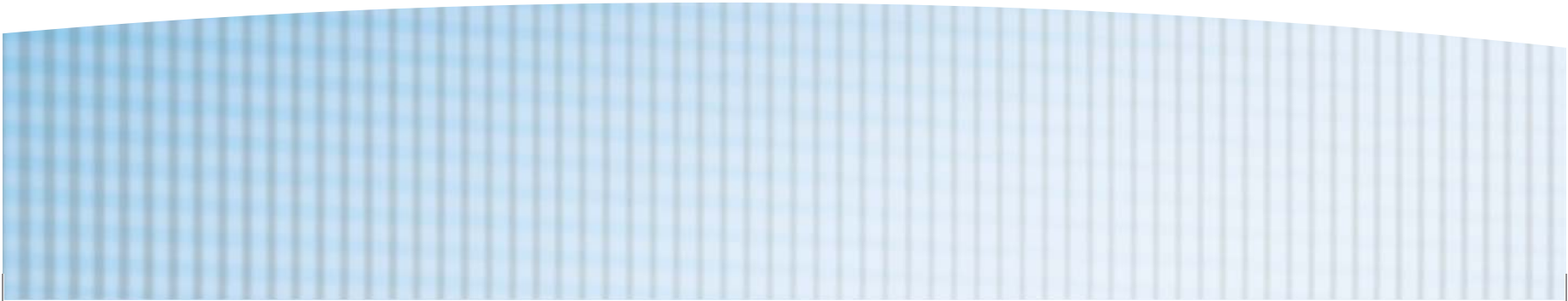


A PROGRAMMATIC APPROACH TO
ENVIRONMENTAL HYGIENE
FOR HEALTHCARE

A CLINICAL LITERATURE REVIEW



Everywhere It Matters.



Ecolab Environmental Hygiene Key Concepts



Summary

Summary of Research Studies Which Support a Programmatic Approach to Improvements in Environmental Hygiene

By Philip C. Carling, M.D., Boston University School of Medicine

The total cost of HAIs is currently estimated at twenty billion dollars per year. More specifically, research studies have confirmed that the cost of each episode of *C. difficile* infection is approximately \$5000.* During the past few years several studies documented that pathogens such as MSSA, MRSA, Vancomycin-resistant enterococci (VRE), *C. difficile* and *Acinetobacter baumannii* are readily transmitted from environmental surfaces to healthcare workers' hands. In addition it has been shown that patients admitted to rooms previously occupied by individuals infected or colonized with VRE, MRSA, *Acinetobacter baumannii* and *C. difficile* are at significant risk of acquiring these organisms from environmental surfaces contaminated by previously infected or colonized patients occupying the same room. While efforts to improve hand hygiene and isolation practices have been implemented to help mitigate this problem, many recent studies have documented the limitations of such interventions.

On the basis of these studies and recommendations and the CDC Guidelines for Environmental Infection Control in Health-Care settings (2003), a monitoring system was developed specifically to evaluate the thoroughness of environmental cleaning in healthcare settings based on the use of an essentially invisible transparent gel which becomes visible only when a UV light is shined on it. The targeting material, DAZO®, which dries rapidly on surfaces and resists abrasion, is readily and thoroughly removed by all disinfectants. To date, the system has been used as part of structured process improvement programs in a wide range of acute care hospitals. The enclosed materials support the concept that hygienic practice and patient safety can be improved substantially through A) programmatic Environmental Services interventions and B) the use of DAZO to objectively assess and improve cleaning practice. The outline which follows provides an overview of the basis for recommending this programmatic approach. (Also see key concepts)

Key Concept 1: Previously contaminated rooms increase transmission risk. (1-8)

Several important studies have confirmed that there is a significant risk that a patient may acquire a range of hospital-acquired pathogens (HAPs) as a result of environmental contamination by prior room occupants. All studies of this phenomenon published to date have confirmed substantial increased risk of transmission. Huang, et al. found that the risk of acquiring MRSA or VRE was 40% greater when a patient occupied a room previously occupied by a patient on contact precautions for either of these HAPs. Hardy, et al. used PFGE to monitor patients in an ICU and confirmed that 12% of the patients who acquired MRSA during their ICU stay acquired it from prior room occupant environmental contamination. Drees, et al. studied the epidemiology of VRE in two intensive care units and found that there was a 170% increased risk of VRE acquisition if a patient occupied a room previously occupied by a patient infected or colonized by VRE. Indeed, this risk factor far outweighed several other risk factors predictive of VRE acquisition. In a study analyzing the epidemiology of *C. difficile* acquisition in an ICU, Shaughnessy found the risk of acquisition was increased by 110% in patients admitted to rooms previously occupied by patients with active *C. difficile* infection. In a recent study of MRSA and VRE acquisition, Datta found that the risk of acquisition from prior room occupants was increased by 40% for both pathogens.

Key Concept 2: Many patient areas are not well cleaned. (1,9-17)

The development of a method (DAZO) to replace direct observation and/or environmental cultures to assess the thoroughness of disinfection cleaning disclosed substantial opportunities to improve hygienic practice in the first three hospitals studied. In these hospitals only 47% of high touch objects evaluated were found to have been cleaned. Another way to describe this is to say that the average thoroughness of disinfection cleaning (TDC) score was 47%. Expanding this analysis to 36 hospitals and 10 ICUs confirmed an average TDC score of 47.3% and 44% respectively for patient room discharge cleaning. Preliminary studies of OR terminal room cleaning documented an overall TDC score of 25%. Additional studies, which have included analysis of more than

64,000 patient area surfaces in more than 100 research hospitals, have confirmed substantial opportunities for improving environmental cleaning in many healthcare settings. In the first study to directly evaluate the thoroughness of disinfection cleaning, Hayden used covert visual observation of cleaning practice in ICU patient rooms which were found to have an average TDC score of 41%.

Key Concept 3: Cleaning can be programmatically improved. (1,14,15,18-27)

Subsequently a voluntary group of hospitals (the Healthcare Environmental Hygiene Study Group) used DAZO along with standardized education and process improvement interventions to determine if the thoroughness of environmental cleaning could be improved. In **all of the seven** published studies using DAZO, TDC scores improved from an average of 39% to 81% following programmatic interventions, Environmental Services education and objective performance feedback. In the observational study by Hayden, thoroughness of disinfection cleaning improved from 41% to 84% following interventions. In a culture based study Eckstein found a decrease in VRE environmental contamination from 71% to 23% and a decrease in *C. difficile* environmental contamination from 71% to 11% when routine cleaning was supplanted by trained research staff cleaning.

Key Concept 4: Improving the thoroughness of hygienic cleaning decreased environmental HAP contamination (1,14,15,17,23,25,28)

Several recent studies have shown that improving hygienic practice can lead to significant decreases in environmental contamination of high risk objects in the patient zone. In the study by Hayden there was a 47% decrease in environmental contamination when the number of high touch objects cleaned increased from 48% to 85%. Subsequently, Eckstein confirmed an 83% decrease in the *C. difficile* environmental contamination and a 100% decrease in VRE environmental contamination when cleaning was done by a trained research team. Similarly, Goodman confirmed a 40% decrease in environmental contamination with either MRSA or VRE in association with TDC scores increasing from 44% to 71% in 10 ICUs. Dancer, using a dip slide method, confirmed a 33% decrease in aerobic colony counts on high touch objects following implementation of an enhanced cleaning protocol which primarily relied upon the use of additional personnel resources.

Key Concept 5: Improved cleaning decreased acquisition of pathogens (1,6,7,23,25,28,29)

Finally, it is important to note that it has been objectively documented that improved cleaning decreases HAP acquisition by susceptible patients in **all four published studies** to date. In the previously noted study by Hayden, decreased VRE environmental contamination led to an initial 50% decrease in transmission. Following several months of improved cleaning during which the TDC scores ranged from 83 to 85%, acquisition rates decreased by 70% without additional interventions. In the setting of increased *Acinetobacter* transmission in an ICU, Wilks confirmed a sustained 92% decrease in transmission over 18 months following enhanced environmental hygiene. In 2008 Dancer found a 26% decrease in transmission of MRSA in an ICU setting following increased environmental hygiene. Finally, the recent report by Datta, et al. confirmed a significant 20% decrease in MRSA acquisition and a trend towards decreased VRE acquisition in association with objectively improved disinfection cleaning.

Summary

Key Concept 1: Eight evaluations have confirmed an on average 74% increased risk of acquiring a hospital-acquired pathogen from a prior room occupant in hospitals with presumably “average” thoroughness of disinfection cleaning (not programmatically enhanced).

Key Concept 2: Approximately 60% of high touch objects are not cleaned in accordance with existing Environmental Services policies in a wide range of U.S. hospitals.

Key Concept 3: Eight published studies of the DAZO process improvement program have shown an average improvement in TDC scores from 39% measured covertly pre-intervention to 82% (more than 100% improvement over baseline).

Key Concept 4: Programmatically improved hygienic cleaning decreased environmental contamination, on average, 68% from baseline for a range of HAPs in six published studies.

Key Concept 5: In Five prospective published studies, improved environmental cleaning decreased HAP transmission, on average, by 40%.

* Enhancing patient safety by reducing healthcare-associated infections: The role of discovery and dissemination. Infect Control Hosp Epidemiol 2010; 31:118-123.

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References by Key Concept

		Key Concept 1	Key Concept 2	Key Concept 3	Key Concept 4	Key Concept 5
		Previously contaminated rooms increase transmission	Many patient areas are not well cleaned	Cleaning can be programmatically improved	Improved cleaning decreases environmental contamination	Improved cleaning decreases acquisition of pathogens
Ref. #	Lead Author					
1	Hayden, MK	X	X	X	X	X
2	Huang, SS	X				
3	Hardy, KJ	X				
4	Drees, M	X				
5	Shaughnessy, M	X				
6	Wilks, M	X				X
7	Datta, R	X				X
8	Martinez, JA	X				
9	Nseir S		X			
10	Carling, PC		X			
11	Carling, PC		X			
12	Carling, PC		X			
13	Boyce, JM		X			
14	Eckstein, BC		X	X	X	
15	Goodman, ER		X	X	X	
16	Jefferson, J (OR)		X			
17	Guerrero, D		X		X	
18	Loftus RW (OR)			X		
19	Carling, PC			X		
20	Carling, PC			X		
21	Po, JL			X		
22	Carling, PC			X		
23	Hota, B			X	X	X
24	Bruno-Murtha, LA			X		
25	Jean, W			X	X	X
26	Sulis, C			X		
27	Clark, P			X		
28	Dancer, SJ				X	X
29	Frabetti A (OR)					X

Abstracts

Environmental Hygiene Literature

Abstract #1

Previously contaminated rooms increase transmission risk	Many patient areas are not well cleaned	Cleaning can be programmatically improved	Improved cleaning decreases environmental contamination	Improved cleaning decreases patient acquisition of pathogens
X	X	X	X	X

Title: Reduction in acquisition of Vancomycin-resistant enterococcus after enforcement of routine environmental cleaning measures

Author: Hayden MK, Bonten MJ, Blom DW, Lyle EA, van de Vijver DA, Weinstein RA

Publication: Clinical Infectious Diseases

Year: 2006

Summary:

BACKGROUND: The role of environmental contamination in nosocomial cross-transmission of antibiotic-resistant bacteria has been unresolved. Using vancomycin-resistant enterococci (VRE) as a marker organism, we investigated the effects of improved environmental cleaning with and without promotion of hand hygiene adherence on the spread of VRE in a medical intensive care unit.

METHODS: The study comprised a baseline period (period 1), a period of educational intervention to improve environmental cleaning (period 2), a "washout" period without any specific intervention (period 3), and a period of multimodal hand hygiene intervention (period 4). We performed cultures for VRE of rectal swab samples obtained from patients at admission to the intensive care unit and daily thereafter, and we performed cultures of environmental samples and samples from the hands of health care workers twice weekly. We measured patient clinical and demographic variables and monitored intervention adherence frequently.

RESULTS: Our study included 748 admissions to the intensive care unit over a 9-month period. VRE acquisition rates were 33.47 cases per 1000 patient-days at risk for period 1 and 16.84, 12.09, and 10.40 cases per 1000 patient-days at risk for periods 2, 3, and 4, respectively. The mean (+/-SD) weekly rate of environmental sites cleaned increased from 0.48+/-0.08 at baseline to 0.87+/-0.08 in period 2; similarly high cleaning rates persisted in periods 3 and 4. Mean (+/-SD) weekly hand hygiene adherence rate was 0.40+/-0.01 at baseline and increased to 0.57+/-0.11 in period 2, without a specific intervention to improve adherence, but decreased to 0.29+/-0.26 in period 3 and 0.43+/-0.1 in period 4. Mean proportions of positive results of cultures of environmental and hand samples decreased in period 2 and remained low thereafter. In a Cox proportional hazards model, the hazard ratio for acquiring VRE during periods 2-4 was 0.36 (95% confidence interval, 0.19-0.68); the only determinant explaining the difference in VRE acquisition was admission to the intensive care unit during period 1.

CONCLUSIONS: Decreasing environmental contamination may help to control the spread of some antibiotic-resistant bacteria in hospitals.

Environmental Hygiene Literature

Abstract #2

Previously contaminated rooms increase transmission risk	Many patient areas are not well cleaned	Cleaning can be programmatically improved	Improved cleaning decreases environmental contamination	Improved cleaning decreases patient acquisition of pathogens
X				

Title: Risk of acquiring antibiotic-resistant bacteria from prior room occupants

Author: Huang SS, Datta R, Platt R

Publication: Archives of Internal Medicine

Year: 2006

Summary:

BACKGROUND: Environmental contamination with methicillin-resistant *Staphylococcus aureus* (MRSA) and vancomycin-resistant enterococci (VRE) occurs during the care of patients harboring these organisms and may increase the risk of transmission to subsequent room occupants.

METHODS: Twenty-month retrospective cohort study of patients admitted to 8 intensive care units performing routine admission and weekly screening for MRSA and VRE. We assessed the relative odds of acquisition among patients admitted to rooms in which the most recent occupants were MRSA positive or VRE positive, compared with patients admitted to other rooms.

RESULTS: Of 11 528 intensive care unit room stays, 10 151 occupants were eligible to acquire MRSA, and 10 349 were eligible to acquire VRE. Among patients whose prior room occupant was MRSA positive, 3.9% acquired MRSA, compared with 2.9% of patients whose prior room occupant was MRSA negative (adjusted odds ratio, 1.4; $P = .04$). VRE, among patients whose prior room occupant was VRE positive, these values were 4.5% and 2.8% respectively (adjusted odds ratio, 1.4; $P = .02$). These excess risks accounted for 5.1% of all incident MRSA cases and 6.8% of all incident VRE cases, with a population attributable risk among exposed patients of less than 2% for either organism. Acquisition was significantly associated with longer post-intensive care unit length of stay.

CONCLUSIONS: Admission to a room previously occupied by an MRSA-positive patient or a VRE-positive patient significantly increased the odds of acquisition for MRSA and VRE. However, this route of transmission was a minor contributor to overall transmission. The effect of current cleaning practices in reducing the risk to the observed levels and the potential for further reduction are unknown.

Environmental Hygiene Literature

Abstract #3

Previously contaminated rooms increase transmission risk	Many patient areas are not well cleaned	Cleaning can be programmatically improved	Improved cleaning decreases environmental contamination	Improved cleaning decreases patient acquisition of pathogens
X				

Title: A study of the relationship between environmental contamination with methicillin-resistant *Staphylococcus aureus* (MRSA) and patients' acquisition of MRSA

Author: Hardy KJ, Oppenheim BA, Gossain S, Gao F, Hawkey PM

Publication: Infection Control and Hospital Epidemiology

Year: 2006

Summary:

OBJECTIVE: The study aimed to examine the presence of methicillin-resistant *Staphylococcus aureus* (MRSA) in the environment and its relationship to patients' acquisition of MRSA.

DESIGN: A prospective study was conducted in a 9-bed intensive care unit for 14 months. At every environmental screening, samples were obtained from the same 4 sites in each bed space. Patients were screened at admission and then 3 times weekly. All environmental and patient strains were typed using pulsed-field gel electrophoresis.

RESULTS: MRSA was isolated from the environment at every environmental screening, when both small and large numbers of patients were colonized. Detailed epidemiological typing of 250 environmental and 139 patient isolates revealed 14 different pulsed-field gel electrophoresis profiles, with variants of EMRSA-15 being the predominant type. On only 20 (35.7%) of 56 occasions were the strains isolated from the patients and the strains isolated from their immediate environment indistinguishable. There was strong evidence to suggest that 3 of 26 patients who acquired MRSA while in the intensive care unit acquired MRSA from the environment.

CONCLUSIONS: This study reveals widespread contamination of the hospital environment with MRSA, highlights the complexities of the problem of contamination, and confirms the need for more-effective cleaning of the hospital environment to eliminate MRSA.

Environmental Hygiene Literature

Abstract #4

Previously contaminated rooms increase transmission risk	Many patient areas are not well cleaned	Cleaning can be programmatically improved	Improved cleaning decreases environmental contamination	Improved cleaning decreases patient acquisition of pathogens
X				

Title: Prior environmental contamination increases the risk of acquisition of vancomycin-resistant enterococci

Author: Drees M, Snydman DR, Schmid CH, Barefoot L, Hansjosten K, Vue PM

Publication: Clinical Infectious Diseases

Year: 2008

Summary:

BACKGROUND: Patients colonized with vancomycin-resistant enterococci (VRE) frequently contaminate their environment, but the environmental role of VRE transmission remains controversial.

METHODS: During a 14-month study in 2 intensive care units, weekly environmental and twice-weekly patient surveillance cultures were obtained. VRE acquisition was defined as a positive culture result >48 h after admission. To determine risk factors for VRE acquisition, Cox proportional hazards models using time-dependent covariates for colonization pressure and antibiotic exposure were examined.

RESULTS: Of 1330 intensive care unit admissions, 638 patients were at risk for acquisition, and 50 patients (8%) acquired VRE. Factors associated with VRE acquisition included average colonization pressure (hazard ratio [HR], 1.4 per 10% increase; 95% confidence interval [CI], 1.2-1.8), mean number of antibiotics (HR, 1.7 per additional antibiotic; 95% CI, 1.2-2.5), leukemia (HR, 3.1; 95% CI, 1.2-7.8), a VRE-colonized prior room occupant (HR, 3.1; 95% CI, 1.6-5.8), any VRE-colonized room occupants within the previous 2 weeks (HR, 2.5; 95% CI, 1.3-4.8), and previous positive room culture results (HR, 3.4; 95% CI, 1.2-9.6). In separate multivariable analyses, a VRE-colonized prior room occupant (HR, 3.8; 95% CI, 2.0-7.4), any VRE-colonized room occupants within the previous 2 weeks (HR, 2.7; 95% CI, 1.4-5.3), and previous positive room culture results (HR, 4.4; 95% CI, 1.5-12.8) remained independent predictors of VRE acquisition, adjusted for colonization pressure and antibiotic exposure.

CONCLUSIONS: We found that prior room contamination, whether measured via environmental cultures or prior room occupancy by VRE-colonized patients, was highly predictive of VRE acquisition. Increased attention to environmental disinfection is warranted.

Environmental Hygiene Literature

Abstract #5

Previously contaminated rooms increase transmission risk	Many patient areas are not well cleaned	Cleaning can be programmatically improved	Improved cleaning decreases environmental contamination	Improved cleaning decreases patient acquisition of pathogens
X				

Title: Evaluation of hospital room assignment and acquisition of *Clostridium difficile* associated diarrhea (CDAD)

Author: Shaughnessy MK, Micielli RL, Depestel DD, Arndt J, Strachan CL, Welch KB, Chenoweth CE

Publication: Infection Control and Hospital Epidemiology

Year: 2011

Summary:

BACKGROUND and OBJECTIVE: *Clostridium difficile* spores may persist in hospital environments for an extended period of time. We evaluated whether admission to a room previously occupied by a patient with *C. difficile* infection (CDI) increased the risk of acquiring CDI.

DESIGN: Retrospective cohort study.

