Appendix A. Literature Search Methods

Electronic Database Searches

ECRI Institute information specialists searched the following databases for relevant information. Search terms and strategies for the bibliographic databases appear below.

Name	Date Limits	Platform/Provider
ClinicalTrials.gov	Through September 17, 2014	U.S. National Institutes of Health
The Cochrane Central Register of Controlled Trials (CENTRAL)	1990 through 2014, Issue 9	Wiley
The Cochrane Database of Methodology Reviews (Methodology Reviews)	1990 through 2014, Issue 9	Wiley
The Cochrane Database of Systematic Reviews (Cochrane Reviews)	1990 through 2014, Issue 9	Wiley
Cumulative Index to Nursing and Allied Health Literature (CINAHL)	1990 through September 16, 2014	EBSCO*host*
Database of Abstracts of Reviews of Effects (DARE)	1990 through 2014, Issue 9	Wiley
EMBASE (Excerpta Medica)	1990 through September 5, 2014	Elsevier
Health Technology Assessment Database (HTA)	1990 through 2014, Issue 9	Wiley
Healthcare Standards Directory (ECRI Institute)	Through September 30, 2014	ECRI Institute
MEDLINE (via EMBASE)	1990 through September 5, 2014	Elsevier
PubMed (In-process, Publisher, and PubMedNotMedline records)	1990 through September 5, 2014	U.S. National Library of Medicine
Scopus*	Through September 30, 2014	Elsevier
U.K. National Health Service Economic Evaluation Database (NHS EED)	1990 through 2014, Issue 9	Wiley
U.S. National Guideline Clearinghouse™ (NGC)	Through September 30, 2014	Agency for Healthcare Research and Quality (AHRQ)

*Scopus was utilized for citation tracking and searching trade publications

Hand Searches of Journal and Nonjournal Literature

Journals and supplements maintained in ECRI Institute's collections were routinely reviewed. Nonjournal publications and conference proceedings from professional organizations, private agencies, and government agencies were also screened. Other mechanisms used to retrieve additional relevant information included review of bibliographies/reference lists from peer-reviewed and grey literature. (Grey literature consists of reports, studies, articles, and monographs produced by federal and local government agencies, private organizations, educational facilities, consulting firms, and corporations. These documents do not appear in the peer-reviewed journal literature. See the *Methods* section, *B. Grey Literature Search*, for a list of grey literature resources searched.)

Bibliographic Database Searches

EMTREE Index Terms, CINAHL Headings, and Text Words

The search strategies employed combinations of free-text keywords as well as controlled vocabulary terms including (but not limited to) the concepts shown in the Topic-specific Search Terms table.

Topic-Specific Search Terms

Concept	Controlled Vocabulary	Text Words
Population (admitted, adult patients in hospital settings)	**EMTREE (EMBASE)** Patient **CINAHL** Patients	Inpatient/s Patient/s
Setting (physical location) (patient rooms and common areas in hospitals and hospital-like settings)	**EMTREE** Health care facility Hospital Hospital discharge **CINAHL** Academic medical centers Health facilities Hospital units Hospitals Patients' rooms+ Patient discharge	Acute care Burn unit/s Common area/s Critical care General ward/s Health care facility/ies Healthcare facility/ies Health care setting/s Healthcare setting/s Hospital/s Hospitalis/zation ICU Institution/s Intensive care Medical facility/ies Medical ward/s Patient care area/s Patient room/s Patient ward/s
Setting (types of surfaces) (high-touch surfaces)	**EMTREE** Fomite Hospital bed Hospital equipment **CINAHL** "beds and mattresses" portable equipment	Bathroom* Bed rail/s Bedrail/s Cart/s Chair/s Clinical surfaces Commode/s Environmental surfaces Fomes Fomite/s Environmental reservoir/s High-contact

Topic-Specific Search Terms (continued)

Concept	Controlled Vocabulary	Text Words
		High-touch Hospital bed/s Hospital surface/s Mobile equipment Portable equipment Railing/s Shared medical equipment Surface contamination Surface microbes Toilet* Wheelchair/s
Infections (broad terms)	**EMTREE** Healthcare associated infection Hospital infection **CINAHL** Cross infection	HAI/s Health care acquired infection/s Health care acquired pathogen/s Health care associated infection/s Health care associated pathogen/s Healthcare acquired infection/s Healthcare acquired pathogen/s Healthcare associated infection/s Healthcare associated pathogen/s Hospital acquired infection/s Hospital associated infection/s Hospital associated pathogen Health care acquired pathogen Healthcare acquired pathogen Hospital acquired pathogen/s Hospital associated pathogen/s
Infections (specific terms) (Clostridium difficile, methicillin-resistant Staphylococcus aureus, and vancomycin-resistant enterococci)	**EMTREE** Clostridium difficile Clostridium difficile infection Enterococcal infection Methicillin resistant staphylococcus aureus Methicillin resistant staphylococcus aureus infection Vancomycin resistant enterococcus **CINAHL** Clostridium difficile Clostridium infections Enterococcus Enterococcal infections Methicillin resistance Methicillin-resistant staphylococcus	Antibiotic resistance Antibiotic-resistant CDI Difficile Methicillin-resistance Methicillin –resistant MRSA Multi-drug resistance Multi-drug-resistant Multidrug resistance Multidrug-resistant Vancomycin resistance Vancomycin-resistant VRE VRE

Topic-Specific Search Terms (continued)

Concept	Controlled Vocabulary	Text Words
	aureus Staphylococcal infections Vancomycin resistance	
General hospital cleaning	**EMTREE** Cleaning disinfection environmental sanitation Infection control **CINAHL** Decontamination, hazardous materials Infection control Sterilization and disinfection	Cleaning Aseptic technique/s Cleaning method/s Cleaning practice/s Cleaning protocol/s Cleaning regimen/s Cleaning routines Cleaning technique/s Discharge cleaning Discharge room cleaning Enhanced cleaning Environmental cleaning Environmental decontamination Environmental disinfection Environmental sanitation Hospital hygiene Housekeeping Precleaning Pre-cleaning Room cleaning Room decontamination Routine cleaning Surface cleaning Surface decontamination Surface disinfection Terminal cleaning Terminal disinfection Terminal room
Disinfection agents	**EMTREE** Bleaching agent Disinfectant agent Quaternary ammonium derivative **CINAHL** Cleaning compounds Disinfectants Quaternary ammonium compounds Sodium hypochlorite	Accelerated hydrogen peroxide Aldehyde/s Alcohol/s Benzalkonium chloride Biocidal Biocide/s Bleach/ing Calcium hypochlorite Chemical agent/s Chemical disinfection Chlorhexidine digluconate Cleaning agent/s

