered cleaned. Conversely, if the target remained, the object was considered not cleaned.

We then used a graphing software program to compare continuous variables using Mann-Whitney or unpaired *t* tests. We also used linear regression methods to determine whether there was a relationship between the thoroughness of cleaning and other variables.

RESULTS

We evaluated a total of 71 implantation ORs from the six acute care hospitals (ie, median 12 rooms per hospital) on the thoroughness with which 946 recommended surfaces were cleaned during terminal disinfection cleaning. Results showed that the mean overall thoroughness of cleaning (ie, expressed as a percentage of objects evaluated) was 25% (standard deviation, 14.8; 95% confidence interval, 9.4 to 40.5) (Table 2). There was wide variation between hospitals (ie, 9% to 50%) regarding thoroughness of cleaning (Figure 2) and specifically how thoroughly each of the 10 objects was cleaned. The variation was particularly evident with respect to the three best-cleaned objects—main field lights, main OR doors, and telephones—which ranged from 0% to slightly above 70% (mean, 32%). In contrast, thoroughness of cleaning of the three least well-cleaned objects—second over-field light, OR light switch, and storage cabinet handle—ranged from 0% to 30% (mean, 13%) (Figure 3). Thoroughness of cleaning did not correlate with the size of the hospital expressed as patient days (ie, a standardized term used in health care epidemiology to represent the number of bed occupancy days per

TABLE 2. Thoroughness of Cleaning

Object	Mean proportion cleaned (%)	Lowest proportion cleaned (%)	Highest proportion cleaned (%)	Standard deviation	95% CI
Main door	34.3	0	72	30.5	2.3 to 66
Main field light	33	0	65	23	9 to 56
Telephone	29.8	13	50	16	13 to 46
Anesthesia machine	28	10	50	17	7.5 to 49
Bovie control	22	0	67	26	0 to 54
Second OR door	21.7	5	65	22	1 to 44
Anesthesia cart	20.6	0	73	31	0 to 59
Main light switch	14.5	3	20	7	7.3 to 22
Second field light	14.2	0	27	12	1 to 34
Storage cabinet handle	5.6	0	17	8	1 to 15
Mean	**24.9**	**9**	**50**	**15**	**9.3 to 40**

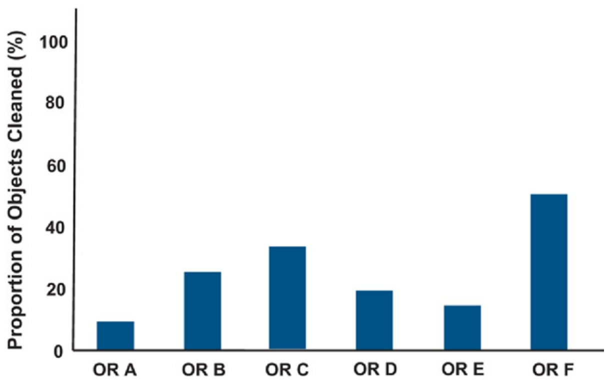

Figure 2. Thoroughness of implantation OR terminal cleaning.

year for a given hospital) in 2006 (R [slope of regression analysis curve] = 0.005; P = .98) or the Medicare case mix index (ie, the most common measure of complexity of case mix used in US hospitals), which ranged from 1.0 to 2.0 in the hospitals evaluated (R = 0.22; P = .32).[44]

DISCUSSION

Despite the use of trained environmental services personnel and policies and procedures in accordance with AORN standards and recommended practices, infection preventionists in the participating hospitals found substantial opportunity to improve the thoroughness of terminal OR disinfection cleaning in the six hospitals. For example, although results showed the thoroughness of OR door push plate cleaning to be more than 70% in two hospitals, two or more objects were not cleaned at all (eg, cabinet door handles, main over-table lights, secondary lights, anesthesia carts) in half of the hospitals evaluated. Cleaning of the over-table field lights, which could shed environmental pathogens directly into the surgical field, averaged only 25.3% (range, 0% to 40%).