SETTING: Medical intensive care unit (ICU) at a tertiary care hospital

METHODS: Patients admitted from January 1, 2005, through June 30, 2006, were evaluated for a diagnosis of CDI 48 hours after ICU admission and within 30 days after ICU discharge. Medical, ICU, and pharmacy records were reviewed for other CDI risk factors. Admitted patients who did develop CDI were compared with admitted patients who did not.

RESULTS: Among 1,844 patients admitted to the ICU, 134 CDI cases were identified. After exclusions, 1,770 admitted patients remained for analysis. Of the patients who acquired CDI after admission to the ICU, 4.6% had a prior occupant without CDI, whereas 11.0% had a prior occupant with CDI ($P = .002$). The effect of room on CDI acquisition remained a significant risk factor ($P = .008$) when Kaplan-Meier curves were used. The prior occupants CDI status remained significant ($p = .01$; hazard ratio, 2.35) when controlling for the current patient's age, Acute Physiology and Chronic Health Evaluation III score, exposure to proton pump inhibitors, and antibiotic use.

CONCLUSIONS: A prior room occupant with CDI is a significant risk factor for CDI acquisition, independent of established CDI risk factors. These findings have implications for room placement and hospital design.

Environmental Hygiene Literature

Abstract #6

Previously contaminated rooms increase transmission risk	Many patient areas are not well cleaned	Cleaning can be programmatically improved	Improved cleaning decreases environmental contamination	Improved cleaning decreases patient acquisition of pathogens
X				X

Title: Control of an outbreak of multidrug-resistant *Acinetobacter baumannii-calcoaceticus* colonization and infection in an intensive care unit (ICU) without closing the ICU or placing patients in isolation

Author: Wilks M, Wilson A., Warwick S, Price E, Kennedy D, Ely A, Millar MR

Publication: Infection Control and Hospital Epidemiology

Year: 2006

Summary:

OBJECTIVE: To describe the control of multidrug-resistant *Acinetobacter baumannii-calcoaceticus* (MDRABC) colonization and infection in an intensive care unit (ICU).

SETTING: An 18-bed ICU in a large tertiary care teaching hospital in London.

INTERVENTIONS: After recognition of the outbreak, a range of infection control measures were introduced over several months that were primarily aimed at reducing environmental contamination with the outbreak strain. Strategies included use of a closed tracheal suction system for all patients receiving mechanical ventilation, use of nebulized colistin for patients with evidence of mild to moderate ventilator-associated pneumonia, improved availability of alcohol for hand decontamination, and clearer designation of responsibilities and strategies for cleaning equipment and the environment in the proximity of patients colonized or infected with MDRABC.

RESULTS: The outbreak lasted from June 2001 through November 2002 and involved 136 new cases of MDRABC infection or colonization. The number of newly diagnosed cases per month reached a maximum of 15 in February 2002, and the number of new cases slowly decreased over the next 9 months.

CONCLUSION: This outbreak was controlled by emphasizing the control of environmental reservoirs and did not require recourse to ward closure or placement of affected patients in isolation.

Environmental Hygiene Literature

Abstract #7

Previously contaminated rooms increase transmission risk	Many patient areas are not well cleaned	Cleaning can be programmatically improved	Improved cleaning decreases environmental contamination	Improved cleaning decreases patient acquisition of pathogens
X				X

Title: Environmental Cleaning Intervention and Risk of Acquiring Multidrug-Resistant Organisms from Prior Room Occupants

Author: Datta R, Platt R, Yokoe DS, Huang SS

Publication: Archives of Internal Medicine

Year: 2011

Summary:

BACKGROUND: Admission to intensive care unit rooms previously occupied by carriers of methicillin-resistant *Staphylococcus aureus* (MRSA) or vancomycin-resistant enterococci (VRE) had been found to confer a 40% increased risk of acquisition, presumably through environmental contamination. Subsequently, a cleaning intervention was shown to reduce MRSA and VRE room contamination. We now evaluate the effect of this intervention on the risk of acquiring MRSA and VRE from prior room occupants.

METHODS: We conducted a retrospective cohort study of patients admitted to 10 intensive care units at a 750-bed academic medical center during the enhanced cleaning intervention (from September 1, 2006, through April 30, 2008; n = 9449) vs baseline (from September 1, 2003, through April 30, 2005; n = 8203) periods. The intervention consisted of targeted feedback using a black-light marker, cleaning cloths saturated with disinfectant via bucket immersion, and increased education regarding the importance of repeated bucket immersion during cleaning. Intensive care units included medical, cardiac, burn/trauma, general surgery, cardiac surgery, thoracic surgery, and neurosurgery units. We calculated the number of room stays involving the potential for MRSA and VRE acquisition and then assessed the frequency at which eligible patients were exposed to rooms in which the prior occupants had MRSA-positive or VRE-positive status.

RESULTS: Acquisition of MRSA and VRE was lowered from 3.0% to 1.5% for MRSA and from 3.0% to 2.2% for VRE ($P < .001$ for both). Patients in rooms previously occupied by MRSA carriers had an increased risk of acquisition during the baseline (3.9% vs 2.9%, $P = .03$) but not the intervention (1.5% vs 1.5%, $P = .79$) period. In contrast, patients in rooms previously occupied by VRE carriers had an increased risk of acquisition during the baseline (4.5% vs 2.8%, $P = .001$) and intervention (3.5% vs 2.0%, $P < .001$) periods.

CONCLUSIONS: Enhanced intensive care unit cleaning using the intervention methods may reduce MRSA and VRE transmission. It may also eliminate the risk of MRSA acquisition due to an MRSA-positive prior room occupant.

Environmental Hygiene Literature

Abstract #8

Previously contaminated rooms increase transmission risk	Many patient areas are not well cleaned	Cleaning can be programmatically improved	Improved cleaning decreases environmental contamination	Improved cleaning decreases patient acquisition of pathogens
X				

Title: Role of environmental contamination as a risk factor for acquisition of vancomycin-resistant enterococci in patients treated in a medical intensive care unit

Author: Martinez JA, Ruthazer R, Hansjosten K, Barefoot L, Snyderman DR

Publication: Archives of Internal Medicine

Year: 2003

Summary:

BACKGROUND: Colonization pressure, proximity to another case, exposure to a nurse who cares for another case, enteral feeding, and the use of sucralfate, vancomycin hydrochloride, cephalosporins, or antibiotics are among the defined risk factors for acquisition of vancomycin-resistant enterococci (VRE) in the intensive care unit (ICU) setting. However, the role of rooms with contaminated environmental surfaces has not been well delineated.

METHODS: Retrospective case-control study conducted on patients admitted to the medical ICU (MICU) of a tertiary-care, university-affiliated medical center during a 9-month period. Patients who acquired VRE (cases) were matched with 2 randomly selected control subjects who did not acquire VRE and had been in the MICU for at least the same number of days.

RESULTS: Thirty cases were matched with 60 appropriate controls. Cases were more likely to have been in the hospital for longer than 7 days before MICU admission ($P = .009$); to have occupied a specific room with persisting contaminated surfaces ($P = .06$); to have had a central venous catheter ($P = .05$); to have received vancomycin ($P = .02$), cephalosporins ($P = .03$), and quinolones ($P = .006$) before MICU admission; and to have received vancomycin ($P = .02$) and metronidazole sodium phosphate ($P = .03$) after MICU admission. Multivariate analysis showed that a hospital stay of longer than 1 week before MICU admission ($P = .04$), use of vancomycin before or after MICU admission ($P = .03$), use of quinolones before MICU admission ($P = .03$), and placement in a contaminated room ($P = .02$) were the best predictors of VRE acquisition.

CONCLUSIONS: Among all other factors associated with VRE transmission, VRE acquisition may depend on room contamination, even after extensive cleaning. This study underscores the need for better cleaning and the role of the environment in transmission of VRE.

Environmental Hygiene Literature

Abstract #9

Previously contaminated rooms increase transmission risk	Many patient areas are not well cleaned	Cleaning can be programmatically improved	Improved cleaning decreases environmental contamination	Improved cleaning decreases patient acquisition of pathogens
X				

Title: Risk of acquiring multi-drug resistant Gram-negative bacilli from prior room occupants in the intensive care unit

Author: Nseir S, Blazejewski C, Lubret R, Wallet F, Courcol R, Durocher A

Publication: Clinical Microbiology and Infection

Year: 2011

Summary:

The objective of this prospective cohort study was to determine whether admission to an intensive care unit (ICU) room previously occupied by a patient with multidrug-resistant (MDR) Gram-negative bacilli (GNB) increases the risk of acquiring these bacteria by subsequent patients. All patients hospitalized for >48 h were eligible. Patients with MDR GNB at ICU admission were excluded. The MDR GNB were defined as MDR *Pseudomonas aeruginosa*, *Acinetobacter baumannii* and extended spectrum β -lactamase (ESBL)-producing GNB. All patients were hospitalized in single rooms. Cleaning of ICU rooms between two patients was performed using quaternary ammonium disinfectant. Risk factors for MDR *P. aeruginosa*, *A. baumannii* and ESBL-producing GNB were determined using univariate and multivariate analysis. Five hundred and eleven consecutive patients were included; ICU-acquired MDR *P. aeruginosa* was diagnosed in 82 (16%) patients. *A. baumannii* in 57 (11%) patients, and ESBL-producing GNB in 50 (9%) patients. Independent risk factors for ICU-acquired MDR *P. aeruginosa* were prior occupant with MDR *P. aeruginosa* (OR 2.3, 95% CI 1.2-4.3, p 0.012), surgery (OR 1.9, 95% CI 1.1-3.6, p 0.024), and prior piperacillin/tazobactam use (OR 1.2, 95% CI 1.1-1.3, p 0.040). Independent risk factors for ICU-acquired *A. baumannii* were prior occupant with *A. baumannii* (OR 4.2, 95% CI 2-8.8, p <0.001), and mechanical ventilation (OR 9.3, 95% CI 1.1-83, p 0.045). Independent risk factors for ICU-acquired ESBL-producing GNB were tracheostomy (OR 2.6, 95% CI 1.1-6.5, p 0.049), and sedation (OR 6.6 95% CI 1.1-40, p 0.041). We conclude that admission to an ICU room previously occupied by a patient with MDR *P. aeruginosa* or *A. baumannii* is an independent risk factor for acquisition of these bacteria by subsequent room occupants. This relationship was not identified for ESBL-producing GNB.

Environmental Hygiene Literature

Abstract #10

Previously contaminated rooms increase transmission risk	Many patient areas are not well cleaned	Cleaning can be programmatically improved	Improved cleaning decreases environmental contamination	Improved cleaning decreases patient acquisition of pathogens
	X			

Title: An evaluation of patient area cleaning in 3 hospitals using a novel targeting technique

Author: Carling PC, Briggs J, Hylander D, Perkins J

Publication: American Journal of Infection Control

Year: 2006

Summary:

BACKGROUND: Although environmental cleaning and disinfecting practices have become a cornerstone of patient care, assessment of actual compliance with such procedures has not been reported. Using a novel methodology, we developed a means to monitor directly such activities.

METHODS: A nontoxic target solution, which intensely fluoresces with a black light, was formulated to be inconspicuous yet readily removed by housekeeping products. Small volumes of material were confidentially applied to 12 target sites in patient rooms in 3 hospitals following terminal cleaning. The targets were reevaluated following terminal cleaning after several patients had occupied the room.

RESULTS: One hundred fifty-seven rooms and 1404 targets were evaluated. In the 3 hospitals studied, only 45%, 42%, and 56% of targets were removed by routine terminal cleaning/disinfecting activities. The frequency with which various individual sites were cleaned varied widely but was similar in all hospitals.

CONCLUSION: The use of a novel target compound to evaluate housekeeping practices confirmed high rates of cleaning of traditional sites but poor cleaning of many sites that have significant potential for harboring and transmitting microbial pathogens. This methodology has the potential for being used to evaluate objectively the cleaning/disinfecting activities in various health care settings.

Environmental Hygiene Literature

Abstract #11

Previously contaminated rooms increase transmission risk	Many patient areas are not well cleaned	Cleaning can be programmatically improved	Improved cleaning decreases environmental contamination	Improved cleaning decreases patient acquisition of pathogens
	X			

Title: Intensive care unit environmental cleaning: an evaluation in sixteen hospitals using a novel assessment tool

Author: Carling PC, Von Beheren S, Kim P, Woods C; Healthcare Environmental Hygiene Study Group

Publication: Journal of Hospital Infection

Year: 2007

Summary:

Despite isolation precautions and enhanced hand hygiene product use, the transmission of healthcare-associated pathogens remains a major problem. Recent studies have confirmed that microbial contamination of the environment in intensive care units (ICUs) can lead to colonisation and infection of patients. Although environmental disinfectants have been used to minimize the spread of microbial pathogens, suboptimal cleaning may limit the effectiveness of such activities. In order to evaluate the thoroughness of cleaning near-patient surfaces, a transparent, easily cleanable and environmentally stable solution was developed that fluoresces when exposed to UV light. The solution was used to mark a standardized group of frequently touched objects in ICU patient rooms following discharge cleaning. These sites were then evaluated after at least two patients had occupied the room and at least two terminal cleanings had been completed. Evaluation of 2320 objects in 197 patient areas disclosed that 57.1% of the standardized sites were cleaned following discharge of the room's occupant in the 16 ICUs studied. Although high rates of cleaning (80%) were found for toilet seats, sinks and tray tables, consistently low rates of cleaning (<30%) were documented for several objects at high risk of becoming contaminated with nosocomial pathogens, including bedpan cleaners, toilet area handholds, doorknobs and light switches.

Environmental Hygiene Literature

Abstract #12

Previously contaminated rooms increase transmission risk	Many patient areas are not well cleaned	Cleaning can be programmatically improved	Improved cleaning decreases environmental contamination	Improved cleaning decreases patient acquisition of pathogens
	X			

Title: Identifying opportunities to improve environmental hygiene in multiple healthcare settings

Author: Carling PC, Po JL, Bartley J, Herwaldt L; Healthcare Environmental Hygiene Group

Publication: Abstract, SHEA 5th Decennial Meeting; Atlanta GA

Year: 2010

Summary:

BACKGROUND: Observational studies have suggested that improving environmental disinfection cleaning (EDC) of patient rooms decreases transmission of MRSA, *C. difficile* and *A. baumannii*. Prospective studies of EDC and transmission of MRSA and VRE have confirmed that suboptimal thoroughness of disinfection cleaning (TDC) facilitates transmission of MRSA and VRE and that improved EDC can decrease transmission. To improve EDC practices and, thereby, patient safety, one must first document that TDC needs improvement.

OBJECTIVE: To evaluate the thoroughness of hygienic cleaning of surfaces that have significant potential for transmitting hospital-associated pathogens in a range of healthcare facilities and settings.

METHODS: A novel fluorescent targeting system was covertly used to objectively evaluate if TDC of standardized sets of high risk objects was performed in a manner consistent with established guidelines and the Center for Medicare and Medicaid Services' requirements.

RESULTS: Terminal TDC in the first 36 acute care hospitals studied (48%) was similar to that found in 50 hospitals participating in the Iowa MRSA Reduction Project (62%), 14 other test hospitals (42%) 16 hospital's operating rooms (32%), and 7 hospitals' neonatal intensive care units (36%). Daily TDC in ICU isolation rooms in 7 hospitals (31%), in 4 ambulatory chemotherapy suites (26%), in 4 dialysis units (28%), and in 4 long-term care facilities (34%) was also suboptimal. Overall, the mean TDC was 47.9% (Range = 3 to 88, 95% CI-44.8 - 50.9).

CONCLUSIONS: Nine studies of TDC which included > 62,500 high touch surfaces in 103 different institutions and 142 study sites identified opportunities for improved cleaning in all venues, documenting that TDC must be improved across a broad range of U.S. healthcare settings as part of efforts to prevent transmission of pathogens. In addition, these results indicate that our methodology meets the specifications of the Department of Health and Human Services Action Plan to Prevent Healthcare Associated Infections (June 2009) which stated: "Standardized methods (i.e. performance methods) that are feasible, valid and reliable" should be used "for measuring and reporting compliance with broad based HAI prevention practices that must be practiced consistently by a large number of healthcare personnel".



Environmental Hygiene Literature

Abstract #13

Previously contaminated rooms increase transmission risk	Many patient areas are not well cleaned	Cleaning can be programmatically improved	Improved cleaning decreases environmental contamination	Improved cleaning decreases patient acquisition of pathogens
	X			

Title: Monitoring the effectiveness of hospital cleaning practices by use of an adenosine triphosphate bioluminescence assay

Author: Boyce JM, Havill NL, Dumigan DG, Golebiewski M, Balogun O, Rizvani R

Publication: Infection Control and Hospital Epidemiology

Year: 2009

Summary:

OBJECTIVE: To evaluate the usefulness of an adenosine triphosphate (ATP) bioluminescence assay for assessing the efficacy of daily hospital cleaning practices.

DESIGN: A 2-phase prospective intervention study.

SETTING: A university-affiliated community teaching hospital.

METHODS: During phase I of our study, 5 high-touch surfaces in 20 patient rooms were sampled before and after daily cleaning. Moistened swabs were used to sample these surfaces and were then plated onto routine and selective media, and aerobic colony counts were determined after 48 hours of incubation. Specialized ATP swabs were used to sample the same high-touch surfaces in the 20 patient rooms and were then placed in luminometers, and the amount of ATP present was expressed as relative light units. During phase II of our study, after in-service housekeeper educational sessions were given, the housekeepers were told in advance when ATP readings would be taken before and after cleaning.

RESULTS: During phase I, the colony counts revealed that the 5 high-touch surfaces were often not cleaned adequately. After cleaning, 24 (24%) of the 100 surface samples were still contaminated with methicillin-resistant *Staphylococcus aureus*, and 16 (16%) of the 100 surface samples still yielded vancomycin-resistant enterococci. ATP readings (expressed as relative light units) revealed that only bathroom grab bars and toilet seats were significantly cleaner after daily cleaning than before. During phase II, a total of 1,013 ATP readings were obtained before and after daily cleaning in 105 rooms. The median relative light unit was significantly lower (ie, surfaces were cleaner) after cleaning than before cleaning for all 5 high-touch surfaces.

CONCLUSIONS: Suboptimal cleaning practices were documented by determining aerobic colony counts and by use of an ATP bioluminescence assay. ATP readings provided quantitative evidence of improved cleanliness of high-touch surfaces after the implementation of an intervention program.

Environmental Hygiene Literature

Abstract #14

Previously contaminated rooms increase transmission risk	Many patient areas are not well cleaned	Cleaning can be programmatically improved	Improved cleaning decreases environmental contamination	Improved cleaning decreases patient acquisition of pathogens
	X	X	X	

Title: Reduction of *Clostridium difficile* and vancomycin-resistant enterococcus contamination of environmental surfaces after an intervention to improve cleaning methods

Author: Eckstein BC, Adams DA, Eckstein EC, Rao A, Sethi AK, Yadavalli GK, Donskey CJ

Publication: BioMed Central Infectious Diseases Clinical Infectious Diseases

Year: 2007

Summary:

BACKGROUND: Contaminated environmental surfaces may play an important role in transmission of some healthcare-associated pathogens. In this study, we assessed the adequacy of cleaning practices in rooms of patients with *Clostridium difficile*-associated diarrhea (CDAD) and vancomycin-resistant Enterococcus (VRE) colonization or infection and examined whether an intervention would result in improved decontamination of surfaces.

METHODS: During a 6-week period, we cultured commonly touched surfaces (i.e. bedrails, telephones, call buttons, door knobs, toilet seats, and bedside tables) in rooms of patients with CDAD and VRE colonization or infection before and after housekeeping cleaning, and again after disinfection with 10% bleach performed by the research staff. After the housekeeping staff received education and feedback, additional cultures were collected before and after housekeeping cleaning during a 10-week follow-up period.