Topic-Specific Search Terms (continued)

Concept	Controlled Vocabulary	Text Words
		Disinfectant/s Disinfecting Disinfection agent/s Germicidal Germicide/s Glutaraldehyde Guanidine hydrochloride Hypochlorite/s Ortho-phthalaldehyde Orthophthalaldehyde Peracetic acid Phenol Phenols Phenolic/s QAC/s Quaternary ammonium Sodium dichloroisocyanurate Sporicidal Sporicide/s Vinegar
Automated devices	**EMTREE** Disinfection system Hydrogen peroxide Ultraviolet irradiation Ultraviolet radiation Vapor Water vapor **CINAHL** Hydrogen peroxide Ultraviolet rays	Aerosol Automated cleaning Automated device/s Automated decontamination Automated disinfection Automated surface Fogging Hydrogen peroxide H2O2 Mist No-touch Non-touch Pulsed ultrasound Pulsed xenon Room sterilisation Room sterilization Self-disinfecting Self disinfection Steam Superoxidis/zed water Ultraviolet disinfection Ultraviolet irradiation Ultraviolet light

Topic-Specific Search Terms (continued)

Concept	Controlled Vocabulary	Text Words
		Ultraviolet radiation UV disinfection UV irradiation UV light UV radiation Vapor/ization Vapour/isation 405-nm 405nm
Enhanced coatings and surfaces	**EMTREE** Copper Material coating **CINAHL** Copper	Antimicrobial coating/s Antimicrobial-impregnated Antimicrobial surface/s Coated Coating/s Copper-coated Copper-impregnated Copper surface/s Silver-coated Silver-impregnated Silver surface/s
Cleaning personnel and training	**EMTREE** Hospital service Housekeeping Staff training **CINAHL** Education Housekeeping department Staff development	Cleaning personnel Cleaning service/s Cleaning staff Cleaning worker/s Environmental services Environmental technician/s Housekeeper/s Housekeeping Service worker/s Staff
Measuring and monitoring cleanliness	**EMTREE** Adenosine triphosphate Bioluminescence Hospital hygiene **CINAHL** Adenosine triphosphate Luminescent measurements	Adenosine triphosphate ATP Bioluminescence Cleanliness Fluorescent marker/s Glo-germ Glogerm Hospital hygiene Surface hygiene

Search Strategies

The strategy below is presented in EMBASE syntax; the search was simultaneously conducted across EMBASE and MEDLINE. A similar strategy was used to search the databases comprising CINAHL, the Cochrane Library, and PubMed.

EMBASE/MEDLINE Strategy

Set #	Concept	Search Statement
1	Infections (broad terms, healthcare-associated)	("healthcare associated infection" OR "hospital infection")/de
2		(("health care acquired" next/1 (infection* OR pathogen*)) OR ("healthcare acquired" next/1 (infection* OR pathogen*)) OR ("hospital acquired" next/1 (infection* OR pathogen*)) OR ("health care associated" next/1 (infection* OR pathogen*)) OR ("healthcare associated" next/1 (infection* OR pathogen*)) OR ("hospital associated" next/1 (infection* OR pathogen*))):ti,ab
3		(HAI OR HAIs):ti
4	Infections (specific terms-bacterial)	("clostridium difficile" OR "clostridium difficile infection" OR "methicillin resistant staphylococcus aureus" OR "methicillin resistant staphylococcus aureus infection" OR enterococcus OR "vancomycin resistant enterococcus" OR "enterococcal infection")/de
5		((antibiotic OR "multi-drug" OR multidrug OR methicillin OR vancomycin) next/1 resistan*):ti,ab OR difficile:ti,ab OR ("methicillin resistant" next/2 aureus):ti,ab OR ("vancomycin resistant" next/1 enterococc*):ti,ab
6		(CDI OR MRSA OR VRE):ti
7	Limit to patients	(#4 OR #5 OR #6) AND (patient/exp OR (inpatient* OR patient*):ti,ab)
8	Combine infection sets	#1 OR #2 OR #3 OR #7
9	Setting (hospitals, inpatient facilities, patient rooms)	("health care facility" OR "hospital discharge")/de OR hospital/exp
10		("acute care" OR "burn unit" OR "burn units" OR "common area" OR "common areas" OR "critical care" OR "healthcare facility" OR "healthcare facilities" OR "health care facility" OR "health care facilities" OR "healthcare setting" OR "healthcare settings" OR "health care setting" OR "health care settings" OR hospital OR hospitalis* OR hospitaliz* OR ICU OR institution OR institutions OR "intensive care" OR "patient care area" OR "medical facility" OR "medical facilities" OR "patient care areas" OR "patient room" OR "patient rooms" OR "patients rooms" OR ward OR wards):ti,ab
11	Setting (high-touch surfaces)	(fomite OR "hospital bed" OR "hospital equipment")/de
12		(fomes OR fomite* OR "environmental reservoir" OR "environmental reservoirs" OR "surface contamination" OR "surface microbes"):ti,ab
13		(bathroom* OR "bed rail" OR "bed rails" OR bedrail* OR cart OR carts OR chair OR chairs OR "clinical surfaces" OR commode* OR "environmental surfaces" OR "high contact" OR "high-touch" OR "hospital bed" OR "hospital beds" OR "hospital surfaces" OR "mobile equipment" OR "portable medical equipment" OR railing OR railings OR toilet* OR "shared medical equipment" OR wheelchair*):ti,ab
14	Combine setting sets	#9 OR #10 OR #11 OR #12 OR #13
15	Combine sets (any infection or setting)	#8 OR #14

EMBASE/MEDLINE Strategy (continued)