Patient room cleaning in a subsequent study[45] that analyzed the effect of a structured educational intervention program to improve the thoroughness of terminal room cleaning in 36 hospitals resulted in a 78% improvement in cleaning. Similarly, the thoroughness of terminal patient room cleaning improved from 53% to 80% in a group of 12 hospitals in a single health care system that used internal benchmarking and the same targeting tool used in this project.[46]

LIMITATIONS

This project evaluation has several limitations. For example, although it represents the first in-depth analysis to identify institution-specific opportunities to improve OR suite environmental cleaning and disinfecting activities, the relatively limited number of institutions participating in the project precludes direct generalization of these results to other acute care hospitals, even though the geographic diversity, wide range in size of hospitals, and scope of the procedure mix would suggest that similar results may be found in other institutions. In addition, infection preventionists in the participating hospitals who had preexisting concerns about the thoroughness of terminal OR cleaning in their own facility may have joined the study group because of these internal concerns. Limitations of the project design precluded correlating the thoroughness of cleaning with either environmental cultures or SSI rates.

CONCLUSION

The objective documentation of opportunities for improvement related to OR environmental cleaning in the implantation ORs in the evaluated hospitals may suggest that suboptimal cleaning is

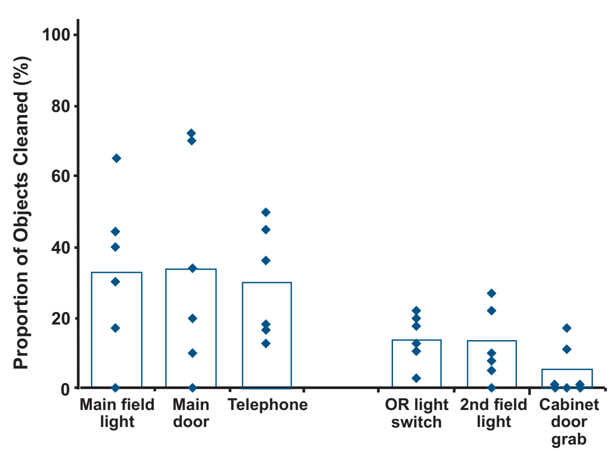

Figure 3. The three best-cleaned and three least-cleaned OR objects.

a more widespread issue. Based on the results of this evaluation project, staff members in the six hospitals have implemented process improvement interventions including structured educational activities and objective performance feedback to the OR environmental services staff members. These initiatives have already led to improvement in the thoroughness of daily terminal cleaning at several sites.

Further studies will be needed to clarify the effect of improved OR environmental hygiene on patient and health care worker safety. "The main challenge to prevention [of health care-associated infections] has been not the lack of guidelines, but rather a dearth of methods for efficient and consistent implementation of recommended practices"[47(pS2)] to minimize such infections. AORN