RESULTS: Of the 17 rooms of patients with VRE colonization or infection, 16 (94%) had one or more positive environmental cultures before cleaning versus 12 (71%) after housekeeping cleaning ($p = 0.125$), whereas none had positive cultures after bleach disinfection by the research staff ($p < 0.001$). Of the 9 rooms of patients with CDAD, 100% had positive cultures prior to cleaning versus 7 (78%) after housekeeping cleaning ($p = 0.031$). After an education intervention, rates of environmental contamination after housekeeping were significantly reduced.

CONCLUSION: Our findings provide additional evidence that simple educational interventions directed at housekeeping staff can result in improved decontamination of environmental surfaces. Such interventions should include efforts to monitor cleaning and disinfection practices and provide feedback to the housekeeping staff.

Environmental Hygiene Literature

Abstract #15

Previously contaminated rooms increase transmission risk	Many patient areas are not well cleaned	Cleaning can be programmatically improved	Improved cleaning decreases environmental contamination	Improved cleaning decreases patient acquisition of pathogens
	X	X	X	

Title: Impact of an environmental cleaning intervention on the presence of Methicillin-resistant *Staphylococcus aureus* and Vancomycin-resistant enterococci on surfaces in intensive care unit rooms

Author: Goodman ER, Platt R, Bass R, Onderdonk AB, Yokoe DS, Huang SS

Publication: Infection Control and Hospital Epidemiology

Year: 2008

Summary:

OBJECTIVES: To evaluate the adequacy of discharge room cleaning and the impact of a cleaning intervention on the presence of methicillin-resistant *Staphylococcus aureus* (MRSA) and vancomycin-resistant enterococci (VRE) on environmental surfaces in intensive care unit (ICU) rooms.

DESIGN: Prospective environmental study.

SETTING AND SAMPLE: Convenience sample of ICU rooms in an academic hospital.

METHODS AND INTERVENTION: The intervention consisted of (1) a change from the use of pour bottles to bucket immersion for applying disinfectant to cleaning cloths, (2) an educational campaign, and (3) feedback regarding adequacy of discharge cleaning. Cleaning of 15 surfaces was evaluated by inspecting for removal of a preapplied mark, visible only with ultraviolet lamp ("black-light"). Six surfaces were cultured for MRSA or VRE contamination. Outcomes of mark removal and culture positivity were evaluated by x2 testing and generalized linear mixed models, clustering by room.

RESULTS: The black-light mark was removed from 44% of surfaces at baseline, compared with 71% during the intervention ($P < .001$). The intervention increased the likelihood of removal of black-light marks after discharge cleaning (odds ratio, 4.4; $P < .001$), controlling for ICU type (medical vs. surgical) and type of surface. The intervention reduced the likelihood of an environmental culture positive for MRSA or VRE (proportion of cultures positive, 45% at baseline vs. 27% during the intervention; adjusted odds ratio, 0.4; $P = .02$). Broad, flat surfaces were more likely to be cleaned than were doorknobs and sink or toilet handles.

CONCLUSIONS: Increasing the volume of disinfectant applied to environmental surfaces, providing education for Environmental Services staff, and instituting feedback with a black-light marker improved cleaning and reduced frequency of MRSA and VRE contamination.

Environmental Hygiene Literature

Abstract #16

Previously contaminated rooms increase transmission risk	Many patient areas are not well cleaned	Cleaning can be programmatically improved	Improved cleaning decreases environmental contamination	Improved cleaning decreases patient acquisition of pathogens
	X			

Title: A novel technique to identify opportunities for improving environmental hygiene in the operating room

Author: Jefferson J, Whalen R, Dick B, Carling PC

Publication: AORN Journal

Year: 2010

Summary:

Cleaning and disinfection of the environment has long been a cornerstone of optimizing patient safety in Operating Rooms. What has been lacking is an easy to use, objective method to determine whether or not high-touch, potentially contaminated surfaces have been cleaned during terminal room cleaning. Our study illustrates the use of a transparent, easily removable, environmentally stable disclosing agent and a hand-held ultraviolet light to determine if potentially contaminated surfaces were contacted by a wet disinfection cleaning cloth during terminal cleaning of the operating rooms studied. While only 237/946 (25%) of targeted surfaces had the disclosing agent removed (cleaned), the use of the disclosing agent for staff education and process monitoring has led to significant improvements in the disinfection cleaning process in studies by the Healthcare Environmental Hygiene Study Group using the evaluation system described in this report.

Environmental Hygiene Literature

Abstract #17

Previously contaminated rooms increase transmission risk	Many patient areas are not well cleaned	Cleaning can be programmatically improved	Improved cleaning decreases environmental contamination	Improved cleaning decreases patient acquisition of pathogens
	X		X	

Title: Beyond the “Hawthorne effect”: reduction of *Clostridium difficile* environmental contamination through active intervention to improve cleaning practices

Author: Guerrero D, Carling PC, Jury L, Ponnada S, Nerandzik M, Eckstein EC, Donskey C

Publication: Abstract, SHEA Fifth Decennial Meeting

Year: 2010

Summary:

BACKGROUND: Several recent publications had raised concerns that bleach may be less effective for eradication of *Clostridium difficile* spores from environmental surfaces than new technologies such as hydrogen peroxide vapor. Because bleach is effective in killing spores in vitro, we hypothesized that the reduced efficacy of bleach disinfection is attributable to inadequate application by housekeeping staff rather than failure of the product.

OBJECTIVE: To examine the efficacy of bleach disinfection on *C. difficile* spores in hospital rooms before and after interventions to improve housekeeping cleaning.

METHODS: We performed a 3-stage intervention: 1) Baseline observations of housekeeping cleaning practices; 2) Education of housekeeping in combination with direct observation of staff during room cleaning; 3) Direct supervision of housekeeping staff cleaning practices to ensure correct application of bleach. A commercial bleach product Clorox® Clean-Up® (Oakland, CA) containing 18,400 parts per-million sodium hypochlorite was used in all rooms. To assess the efficacy of bleach disinfection, we applied non-toxigenic *C. difficile* spores to high touch surfaces (i.e., the bedrail, lateral edge of the bedside table, and drawer handles) before cleaning and cultured the sites after cleaning.

RESULTS: Prior to the intervention, 19 of 30 (63%) environmental surfaces were positive for *C. difficile* after housekeeping cleaning; observations indicated that the high-touch surfaces were often not cleaned adequately and bleach was frequently wiped off surfaces without allowing sufficient contact time. During the period of education and observation of cleaning practices, the percentage of positive cultures was significantly reduced (9 of 45, 20%; $P < 0.001$) and observations indicated that high-touch surfaces were still

not consistently cleaned. During the period of direct supervision of staff, 0 of 30 culture sites were positive ($P < 0.001$).

CONCLUSIONS: When applied correctly, bleach is very effective in eliminating *C. difficile* spores from surfaces in hospital rooms. Although simple interventions such as education and observation of housekeeping staff can improve environmental disinfection, strategies such as direct supervision of cleaning may be required to attain optimal results.



Environmental Hygiene Literature

Abstract #18

Previously contaminated rooms increase transmission risk	Many patient areas are not well cleaned	Cleaning can be programmatically improved	Improved cleaning decreases environmental contamination	Improved cleaning decreases patient acquisition of pathogens
	X			

Title: Hand contamination of anesthesia providers is an important risk factor for intraoperative bacterial transmission

Author: Loftus RW, Muffly MK, Brown JR, Beach ML, Koff MD, Corwin HL, Surgenor SD, Kirkland KB, Yeager MP

Publication: Anesthesia and Analgesia

Year: 2011

Summary:

BACKGROUND: We have recently shown that intraoperative bacterial transmission to patient IV stopcock sets is associated with increased patient mortality. In this study we hypothesized that bacterial contamination of anesthesia provider hands before patient contact is a risk factor for direct intraoperative bacterial transmission.

METHODS: Dartmouth-Hitchcock Medical Center is a tertiary care and level 1 trauma center with 400 inpatient beds and 28 operating suites. The first and second operative cases in each of 92 operating rooms were randomly selected for analysis. Eighty-two paired samples were analyzed. Ten pairs of cases were excluded because of broken or missing sampling protocol and lost samples. We identified cases of intraoperative bacterial transmission to the patient IV stopcock set and the anesthesia environment (adjustable pressure-limiting valve and agent dial) in each operating room pair by using a previously validated protocol. We then used biotype analysis to compare these transmitted organisms to those organisms isolated from the hands of anesthesia providers obtained before the start of each case. Provider-origin transmission was defined as potential pathogens isolated in the patient stopcock set or environment that had an identical biotype to the same organism isolated from hands of providers. We also assessed the efficacy of the current intraoperative cleaning protocol by evaluating isolated potential pathogens identified at the start of case 2. Poor intraoperative cleaning was defined as 1 or more potential pathogens found in the anesthesia environment at the start of case 2 that were not there at the beginning of case 1. We collected clinical and epidemiological data on all the cases to identify risk factors for contamination.

RESULTS: One hundred sixty-four cases (82 case pairs) were studied. We identified intraoperative bacterial transmission to the IV stopcock set in 11.5% (19/164) of cases, 47% (9/19) of which were of provider origin. We identified intraoperative bacterial transmission to the anesthesia environment in 89% (146/164) of cases, 12% (17/146) of which were of provider origin. The number of rooms that an attending anesthesiologist supervised simultaneously, the age of the patient, and patient discharge from the operating room to an intensive care unit were independent predictors of bacterial transmission events not directly linked to providers.

CONCLUSION: The contaminated hands of anesthesia providers serve as a significant source of patient environmental and stopcock set contamination in the operating room. Additional sources of intraoperative bacterial transmission, including postoperative environmental cleaning practices should be further studied.



Environmental Hygiene Literature

Abstract #19

Previously contaminated rooms increase transmission risk	Many patient areas are not well cleaned	Cleaning can be programmatically improved	Improved cleaning decreases environmental contamination	Improved cleaning decreases patient acquisition of pathogens
		X		

Title: Improving cleaning of the environment surrounding patients in 36 acute care hospitals

Author: Carling PC, Parry MM, Rupp ME, Po JL, Dick B, Von Beheren S, Healthcare Environmental Hygiene Study Group

Publication: Infection Control and Hospital Epidemiology

Year: 2008

Summary:

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.

Environmental Hygiene Literature

Abstract #20

Previously contaminated rooms increase transmission risk	Many patient areas are not well cleaned	Cleaning can be programmatically improved	Improved cleaning decreases environmental contamination	Improved cleaning decreases patient acquisition of pathogens
		X		

Title: Improving environmental hygiene in 27 ICUs to decrease multi-drug resistant bacterial transmission

Author: Carling PC, Parry MF, Bruno-Murtha LA, Dick B

Publication: Critical Care Medicine

Year: 2010

Summary:

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 post-interventional 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, 3,532 environmental surfaces (14 standardized objects) were assessed after terminal cleaning in 260 intensive care unit rooms. Only 49.5% (1,748) 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.

See also:

Miller BA, Sexton DJ. Shedding light on new methods to improve hospital cleanliness: The use of ultraviolet monitors as surrogate markers for bacterial contamination. Crit Care Med 2010 Vol. 8, No. 4 pp. 1212-14.



Environmental Hygiene Literature

Abstract #21

Previously contaminated rooms increase transmission risk	Many patient areas are not well cleaned	Cleaning can be programmatically improved	Improved cleaning decreases environmental contamination	Improved cleaning decreases patient acquisition of pathogens
		X		

Title: Dangerous cows: an analysis of disinfection cleaning of computer keyboards on wheels

Author: Po JL, Burke R, Sulis C, Carling PC

Publication: American Journal of Infection Control

Year: 2009

Summary:

Keyboards in intensive care units have been shown to serve as reservoirs for multidrug-resistant microorganisms. The thoroughness of disinfection cleaning of keyboards on computers on wheels (COWs) in an intensive care units of an academic medical center were evaluated using an invisible florescent marker, and the movements of the COWs were tracked using their serial numbers. Following a series of educational and programmatic interventions, we were able to improve the thoroughness of cleaning to 100%.

Environmental Hygiene Literature

Abstract #22

Previously contaminated rooms increase transmission risk	Many patient areas are not well cleaned	Cleaning can be programmatically improved	Improved cleaning decreases environmental contamination	Improved cleaning decreases patient acquisition of pathogens
		X		

Title: Achieving sustained improvement in environmental hygiene using coordinated benchmarking in 12 hospitals

Author: Carling PC, Eck EK

Publication: Abstract, SHEA Fifth Decennial

Year: 2010

Summary:

BACKGROUND: Microbial contamination of the near patient environment has become increasingly recognized as having a role in the transmission of healthcare associated pathogens. Indeed, since 2007, the Center for Medicare Services has required that “The infection and prevention control program (for healthcare facilities) must include appropriate monitoring of housekeeping activities to ensure that the hospital maintains a sanitary environment”(CMS, Condition of Participation Guideline 482.42.).

OBJECTIVE: In order to determine if a previously validated indirect method of analyzing the thoroughness of disinfection cleaning (TDC) could serve as a benchmarking metric, we undertook a prospective analysis of 12 related acute care hospitals within a single healthcare system to assess the potential impact of such a coordinated program in achieving process improvement.

METHODS: The 12 hospitals ranged from 200 to 500 beds and included both tertiary and secondary care institutions. The TDC of 14 high touch objects was evaluated at the time of discharge using a fluorescent dye based targeting system. A structured three phase intervention was then utilized as previously described (ICHE 2008; 29:1035-1041). During each phase, cleaning scores (proportion of objects cleaned) were provided to the environmental services staff and each hospital's leadership and were reviewed on a regular basis during system-wide quality assurance meetings where they were further analyzed.

RESULTS: Covert pre-intervention analysis of the TDC of 5,040 surfaces in 360 patient rooms in the 12 hospitals disclosed cleaning scores ranging from 3 to 71%. Following structured educational interventions with environmental services personnel (Phase II), scores improved to between 24 and 98% with 5 of the hospitals scoring greater than 80%. Following education, further analysis of TDC was undertaken and feedback provided (Phase III) which led to scores improving to between 53 and 96 %. Cyclic re-monitoring and feedback as well as ongoing discussion at monthly system-wide review sessions led to a sustained high level of terminal TDC (greater than 85%) in 11 of the 12 study hospitals.

CONCLUSIONS: 1.) Phase I of the study disclosed previously unsuspected differences in TDC despite the existence of essentially identical terminal room cleaning policies in all hospitals. 2.) Rapid improvement in TDC following education alone was realized in 10 of the 12 hospitals prior to inter-group benchmarking. 3.) Group benchmarking of TDC scores substantially facilitated further improvement in cleaning. 4.) The ongoing transparency engendered by the system-wide program has facilitated the ability to sustain gains over time. 5.) A patient safety oriented, non-punitive environment as well as individual hospital and system-wide leadership support were critical components of the success of the program.

Environmental Hygiene Literature

Abstract #23

Previously contaminated rooms increase transmission risk	Many patient areas are not well cleaned	Cleaning can be programmatically improved	Improved cleaning decreases environmental contamination	Improved cleaning decreases patient acquisition of pathogens
		X	X	X

Title: Interventional evaluation of environmental contamination by vancomycin-resistant enterococci: Failure of personnel, product, or procedure?

Author: Hota B, Blom DW, Lyle EA, Weinstein RA, Hayden MK

Publication: Journal of Hospital Infection

Year: 2009

Summary:

It is not clear whether improvement in environmental decontamination is more efficiently achieved through changes in cleaning products, cleaning procedures, or performance of cleaning personnel. To assess the impact of cleaning performance on environmental contamination with vancomycin-resistant enterococci (VRE), we conducted a sequential trial in which a multifaceted environmental cleaning improvement intervention was introduced in a medical intensive care unit and respiratory step-down unit. The intervention included educational lectures for housekeepers and an observational programme of their activities without changes in cleaning products or written procedures. Following these interventions, the proportion of environmental sites cleaned improved from 49% to 85% ($P<0.001$); contamination of environmental sites declined from 21% to 8% ($P<0.0001$) before cleaning and from 13% to 8% ($P<0.0001$) after cleaning. The improved cleaning and contamination rates persisted in a washout period. In a multivariate model, cleaning thoroughness strongly influenced the degree of environmental contamination, with a 6% decline in VRE prevalence with every 10% increase in percentage of sites cleaned. These findings suggest that surface contamination with VRE is due to a failure to clean rather than to a faulty cleaning procedure or product.

Environmental Hygiene Literature

Abstract #24

Previously contaminated rooms increase transmission risk	Many patient areas are not well cleaned	Cleaning can be programmatically improved	Improved cleaning decreases environmental contamination	Improved cleaning decreases patient acquisition of pathogens
		X		

Title: Molecular epidemiology of MRSA during an active surveillance program

Author: Bruno-Murtha LA, Harkness D, Stiles T, Han L, Carling PC

Publication: Abstract, SHEA 19th Annual Meeting

Year: 2009

Summary:

BACKGROUND: Active surveillance cultures (ASC) for MRSA can facilitate recognition of colonized patients (PTs). Discharge surveillance cultures (DSC) have also been recommended to assess transmission (TM). In order to optimize MRSA control, ASC were obtained and all MRSA isolates were characterized by pulsed-field gel electrophoresis (PFGE).

OBJECTIVE: To determine whether ASC and a surveillance definition for TM can reliably measure MRSA cross-transmissions (CT).

METHODS: Beginning 2/6/07, nasal ASC were obtained on the day of admission (ADM) to a 9 single room medical-surgical ICU, and for MRSA negative PTs, weekly and at discharge. Colonization was defined as imported if identified within 2 calendar days (CD) of ADM, vs. acquired if identified > 2 CD after ADM. PFGE was performed on batched surveillance or clinical isolates to determine relatedness among imported and acquired strains and to characterize circulating clones. A monthly TM rate was defined as the number of PTs acquiring MRSA > 2 CD after ADM divided by the number of PTs without MRSA X 100. Contact precautions (CP) were used for previously documented, colonized, or infected PTs. Hand hygiene compliance (HHC) was monitored. Terminal room cleaning was evaluated with a fluorescent marking agent.

RESULTS: 73 of 78 MRSA isolates were typed. 87% originated from healthcare (HC) lineages, primarily USA clone 100; 13% were community-acquired, primarily USA clone 300. The mean TM rate was 2% (Std Dev 2.4) over 17 months. Among 16 acquisitions, only 5 had PFGE patterns identical to an index case. Of these 5 cross-transmissions (CT), 4 were USA clone 100 (3 distinct subtypes); 1 was USA clone 800. Among 5 index PTs, 4 were intubated, 3 had + clinical cultures (CC), 5 had + ASC, and 2 were treated for pneumonia. All 5 PTs who acquired a clone identical to an index case were intubated, 3 had + CC, 2 were treated for pneumonia, and 3 died. 2 PTs acquired MRSA in a room vacated within 1 day by an index case, both during periods of poor environmental cleaning (Table). HHC improved.

	March	May	June	July	August	January	February	March	June
No. of Patients Acquiring MRSA	2	1	2	3	1	1	1	3	2
MRSA Transmission Rate (%)	4	1.7	3.9	6.5	2	1.9	1.8	7.3	4.4
No. of Patients with Cross-Transmission	2 [#]	0	0	0	0	0	0	1	2 [#]
Hand Hygiene Compliance (%)	82	100	100	25	ND	ND	100	100	100
Terminal Room Cleaning ^a (%)			33 ^b		65 ^c				28

[#] 1 proven clonal transmission < 2 calendar days after admission, occurring in a room vacated by the index case. Months not shown had no transmission.
ND Not done, ^a High touch surfaces cleaned, ^b Baseline assessment, ^c Following training of environmental staff

CONCLUSIONS: ASC overestimate MRSA CT, although ASC remain useful to facilitate CP. PFGE demonstrated that the CT rate was 0.62% or 69% less than the TM rate during a period of high ASC protocol compliance. Culture-based nasal surveillance may underestimate imported cases. Most acquisitions reflected the emergence of endogenous flora. Intubation and environmental contamination may be risk factors for CT. CT occurred in two PTs within 2 CD of admission; without PFGE, these cases would have been considered imported. All CTs originated from HC lineages. Enhanced prevention strategies for intubated PTs and efforts to improve environmental cleaning may reduce CT in our ICU. PFGE validation is required to reliably measure MRSA CT. A surveillance definition for TM has limitations.