Set #	Concept	Search Statement
16	General cleaning	(cleaning OR disinfection OR "environmental sanitation")/de OR "infection control"/mj
17		("cleaning method" OR "cleaning methods" OR "cleaning practice" OR "cleaning practices" OR "cleaning protocol" OR "cleaning protocols" OR "cleaning regimen" OR "cleaning regimens" OR "cleaning routines" OR "cleaning technique" OR "cleaning techniques" OR "discharge cleaning" OR "discharge room cleaning" OR "enhanced cleaning" OR "environmental cleaning" OR "environmental decontamination" OR "environmental disinfection" OR "environmental sanitation" OR "hospital cleaning" OR "pre cleaning" OR precleaning OR "room cleaning" OR "room decontamination" OR "routine cleaning" OR "surface cleaning" OR "surface disinfection" OR "surface decontamination" OR "terminal cleaning" OR "terminal disinfection" OR "terminal room"):ti,ab
18		(cleaning OR decontamination OR disinfect* OR "infection control"):ti
19	Disinfectants	"disinfectant agent"/exp OR ("bleaching agent" OR "quaternary ammonium derivative"/de)
20		(biocidal OR biocide* OR "chemical agent" OR "chemical agents" OR "chemical disinfection" OR "cleaning agent" OR "cleaning agents" OR disinfectant* OR "disinfecting agent" OR "disinfecting agents" OR "disinfection agent" OR "disinfection agents" OR germicidal OR germicide* OR sporicidal OR sporicide*):ti,ab
21		("accelerated hydrogen peroxide" OR aldehyde* OR alcohol OR alcohols OR bleach OR bleaching OR "benzalkonium chloride" OR "calcium hypochlorite" OR "chlorhexidine digluconate" OR glutaraldehyde OR "guanidine hydrochloride" OR hypochlorite* OR "ortho-phthalaldehyde" OR orthophthalaldehyde OR "peracetic acid" OR phenolic* OR phenol OR phenols OR "quaternary ammonium" OR QACs OR "sodium dichloroisocyanurate" OR "sodium hypochlorite" OR vinegar):ti,ab
22	Limit to disinfectant studies to cleaning	(#19 OR #20 OR #21) AND (clean* OR decontaminat* OR disinfect* OR housekeep*):ti,ab
23	Automated devices	("disinfection system" OR "ultraviolet irradiation" OR "ultraviolet radiation")/de OR ("hydrogen peroxide" AND (vapor OR "water vapor"))/de
24		(automated next/2 (cleaning OR device* OR decontamination OR disinfection)):ti,ab OR (("no touch" OR "non touch") next/1 disinfect*):ti,ab OR ("room sterilisation" OR "room sterilization" OR "self disinfecting"):ti,ab
25		((405nm OR "405 nm" OR "pulsed ultrasound" OR "pulsed xenon" OR ((ultraviolet OR UV) next/1 (disinfection OR light OR irradiation OR radiation))):ti,ab) AND (clean* OR decontaminat* OR disinfect* OR room OR rooms):ti,ab
26		"superoxidised water":ti,ab OR "superoxidized water":ti,ab OR (("hydrogen peroxide" OR H2O2) AND (aerosol* OR fogging OR mist OR steam OR system OR systems OR vapor* OR vapour*)):ti,ab
27	Enhanced coatings and surfaces	(copper AND "material coating")/de
28		"self disinfecting":ti,ab OR ((antimicrobial OR copper OR silver) NEAR/2 (coated OR coating* OR impregnated OR surface*)):ti,ab
29	Cleaning personnel and training	("hospital service" OR housekeeping OR "staff training")/de
30		("cleaning personnel" OR "cleaning service" OR "cleaning services" OR "cleaning staff" OR "cleaning workers" OR "environmental services" OR "environmental technician" OR "environmental technicians" OR housekeeper* OR housekeeping OR "service worker" OR "service workers"):ti,ab

EMBASE/MEDLINE Strategy (continued)

Set #	Concept	Search Statement
31	Measuring and monitoring cleanliness	("adenosine triphosphate" AND bioluminescence)/de OR ("hospital hygiene")/de
32		(((("adenosine triphosphate" OR ATP) next/1 bioluminescen*) OR cleanliness OR "fluorescent marker" OR "fluorescent markers" OR "glo germ" OR glogerm OR "hospital hygiene" OR "surface hygiene"):ti,ab
33	Combine sets (any cleaning concept)	#16 OR #17 OR #18 OR #22 OR #23 OR #24 OR #25 OR #26 OR #27 OR #28 OR #29 OR #30 OR #31 OR #32
34	Combine sets (any infection or setting AND any cleaning concept)	#15 AND #33
35	Limit to English-language publications	#34 AND [english]/lim
36	Remove undesired publication types	#35 NOT ('conference paper'/exp OR ('case report' OR book OR erratum OR letter OR note OR 'short survey')/de OR (book OR conference OR erratum OR letter OR note OR 'short survey'):it OR (book OR 'conference proceeding'):pt)
37	Limit to publications with abstracts	#36 AND [abstracts]/lim
38	Remove animal and in vitro studies	#37 NOT ([animal cell]/lim OR [animal experiment]/lim OR [animal model]/lim OR [animal tissue]/lim OR "in vitro study"/de)
39	Remove pediatric studies	#38 NOT (adolescen* OR babies OR child* OR fetal OR infant OR infants OR neonat* OR newborn* OR NICU OR paediatric* OR pediatric* OR school OR schools OR teen* OR youth*):ti
40	Remove undesired geographic locations	#39 NOT (africa/exp OR asia/exp OR mexico/de OR "oceanic regions"/exp OR "south and central america"/exp)
41	Limit by publication date	#40 AND [1990-2014]/py
42	Limit to meta-analyses and systematic reviews published	#41 AND ("meta analysis"/de OR "systematic review"/de OR ("evidence base" OR "evidence based" OR "meta analysis" OR methodologic* OR pooled OR "quantitative analysis" OR "quantitative review" OR "research synthesis" OR search* OR "systematic review"):ti,ab)
43	Limit to clinical studies	#41 AND (("comparative study" OR "controlled study" OR "experimental study" OR "field study" OR "in vivo study" OR methodology OR model OR "observational study" OR "pilot study" OR "prevention study" OR "quasi experimental study" OR "trend study" OR "validation study")/exp OR (analysis OR "case control" OR clinical OR cohort OR comparison OR "matched controls" OR random* OR study OR trial):ti,ab OR article/de OR article:it OR "article in press":it OR "priority journal"/de)
44	Limit to narrative reviews published from 2009 onward	#41 AND (review/de OR review:it OR (overview OR review):ti) AND [2009-2014]/py
45	Limit to clinical practice guidelines	#41 AND (practice guideline/exp OR ("best practice" OR "best practices" OR consensus OR guidance OR guideline* OR recommendation* OR standard* OR statement):ti)
46	Combine sets	#42 OR #43 OR #44 OR #45

EMBASE Syntax:

*	=	truncation character (wildcard)
NEAR/*n*	=	search terms within a specified number (*n*) of words from each other in any order
NEXT/*n*	=	search terms within a specified number (*n*) of words from each other in the order specified
/	=	search as a subject heading
exp	=	"explodes" controlled vocabulary term (e.g., expands search to all more specific related terms in the vocabulary's hierarchy)
mj	=	denotes a term that has been searched as a major subject heading
/de	=	search in the descriptors field (controlled terms and keywords)
:lnk	=	floating subheading
:it,pt.	=	source item or publication type
:ti.	=	limit to title
:ti,ab.	=	limit to title and abstract fields

Appendix B. Excluded Studies Based on Review of Full-Length Articles

Not a location or setting of interest

Aiken ZA, Wilson M, Pratten J. Evaluation of ATP bioluminescence assays for potential use in a hospital setting. Infect Control Hosp Epidemiol. 2011 May;32(5):507-9. PMID: 21515983

Ali S, Moore G, Wilson AP. Effect of surface coating and finish upon the cleanability of bed rails and the spread of Staphylococcus aureus. J Hosp Infect. 2012 Mar;80(3):192-8. PMID: 22264495

Allen G. Implementing AORN recommended practices for environmental cleaning. AORN J. 2014 May;99(5):570-82. PMID: 24766919

Bartels MD, Kristoffersen K, Slotsbjerg T, et al. Environmental meticillin-resistant Staphylococcus aureus (MRSA) disinfection using dry-mist-generated hydrogen peroxide. J Hosp Infect. 2008 Sep;70(1):35-41. PMID: 18621434

Berendt AE, Turnbull L, Spady D, et al. Three swipes and you're out: How many swipes are needed to decontaminate plastic with disposable wipes? Am J Infect Control. 2011 Jun;39(5):442-3. PMID: 21306797

Berrington AW, Pedler SJ. Investigation of gaseous ozone for MRSA decontamination of hospital side-rooms. J Hosp Infect. 1998 Sep;40(1):61-5. PMID: 9777523

Bradley CR, Fraise AP. Heat and chemical resistance of enterococci. J Hosp Infect. 1996 Nov;34(3):191-6. PMID: 8923273

Cheng KL, Boost MV, Chung JW. Study on the effectiveness of disinfection with wipes against methicillin-resistant Staphylococcus aureus and implications for hospital hygiene. Am J Infect Control. 2011 Sep;39(7):577-80. PMID: 21641084

Doan L, Forrest H, Fakis A, et al. Clinical and cost effectiveness of eight disinfection methods for terminal disinfection of hospital isolation rooms contaminated with Clostridium difficile 027. J Hosp Infect. 2012 Oct;82(2):114-21. PMID: 22902081

Gillespie EE, Scott C, Wilson J, et al. Pilot study to measure cleaning effectiveness in health care. Am J Infect Control. 2012 Jun;40(5):477-8. PMID: 21937146

Gilmour D, Cooper R. Feedback from members on decontamination services. J Perioper Pract. 2008 Jul;18(7):279-80. PMID: 18710125

Griffith CJ, Cooper RA, Gilmore J, et al. An evaluation of hospital cleaning regimes and standards. J Hosp Infect. 2000 May;45(1):19-28. PMID: 10833340

Griffith CJ, Malik R, Cooper RA, et al. Environmental surface cleanliness and the potential for contamination during handwashing. Am J Infect Control. 2003 Apr;31(2):93-6. PMID: 12665742

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Hick JL, Penn P, Hanfling D, et al. Establishing and training health care facility decontamination teams. Ann Emerg Med. 2003 Sep 1;42(3):381-90. PMID: 12944891

Hiom S, Lowe C, Oldcorne M. Development and validation of a method to assess alchohol transfer disinfection procedures. Pharm J. 2004 May 15;272(7299):611-4.

Ismail S, Perni S, Pratten J, et al. Efficacy of a novel light-activated antimicrobial coating for disinfecting hospital surfaces. Infect Control Hosp Epidemiol. 2011 Nov;32(11):1130-2. PMID: 22011544

Jury LA, Cadnum JL, Jennings-Sanders A, et al. Evaluation of an alcohol-based power sanitizing system for decontamination of hospital rooms of patients with methicillin-resistant Staphylococcus aureus carriage. Am J Infect Control. 2010 Apr;38(3):234-6. PMID: 20085852

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Kaupp S, Heizmann WR. Efficacy of disinfectants against multiresistant staphylococci. Klin Labor. 1995;41(12):979-85.

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Lerones C, Mariscal A, Carnero M, et al. Assessing the residual antibacterial activity of clinical materials disinfected with glutaraldehyde, o-phthalaldehyde, hydrogen peroxide or 2-bromo-2-nitro-1,3-propanediol by means of a bacterial toxicity assay. Clin Microbiol Infect. 2004 Nov;10(11):984-9. PMID: 15522001

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Lowe JJ, Gibbs SG, Iwen PC, et al. Impact of chlorine dioxide gas sterilization on nosocomial organism viability in a hospital room. Int J Environ Res Public Health. 2013 Jun;10(6):2596-605. PMID: 23792697

Matlow AG, Wray R, Richardson SE. Attitudes and beliefs, not just knowledge, influence the effectiveness of environmental cleaning by environmental service workers. Am J Infect Control. 2012 Apr;40(3):260-2. PMID: 21741727

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Nerandzic MM, Cadnum JL, Eckart KE, et al. Evaluation of a hand-held far-ultraviolet radiation device for decontamination of Clostridium difficile and other healthcare-associated pathogens. BMC Infect Dis. 2012 May 16;12:120. PMID: 22591268

O'Neill C, Ramage L, Wyatt L, et al. Quality control is indispensable for automated dilution systems with accelerated hydrogen peroxide. Can J Infect Control. 2009 Winter;24(4):226-8. PMID: 20128258

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Wren MW, Rollins MS, Jeanes A, et al. Removing bacteria from hospital surfaces: a laboratory comparison of ultramicrofibre and standard cloths. J Hosp Infect. 2008 Nov;70(3):265-71. PMID: 18801594

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You E, Song H, Cho J, et al. Reduction in the incidence of hospital-acquired Clostridium difficile infection through infection control interventions other than the restriction of antimicrobial use. Int J Infect Dis. 2014 May;e9-e10. PMID: 24583565

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Appendix C. Clinical Evidence