References

1. Lister J. On the antiseptic principle in the practice of surgery. *Lancet*. 1867;90(2299):353-356.
2. Ginsberg F. There is no time to let down an infection control program. *Mod Hosp*. 1962;98:116-118.
3. Yavuz SS, Bicer Y, Yapici N, et al. Analysis of risk factors for sternal surgical site infection: emphasizing the appropriate ventilation of the operating theaters. *Infect Control Hosp Epidmiol*. 2006;27(9):958-963.
4. Blanchard J. Terminal cleaning [Clinical Issues]. *AORN J*. 2009;89(2):409-411.
5. Fukada T, Iwakiri H, Ozaki M. Anesthetists' role in computer keyboard contamination in an operating room. *J Hosp Infect*. 2008;70(2):148-153.
6. Baillie JK, Sultan P, Graveling E, Forrest C, Lafong C. Contamination of anesthesia machines with pathogenic organisms. *Anesthesia*. 2007;62(12):1257-1261.
7. Standards 2010. The Joint Commission. http://www.jointcommission.org/Standards/. Accessed January 30, 2010.
8. *State Operations Manual. Appendix A Interpretive Guidelines for Hospitals*. Centers for Medicare & Medicaid Services. http://cms.hhs.gov/manuals/Downloads/som107ap_a_hospitals.pdf. Accessed January 31, 2010.
9. *Guidelines for Environmental Infection Control in Health-Care Facilities*. Atlanta, GA: Centers for Disease Control and Prevention; 2003. http://www.cdc.gov/hicpac/pdf/guidelines/eic_in_HCF_03.pdf. Accessed January 20, 2010.
10. Boyce JM. Coagulase-negative staphylococci. In: Mayhall CG, ed. *Hospital Epidemiology and Infection Control*. 3rd ed. Philadelphia, PA: Lippincott Williams and Wilkins; 2004:495-516.
11. L'Ecuyer PB, Murphy D, Little JR, Fraser VJ. The epidemiology of chest and leg wound infections following cardiothoracic surgery. *Clin Infect Dis*. 1996;22(3):424-429.
12. Mossad SB, Serkey JM, Longworth DL, Cosgrove DM III, Gordon SM. Coagulase-negative staphylococcal sternal wound infections after open heart operations. *Ann Thorac Surg*. 1997;63(2):395-401.
13. Bitkover CY, Gardlund B. Mediastinitis after cardiovascular operations: a case-control study of risk factors. *Ann Thorac Surg*. 1998;65(1):36-40.
14. Bellchambers J, Harris JM, Cullinan P, Gaya H, Pepper JR. A prospective study of wound infection in coronary artery surgery. *Eur J Cardiothorac Surg*. 1999;15(1):45-50.
15. Fakih MG, Sharma M, Khatib R, et al. Increase in the rate of sternal surgical site infection after coronary artery bypass graft: a marker of higher severity of illness. *Infect Control Hosp Epidemiol*. 2007;28(6):655-660.
16. Khanlari B, Estermann L, Weisser M, et al. A rifampicin-containing antibiotic regimen is associated with better outcome in deep sternal wound infections [Abstract K-573]. In: *Program and Abstracts of the 48th Annual ICAAC/IDSA 46th Annual Meeting*. Washington, DC; 2008:465-466.
17. Widmer AF. New developments in diagnosis and treatment of infection in orthopedic implants. *Clin Infect Dis*. 2001;33(Suppl 2):S94-S106.
18. Arciola CR, Cervellati M, Pirini V, Gamberini S, Montanaro L. Staphylococci in orthopaedic surgical wounds. *New Microbiol*. 2001;24(4):365-369.
19. Huotari K, Lyytikäinen O; Hospital Infection Surveillance Team. Impact of postdischarge surveillance on the rate of surgical site infection after orthopedic surgery. *Infect Control Hosp Epidemiol*. 2006;27(12):1324-1329.
20. Berbari EF, Osmon DR, Carr A, et al. Dental procedures as risk factors for prosthetic hip or knee infection: a hospital-based prospective case-control study. *Clin Infect Dis*. 2010;50(1):8-16.
21. Kanafani ZA, Dakdouki GK, El-Dbouni O, Bawwab T, Kanj SS. Surgical site infections following spinal surgery at a tertiary care center in Lebanon: incidence, microbiology, and risk factors. *Scand J Infect Dis*. 2006;38(8):589-592.
22. Kourbeti IS, Bertsias G, Karabetsos DA, Vakis AF. Neurosurgical infections in a University Hospital: A 3-year retrospective study [Abstract 811]. In: *Program and Abstracts of the 45th Annual Meeting of IDSA*. San Diego, CA; October 4-7, 2007:189.
23. Sauer F, Jesel L, Camuzet G, et al. Antimicrobial prophylaxis before defibrillator and pace-maker implantation: A retrospective study [Abstract K-574]. In: *Program and Abstracts of the 48th Annual ICAAC/IDSA 46th Annual Meeting*. Washington, DC; 2008:466.
24. Mattner F, Ott E, Sohr D, Teebken O. Surgical site infections following vascular surgery [Abstract 810]. In: *Program and Abstracts of the 45th Annual Meeting of IDSA*. San Diego, CA; October 4-7, 2007:189.
25. Gordon RJ, Quagliarello B, Lowy FD. Ventricular assist device-related infections. *Lancet Infect Dis*. 2006;6(7):426-437.
26. Shoham S, Miller LW. Cardiac assist device infections. *Curr Infect Dis Rep*. 2009;11(4):268-273.
27. Kestle JR, Garton HJ, Whitehead WE, et al. Management of shunt infections: a multicenter pilot study. *J Neurosurg*. 2006;105(Suppl 3):177-181.