Environmental Hygiene Literature

Abstract #25

Previously contaminated rooms increase transmission risk	Many patient areas are not well cleaned	Cleaning can be programmatically improved	Improved cleaning decreases environmental contamination	Improved cleaning decreases patient acquisition of pathogens
		X	X	X

Title: The “A team”: An environmental services intervention to control multi-drug resistant *Acinetobacter*

Author: Jean W, Blum N, Fisher V, Douglas G, Flanagan T, Ostrosky L

Publication: Abstract, SHEA Fifth Decennial Meeting

Year: 2010

Summary:

BACKGROUND: An outbreak of MDRA consisting of 18 cases from June to July 2009 was identified in an ICU in a tertiary care center. Analysis showed that, despite stringent cleaning protocols using 10% bleach and checklists, some of the cases occurred in rooms previously occupied by other MDRA-infected patients.

OBJECTIVE: We sought to investigate if a protocolized double terminal clean performed by especially trained environmental services personnel was effective in reducing the number of MDRA-culture positive rooms and if this intervention would facilitate control of the outbreak.

METHODS: With the support of environmental services and hospital administrators, the “A team” was created. “A team” members were identified as the most thorough housekeepers of every shift and they were tasked with post discharge cleaning of rooms where patients with MDRA were housed. Upon discharge, infection control notified environmental services and a sign with a lock symbol was affixed on the door of the room to block it for the duration of cleaning. Also, no furniture could be removed from the room until the lock sign was removed. The new protocol consisted of two terminal cleanings performed by separate members of the “A team”, done 45 minutes apart. After cleaning, infection control staff cultured room surfaces systematically with enriched media to validate the effectiveness of the cleaning.

RESULTS: When regular terminal cleaning was in place in the two weeks prior to starting the “A team” initiative, 109 items in different rooms were cultured and 17% were positive for MDRA. These accounted for 10% (week 1) and to 30% (week 2) of rooms cultured having at least one surface positive for MDRA. In the first week of the “A team” initiative, there were a total of 123 items cultured and none grew MDRA, reducing the percentage of culture positive rooms to 0%. Since implementing this new cleaning protocol house-wide, there has been no documented in-house transmission of MDRA.

CONCLUSIONS: A multidisciplinary intervention involving administration, environmental services, nursing, and infection control resulted in a reduction in MDRA contaminated surfaces and cases. Multidisciplinary/multifaceted interventions are useful in controlling MDRA transmission.



Environmental Hygiene Literature

Abstract #26

Previously contaminated rooms increase transmission risk	Many patient areas are not well cleaned	Cleaning can be programmatically improved	Improved cleaning decreases environmental contamination	Improved cleaning decreases patient acquisition of pathogens
		X		

Title: Completeness of cleaning critical care transport vehicles

Author: Sulis C, Estanislao R, Wedel S, Carling PC

Publication: Abstract, SHEA Fifth Decennial

Year: 2010

Summary:

BACKGROUND: Boston MedFlight (BMF) is a critical care transport service with 3000 calls per year divided between 3 rotor wing, 1 fixed wing, and 2 ground vehicles. Patients may be transported from the scene of an acute traumatic injury (16%) or between hospitals (84%). Environmental contamination of shared medical equipment and high touch surfaces (targets) is believed to play a role in the transmission of various pathogens in hospitals; and there are systems to assess completeness of cleaning (cleaning). Cleaning has not been assessed in critical care transport vehicles where crew are expected to disinfect all potentially contaminated surfaces between each case. BMF crew are taught that disinfection of surfaces between patients are key components of the infection control program and of the safety culture of the organization.

OBJECTIVE: The goal of this project was to evaluate cleaning of a defined set of targets in the vehicles operated by BMF.

METHODS: The infection control officer evaluated cleaning of ten targets common to all transport vehicles using a previously validated method that uses a fluorescent marking dye. Cleaning was considered "complete" if the fluorescent mark was totally removed from the target when assessed 24 hours after marking. Targets were also visually inspected for evidence of gross contamination with blood or body fluids. Targets included wall and portable suction, defibrillator (buttons, touch screen), ventilator (on/off switch, reset buttons), and monitor (BP and EKG recorders, touch screen). Baseline data were collected in March 2009. Review of updated Health Department guidance for Emergency Medical Services regarding disinfection practices was completed in April 2009 in response to the appearance of pandemic Influenza. Follow-up data were collected in April and July.

RESULTS: 2900 standardized environmental targets (10 objects) were assessed. Some targets were cleaned frequently regardless of the vehicle (average for defibrillator screen 65%, ventilator controls 68%, and monitor screen 92% of the time). Other items, such as the BP monitor were cleaned more frequently in ground vehicles than in the aircraft (Z score for comparison of proportions 9.1464, $p < 0.0001$). Cleaning increased in all vehicles after the April update, but improvements have not been consistently sustained.

CONCLUSIONS: This is the first time an objective method has been used to assess cleaning of patient transport vehicles. Although all targets appeared to be clean on visual inspection, an opportunity for improvement was identified. Potential causes of incomplete cleaning include shared responsibility for disinfection (no single crew member assigned), ineffective technique, or competing priorities related to patient management. As a result of this study, crews were re-educated and will be provided with objective real-time feedback both to improve performance and to understand and mitigate barriers to effective cleaning.

Environmental Hygiene Literature

Abstract #27

Previously contaminated rooms increase transmission risk	Many patient areas are not well cleaned	Cleaning can be programmatically improved	Improved cleaning decreases environmental contamination	Improved cleaning decreases patient acquisition of pathogens
		X		

Title: Goo be gone – evaluation of compliance with cleaning of multiple high touch (HT) surfaces using fluorescent “goo”

Author: Clark P, Young L, Silvestri S, Muto CA

Publication: Abstract, SHEA Fifth Decennial

Year: 2010

Summary:

BACKGROUND: Contaminated environmental surfaces play an important role in the transmission of epidemiologic significant organisms. It has been well documented that pathogens such as MRSA, VRE, *C.diff*, MDR *Acinetobacter*, and other gram negative rod's are transmitted from environmental surfaces to HCW's hand. The University of Pittsburgh Medical Center (UPMC) Presbyterian is a 766-bed tertiary care facility. An average of 164 (21%) patients are in contact precautions daily. Environmental rounds are conducted in all ICUs and attended by infection control (IC), environmental services (ES) and clinical staff. Patient care areas appeared unsoiled but there was concern that all surfaces were not getting effectively cleaned.

OBJECTIVE: To evaluate compliance with cleaning multiple HT surfaces in patient rooms post discharge before and after feedback (F) of initial results and education (E).

METHODS: An electronic Bed Tele Tracking process (BTT) was used to monitor patient discharges. At discharge, IC was notified and room was "spotted" with a fluorescent "goo" solution. If available, 14 HT sites per room were sampled. Upon arrival of ES, the BTT was updated to "clean in progress" and upon completion to "cleaned". Each "cleaned" room was evaluated by IC using an UV light to determine if the spots were removed by routine cleaning. Overall, 70 rooms were to be evaluated. Interim analysis was performed after 35. Results were shared with ES and group and individual E was provided. Post intervention evaluations are underway. To date, data is available for 8 rooms post intervention.

RESULTS:

Compliance with spot removal of High-touch Surfaces									
	Pre N = 35			Post N =8					
Object	# spotted	# spotless	%	# spotted	# spotless	%	OR	CI	P value
Toilet Seat	29	16	55	8	7	88	0.18	0.01,1.81	0.12
Toilet Handle	24	10	42	8	6	75	0.24	0.03,1.78	0.22
Toilet Hand Hold (s)	22	6	27	8	4	50	0.38	0.05,2.63	0.38
Sink Top	25	18	64	8	4	50	2.57	0.38,17.94	0.39
Light Switch In Room	32	3	9	8	4	50	0.10	0.01,0.85	0.02
BR Door Closers	24	4	17	8	6	75	0.07	0.01,0.59	0.004
Side Rail	31	17	55	8	1	13	8.50	0.84,207	0.05
Bedside Table	22	15	68	8	4	50	2.14	0.31,15.21	0.42
Telephone	23	7	30	7	5	71	0.17	0.02,1.45	0.08
Call Box	27	16	59	7	6	88	0.24	0.01,2.65	0.38
Tray Table	26	19	73	6	6	100	0	0,3.43	1.00
Pt Chair	25	12	48	3	3	100	0	0,2.61	0.23
Room Door Closers	28	2	7	8	5	63	0.05	0,0.47	0.003
BR Light Switch	7	3	43	8	5	63	0.69	.25,1.88	0.62
Total	345	148	43	103	66	64	0.42	0.26,0.68	0.0002
Compliance for each room (range)	8-100 (43)			15 -100% (64)					

CONCLUSIONS: Despite the facilities appearance of cleanliness, overall thoroughness of discharge cleaning prior to F and E was 43% for all surfaces evaluated and C within a room was as low as 8%. ES do not routinely get feedback on their performance. Providing group and individual E significantly improved overall C with spot removal and bettered cleaning methods and C with all HT surfaces significantly increased. All HT surfaces initially associated with low C (<20%) significantly improved C post intervention.

Environmental Hygiene Literature

Abstract #28

Previously contaminated rooms increase transmission risk	Many patient areas are not well cleaned	Cleaning can be programmatically improved	Improved cleaning decreases environmental contamination	Improved cleaning decreases patient acquisition of pathogens
			X	X

Title: Measuring the effect of enhanced cleaning in a UK hospital: a prospective crossover study

Author: Dancer SJ, White LF, Lamb J, Girvan EK, Robertson C

Publication: BMC Medicine

Year: 2009

Summary:

BACKGROUND: Increasing hospital-acquired infections have generated much attention over the last decade. There is evidence that hygienic cleaning has a role in the control of hospital-acquired infections. This study aimed to evaluate the potential impact of one additional cleaner by using microbiological standards based on aerobic colony counts and the presence of *Staphylococcus aureus* including meticillin-resistant *S. aureus*.

METHODS: We introduced an additional cleaner into two matched wards from Monday to Friday, with each ward receiving enhanced cleaning for six months in a cross-over design. Ten hand-touch sites on both wards were screened weekly using standardized methods and patients were monitored for meticillin-resistant *S. aureus* infection throughout the year-long study. Patient and environmental meticillin-resistant *S. aureus* isolates were characterized using molecular methods in order to investigate temporal and clonal relationships.

RESULTS: Enhanced cleaning was associated with a 32.5% reduction in levels of microbial contamination at hand-touch sites when wards received enhanced cleaning ($P < 0.0001$; 95% CI 20.2%, 42.9%). Near-patient sites (lockers, overbed tables and beds) were more frequently contaminated with meticillin-resistant *S. aureus* than sites further from the patient ($P = 0.065$). Genotyping identified indistinguishable strains from both hand-touch sites and patients. There was a 26.6% reduction in new meticillin-resistant *S. aureus* infections on the wards receiving extra cleaning, despite higher meticillin-resistant *S. aureus* patient-days and bed occupancy rates during enhanced cleaning periods ($P = 0.032$; 95% CI 7.7%, 92.3%). Adjusting for meticillin-resistant *S. aureus* patient-days and based upon nine new meticillin-resistant *S. aureus* infections seen during routine cleaning, we expected 13 new infections during enhanced cleaning

periods rather than the four that actually occurred. Clusters of new meticillin-resistant *S. aureus* infections were identified 2 to 4 weeks after the cleaner left both wards. Enhanced cleaning saved the hospital 30,000 pounds to 70,000 pounds.

CONCLUSION: Introducing one extra cleaner produced a measurable effect on the clinical environment, with apparent benefit to patients regarding meticillin-resistant *S. aureus* infection. Molecular epidemiological methods supported the possibility that patients acquired meticillin-resistant *S. aureus* from environmental sources. These findings suggest that additional research is warranted to further clarify the environmental, clinical and economic impact of enhanced hygienic cleaning as a component in the control of hospital-acquired infection.

Environmental Hygiene Literature

Abstract #29

Previously contaminated rooms increase transmission risk	Many patient areas are not well cleaned	Cleaning can be programmatically improved	Improved cleaning decreases environmental contamination	Improved cleaning decreases patient acquisition of pathogens
			X	

Title: Experimental evaluation of the efficacy of sanitation procedures in operating rooms

Author: Frabetti A, Vandini A, Balboni P, Triolo F, Mazzacane S

Publication: American Journal of Infection Control

Year: 2009

Summary:

BACKGROUND: There remains much debate on how to define an adequate sanitation protocol in hospital environments.

METHODS: The efficacy of a sanitation protocol in the operating room (OR) of a modern hospital was evaluated by measuring bacterial load on different types of finishing materials of all internal surfaces (ie, walls, floors, and furnishings). Samples were obtained before cleaning and over the subsequent 24 hours. A total of 2124 microbiological samples were collected using RODAC plates and sterile swabs.

RESULTS: The data demonstrate a very significant post-sanitation reduction of bacterial load on floors and furnishings; however, no significant data on walls was obtained, because of the low levels of initial contamination (1.50 to 5.98 cfu/100cm²). The increase in post-sanitation bacterial load over time was greater on smooth materials than on porous materials, on which a further reduction in contamination was seen. The study outcomes were confirmed by simulation experiments in which different materials were contaminated with a predetermined bacterial load and then subjected to the sanitation protocol. These simulation experiments were carried out both in vitro and in an eddy-flux testing room that simulated a full-scale OR similar (in terms of architectonic systems) to a real setting.

CONCLUSION: Our data demonstrate that the spatial (vertical/horizontal) disposition of materials affects the initial contamination level, which is always lower on vertical surfaces than on horizontal ones. Moreover, post-sanitation bacterial load recovery is dependent on the physical properties of the surface.

Supporting Guidelines

Supporting Guidelines

Organization	Date	Title	Excerpt	Citation
Centers for Disease Control and Prevention (CDC)	2003	Guidelines for Environmental Infection Control in Health-care Facilities	MRSA and VRE: Use standard cleaning and disinfection protocols to control environmental contamination with antibiotic-resistant, gram-positive cocci. Category IB 1. Pay close attention to cleaning and disinfection of high-touch surfaces in patient-care areas (e.g., bed rails, carts, charts, bedside commodes, bed rails, doorknobs, or faucet handles). Category IB 2. Ensure compliance by housekeeping staff with cleaning and disinfection procedures. 3. Use EPA-registered chemical germicides appropriate for the surface to be disinfected (e.g., either low- or intermediate-level disinfection) as specified by the manufacturer's instructions.	Sehulster L, Chinn RY; CDC; HICPAC. <i>Guidelines for environmental infection control in health-care facilities. Recommendations of CDC and the Healthcare Infection Control Practices Advisory Committee (HICPAC)</i>. MMWR Recomm Rep. 2003 Jun 6;52(RR-10):1-42. http://www.cdc.gov/mmwr/preview/mmwrhtml/rr5210a1.htm Accessed October 13, 2010
Society for Healthcare Epidemiologists of America (SHEA)	2003	SHEA Guideline for Preventing Nosocomial Transmission of Multidrug-resistant Strains of <i>Staphylococcus aureus</i> and <i>Enterococcus</i>	Ensure that the hospital method of disinfecting hospital surfaces for antibiotic-resistant organisms (especially VRE) has been shown to be adequate based on the results of studies of such methods in the healthcare setting or perform cultures in the room of discharged patients to confirm the adequacy of terminal cleaning. This requires review of the disinfectant agent, method and meticulousness of cleaning, dilutions, and contact time. (IB)	Muto CA, Jernigan JA, Ostrowsky BE, Richet HM, Jarvis WR, Boyce JM, Farr BM; SHEA. <i>SHEA guideline for preventing nosocomial transmission of multidrug-resistant strains of Staphylococcus aureus and enterococcus</i>. Infect Control Hosp Epidemiol. 2003 May;24(5):362-86. http://www.journals.uchicago.edu/doi/abs/10.1086/502213 Accessed October 13, 2010
Centers for Disease Control and Prevention (CDC)	2006	Management of MDRO's in Healthcare Settings	Focus on cleaning and disinfecting frequently touched surfaces (e.g., bedrails, bedside commodes, bathroom fixtures in the patient's room, doorknobs) and equipment in the immediate vicinity of the patient. Monitor (i.e., supervise and inspect) cleaning performance to ensure consistent cleaning and disinfection of surfaces in close proximity to the patient and those likely to be touched by the patient and HCP (e.g., bedrails, carts, bedside commodes, doorknobs, faucet handles).	Siegel JD, Rhinehart E; CDC; HICPAC. <i>Management of MDRO's in Healthcare Settings</i>, 2006. p 1-47. http://www.cdc.gov/hicpac/mdro/mdro_0.html Accessed October 13, 2010

Supporting Guidelines

Organization	Date	Title	Excerpt	Citation
Institute for Healthcare Improvement (IHI)	2008	Getting Started Kit: Reduce Methicillin-Resistant <i>Staphylococcus aureus</i> (MRSA) Infection How To Guide	Excerpt not available	5 Million Lives Campaign. <i>Getting Started Kit: Reduce Methicillin-Resistant Staphylococcus aureus (MRSA) Infection How-to Guide</i>. Cambridge, MA: Institute for Healthcare Improvement; 2008. http://www.ihl.org/IHI/Programs/Campaign/MRSAInfection.htm Accessed October 13, 2010
Department of Health and Human Services (DHHS)	2009	Action Plan to Prevent Healthcare-Associated Infections	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 (e.g., compliance hand hygiene, isolation precautions, environmental cleaning practices) in order to prevent infections	Department of Health and Human Services. <i>Action Plan to Prevent Healthcare-Associated Infections</i>. Agency for Healthcare Research and Quality; Office of the Assistant Secretary for Public Affairs; Office of the Assistant Secretary for Planning and Evaluation; Centers for Disease Control and Prevention; Centers for Medicare & Medicaid Services; Food and Drug Administration; National Institutes of Health; Office of the National Coordinator for Health Information Technology; Office of Public Health and Science. 2009 June 22 p.29-30. http://www.hhs.gov/ophs/initiatives/hai/infection.html Accessed October 13, 2010
Center for Medicare and Medicaid Services (CMS)	2009	CMS State Operations Manual	The infection prevention and control program must include appropriate monitoring of housekeeping, maintenance (including repair, renovation and construction activities), and other activities to ensure that the hospital maintains a sanitary environment. Examples of areas to monitor would include: food storage, preparation, serving and dish rooms, refrigerators, ice machines, air handlers, autoclave rooms, venting systems, inpatient rooms , treatment areas, labs, waste handling, surgical areas, supply storage, equipment cleaning, etc.	CMS State Operations Manual. <i>Appendix A – Survey Protocol, Regulations and Interpretive Guidelines for Hospitals</i>. Rev. 47, 2009 Jun 06. https://www.cms.gov/manuals/downloads/som107ap_a_hospitals.pdf Accessed October 13, 2010

Supporting Guidelines

Organization	Date	Title	Excerpt	Citation
Joint Commission Resources (JCR)	2009	Meeting Joint Commission's Infection Prevention and Control Requirements: A Priority Focus Area	Excerpt not available	Soule, B. <i>Meeting Joint Commission's Infection Prevention and Control Requirements: A Priority Focus Area</i> . Oakbrook Terrace, IL: Joint Commission Resources; 2009.
State of California	2009	Senate Bill No. 158, Chapter 294	SECTION 1. (a) The Legislature finds and declares all of the following: (3) A significant percentage of HAI can be prevented with intense programs for surveillance and the development, implementation, and constant evaluation and monitoring of prevention strategies. (b) It is the intent of the Legislature to enact legislation to ensure the occurrence of all of the following: (6) Maintenance of a sanitary environment and patient hygiene to avoid transmission of pathogens that cause HAI.	State of California. Senate Bill No. 158, Chapter 294. <i>An act to amend Sections 1288.5 and 1288.8 of, and to add Sections 1279.6, 1279.7, 1288.45 and 1288.95 to, the Health and Safety Code, relating to health facilities</i> Accessed October 13, 2010
Association of periOperative Registered Nurses (AORN)	2009	Perioperative Standards and Recommended Practices: Recommended Practices for Environmental Cleaning in the Perioperative Setting	Excerpt not available	<i>Recommended Practices for Environmental Cleaning in the Perioperative Setting</i> . In: Perioperative Standards and Recommended Practices. Denver, CO: AORN, Inc. 2009; 439-453.
Association for Professionals in Infection Control and Epidemiology	2009	APIC Text of Infection Control and Epidemiology	Excerpt not available	Church NB and Bjerke NB. <i>Surgical Services</i> . In: APIC Text of Infection Control and Epidemiology, 3 rd Edition. Washington D.C.: APIC. 2009; 45-1-45-15.