Table C-1. Characteristics of systematic reviews

Citation	Objective	Search Strategy	Key Inclusion/ Exclusion Criteria	Evidence Base	Interventions	Relevant Findings	Authors' Conclusions
Amodio and Dino 2014[107] Use of ATP bioluminescence for assessing the cleanliness of hospital surfaces: A review of the published literature (1990-2012)	To systematically review the evidence on ATP bioluminescence	Searches were completed in PubMed and Scopus. Bibliographies of articles retrieved were also searched. 31 articles were considered for inclusion.	Articles were excluded for not pertaining to hospital surfaces, being an experimental design, or being published before 1990.	Studies: 12 studies published from 2000 to 2011 were included. Studies were conducted in the United Kingdom (8), United States (3), and Brazil (1) Methods: Surfaces were monitored after cleaning (4 studies), before and after cleaning (6 studies), or not reported (2) Pathogens were not described.	ATP devices were provided by 3M (5), Biotrace (4) and Hygiena (3). ATP thresholds (RLUs): 100: 2 (16.7%) 250: 5 (41.7%) 500: 4 (33.3%) Both 250 and 500: 1 (8.3%)	ATP measurements before cleaning (RLUs): Ranged from 0 to >500,000 ATP measurements after cleaning (RLUs): Ranged from 3 to 500,000 Failure rates before cleaning: 21.2% to 93.1% Failure rates after cleaning: 5.3% to 96.5%	"Although the use of ATP bioluminescence can be considered a quick and objective method for assessing hospital cleanliness, it appears to be still poorly standardized at both the national and international level."

Table C-1. Characteristics of systematic reviews (continued)

Citation	Objective	Search Strategy	Key Inclusion/ Exclusion Criteria	Evidence Base	Interventions	Relevant Findings	Authors' Conclusions
Mitchell et al. 2013[108] Methods to evaluate environmental cleanliness in healthcare facilities	To describe monitoring methods used in environmental cleaning	Searches in Medline, Cinahl, and PubMed for English language publications. A search of the grey literature included infection-control professional organization websites, Australian state government sites, and international guidelines.	Article addressing the efficacy of cleaning. Environmental cleanliness was categorized as process evaluation (visual inspection, use of fluorescent gel marker) and outcome evaluation (use of ATP or microbial cultures).	124 articles were reviewed. Number of articles included not reported.	Visual inspection, fluorescent gel marker, ATP, microbial cultures	Visual inspection (6 studies): Poor performance at identifying microbial load with 17%–93% more surfaces identified as "clean" than other assessment methods. Fluorescent gel marker (7 studies): Frequently demonstrates a "lack of attention to high-risk surfaces in the near-patient zone." ATP: ATP measurements have low specificity and sensitivity in detecting bacteria (1 study reported sensitivity/specificity of 57%). Factors that may affect ATP readings include residual detergents or disinfectants, including sodium hydrochlorite, eroded surfaces, plasticizers found in microfiber cloths or ammonium compounds found in laundry products. Microbiological sampling: Sampling to detect specific bacteria is "generally only recommended as part of an ongoing outbreak investigation, as a research study, or as part of a policy or process evaluation" since the process may take at least 2 days, requires expertise and lab access.	"Methods that evaluate cleaning performance are useful in assessing adherence to cleaning protocols, whereas methods that sample bio-burden provide a more relevant indication of infection risk. Fast, reproducible, cost-effective and reliable methods are needed for routine environmental cleaning evaluation in order to predict timely clinical risk."

Table C-1. Characteristics of systematic reviews (continued)

Citation	Objective	Search Strategy	Key Inclusion/ Exclusion Criteria	Evidence Base	Interventions	Relevant Findings	Authors' Conclusions
Falagas et al. 2011[69] Airborne hydrogen peroxide for disinfection of the hospital environment and infection control: a systematic review	To review the effectiveness of airborne hydrogen peroxide in a clinical setting	Searches were completed in PubMed through December 2009. Bibliographies of relevant articles were also searched.	Included studies focused on the effectiveness of airborne hydrogen peroxide for reducing bacterial burden in the hospital setting and discussed pathogens naturally dispersed in this setting.	Studies: 10 studies were included. Pathogens addressed were MRSA (5), *C. difficile* (3), and multiple pathogens (2). Settings: Surgical wards, ward side rooms, single isolation rooms, multiple-bed ward bays, bathrooms, and other utility rooms. High-touch areas: Chairs, bed frames, control panels, bedside tables, remote controls, door handles, bed rails, telephones, sink taps, toilet seats, and sites handled by HCWs. Pathogens: MRSA, *C. difficile*, and others	7 studies evaluated the BioQuell HPV system BioQuell Ltd., Andover, Hampshire, UK) 3 studies evaluated a hydrogen peroxide dry-mist system or "dry fog" (Gloster Sante Europe, Labège Cedex, France)	Disinfection: Contamination of sampled environmental sites Before cleaning (9 studies): 39.0% (range: 18.9%–81.0%) After terminal cleaning (6 studies): 28.3% (range: 11.9%–66.1%) After airborne hydrogen peroxide (10 studies): 2.2% (range: 0%–4.0%) Infection Control 1 study indicated eradication of MRSA in 1 20-bed surgical ward. Another study indicated significant reductions in *C. difficile*-associated disease in a 500-bed university-affiliated hospital.	"Data from several relevant studies indicate that disinfection of the hospital environment using airborne hydrogen peroxide in vapour or dry mist formulations, appears to provide additional benefits to currently used cleaning regimens, including inactivation of bacterial spores. Few studies have evaluated the use of airborne hydrogen peroxide disinfection as an adjunctive infection control measure in actual hospital practice. These limited relevant data are favourable, but further studies are needed to assess the effectiveness, safety, costs, and applicability of this novel method against other available cleaning methods."