28. Schreffler RT, Schreffler AJ, Wittler RR. Treatment of cerebrospinal fluid shunt infections: a decision analysis. *Pediatr Infect Dis J.* 2002;21(7):632-636.
29. Maraki S, Kourbett LS, Karabepsos B, et al. Associations between operative site microbial counts and procedure classification in neurosurgery [Abstract K-572]. In: *Program and Abstracts of the 48th Annual ICAAC/IDSA 46th Annual Meeting*. Washington, DC; 2008:465.
30. Rogers KL, Fey PD, Rupp ME. Coagulase-negative staphylococcal infections. *Infect Dis Clin North Am.* 2009;23(1):73-98.
31. McCann MT, Gilmore BF, Gorman SP. *Staphylococcus epidermidis* device-related infections: pathogenesis in clinical management. *J Pharm Pharmacol.* 2008;60(12): 1551-1571.
32. Dancer SJ, White LF, Lamb J, Girvan EK, Robertson C. Measuring the effect of enhanced cleaning in a UK hospital: a prospective cross-over study. *BMC Med.* 2009;7:28. http://www.biomedcentral.com/content/pdf/1741-7015-7-28.pdf. Accessed September 3, 2010.
33. Hall JR. Blood contamination of anesthesia equipment and monitoring equipment. *Anesth Analg.* 1994;78(6): 1136-1139.
34. Girou E, Chevaliez S, Challine D, et al. Determinate roles of environmental contamination and noncompliance with standard precautions and the risk of hepatitis C virus transmission in a hemodialysis unit. *Clin Infect Dis.* 2008;47(5):627-633.
35. Steinmann J, Ciesek S, Friesland M, et al. Novel approach for the validation of disinfectants against hepatitis C virus [Abstract 2-22]. In: *Program and Abstracts of the 36th Annual Meeting of the Association of Practitioners in Infection Control.* Ft Lauderdale, FL; 2009:22-23.
36. Blanchard J, Chobin N. The operating room. In: Jarvis W, ed. *Bennett & Brachman's Hospital Infections*. 5th ed. Philadelphia, PA: Lippincott Williams & Wilkins; 2007:449-460.
37. Recommended practices for environmental cleaning in surgical practice setting. In: *Perioperative Standards and Recommended Practices.* Denver, CO: AORN Inc.; 2010:241-255.
38. Seavey R. Environmental cleaning in the operating room. *Infect Control Today*. 2005;9(3):32-33.
39. Griffith CJ, Cooper RA, Gilmore J, Davies C, Louis M. An evaluation of hospital cleaning regimens and standards. *J Hosp Infect*. 2000;45(1):19-28.
40. Neil JA, Nye PE, Toven LA. Environmental surveillance in the operating room. *AORN J.* 2005;82(1):43-49.
41. Carling PC, Parry MF, Von Beheren SM. Identifying opportunities to enhance environmental cleaning in 23 acute care hospitals. *Infect Control Hosp Epidemiol.* 2008;29(1):1-7.
42. Rhyne L, Ulmer BC, Revell L. Monitoring and controlling the environment. In: *Patient Care During Operative and Invasive Procedures.* Philadelphia, PA: WB Saunders Company; 2000:147-165.
43. Recommended practices for cleaning, handling, and processing anesthesia equipment. In: *Perioperative Standards and Recommended Practices.* Denver, CO: AORN, Inc; 2010:379-388.
44. Short stay hospital (SSH) discharges and case-mix index, by location and bed size of hospital, and procedure status: calendar year 2006. Centers for Medicare & Medicaid Services. http://www.cms.hhs.gov/MedicareMedicaidStatSupp/downloads/2007Table5.12b.pdf. Accessed August 31, 2010.
45. Carling PC, Parry MM, Rupp ME, et al. Improving cleaning of the environment surrounding patients in 36 acute care hospitals. *Infect Control Hosp Epidemiol.* 2008;29(11):1035-1041.
46. Dick B, Carling PC. Using objective benchmarking to improve environmental hygiene in a five hospital group [Abstract 238]. In: *Program and Abstracts of the 36th Annual Meeting of the Association of Practitioners in Infection Control.* Ft Lauderdale, FL: APIC; 2009: 130-131.
47. Yokoe DS, Classen D. Improving patient safety through infection control: a new healthcare imperative. *Infect Control Hosp Epidmiol*. 2008;29(Suppl 1):S3-S11.

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