Organization	Date	Title	Excerpt	Citation
Centers for Disease Control and Prevention	2010	Toolkit: Options for Evaluating Environmental Cleaning	In view of the evidence that transmission of many healthcare acquired pathogens is related to contamination of near-patient surfaces and equipment, all hospitals are encouraged to develop programs to optimize the thoroughness of high touch object cleaning as part of terminal room cleaning at the time of discharge or transfer of patients.	Guh A, Carling P, Environmental Evaluation Workgroup. Options for Evaluating Environmental Cleaning. http://www.cdc.gov/HAI/toolkits/Evaluating-Environmental-Cleaning.html http://www.cdc.gov/HAI/toolkits/Evaluating-Environmental-Cleaning.html Accessed July 7, 2011
Centers for Disease Control and Prevention	2011	Guideline for the Prevention and Control of Norovirus Gastroenteritis Outbreaks in Healthcare Settings	Perform routine cleaning and disinfection of frequently touched environmental surfaces and equipment in isolation and cohorted areas, as well as high-traffic clinical areas. Frequently touched surfaces include, but are not limited to, commodes, toilets, faucets, hand/bedrailing, telephones, door handles, computer equipment, and kitchen preparation surfaces. (Category IB)	MacCannell T, Umscheid CA, Agarwal RK, Lee I, Kuntz G, Stevenson KB, and HICPAC. <i>Guideline for the Prevention and Control of Norovirus Gastroenteritis Outbreaks in Healthcare Settings, 2011. P. 15-16.</i> http://www.cdc.gov/hicpac/pdf/norovirus/Norovirus-Guideline-2011.pdf Accessed July 7, 2011

Options for Evaluating Environmental Cleaning

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Introduction:

In view of the evidence that transmission of many healthcare acquired pathogens (HAPs) is related to contamination of near-patient surfaces and equipment, all hospitals are encouraged to develop programs to optimize the thoroughness of high touch surface cleaning as part of terminal room cleaning at the time of discharge or transfer of patients. Since dedicated resources to implement objective monitoring programs may need to be developed, hospitals can initially implement a basic or Level I program, the elements of which are outlined below. Some hospitals should consider implementing the advanced or Level II program from the start, particularly those with increased rates of infection caused by healthcare acquired pathogens (e.g., high *Clostridium difficile* infection rate). All hospitals that have successfully achieved a Level I program should advance to Level II.

At present, the objective monitoring of the cleaning process of certain high touch surfaces (e.g., the curtain that separates patient beds) beyond those outlined in the attached checklist is not well defined. Additionally, there is no standard method for measuring actual cleanliness of surfaces or the achievement of certain cleaning parameters (e.g., adequate contact time of disinfectant) or for defining the level of microbial contamination that correlates with good or poor environmental hygienic practices. As our understanding of these issues evolve and a standardization of assessment in these respective areas can be developed and practically implemented, hospitals that have obtained a high compliance rate with surface cleaning as outlined in the Level II program are encouraged to advance their efforts in optimizing environmental hygienic practices.

Level I Program

Elements of the program:

1. The program will be an infection preventionist/hospital epidemiologist infection prevention & control (IPC) based program internally coordinated and maintained through environmental services (ES) management level participation. The goal should be seen as a joint (IPC/ES), team effort during planning implementation and ongoing follow-up phases.
2. Each program will be hospital-specific and based on a joint (IC/ES) definition of institutional expectations consistent with the CDC standards^{1,2} and the attached check list. The responsibilities of ES staff and other hospital personnel for cleaning high touch surfaces (e.g., equipment in ICU rooms) will be clearly defined.
3. Structured education of the ES staff to define programmatic and institutional expectations will be carried out and the proportion of ES staff who participate

will be monitored (see Elements of the Educational Intervention – Appendix A).

4. Development of measures for monitoring along with methods and identified staff for carrying out monitoring will be undertaken by the IPC/ES team. Monitoring measures may include competency evaluation of ES staff by ES management, IPC staff or, preferably, both. Teams are also encouraged to utilize patient satisfaction survey results in developing measures. Regular ongoing structured monitoring of the program will be performed and documented.
5. Interventions to optimize the thoroughness of terminal room cleaning and disinfection will be a standing agenda item for the Infection Control Committee (ICC) or Quality Committee as appropriate for the facility.
6. Consideration of the feasibility of moving to the Level II program will be discussed by the ICC and documented in the committee minutes.

Reporting:

Results should be reported to the ICC and facility leadership.

Level II Program

Elements of the Program

1. The program will be an infection preventionist/hospital epidemiologist infection prevention & control (IPC) based program internally coordinated and maintained through environmental services (ES) management level participation. The goal should be seen as a joint (IPC/ES), team effort during planning implementation and ongoing follow-up phases.
2. Each program will be hospital-specific and based on a joint (IC/ES) definition of institutional expectations consistent with the CDC standards^{1,2} and the attached check list. The responsibilities of ES staff and other hospital personnel for cleaning high touch surfaces (e.g., equipment in ICU rooms) will be clearly defined.
3. Either covertly or in conjunction with ES staff, an objective assessment of the terminal room thoroughness of surface disinfection cleaning will be done using one or more of the methods discussed below (see Objective Methods for

Evaluating Environmental Hygiene - Appendix B) to document the pre-intervention thoroughness of disinfection cleaning (generally referred to as the “TDC Score” calculated as # of objects cleaned / total # of objects evaluated X 100). Such results will be maintained by the institution and used internally to optimize programmatic and educational interventions.

4. Structured education of the ES staff to define programmatic and institutional expectations will be carried out and the proportion of ES staff who participate will be monitored. It would be expected that the results of the pre-intervention objective evaluation of disinfection cleaning be incorporated into the ES educational activity in a non-punitive manner (see Elements of the Educational Intervention – Appendix A).
5. Scheduled ongoing monitoring of the TDC cleaning using one or more of the objective monitoring approaches discussed in Appendix B will be performed at least three times a year. The monitoring will use a projected sample size based on the previous level of TDC in order to detect a 10-20% change in performance (see Sample Size Determination – Appendix C). The results will be recorded in an excel spreadsheet to calculate aggregate TDC scores (see Appendix D).
6. The results of the objective monitoring program and the objectively developed TDC scores will be used in ongoing educational activity and feedback to the ES staff following each cycle of evaluation. It is recommended that such results be shared more widely within and beyond the institution as useful and appropriate.
7. Results of the objective monitoring program and interventions to optimize the thoroughness of terminal room cleaning and disinfection will be a standing agenda item for the Infection Control Committee (ICC).

Reporting:

Results should be reported to the ICC and facility leadership and could be reported to the state health department through the state prevention collaborative coordinator by various mechanisms (e.g., NHSN template), depending on infrastructure.

¹ Guidelines for Environmental Infection Control in Healthcare Facilities, 2003
(http://www.cdc.gov/hicpac/pdf/guidelines/eic_in_HCF_03.pdf)

² Guideline for Disinfection and Sterilization in Healthcare Facilities, 2008
(http://www.cdc.gov/hicpac/pdf/guidelines/Disinfection_Nov_2008.pdf)

Figure 1

Evaluating Patient Zone Environmental Hygiene					
Method	Ease of Use	Identifies Pathogens	Useful for Individual Teaching	Directly Evaluates Cleaning	Published Use in Programmatic Improvement
Direct Practice Observation	Low	No	Yes	Yes	1 Hospital
Swab cultures	High	Yes	Not Studied	Potentially	1 Hospital
Agar slide cultures	Good	Limited	Not Studied	Potentially	1 Hospital
Fluorescent gel	High	No	Yes	Yes	49 Hospitals
ATP system	High	No	Yes	Potentially	2 Hospitals

Supporting Research

Supporting Research References

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Title: Evaluation of a programmatic approach to improving patient room cleaning outcomes

Author: McCracken E, Martin K, Homan L

Publication: Poster-Association for Professionals in Infection Control and Epidemiology Educational Conference and International Meeting

Year: 2010

Summary:

ISSUES: Many patient rooms are not well cleaned, and there is increasing evidence that a programmatic approach to environmental hygiene can improve outcomes (1). Cleaning of high touch objects is critical to prevent transmission of pathogens from the environment to the patients (2). Methods used to monitor and evaluate the effectiveness of environmental hygiene are often subjective (3).

PROJECT: A pilot study was conducted at two sites, a 650-bed urban hospital and a 350 bed non-urban hospital, to evaluate the impact of a new programmatic approach on environmental hygiene (EH) practices, efficiency, sustainability and staff satisfaction. The program included the use of products, tools, processes, enhanced staff training and engagement, staff surveys and objective EH monitoring tools such as fluorescent marking gel and environmental cultures to monitor effectiveness of environmental cleaning. A pre- and post-intervention assessment of EH practices, efficiency, product usage and staff competency was conducted.

METHODS:

- ▲ EH practice effectiveness was evaluated by measuring the percentage of high touch objects (HTO's) cleaned as evidenced by the removal of a fluorescent gel mark that was applied to HTO's before discharge cleaning. If, after Environmental Services (ES) staff performed discharge cleaning, the fluorescent gel mark was disturbed, it was documented as a "pass". If the gel mark was not disturbed, it was documented as a "fail".
 - ▲ At Site A, in addition to gel marking, an environmental culture obtained from the same HTO's was used to measure total aerobic colony counts before and after cleaning. Any value for culture colony forming units (cfu) that was above a 0 was considered a failure. Therefore, the culture data was coded as either pass or fail.
 - ▲ For all gel and culture data collected, an attribute agreement analysis was performed in Minitab. This analysis identified what percent of the results agreed—both gel and culture "pass" or both "fail" (where gel removal=pass and culture result 0 cfu=pass).
 - ▲ A best practices audit tool was employed to evaluate practices during direct observation.
 - ▲ Room turnover, defined as the time the ES staff entered the patient room to the time that room cleaning was completed, was used as a measure of efficiency.
 - ▲ Dispenser accuracy was evaluated by measuring disinfectant concentration parts per million (PPM) in dispensed use solution.
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- ▲ Pre- and post-intervention chemical and water consumption was used to measure sustainability.
- ▲ The effectiveness of classroom and hands-on training on EH best practices was measured using a 10 question staff competency exam.

RESULTS: EH practice effectiveness, as measured by the percent of disturbed or removed fluorescent gel marks on high touch surfaces at Site A and Site B, was 85.3% and 83.1%, respectively. Pre-Intervention EH practice effectiveness was 55.7% and 78.4% at Site A and Site B, respectively. (See Table 1)

Table 1. Environmental hygiene practices, as measured by percent pass in disturbance of a fluorescent marking gel on high touch surfaces pre- and post-intervention

Site	# HTO's marked pre- intervention	% Pass pre-intervention	# HTO's marked post- intervention	% Pass post-intervention
Site A	564	55.7%	360	85.3%
Site B	464	78.4%	1063	83.1%

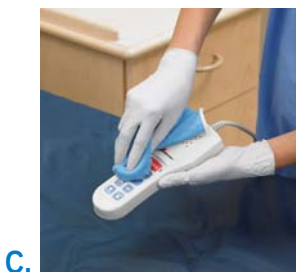
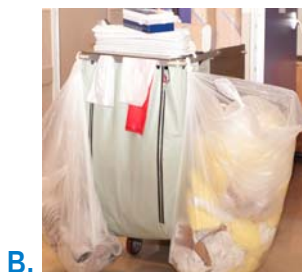
There was a higher correlation between gel disturbance “pass” and 0 cfu “pass” after implementing a multi-modal environmental hygiene program at Site A. (See Table 2)

Table 2. Percent agreement between gel disturbance and 0 cfu culture, Site A.

Period	# of HTOs	% Agreement between “pass” gel & 0 cfu “pass” culture
Pre-intervention	168	60.1%
Post-intervention	295	78.6%

The best practices audit tool for direct observation identified several areas for improvement, including:

- Training to prevent food/drink on carts
- Techniques to organize carts and minimize cross-contamination
- Support of best practice cleaning and efficiency
- Reinforcement of the proper use of PPE



- ▲ Pre-intervention evaluation identified inaccuracies in hospital dispensing systems. Post intervention, samples taken identified 75% accuracy at Site A and 100% accuracy at Site B.
- ▲ The discharge cleaning time improved by 23.8% at Site A and 6% at Site B.
- ▲ Water and chemical usage on floors and surfaces decreased at both sites. (See Table 3)

Table 3. Decreases in water and chemical usage on floors and surfaces

Site	Water usage decrease	Chemical usage decrease on floors	Chemical usage decrease on surfaces
Site A	94%	85%	74%
Site B	84%	95%	43%

- ▲ Staff competency scores measured pre-and post-intervention increased from 60% to 88% at Site A and from 78% to 90% at Site B.

LESSONS LEARNED: Use of a programmatic approach incorporating products, tools and processes, enhanced staff training and engagement, staff surveys and objective environmental hygiene monitoring tools can improve environmental hygiene practices, efficiency, sustainability and staff satisfaction. Fluorescent marking gel is a surrogate marker for bacterial contamination in patient rooms when used as part of a comprehensive environmental hygiene program.

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Supporting Research Abstract #2

Title: Disinfection of hospital rooms contaminated with vancomycin-resistant *Enterococcus faecium*

Author: Byers KE, Durbin LJ, Simonton BM, Anglim AM, Adal KA, Farr BM

Publication: Infection Control and Hospital Epidemiology

Year: 1998

Summary:

This study covers disinfection, and describes a switch from a spray-method of applying a quaternary ammonium disinfectant compound to a bucket method. Sixteen percent of hospital room surfaces remained colonized by vancomycin-resistant enterococci (VRE) after routine terminal disinfection. Disinfection with a new "bucket method" resulted in uniformly negative cultures. Conventional cleaning took an average of 2.8 disinfections to eradicate VRE from a hospital room, while only one cleaning was required with the bucket method.

Title: Effect of subinhibitory concentrations of benzalkonium chloride on the competitiveness of *Pseudomonas aeruginosa* grown in continuous culture.

Author: Mc Cay PH, Ocampo-Sosa AA, Fleming GT

Publication: Microbiology

Year: 2010

Summary:

This study investigates the link between adaptation to biocides and antibiotics in *Pseudomonas aeruginosa*. An enrichment continuous culture of *P. aeruginosa* NCIMB 10421 (MIC 25 mg BKC l(-1)) was operated ($D=0.04$ h(-1), 792 h) with added benzalkonium chloride (BKC). A derivative, PA-29 (696 h), demonstrated a >12-fold decrease in sensitivity to the biocide (MIC >350 mg BKC l(-1)). The variant demonstrated a 256-fold increase in resistance to ciprofloxacin, with a mutation in the *gyrA* gene (Thr-83-->Ile). Similarly, culturing of the original strain in a continuous-culture system with ciprofloxacin selection pressure led to the evolution of BKC-adapted populations (MIC 100 mg BKC l(-1)). Efflux pump activity predominantly contributed to the developed phenotype of PA-29. An amino acid substitution (Val-51-->Ala) in *nfxB*, the Mex efflux system regulator gene, was observed for PA-29. Overexpression of both MexAB-OprM and MexCD-OprJ was recorded for PA-29. Similarly, *mexR*, a repressor of the Mex system, was downregulated. Competition studies were carried out in continuous culture between PA-29 and the original strain (in the presence of subinhibitory concentrations of BKC). The outcome of competition was influenced by the concentration of biocide used and the nature of limiting nutrient. The inclusion of 1 mg BKC l(-1) in the medium feed was sufficient to select ($S=0.011$) for the BKC-adapted strain in magnesium-limited culture. Conversely, the presence of 10 mg BKC l(-1) in the medium supply was insufficient to select for the same organism ($S=-0.017$) in the glucose-limited culture. These results indicate the importance of environmental conditions on selection and maintenance of biocide adaptation.

Title: Performance of ultramicrofibre cleaning technology with and without addition of a novel copper-based biocide

Author: Hamilton D, Foster A, Ballantyne L, Kingsmore P, Bedwell D, Hall TJ, Hickok SS, Jeanes A, Coen PG, Gant VA

Publication: Journal of Hospital Infection

Year: 2010

Summary:

This study compared the bacterial removal performance of ultramicrofibre cloths and mops (UMF) moistened with water (UMF + water), with those moistened with a novel copper-based biocide (UMF + CuWB50, 300ppm) in several working hospital environments, specifically accident and emergency (A&E) and three other wards. A total of 13 defined sampling sites (10 sites per ward) were sampled in order to retrieve, culture, and enumerate total viable (bacterial) counts (TVC) for each site. We sampled 1h before, and 1 and 4h after, cleaning three times per week. The trial ran for 7 weeks. Two wards were cleaned with UMF + water for 3 weeks, and UMF + CuWB50 for 4 weeks. The reverse applied to the other two wards in a cross-over design fashion, to eliminate ward- and times specific bias. Multivariate statistical analyses were used to establish extent and significance of any perceived differences, and to eliminate the effects of potential confounders. Cleaning with UMF + water reduced TVC on the test surfaces by 30%, whereas cleaning with TVC + CuWB50 reduced TVC by 56%. CuWB50 had two separate effects; a direct antibacterial effect (evident shortly after cleaning), and a residual antibacterial effect that lasted approximately 2 weeks. The residual effect requires regular application of CuWB50 if it is to persist. This 'real life' hospital implementation study demonstrates encouraging microbiological cleaning performance for UMF, which is further enhanced with CuWB50.

Title: Quality control is indispensable for automated dilution systems with accelerated hydrogen peroxide.

Author: O'Neill C, Ramage L, Wyatt L, Ballantyne L

Publication: Canadian Journal of Infection Control

Year: 2009

Summary:

BACKGROUND: Hamilton Health Sciences (HHS) is a large teaching hospital with over 1000 beds consisting of three acute care sites, one regional cancer center and two rehabilitation/complex chronic care facilities. The use of chemical dilution control systems to dilute concentrated accelerated hydrogen peroxide (AHP) disinfectant to an ideal strength for effective environmental decontamination is a growing trend in healthcare. These systems, compared to manual dilution methods, are economical, efficient and promote a safer workplace. However, quality control (QC) and preventative maintenance standards to ensure performance are lacking in the environmental and healthcare cleaning industries. The automated systems used to dilute concentrated AHP products for disinfection cleaning were assessed for reliability at HHS-Henderson acute care site.

METHOD: The control systems used on three clinical units to dilute concentrated AHP products, 7% Percept at 1:16 dilution (0.5%) and 3% PerDiem at 1:256 dilution (0.01%), were evaluated daily for reliability over 30 days. Virox AHP indicator test strips were used once a day to check use-dilution of Percept at 5000 parts per million (ppm) AHP and PerDiem at 100 ppm AHP. QC was repeated if the initial test was outside the acceptable range. Vendor service was arranged for the dilution system when repeat QC failed. Ready-to-use AHP product was employed until the system was functional.

RESULTS: Overall, nine QC failures were detected on all systems during a 30-day testing period, specifically, five failures on one system, three on the second and one on the third. Seven failures involved Percept with results at < or =500 ppm, well below the acceptable 5000 ppm concentration, and two involved PerDiem at 500 ppm, well above the required concentration.

CONCLUSION: Disinfectants must be used in the dilution specified by the manufacturer for optimal decontamination. Although there are benefits with using automated dilution systems in healthcare settings, findings show that attention must be given to quality control and preventative maintenance to ensure optimum results.

Title: Reducing room turnaround time at a regional hospital.