Table C-1. Characteristics of systematic reviews (continued)

Citation	Objective	Search Strategy	Key Inclusion/ Exclusion Criteria	Evidence Base	Interventions	Relevant Findings	Authors' Conclusions
Dettenkofer et al. 2004[70] Does disinfection of environmental surfaces influence nosocomial infection rates?	To review evidence for the effects of disinfection of environmental surfaces on hospital-acquired infection rates	Biological Abstracts/BIOSIS Previews (1980–1988/ 1989–2001); Cochrane Library (2001, Issue 4) Cochrane Clinical Trials Register; HECLINET: Health Care Literature Information Network (1969–2000); Medline (Ovid, 1966–2001); Science Citation Index (1991–1996); SwetScan (1997–2001); Web of Science (Science Citation Index Expanded, 1997–2001); EMBASE (1974–2001) and EMBASE alert; and Somed (1978–2000). General internet search was also undertaken.	Randomized controlled trials, cohort, case-control, and observational studies in English, German, French, Italian, and Spanish evaluating use of disinfectant or detergent for "inanimate surfaces" in health care settings were included.	4 trials discussed impact of disinfectant vs. detergent on environmental surfaces. Dharan study compared NI rates in 2 different wings of a medical unit over 4 months. Danforth study used a crossover design to examine NI rates in 8 wards in a tertiary care teaching hospital over 3 months. Daschner study examined NI rates in ICU units over 12 months. Mayfield study examined use of 2 disinfectants on incidence of *C. difficile* in bone marrow transplant patients and patients in neurosurgical ICU and general medicine units. High-touch areas: Floors, furniture, bathrooms, toilets, and isolation rooms (Dharan) Floor (Danforth) Floor, patient care equipment, bedside tables, and bed frame (Daschner) Not described (Mayfield) Pathogens: MRSA, *C. difficile*, and others	Dharan study QAC, an active oxygen-based compound, and an alcohol solution Danforth study Disinfectant orthobenzyl parachlorophenol or detergent Daschner study Disinfectant (0.5% aldehyde) and detergent Mayfield study QAC or 1:10 hypochlorite solution	Dharan study *Detergent only:* Increase in bacterial surface counts *QAC:* No reduction in bacterial counts *Active oxygen-based compound, the alcohol solution, and the dust-attracting floor mop:* Significant reduction of bacterial counts. Dharan, Danforth and Dashner studies *Occurrence of NI:* No significant difference Mayfield study: *CDAD incidence:* Significant decrease in rates in bone marrow transplant patients, no reduction in patients on neurosurgical intensive care or general medicine unit	"Disinfectants may pose a danger to staff, patients, and the environment and require special safety precautions. However, targeted disinfection of certain environmental surfaces is in certain instances an established component of hospital infection control. Given the complex, multifactorial nature of nosocomial infections, well-designed studies that systematically investigate the role of surface disinfection are required."

ATP=adenosine triphosphate; CDAD=Clostridium difficile-associated diarrhea; *C. difficile=Clostridium difficile*; HCW=healthcare workers; ICU=intensive care unit; MRSA=methicillin-resistant staphylococcus aureus; NI=nosocomial infection; QAC=quaternary ammonium compound; RLU=relative light unit

Table C-2. Study characteristics of cleaning and disinfection studies

Author	Country	Study Design	General Cleaning Method	Study Length	Sample Size	Primary Setting	Pathogens	High-Touch Objects
Best et al. 2014[74]	United Kingdom	Before/after	SC and AC	20 weeks	342 sites	Rehabilitation ward	*C. difficile*	Bed, curtain track, wall trunking, patient line boxes, tops of hoist rail
Boyce et al. 2014[105]	United States	Before/after	EC	4 weeks	9 rooms 1,155 samples	Ward not specified	NR	Bed rail, remote control, toilet, tray table, telephone, doorknob, sink
Haas et al. 2014[86]	United States	Before/after	AC	2 years	11,389 rooms	Ward not specified	*C. difficile*, MRSA, VRE	NR
Jinadatha et al. 2014[1]	United States	Non-randomized controlled	SC and AC	2 months	20 rooms (10 per arm)	Ward not specified	MRSA	Bed rail, call buttons, toilet, tray table, bathroom handrail
Mitchell et al. 2014[50]	Australia	Interrupted time series	SC and AC	6 years	3,600 discharge cleans	Ward not specified	MRSA	Bed, vent, sink, console, chair, table, locker, mattress, pillow
Sjöberg et al. 2014[104]	Sweden	Before/after	SC	8 months	10 rooms 150 samples	NR	*C. difficile*	Bed rail, call button, side table, toilet, doorknob
Wiemken et al. 2014[106]	United States	Randomized controlled	SC	1 month	9 rooms	Ward not specified	Hardy pathogens	Side table, toilet, sink
Anderson et al. 2013[75]	United States	Prospective cohort	AC	15 months	27 rooms 142 samples	Ward not specified	Various pathogens including: *C. difficile*, VRE	Bed rail, floor, side table, toilet, chair arm, overbed table, sink counter
Boyce and Havill 2013[89]	United States	Before/after	SC	NR	72 rooms	Ward not specified	NR	Bed rail, remote control, toilet, tray table, phone, bedside panel, chair arm, blood pressure cuff, grab bar, and faucet handle
Friedman et al. 2013[61]	Australia	Interrupted time series	SC	10 days	21 rooms 1,026 samples	Cancer ward	VRE	Floor, remote control, toilet, tray table, phone, locker drawer handle, bathroom tap
Gillespie et al. 2013[63]	Australia	Before/after	SC	3 months	10 rooms 200 samples	General medical ward, residential aged care ward	*C. difficile*, VRE	Not specified
Hess et al. 2013[90]	United States	Randomized controlled	SC	10 months	132 rooms 4,444 samples	ICU, surgical ward	Various pathogens including: MRSA	Bed rail, call button, light switch, tray table, bed control, desk, intravenous poles and infusion pumps, phone, room sink, supply cart, and others
Levin et al. 2013[87]	United States	Interrupted time series	AC	1 year	NR	ICU, contact precaution and other rooms	*C. difficile*	Patient room, including bathroom

Table C-2. Study characteristics of cleaning and disinfection studies (continued)

Author	Country	Study Design	General Cleaning Method	Study Length	Sample Size	Primary Setting	Pathogens	High-Touch Objects
Mahida et al. 2013[88]	United Kingdom	Before/after	AC	NR	6 rooms 32 locations	Intensive therapy unit, OR, and ward isolation room	Various pathogens including: MRSA, VRE	Not specified
Manian et al. 2013[103]	United States	Before/after	SC and AC	3 years	870 rooms 1,123 rounds of cleaning	Ward not specified	*C. difficile*	Bed rail, call button, light switch, telephone, doorknob, sink
Passaretti et al. 2013[77]	United States	Prospective cohort	SC and AC	30 months	1,039 rooms 6,607 patients	ICU	Various pathogens including: *C. difficile*, MRSA, VRE	Bed rail, computer keyboard, electronic monitoring equipment
Salgado et al. 2013[73]	United States	Randomized controlled	SC and EC	11 months	16 rooms (8 copper, 8 standard) 614 patients (294 cared for in rooms with copper)	ICU	*C. difficile*, MRSA, VRE	Bed rail, overbed table, bed footboard, intravenous poles and arms of the visitors chair
Schmidt et al. 2013[72]	United States	Non-randomized controlled	AC and EC	3 months	75 beds	ICU	Various pathogens	Bed rail
Sigler and Hensley 2013[76]	United States	Before/after	SC	NR	10 rooms	Rooms occupied by patients with Staph infections (usually MRSA)	Various pathogens including: MRSA	Bed rail, call button, floor, tray table, sink, TV button, telephone
Sitzlar et al. 2013[64]	United States	Interrupted time series	SC and AC	21 months	NR	General medical ward, surgical ward	*C. difficile*	Bed rail, call button, toilet, tray table, telephone
Goldenberg et al. 2012[57]	United Kingdom	Before/after	SC	4 months	13 wards	General medical ward, surgical ward, plastic surgery, orthopedics, elderly care, acute admissions	*C. difficile*	Bed rail, call button, floor, remote control, toilet, telephone, locker, chair, sluice room, side room, mop bucket, and others
Grabsch et al. 2012[91]	Australia	Interrupted time series	SC	24 months	NR	ICU, cancer ward, liver transplant, renal	VRE	Call button, curtain, locker handle, chair, chart, supplies trolley, phone
Havill et al. 2012[93]	United States	Non-randomized controlled	AC	NR	15 rooms	Ward not specified	Various pathogens including: *C. difficile*	Bed rail, remote control, toilet, tray table

Table C-2. Study characteristics of cleaning and disinfection studies (continued)

Author	Country	Study Design	General Cleaning Method	Study Length	Sample Size	Primary Setting	Pathogens	High-Touch Objects
Kundrapu et al. 2012[78]	United States	Randomized controlled	SC	NR	70 patients	Ward not specified	*C. difficile*, MRSA	Bed rail Call button Side table Toilet telephone, chair, wall mounted vital signs equipment, IV medication stand, door knobs and handles,
Schmidt et al. 2012[79]	United States	Randomized controlled	SC and AC	3 months	NR	Ward not specified	Various pathogens including: MRSA, VRE	Bed rail
Schmidt et al. 2012[92]	United States	Before/after	SC and EC	43 months	1,587 rooms 9,522 objects	ICU	*C. difficile*, MRSA, VRE	Bed rail, call button, tray table, intravenous stand, visitor chair, computer mouse, data input device
Boyce et al. 2011[82]	United States	Before/after	AC	NR	25 rooms	Ward not specified	*C. difficile*	Bed rail, toilet, tray table, television remote
Carter and Barry 2011[58]	United Kingdom	Before/after	SC	18 months	NR	NR	*C. difficile*	Light switch, toilet, furniture, bed frame, intravenous pump
Chan et al. 2011[81]	Australia	Non-randomized controlled	SC and AC	NR	NR	Ward not specified	VRE	Call button, side, toilet, arm rest, cotside
Orenstein et al. 2011[94]	United States	Before/after	SC	2 years	NR	General medical ward	*C. difficile*	Not specified
Sexton et al. 2011[80]	United States	Before/after	Steam vapor	2 days	8 rooms	Long-term care wing	Various pathogens including: C. difficile, MRSA	Bed rail, side table, guest chair arm, sink, door push panel
Wilson et al. 2011[83]	United Kingdom	Randomized crossover	SC and “enhanced cleaning”	1 year	20,736 samples 1,152 bed days	ICU	Various pathogens including: *C. difficile*, MRSA, VRE	Bed rail, drawer handle, chart, keyboard, syringe driver, nurses hand, monitor
Alfa et al. 2010[84]	Canada	Before/after	SC	19 months	243 patients 714 samples	Ward not specified	*C. difficile*	Toilet
Casey et al. 2010[99]	United Kingdom	Non-randomized controlled	EC	10 weeks	NR	General medical ward, common area	Various pathogens including: *C. difficile*, MRSA, VRE	Toilet, sink, door push plate

Table C-2. Study characteristics of cleaning and disinfection studies (continued)

Author	Country	Study Design	General Cleaning Method	Study Length	Sample Size	Primary Setting	Pathogens	High-Touch Objects
Hacek et al. 2010[96]	United States	Before/after	SC	3 years	All rooms occupied by patients with *C. difficile* in 3 hospitals; # not specified	Ward not specified	*C. difficile*	Bed, bed rail, bed control, floor, side table, toilet, tray table, doorknob, sink, wall
Hamilton et al. 2010[98]	United Kingdom	Non-randomized controlled	SC	7 weeks	NR	Ward not specified	NR	Bed, floor, tray table
Hedin et al. 2010[97]	Sweden	Non-randomized controlled	EC	3 weeks	12 rooms 36 samples	infectious disease ward	Various pathogens including: MRSA	Side table
Rutala et al. 2010[95]	United States	Before/after	AC	8 months	8 rooms	Ward not specified	*C. difficile*, MRSA	Bed rail, floor
Andersen et al. 2009[85]	Norway	Non-randomized controlled	SC	NR	4 rooms 192 samples	Geriatric ward	Various pathogens including: *C. difficile*, MRSA, VRE	Floor
McMullen et al. 2007[100]	United States	Non-randomized controlled	SC	2.5 years	Entire medical and surgical ICUs included for 2 1/2 years	ICU, common area	*C. difficile*	Not specified
Whitaker et al. 2007[59]	United States	Before/after	SC	2 years	NR	Ward not specified	*C. difficile*	"Every lateral surface"
De Lorenzi et al. 2006[101]	Italy	Non-randomized controlled	Mopping methods	5 days	2 rooms	Surgical ward	NR	Floor
Wilcox et al. 2003[102]	United Kingdom	Non-randomized controlled	SC	2 years	1,128 samples	2 "elderly medicine wards"	*C. difficile*	Bed rail, floor, toilet
Byers et al. 1998[71]*	United States	Before/after	SC	NR	10 conventional rooms, 4 bucket method; 376 conventional samples, 135 bucket samples	Ward not specified	VRE	Bed rail, floor, side table, intravenous pole, phone, blood pressure cuff, wall panel control

*Described an outbreak situation

AC=automated cleaning; *C. difficile=Clostridium difficile*; EC=enhanced coating; ICU=intensive care unit; MRSA=methicillin-resistant *staphylococcus aureus*; NR=not reported; OR=operating room; SC=surface cleaning; VRE=vancomycin-resistant enterococci