Author: Brown EC, Kros J

Publication: Quality Management in Health Care

Year: 2010

Summary:

Room turnaround time is a vital measure of performance for a number of service industries. For hospitals, reducing the room turnaround time leads to increased revenues as well as increased patient satisfaction. If a room is ready sooner, a waiting patient is required to spend less time in the emergency department. This article explores one hospital's approach to reduce room turnaround time. Process-mapping techniques as well as heuristic approaches integrated into an existing bed-tracking system are examined. The article also explores the practical steps the hospital took to improve room turnaround time. Infection control is a requirement for any hospital; therefore, an examination of the current room-cleaning procedures is included to verify that the improved room turnaround time did not come at the expense of infection control. Using initial data from 2004 and current data from 2008, the magnitude of the reduction in room turnaround time is analyzed.

Title: Evaluation of the use of Adenosine Triphosphate (ATP) in auditing patient room cleanliness

Author: Eder AR, Brown ER, Carbone HL, Thompson KM

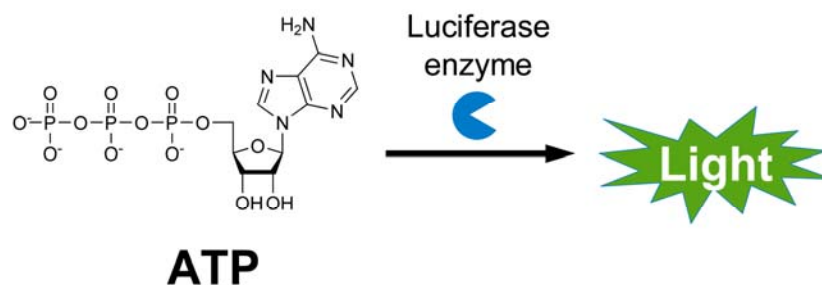
Publication: Poster-Association for Professionals in Infection Control and Epidemiology Educational Conference and International Meeting

Year: 2009

Summary:

BACKGROUND/OBJECTIVES: The measurement of adenosine triphosphate (ATP) by a bioluminescence reaction (Figure 1) has been used in the food industry as an alternative method of monitoring environmental contamination. It is well established that visual assessment alone is a poor indicator of cleaning efficacy, and microbiological monitoring cannot rapidly demonstrate cleaning problems, as cultures may not be available for several days.

Figure 1. Diagram of ATP Luciferase reaction.



The CDC Guidelines for Environmental Infection Control in Health Care Facilities states that routine environmental surface sampling is neither cost effective nor warranted, and cautions that meaningful results are dependent on appropriate media and sampling technique. Surface sampling is used currently for research, as part of an epidemiologic investigation, or as part of a comprehensive approach for specific quality assurance purposes. As a research tool, surface sampling has been used to determine a) potential environmental reservoirs of pathogens, b) survival of microorganisms on surfaces, and c) the sources of the environmental contamination. While there are several published standards for sampling in the food industry, there are currently no published standards for the healthcare setting (i).

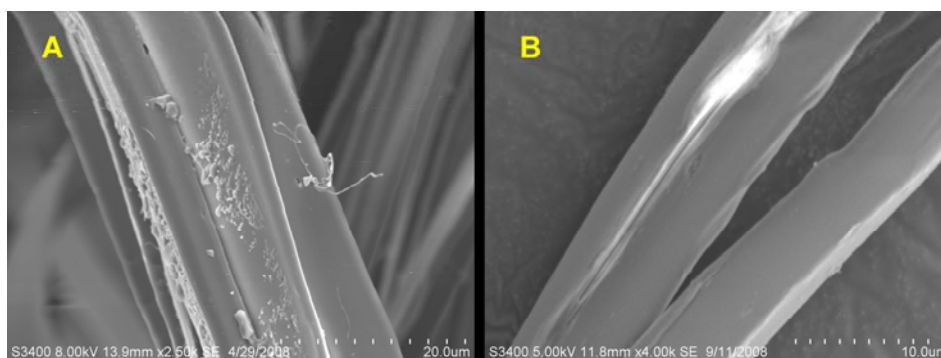
ATP bioluminescence is not directly equivalent to microbial monitoring, as both living and recently killed organisms will “spill” ATP on surfaces. Microorganisms most certainly produce ATP, but ATP levels vary depending on

organism type and growth phase. Consequently, there is no known correlation between ATP level and numbers of microorganisms (therefore potential pathogens) present on a surface. For ATP measurement to be meaningful with respect to microbial contamination, non-microbial ATP needs to be reduced by treating samples either chemically or with bacteriophage before reading (ii, iii). While some commercial systems are capable of measuring and calculating microbial ATP in aqueous systems, they are limited in their ability to reliably detect the microbial ATP on a dry, hard surface (iv, v).

During one field study, it was noted that the differences in ATP readings pre- and post-cleaning with quaternary disinfectant were greater when the current cotton terry cloths were used in comparison to microfiber cloths. This finding was statistically significant, and counters published literature and laboratory data with regard to better cleaning efficacy of microfiber cloth (vi, vii, viii), if one were to assume that ATP levels correlated to microbial contamination and potential for infection (ix).

In investigating this issue, our data has demonstrated that used, but laundered, microfiber cloths may give a false positive reading for ATP, as evidenced by a lack of viable bacteria, coupled with high RLU (Fig. 2) (x). These data suggest the presence of one (or more) interferences that may be transferred to clean (O RLU) surfaces when the cloth is wet.

Figure 2. (A) Microfiber cloth inoculated with MRSA; expected result (B) Microfiber cloth tested for experiment, indicating absence of bacteria on the cloth surface.



EXPERIMENTAL DESIGN:

Analytical Equipment:

ATP Linear Range:

The operational (linear) range of two commercial ATP readers was determined by creating standards of ATP in purified water, and pipetting 25 μ L of the solution onto each ATP swab. Readings were obtained immediately using the corresponding ATP reader.

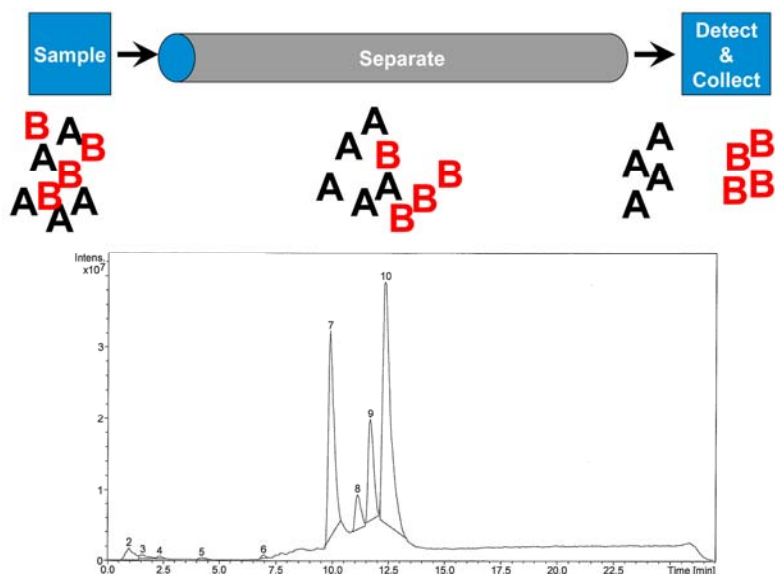
Sample Preparation:

A microfiber cloth that was freshly laundered and determined to be free of bacterial colonies was soaked in purified water until all water was absorbed into the cloth. Water was wrung out of the cloth, and reserved for further analysis

HPLC Fraction Collection:

An HPLC (high-performance liquid chromatography) was used to identify the presence of residual chemicals found in cloth eluent. HPLC fraction collection was conducted on microfiber cloth eluent. Following concentration of the eluent, chromatography was compared to a standard of ATP. This technique allows chemicals to be separated in time (Fig. 3) and allows the user to isolate and determine the RLU readings for a single component.

Figure 3. HPLC fraction collector diagram and representative data.



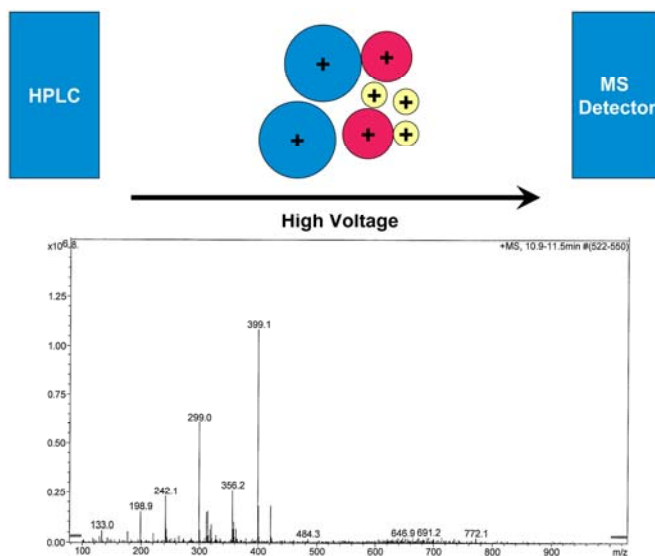
Sample ATP Readings:

Each cloth eluent and each HPLC Fraction were tested via an ATP luciferase assay by pipetting 25 μ L of the solution of interest onto an ATP swab. Readings were obtained immediately using the corresponding ATP reader.

LC-MS (HPLC with Mass Spectrometry):

Each HPLC fraction was analyzed via LC-MS (Fig. 4), which allows for a preliminary identification of chemicals based on mass and time spent in the HPLC column. The Mass Spectrometer works by creating a charge on each molecule in the sample, and detecting these molecules on a mass-to-charge (m/z) ratio. By comparing the mass of chemicals in the sample to ATP, it is also possible to definitively determine if ATP is present.

Figure 4. LC-MS diagram and representative data.

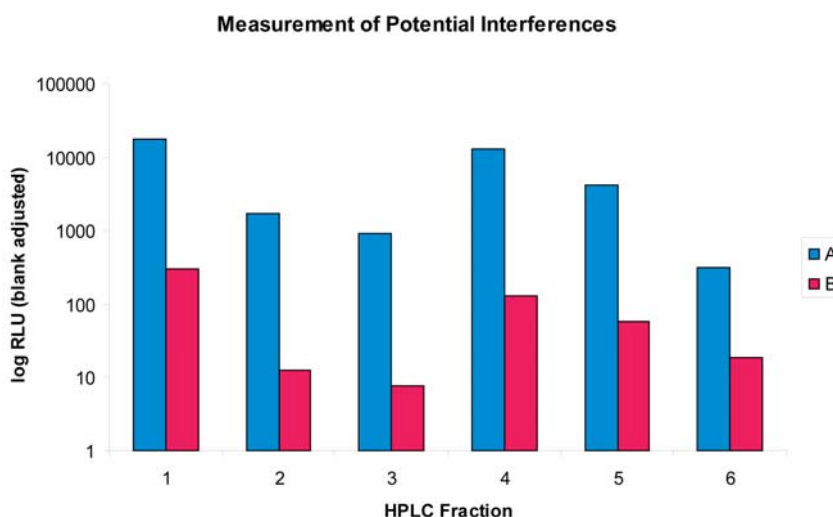


RESULTS: However, it is known that other chemicals and biomolecules can also give a positive reading for ATP using a Luciferase assay; in this experimentation, the operational range was not determined for other chemicals.

Microfiber cloth eluent was tested by the Luciferase assay, and yielded a signal of 3352 for reader A and 163 for reader B. Analysis by LC-MS demonstrated that ATP was not present in the cloth eluent from which Fractions 1-6 were obtained.

Fractions 1-6, collected from the HPLC fraction collector, all gave a positive signal for ATP compared to a blank reading (Fig. 5), as measured by the Luciferase assay probes. LC-MS results demonstrated that ATP (m/z 508) was not present in any of the fractions, particularly Fraction 5, which is where ATP would normally be found. These results indicate that the positive readings for Fractions 1-6 were false positive.

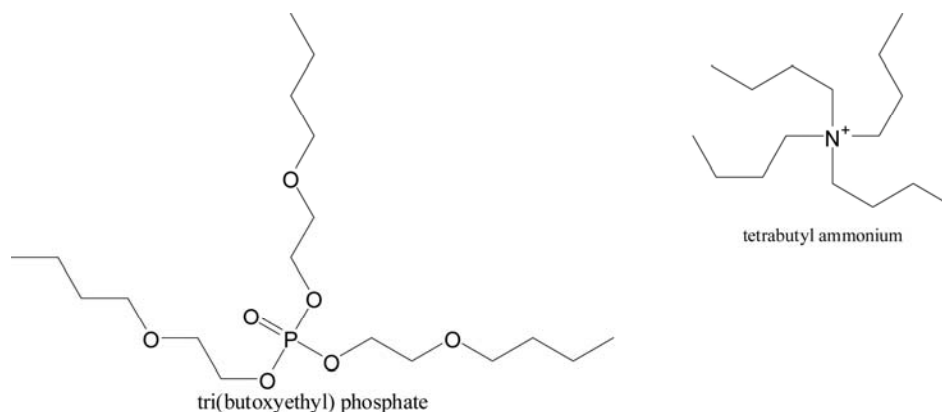
Figure 5. Luciferase readings of isolated fractions.



Identification of chemicals in the fractions is ongoing, but tentative identification of unknowns in the various fractions has been possible.

Further analysis of LC-MS data allowed for tentative identification of Tri (butoxyethyl) phosphate in Fraction 3 (Figure 6); this compound is one of several plasticizers known to be used in the commercial production of synthetic fibers and materials, like microfiber cloths. Tri (butoxyethyl) phosphate was also observed in microfiber cloth eluent, but not in products used to launder the cloth, further substantiating that this compound is inherent to cloth material.

Figure 6. Chemical structures of identified compounds found in (A) Fraction 3 (B) all fractions.



In addition, fractions testing positive for ATP all had low levels of tetrabutyl ammonium compounds, which may also be a positive interferent in the Luciferase assay. It is hypothesized that this compound was transferred to the microfiber cloth from residual fabric softener present in the laundering process.

CONCLUSIONS: The use of ATP as a hygiene audit tool in healthcare is not recommended due to the variability and potential for interference that the healthcare environment provides. Clearly, there is an appeal to the generation of quantitative data to compare clean and dirty areas rather than subjective visual examination. However, outcomes using ATP as a marker cannot be directly correlated to microbial contamination and the potential for infection. In our study, substances were found to interfere with the measurement of ATP.

The use of ATP as an educational and training tool may have some merit, and some have proposed the use of ATP as an educational tool in the healthcare and institutional markets. While there is some relationship between RLU readings and environmental cleanliness – there is also a lack of available standards and knowledge of interfering variables in this environment. This type of application should be approached with caution, and presented in a responsible way so that the limitations of the system are clear. There are significant differences in the sensitivity and reproducibility of results of ATP systems offered by different manufacturers (xii, xiii).

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Title: Do surface and cleaning chemistries interfere with ATP measurement systems for monitoring patient room hygiene?

Author: Brown EC, Eder AR, Thompson KM

Publication: Journal of Hospital Infection

Year: 2010

Summary:

A letter to the editor describing research that confirms previously reported findings that cleaning chemistries can interfere with ATP luminometer readings. The authors suggest that such interference, along with the presence of non-viable bacterial ATP and non-microbial ATP, may explain the relatively poor specificity of the ATP bioluminescence tool in previous studies. The authors recommend that further efforts to use the ATP tool to establish cleanliness standards in healthcare settings should await clarification and modification of the tool to improve its specificity.

Title: Evaluation of quat absorption and efficacy of cleaning cloths

Author: Grieme LE, Thompson KM, Carbone HL

Publication: Poster-Association for Professionals in Infection Control and Epidemiology Educational Conference and International Meeting

Year: 2009

Summary:

BACKGROUND/OBJECTIVES: Quaternary ammonium disinfectants are frequently used on hospital surfaces. Recently, concern has arisen around the discovery that the active ingredient (quat) has a tendency to become attracted to and absorbed into fabrics. Furthermore, quaternary ammonium chlorides (quats) are cationic, or positively charged, surfactants, and they are attracted to fabric surfaces which are anionic, or negatively charged. This results in a portion of the quats becoming unavailable to adequately kill the microorganisms that may be present (i).

One study suggests that soaking cloths in disinfectant instead of using a pour bottle of disinfectant may provide a reduced likelihood of isolating either MRSA or VRE from the environment (ii). This correlates well with our previous studies documenting the effects of quat concentration with respect to soak time, volume of disinfectant and textile type (iii).

Both cotton terry cloth and microfiber cloths are used by housekeeping in healthcare facilities to apply disinfectant. Microfiber textile tools have been noted to maximize the efficiency of housekeepers as well as provide better cleaning (iv, v). Superior cleaning and disinfection has previously been observed with the use of microfiber textile tools (vi, vii). This study observes effects of quat absorption and antimicrobial efficacy of each type of fabric.

METHODS: Large petri plates inoculated with MRSA were used to simulate 6 heavily-contaminated sites in a patient area. Disinfection efficacy of microfiber-cloth and cotton-terry-cloth swatches that had been soaked in two commercially-available quat disinfectant products was tested by using saturated cloths to wipe six consecutive inoculated plates. See test plan below.

Quat Use-Solution	Cloth Type	Usage
Product A	Microfiber	For each product and cloth type, use one saturated cloth piece to wipe six inoculated petri plates
Product A	Cotton Terry	
Product B	Microfiber	
Product B	Cotton Terry	

TEST PROCEDURE: MRSA (Methicillin-resistant *Staphylococcus aureus* ATCC 33592) was grown in AOAC Nutrient Broth to 2.2×10^8 CFU/mL. From that 24-hour culture, 0.25 mL was pipetted into each of 24 large petri dishes (150 mm x 15 mm) and spread with a plastic sterile hockey stick into a circle approximately 10 cm in diameter. The inoculated plates were dried in a 35°C incubator for 30 minutes.

By calculation, approximately 5.5×10^7 CFU was applied to each plate (2.2×10^8 CFU/mL x 0.25 mL applied).

Two quat products (Product A and Product B) were diluted to label use concentrations. Microfiber and cotton terry cloth fabric pieces (each approximately 9 cm x 9 cm) were soaked in the prepared use-solutions of Product A and Product B for at least 15 minutes.

The soaked cloth pieces were handled with sterile gloves. Before being used to wipe inoculated plates, enough of the disinfectant use-solution was squeezed from a soaked cloth piece to leave it feeling “comfortably wet”. The saturated weight of each cloth piece was documented and the average weight of the liquid, for each product within each cloth type, did not vary by more than 0.1 g. Then the cloth was used to wipe 6 inoculated plates, in sequence at 10-second intervals, wiping each plate for about 10 seconds. Ten minutes after beginning to wipe the plates, again at 10-second intervals in the same sequence, approximately 50 mL of D/E Neutralizing Agar was poured into each plate and the plate was swirled.

Ten minutes after wiping the last inoculated plate, the disinfectant-soaked wiping cloth was put into a sterile stomacher bag containing 99 mL D/E Neutralizing Broth and the bag was stomached for 30 seconds. Considering the neutralizer in the stomacher bag as the 10-2 dilution of the number of MRSA on the wiping cloth, 10-2 and 10-4 dilutions were pour-plated to D/E Neutralizing Agar.

NEUTRALIZATION CONTROLS: Previous work had established that the ~50 mL of D/E Neutralizing Agar poured into the wiped plates was sufficient to neutralize Product A (and was assumed to be sufficient to neutralize Product B, which had a lower quat concentration—see Chart 1 in Results).

Adequacy of the 99-mL D/E Broth used to neutralize quat disinfectant remaining on cloths after wiping 6 plates had also been verified.

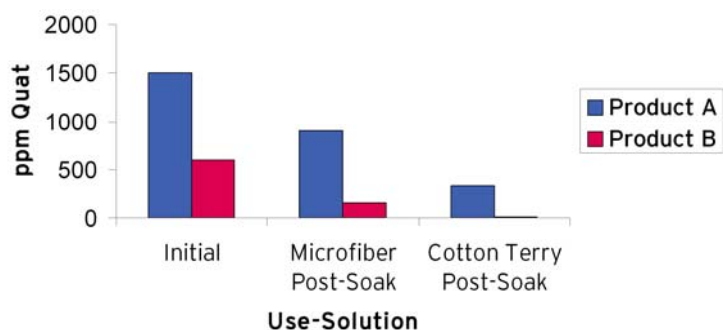
Quat concentration in the initial use-solutions of Product A and Product B (diluted per label) was titrated with a quat test kit. After the microfiber- and terry-cloth swatches were soaked in the Product A and Product B use-solutions the quat concentration in each of the four post-soaking solutions was checked again.

Figure #1: D/E Neutralizing Agar (Becton Dickinson, Sparks, MD) was used for plating surviving organisms. The sterile agar is purple in color; a yellow color indicates the presence of microbial growth.



RESULTS:

Chart 1. Quat Absorption by Microfiber and Cotton Terry Cloth



MRSA Survivors on Disinfectant-Soaked Cloths after Sequentially Wiping 6 Inoculated Petri Plates (10-minute Exposure)

Product / Cloth Type	CFU per Cloth*
Product A / Microfiber	<100
Product A / Cotton Terry Cloth	<100
Product B / Microfiber	2.9×10^4
Product B / Cotton Terry Cloth	3.3×10^3

*99 mL of D/E Broth neutralizer in the stomacher bag is considered 10-2 dilution of the number of organisms on the cloth.

MRSA Survivors (CFU / Plate) on 6 Inoculated Petri Plates after Sequential Disinfection (Calculated Initial Inoculation 5.5×10^7 CFU per Plate; Exposure Time: 10 Minutes)

Inoculated Plate	CFU per Wiped Petri Plate			
	Product A Microfiber Cloth	Product A Cotton Terry Cloth	Product B Microfiber Cloth	Product B Cotton Terry Cloth
1	<1	<1	<1	3
2	<1	<1	1	1
3	<1	<1	1	3
4	<1	<1	2	15
5	<1	<1	3	36
6	<1	<1	86	41

CONCLUSIONS: Quat absorption occurs in cotton terry cloth as well as in microfiber cloth. Microfiber appears to be superior to cotton terry cloth in accounting for quat absorption, cleaning and disinfection efficacy, as well as in preventing organism transfer to clean surfaces. When using a quaternary disinfectant, quat absorption should be considered with any application which requires the use of a textile tool (cloth, mop, etc.).

Disinfectants which are labeled to deliver a high ppm active quat in solution to account for the quat absorption with textiles appear to be the biggest factor in delivering the proper disinfectant level to a surface. The method of allowing fabric to soak and absorb a high dilution level of quaternary disinfectant allows the solution to plateau at the disinfection level. The proper disinfectant level will provide disinfection efficacy against a high level (5.5×10^7 CFU/ 150 mm petri plate) MRSA on the surface, as well as prevent subsequent cross-contamination of surfaces.

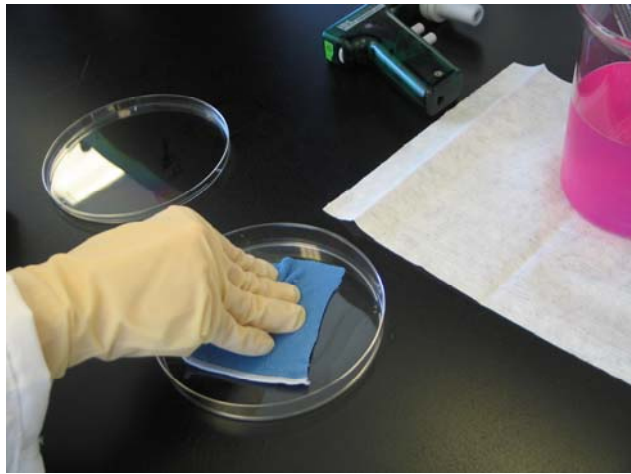


Figure #2: Microfiber cloth swatch saturated with product A applied to a contaminated petri plate.

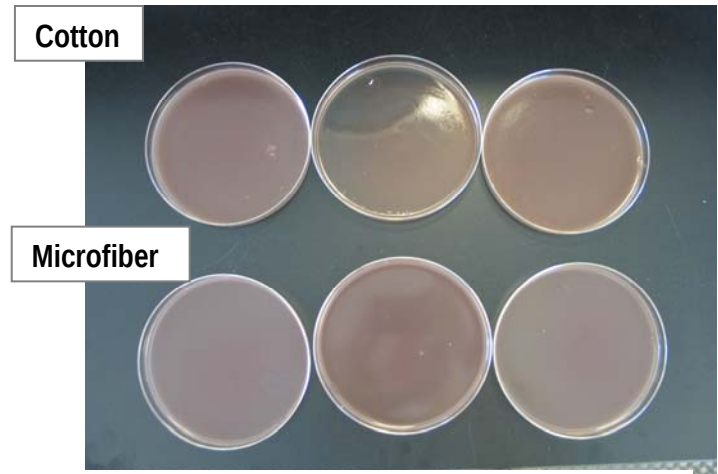


Figure #3: Results of the final three plates in the six plate series of contaminated plates: cotton cloth, microfiber cloth saturated with product A.



Figure #4: Cotton cloth swatch saturated with product B applied to a contaminated petri plate.

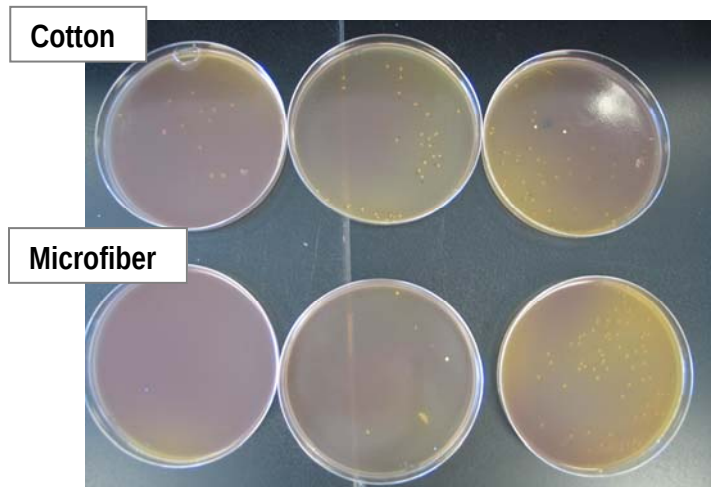


Figure #5: Results of the final three plates in the six plate series of contaminated plates: cotton cloth, microfiber cloth saturated with product B.

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Title: Quat absorption onto textiles

Author: Ecolab

Publication: White paper

Year: 2010

Summary:

INTRODUCTION: Proper disinfection is a function of different variables, such as the concentration of disinfectant applied to surfaces, disinfectant interaction with wipes and mops, volume of product applied, cleaning procedures, and use of appropriate tools.

The type of disinfectant used, particularly the active ingredient, is clearly also an important aspect of proper disinfection. Disinfectants based on quaternary ammonium chloride surfactants (quats) have been the primary means of disinfecting environmental surfaces in medical facilities for several decades. They exhibit the following benefits:

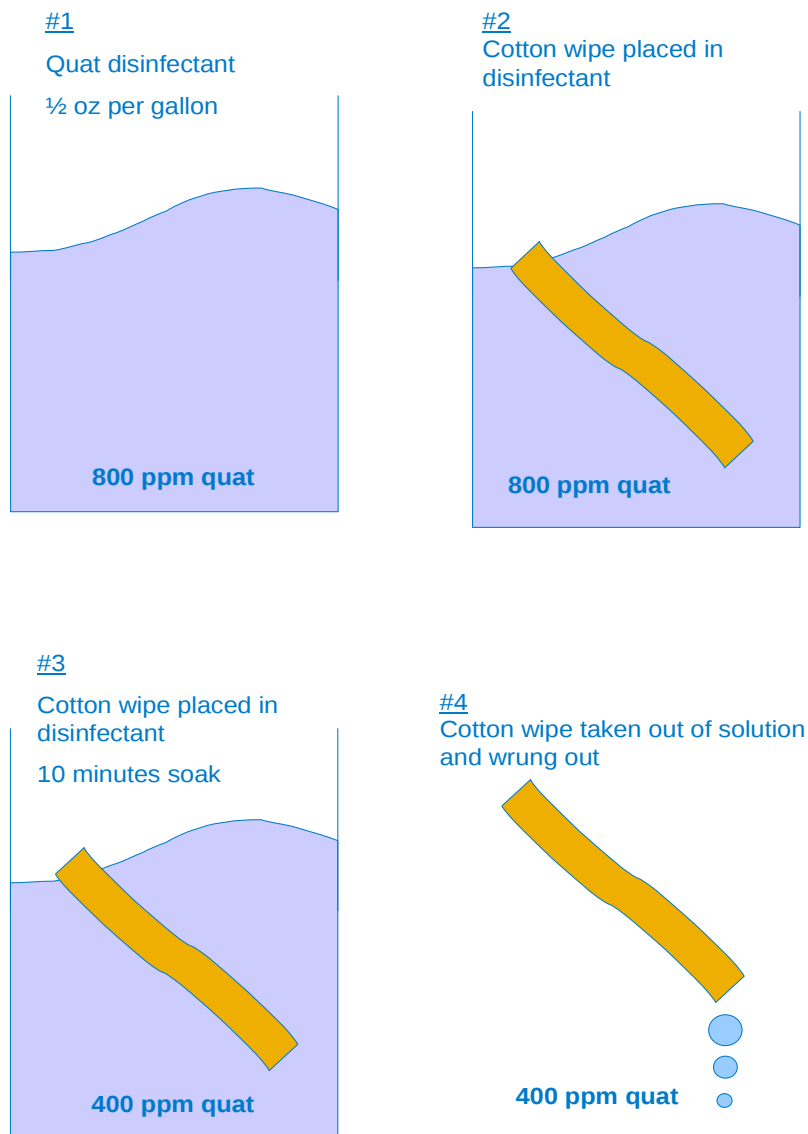
- ▲ Broad-spectrum germicidal efficacy against vegetative bacteria, fungi, and numerous viruses
- ▲ Relatively low toxicity at use levels
- ▲ Good compatibility with most environmental surfaces
- ▲ Long shelf life
- ▲ Low odor
- ▲ Economical: good value vs. other disinfectants

Because of this combination of properties, it is anticipated that quat disinfectants will remain a mainstay for hospital disinfection for years to come.

ISSUES OF QUAT ABSORPTION: Recently, concern has arisen around the discovery that the active ingredient (quat) has a tendency to become attracted to and absorbed into fabrics. Furthermore, quaternary ammonium chlorides (quats) are cationic, or positively charged, surfactants, and they are attracted to fabric surfaces which are anionic, or negatively charged. This results in a portion of the quats becoming unavailable to disinfect hard surfaces.

For example, a pail is filled with one gallon of disinfectant solution diluted at $\frac{1}{2}$ oz/gal, and the active ingredient concentration is measured at 800 ppm. After a cotton wipe is placed in the solution and allowed to soak for 10 minutes, the quat level remaining in solution may decrease to 400 ppm or less. This drop in concentration occurs because the quat is absorbed into the cotton fabric. When the wipe is removed from the liquid and excess solution

is wrung out, the collected solution is also 400 ppm or less (see figures below for visual example). Therefore, the solution applied to the surface to be disinfected contains less than the intended 800 ppm quat.



DISINFECTANT APPLICATION: Disinfectant can be applied to surfaces in several ways, including:

- ▲ Spraying
- ▲ Dip & Wipe
- ▲ Soak & Wipe

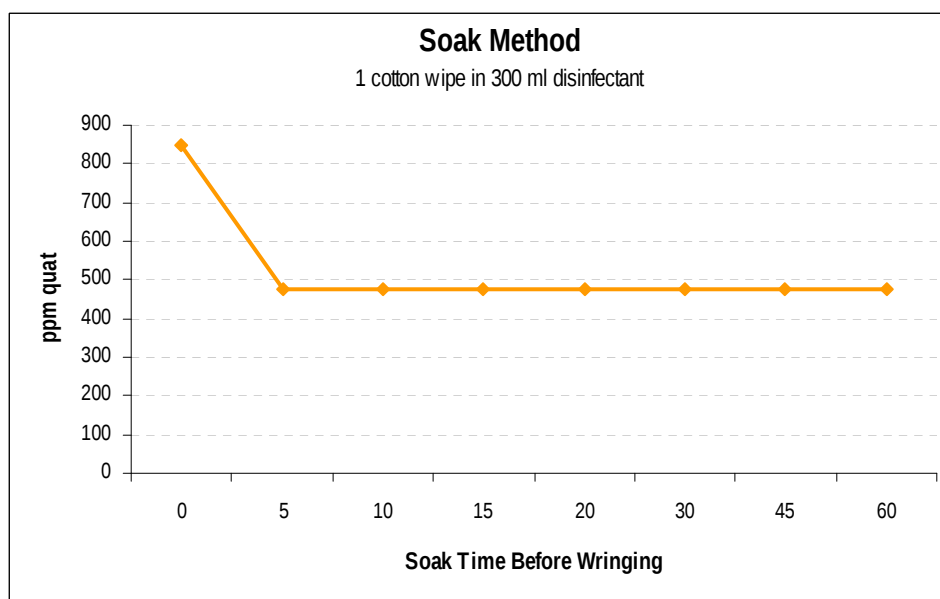
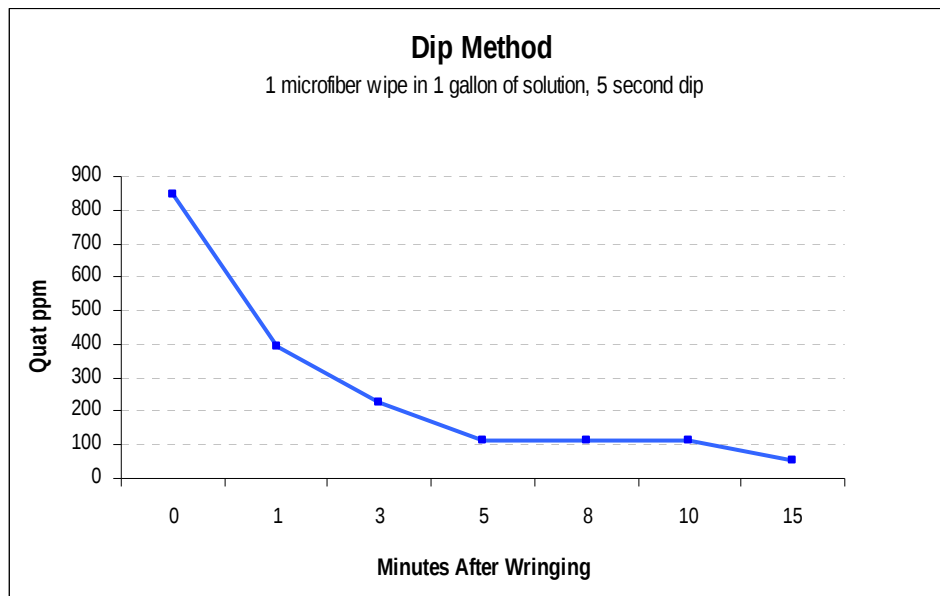
Spraying has the advantage of direct disinfectant application, which bypasses the issue of quat absorption. However, spraying has several disadvantages, including ergonomic concerns, overspray, and difficulty in covering surfaces such as the undersides of bedrails. In addition, if not done properly, spraying can atomize a portion of the disinfectant into the air and can subsequently be breathed in by workers and patients.

The Dip & Wipe method involves dipping a dry wipe into disinfectant solution for 5-10 seconds, then wringing out excess solution. The wipe is then immediately used to disinfect hard surfaces. In this method, a wipe weighing 50 grams dry is dipped into a pail holding one gallon of disinfectant solution. After wringing, the wipe may hold

approximately 150 mL of disinfectant solution, some of which will be spread over the surfaces being wiped. Wiping the various surfaces in a hospital room takes approximately 10 minutes. A disadvantage of this method is that it carries the possibility of quat absorption over the time that the wipe is used.

In the Soak & Wipe method, the wipe is allowed to soak in the disinfectant solution before use for anywhere from 10 minutes to 8 hours. At the beginning of a shift, a number of wipes are placed in a container of disinfectant solution. The wipes are taken out as needed throughout the shift and any excess solution is wrung out. The wipe is then used to clean and disinfect. Again, an average hospital room may take 10 minutes. A key concern around this method is the issue of quat absorption occurring while the wipes soak in the solution, sometimes for up to 8 hours.

The following graphs illustrate the drop in quat concentration with the Dip & Wipe and Soak & Wipe methods.



FACTORS AFFECTING QUAT ABSORPTION: Several factors affect quat absorption, including the following:

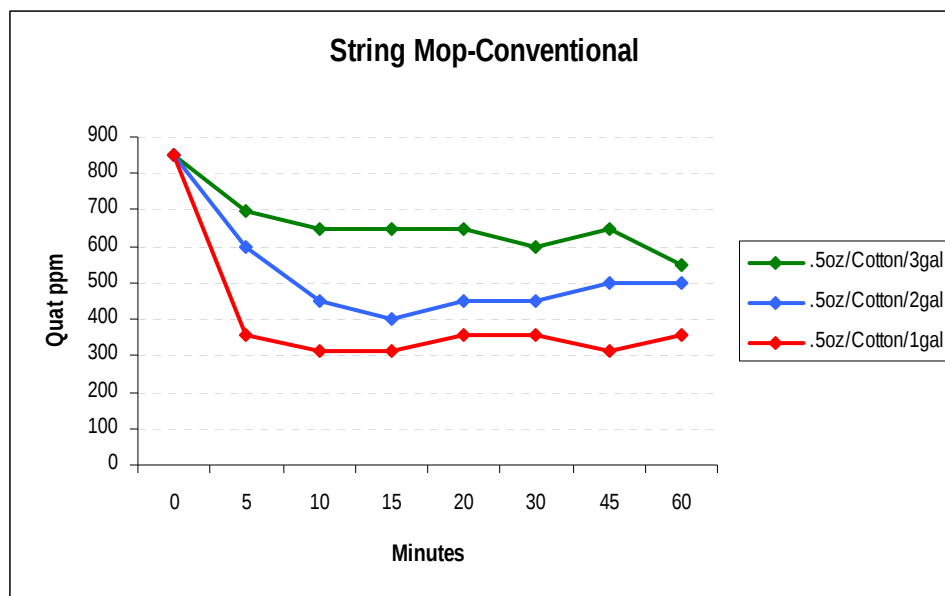
- ▲ Soak time
- ▲ Volume of disinfectant solution per wipe or mop
- ▲ Fabric type
- ▲ Time spent in disinfectant solution

Soak Time: Fabric absorbs quat fairly quickly. Much of the absorption may occur in less than 5 minutes.

Volume of Disinfectant Solution Per Wipe or Mop: This is one of the most important factors. The greater the volume of disinfectant solution per wipe, the less is the relative absorption. As an example for illustrative purposes only, if one wipe were dipped into a 5 gallon bucket of disinfectant solution and left for one hour, the overall ppm quat in the bucket would not be affected very much. The wipe could be removed from the bucket, wrung out, and used. In this case the quat concentration in the bucket and in the wipe would still be very high, due to the large amount of disinfectant (5 gallons) in comparison to fabric (1 wipe).

If, however, if a 32 oz (large) cotton string mop were soaked in 1 gallon of disinfectant solution for one hour, the quat concentration in the disinfectant solution in both the pail and the mop would be reduced to a very low level, since the mop would have absorbed much of the quat. This is because there was not as much quat available relative to the large amount of fabric.

In the following graph, cotton mops were soaked in 1, 2, or 3 gallons of disinfectant solution. As can be seen, the most quat absorption occurred in the 1 gallon soak, and the least quat absorption was observed in the 3 gallon soak.



Fabric Type: Different textiles absorb quat differently based on composition.

Time Spent in Disinfectant Solution: In the Soak & Wipe method, the cloth has time to absorb quat from the entire bucket of solution. In the Dip & Wipe method, once the wipe is dipped and wrung out, it begins to absorb quat only from the solution in the wipe. The amount of solution in the bucket is not as important for the Dip & Wipe method as it is in the Soak & Wipe method, since the cloth does not remain in the solution to continue to absorb the active ingredient.

FACTORS IMPACTING REQUIRED QUAT CONCENTRATION: The amount of quaternary ammonium chloride required to disinfect depends on several factors:

- ▲ The specific disinfectant formula
- ▲ The organism targeted for disinfection
- ▲ Water hardness

Formula: A disinfectant formula typically contains several components, including a quat active ingredient, surfactants, detergent builders, possibly solvents, fragrance, etc. Different formulas vary in the selected surfactants and builders and their levels, and they also utilize different quat compounds, some of which are more effective than others with regard to specific microorganisms. The way the product is formulated affects its disinfecting efficiency, in terms of quat levels required to effectively achieve bactericidal and virucidal activity.

Organism: Some organisms are more difficult for quats to kill than others. For example, *Pseudomonas aeruginosa* generally requires a higher concentration of quat to disinfect than does *Salmonella choleraesuis*.

Hard Water: Some disinfectants claim a hard water tolerance, which means they have been tested for use in hard water. If a product does not carry a hard water claim, there is no assurance that it will be effective if diluted in hard water. Disinfectants approved for use in hard water generally contain more quat than those that are not listed for use in hard water.

When a disinfectant is registered with the federal Environmental Protection Agency (EPA), the registrant must supply data verifying that the formula effectively kills the organisms claimed on the product label. The data is generated at the lowest dilution concentration listed on the label. There is no assurance that a product is capable of disinfection at levels less than those at which there is data to support. Therefore, it is important to ensure that a disinfectant is used in a manner that provides the required level of actives to the surface being cleaned and disinfected.

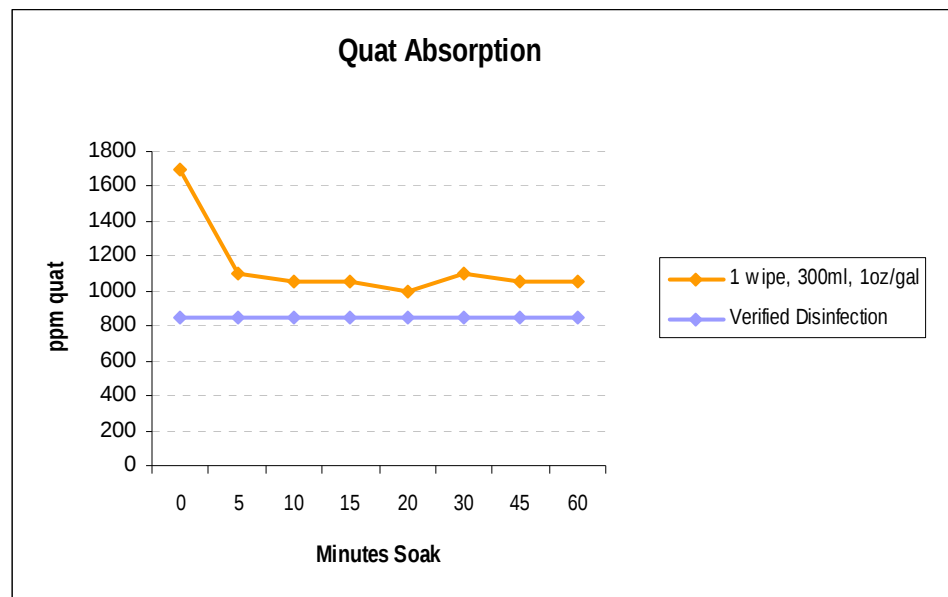
SOLUTIONS: Given the concern around quat absorption, solutions have been proposed to ensure that a sufficient concentration of quat is applied to surfaces to adequately disinfect.

- ▲ At least two manufacturers have promoted wipes made from specific textiles that exhibit less quat absorption. In some cases these wipes may prove useful for environmental surface cleaning, though they typically do not hold enough liquid to be practical.
 - ▲ A quaternary disinfectant registered for use at concentrations sufficient to compensate for quat absorption. For example, the Ecolab Quaternary Disinfectant Cleaner has germicidal efficacy at 848 ppm quat. The product is diluted at 1.2 oz per gallon, providing 2035 ppm quat, when the wipes and mops are to be soaked and subsequently absorb quat. After the textiles have absorbed quat, there is still a sufficient concentration to provide the required 848 ppm for disinfection. This dilution flexibility is not true of most disinfectants. EPA regulations require that a disinfectant is used in accordance with its label. Furthermore, the Ecolab microfiber wipes provided are designed to hold enough solution to clean large areas.
-

▲ Ecolab's system addresses all aspects that impact proper disinfection:

- Disinfectant: Ecolab Quaternary Disinfectant Cleaner
- Proper dilution: Titrate dispensing equipment to ensure appropriate disinfectant dilution
- Textiles interaction: Interaction of the Quaternary Disinfectant Cleaner with the Ecolab microfiber wipes and mops to ensure the correct amount of Quaternary Disinfectant Cleaner disinfectant is being applied
- Training: Detailed training for staff to ensure the correct amount of Quaternary Disinfectant Cleaner disinfectant is being applied

- ▲ The following graph illustrates that when Quaternary Disinfectant Cleaner is diluted at 1oz/gal, the initial quat level is 1700 ppm. After a microfibre wipe has finished absorbing quat, there is still at least 848ppm available for disinfection. Generally, it is recommended that Quaternary Disinfectant Cleaner be diluted to 1.2 ounces per gallon to account for variances in the textile condition.



As stated earlier, quat absorption is one key element that affects proper disinfection. However, effective disinfection of environmental surfaces is best considered to be a combination of the proper disinfectant and its interaction with specific textiles used at the proper concentration, applied in a sufficient quantity, and left to stand for a given period of time. To ensure that all of these elements are present and that surfaces involved in microbial transmission are being treated, proper training on application procedures is vital. Also, if equipment and cleaning systems including carts, mops, wipes, and dispensers are systematized or configured in such a way as to make proper procedures convenient, it is reasonable to expect improved results.

CONCLUSION: The absorption of quaternary ammonium compound has been recently recognized as an issue of concern for the cleaning and disinfection industry. While the extent of quat absorption varies by the volume of solution per wipe, the textile type, and the disinfectant application method, it has been established that textiles typically absorb so much quat under regular use dilutions that a level of active ingredient lower than that supported by data is often applied to hard surfaces. Ecolab's system addresses all issues that impact the disinfection process, helping ensure that it is done properly.

Title: Evaluation of ATP Bioluminescence Assays for Potential Use in a Hospital Setting

Author: Aiken ZA, Wilson M, Pratten J

Publication: Infection Control and Hospital Epidemiology

Year: 2011

Summary:

ATP bioluminescence is being applied in hospitals to measure surface contamination. We compared commercial luminometers for detecting the number *Staphylococcus aureus* associated with surfaces. The data showed that the ATP bioluminescence methods tested were not robust enough to generate quantitative data on bacterial numbers, especially at low concentrations.

“The work demonstrated that ATP bioluminescence was not suitable for accurately detecting the number of bacteria on a test surface over a range of concentrations. Previous studies have shown that luminometers are unable to detect low numbers of bacteria from a test surface, specifically $<10^3$ CFU/cm, and have demonstrated poor correlation between CFU and RLU outside of a laboratory setting.”

Title: Limitations of ATP Bioluminescence

Author: Ecolab

Publication: White Paper

Year: 2011

Summary:

WHAT IS ATP BIOLUMINESCENCE?

ATP is a chemical that is in every living cell, and when exposed to the enzyme firefly luciferase, produces light.

The sensors in commercially available ATP readers detect light when ATP or another molecule interacts with the luciferase and fluoresces in the same wavelength as the sensor. This light reading is translated into a relative light unit (RLU) by the ATP reader.

WHAT ATP BIOLUMINESCENCE IS NOT

- ▲ ATP is not a microorganism counter
- ▲ ATP measures all organic debris both microbial and non-microbial
- ▲ Microbial organic debris includes both live and dead bacteria
- ▲ Organic debris accounts for 66% of ATP on surfaces(1)
- ▲ ATP does not detect viruses
- ▲ ATP does not detect bacterial spores

ATP readers cannot differentiate between ATP that is present from live bacteria and ATP that has been released from dead bacteria. In environments that are hosed down after cleaning, such as food processing plants or breweries, this doesn't matter, as all dead bacteria are washed away after sanitizing. Disinfectants in a hospital are allowed to remain on the surface. Assuming the disinfectant is properly diluted all bacteria that are exposed to the disinfectant are killed. Most bacteria should be removed from the mechanical action of wiping with a cloth, but some dead bacteria do remain on the surface. The dead bacteria will leak ATP out of their disrupted membranes, and it is not possible to differentiate between the ATP of live vs. dead bacteria.

ATP readers cannot detect viral contamination. Viruses are unlike cellular organisms in that they do not have ATP.

ATP readers cannot detect endospores present in the environment, such as *C. difficile*. The coat on the spores is so thick that ATP does not exit the membrane in readily detectable quantities (2), and is not available for interaction with the luciferase.

ATP DOES NOT SET A UNIVERSAL STANDARD OF CLEAN

- ▲ An ATP RLU (Relative Light Unit) standard has not been set to define clean versus contaminated surfaces
- ▲ Results vary between commercially available systems
- ▲ Readout scales vary more than 10 fold (3)
- ▲ Sensitivity varies (4)
- ▲ A standard of 500 RLU has been proposed, but in a study by Griffith, et al (5) 89% failed to meet the proposed standard of <500 RLU while only 27% of same surfaces failed the accepted aerobic colony count cleanliness standard of <2.5 cfu/cm².

The RLU is not a real number, but a relative number, which is calibrated for each individual system. What may be 250 RLU in one sensor might be 1000 RLU in another, based only on the sensitivity of the sensor and the calibration of the tool. This means that there cannot be a universal standard of clean or a cutoff for dirty. There can only be a comparison of a surface before it was cleaned to the same surface after it was cleaned.

SURFACE INTERFERENCES MAY ARTIFICIALLY INCREASE OR DECREASE RLU READINGS

- ▲ Interferences in either the molecular interaction or the sensor detection include:
 - ▲ Falsely decreased RLU readings (quenching)
 - ▲ Falsely increased RLU readings
 - ▲ Bleach-based disinfectants quench the ATP reaction (6)
 - ▲ There are additional environmental factors that can also either falsely increase or decrease RLU readings:
 - ▲ Detergents and disinfectants (7)
 - ▲ Plasticizers found in microfiber cloths (8)
 - ▲ Ammonium compounds found in laundry chemistries (8)
 - ▲ Environmental surfaces in poor condition (5)

In addition to variability within readers, there is also added variability coming from the environment of use. Unlike food processing plants where ATP readers are used on only stainless steel equipment that is free of chemistries, healthcare settings provide a variety of surfaces (plastics, metals, fabric, wood) with different residual chemistries on those surfaces (cleaners, disinfectants, bleach). While each of these interferences alone may not have a large effect, they each increase the complexity of proper use and interpretation of the data. This is one of the reasons that clinical use of the ATP data has not shown good correlation with culture counts in many studies.(5) The variability can either cause high RLU readings, indicating a surface is dirty when it is properly disinfected (as in the case of residual quaternary disinfectant) or low RLU readings, indicating that a surface has been disinfected when it is still contaminated (as in the case of oils or certain surfactants).

OTHER CONSIDERATIONS

- ▲ Refrigeration before use is required for most ATP swabs. There is no indicator on package to ensure that temperature has been maintained during shipping and storage.
- ▲ Storage: According to the CDC Toolkit: Options for Evaluating Environmental Hygiene, each high touch object (HTO) should be swabbed pre and post cleaning.(6) This requires storage space for the large quantity required for monitoring.
- ▲ Cost: Hospitals need one or two swabs for every high touch object in a room with 17 HTOs per room (34 swabs per room if sampling pre- and post-cleaning).
- ▲ Time: More time is required for ATP monitoring given the number of swabs and processing time needed for each HTO.

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Title: Is it really clean? Evaluation of the DAZO Fluorescent Marker Method for Monitoring Environmental Cleaning

Author: Sitzlar BM, Sethi AK, Jury LA, Guerrero D, Cadnum JL, Donskey CJ

Publication: Poster, Society for Healthcare Epidemiologists of America Annual Scientific Meeting

Year: 2011

Summary:

Background: The DAZO® fluorescent targeting method has been developed as a means to objectively evaluate the thoroughness of cleaning of high-touch surfaces in healthcare settings. However, few studies have validated the effectiveness of this method as a means to monitor room disinfection.

Objective: To test the hypothesis that removal of DAZO from selected sites on high-touch surfaces correlates with removal of bacteria from those sites and with cleaning of alternate sites on the same surfaces.

Methods: In 50 rooms being cleaned by housekeepers, DAZO was applied to high-touch surfaces (i.e., bed rail, top surface; bedrail, bottom surface; bedside table, top surface; bedside table, bottom hand grip; call button; telephone; toilet seat; and bathroom hand rail) before cleaning and removal (graded as complete, partial, or no removal) was assessed after cleaning. Non-toxigenic *C. difficile* spores (~4 log₁₀ colony-forming units) were inoculated onto a 1 cm² area of 4 sites (table, bed rail, call button, telephone) directly adjacent to the DAZO placement and quantitative cultures were performed after cleaning. For the same 4 sites, cultures for total aerobic bacteria were collected before and after cleaning.

Results: Only 46% of sites had complete removal of DAZO and there was wide variation among sites (Figure). Removal of DAZO correlated inversely with total bacterial counts (correlation coefficient -0.50; $P < 0.01$) and positively with removal of *C. difficile* spores (correlation coefficient -0.63; $P < 0.01$). DAZO was completely removed from 66%-76% of the top surfaces of the bed rail and bedside table, but from <20% of the bottom surfaces.

Conclusions: Removal of DAZO correlated well with removal of bacteria or *C. difficile* spores from the site of marker placement, but did not ensure that other high-touch sites on the same surfaces were cleaned.

Title: Environmental Services performance improvement in the ICU using a cleaning checklist, educational video, and fluorescent marking solution with rapid-cycle feedback

Author: Fitzgerald T, Sholtz L, Marion N, Adler A, Turner P, Thomas C, Carling PC

Publication: Poster, Society for Healthcare Epidemiologists of America Annual Scientific Meeting

Year: 2011

Summary:

Issue: Microbiological pathogens are known to contaminate the patient care environment and inadequate cleaning may result in the transmission of potential pathogens to patients. Healthcare facilities rely on their Environmental Service Departments (EVS) to clean and disinfect the patient care environment. However, visual inspection does not ensure that adequate disinfection has taken place.

Project: In collaboration with Environmental Services, the Epidemiology Department set out to achieve optimal cleaning and disinfection of the ICU environment using a practical and sustainable approach. A 43-point cleaning checklist was developed to include 15 high-touch items which were marked with a transparent, ultraviolet-tagged marking solution (DAZO®). EVS personnel received instruction regarding room disinfection with an emphasis on cleaning high-touch surfaces and how to use the checklist. Cleanliness was graded on the basis of removal of the marking solution post cleaning. Baseline EVS performance data was collected over three different periods. An educational DVD encompassing cleaning of high-touch items was developed, and all EVS personnel were required to view the video. Fifteen rooms in each of the 3 Adult ICUs were surveyed each month to assess performance. Unit-specific results were tallied monthly and rapidly fed back during face-to-face meetings with EVS personnel.

Results: Baseline data consisted of 1715 fluorescent-marked surfaces evaluated in 90 ICU rooms. Performance of cleaning these surfaces was 52%. The post evaluation period consisted of 6 months (176 rooms marked and 2640 surfaces evaluated). After initial viewing of the training video by all EVS personnel in the first post-evaluation month, compliance improved to 60%. Continued improvement was seen in subsequent months as the rapid feedback continued, with a high of 83%.

Lessons Learned: Education of EVS personnel, introduction of a cleaning checklist, and viewing of an educational video by EVS staff only slightly increased cleaning performance. Face-to-face reporting of cleaning results was well received by EVS staff, further developed a collaborative relationship between Epidemiology and EVS, and contributed to increased cleaning performance. Maintenance of the program will continue quarterly and future studies will correlate environmental cleanliness with prevention of HAIs.

Title: Environmental Best Practices for Health Care Facilities: Using Microfiber Mops in Hospitals

Author: N/A

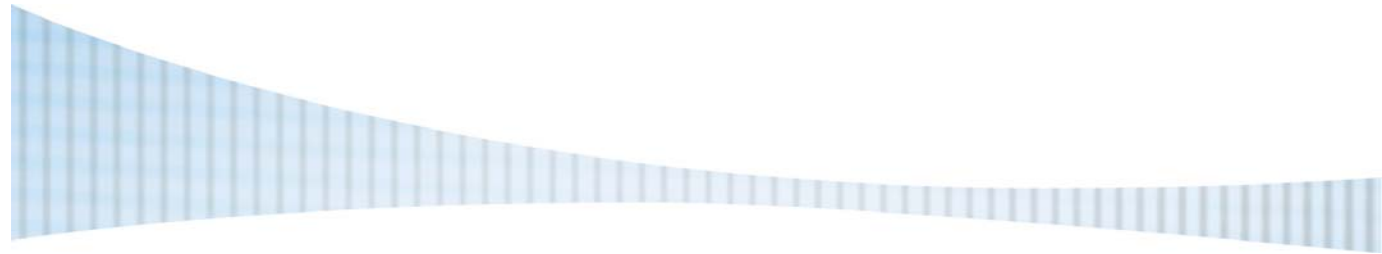
Publication: Fact Sheet: United States Environmental Protection Agency

Year: 2002

Summary:

Using conventional loop mops for wet mopping of patient care areas has long been the standard in floor cleaning for janitorial operations in hospitals. However, the health care industry has taken recent interest in evaluating hard floor maintenance techniques in terms of employee, patient, and environmental health. Many floor cleaners used in hospitals contain harsh chemicals such as quaternary ammonium chlorides and butoxyethanol, which can be harmful to human health and the environment. To reduce the risk of cross contamination for patients, conventional mopping techniques require janitors to change the cleaning solution after mopping every two or three rooms—meaning that cleaning solutions (including both chemicals and several gallons of water) are constantly being disposed of and replenished.

Some facilities have begun using a new mopping technique involving microfiber materials to clean floors. Microfibers are densely constructed, polyester and polyamide (nylon) fibers that are approximately 1/16 the thickness of a human hair. The density of the material enables it to hold six times its weight in water, making it more absorbent than a conventional, cotton loop mop. Also, the positively charged microfibers attract dust (which has a negative charge), and the tiny fibers are able to penetrate the microscopic surface pores of most flooring materials. These characteristics make microfiber an effective mopping material.



Title: Microbiologic evaluation of microfiber mops for surface disinfection

Author: Rutala WA, Gergen MF, Weber DJ

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Summary:

BACKGROUND: Recently, healthcare facilities have started to use microfiber mopping technique rather than a conventional, cotton string mop.

METHODS: The effectiveness of microfiber mops to reduce microbial levels on floors was investigated. We compared the efficacy of microfiber mops with that of conventional, cotton string mops in 3 test conditions (cotton mop and standard wringer bucket, microfiber mop and standard wringer bucket, microfiber system). Twenty-four rooms were evaluated for each test condition. RODAC plates containing D/E Neutralizing Agar were used to assess “precleaning” and “postcleaning” microbial levels.

RESULTS: The microfiber system demonstrated superior microbial removal compared with cotton string mops when used with a detergent cleaner (95% vs 68%, respectively). The use of a disinfectant did not improve the microbial elimination demonstrated by the microfiber system (95% vs 95%, respectively). However, use of disinfectant did significantly improve microbial removal when a cotton string mop was used (95% vs 68%, respectively).

CONCLUSION: The microfiber system demonstrated superior microbial removal compared with cotton string mops when used with a detergent cleaner. The use of a disinfectant did not improve the microbial elimination demonstrated by the microfiber system.

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