Table C-3. Methods of cleaning and disinfection studies*

Author	Cleaning Method	Monitoring Method	Implementation Tools
Best et al. 2014[74]	Chlor-Clean disinfectant (Gues Medical Ltd, Aylesford, UK), Deprox hydrogen peroxide decontamination unit (Hygiene Solutions, Kings Lynn, UK)	Sponge/wipe cultures	NR
Boyce et al. 2014[105]	Organosilane antimicrobial coatings (Eco Antimicrobial; Micro-Texpur, Conover, NC; and Bio-Protect AM500; PureShield, Inc, Jupiter, FL)	Agar slide cultures	NR
Haas et al. 2014[86]	Pulsed xenon ultraviolet light (PPX-UV)(Xenex Corp., Austin, TX)	NR	NR
Jinadatha et al. 2014[1]	Dispatch bleach solution, PPX-UV (Xenex Healthcare Services, San Antonio, TX)	Contact plates	NR
Mitchell et al. 2014[50]	ph neutral detergent, dry hydrogen vapor room decontamination system (Nocospray, EquipMed, North Ryde, New South Wales, Australia)	Swab cultures	Competency-based training, staff feedback
Sjöberg et al. 2014[104]	Potassium monopersulfate-based disinfectant Virkon™ (Antec International Ltd, Sudbury, UK)	NR	NR
Wiemken et al. 2014[106]	Sodium hypochlorite cleaner/disinfectant solutions (ready-to-use wipes versus bucket method)	Fluorescent/UV markers	Employee productivity and compliance
Anderson et al. 2013[75]	Ultraviolet-C (UV-C) emitter (Tru-D Smart UVC, Lumalier, Memphis, TN).	Contact plates	NR
Boyce and Havill 2013[89]	Hydrogen peroxide disinfectant wipe (Activated Hydrogen Peroxide; Clorox Healthcare)	ATP bioluminescence, Agar contact plates for aerobic bacteria	NR
Friedman et al. 2013[61]	Benzalkonium chloride-based product, Viraclean (Whiteley Industries PTY LTD, Tomago, New South Wales, Australia) or disposable V-wipes	Swab cultures	Audits
Gillespie et al. 2013[63]	Ultramicrofiber cloths (Johnson Diversey, Racine, WI) and steam (UMF/steam) technology	ATP bioluminescence, Fluorescent/UV markers, visual observation, swab cultures	Education, infection control sessions for cleaning staff, feedback from staff focus groups
Hess et al. 2013[90]	Enhanced cleaning (cleaning targeted at frequently touched, frequently contaminated surfaces), with wipes saturated with quaternary ammonium	Fluorescent/UV markers, swab cultures	NR
Levin et al. 2013[87]	PPX-UV device (Xenex Healthcare Services, San Antonio, TX)	NR	NR
Mahida et al. 2013[88]	UV-C (Tru-D™; manufacturer not specified)	Surface contact plates and seeded petri dishes	NR
Manian et al. 2013[103]	Bleach, hydrogen peroxide vapor decontamination (Bioquell, Andover, UK)	NR	NR
Passaretti et al. 2013[77]	Quaternary ammonium compound (QAC; 3M, St Paul, Minnesota). Oxivir disinfectant (Johnson Diversity, Sturtevant, Wisconsin), and hydrogen peroxide vapor (Bioquell, Horsham, PA)	Swab cultures	NR
Salgado et al. 2013[73]	Virex 256 (Johnson-Diversey), Dispatch (Caltech Industries), and Cavicide (Metrex); copper enhanced surfaces	NR	NR
Schmidt et al. 2013[72]	Virex II 256 dispensed from an automated dilution system (Use Solution, Johnson Diversey); copper enhanced surfaces	Wipes	NR
Sigler and Hensley 2013[76]	QAC, microfiber cloths and mops	Visual observation	NR

Table C-3. Methods of cleaning and disinfection studies* (continued)

Author	Cleaning Method	Monitoring Method	Implementation Tools
Sitzlar et al. 2013[64]	Clorox Germicidal Wipes, UV-C (Tru-D, Lumalier, Memphis, TN)	ATP bioluminescence, fluorescent/UV markers	Education and feedback to staff (monthly meeting, small group meetings, and for individuals); a dedicated daily disinfection team and implementation of a process requiring supervisory assessment and clearance of terminally cleaned CDI rooms
Goldenberg et al. 2012[57]	A chlorine dioxide-based disinfectant, Difficil-S (Clinimax Ltd, Bury St Edmunds, UK).	Swab cultures	Training on preparation, use, and storage of the product; monthly environmental cleaning audits
Grabsch et al. 2012[91]	Bleach-Clean, a bleach-based disinfection program	Swab cultures	Employment of cleaning supervisors; new verbal and written training program for cleaners; new system of performance appraisal and benchmarking; regular monthly screening of standardizes sites
Havill et al. 2012[93]	Hydrogen peroxide vapor (Bioquell, Horsham, PA) vs. UV-C (Tru-D, Lumalier, Memphis, TN)	Agar slide cultures	NR
Kundrapu et al. 2012[78]	Daily cleaning of high-touch surfaces vs. cleaning only when soiled	Glove and hand plate cultures	NR
Schmidt et al. 2012[79]	Virex 256 soaked on a washcloth, QAC as a microdroplet from the PureMist system (PureCart Systems, Green Bay, WI)	Agar slide cultures	NR
Schmidt et al. 2012[92]	Virex 256 (Johnson-Diversey), Dispatch (Caltech Industries), and Cavicide (Metrex); copper-enhanced surfaces	Swab cultures	NR
Boyce et al. 2011[82]	Mobile UV-C (Tru-D; Lumalier, Memphis, TN)	Contact plates	NR
Carter and Barry 2011[58]	Peracetic acid-releasing sporicidal wipes	NR	Training, infection prevention, and control awareness days, ward visits by nurses included feedback with staff; flyers and newsletters were disseminated.
Chan et al. 2011[81]	A neutral detergent (HC90, Agar Cleaning Systems, Preston, Victoria, Australia) two hypochlorite-based products Bleach (Agar Cleaning Systems, Preston, Victoria, Australia) and Det-Sol 500 (Eucalip Bio Chemicals, Dandenong South, Victoria, Australia) ; and hydrogen peroxide vapour (Nocospray, EquipMed, North Ryde, NSW, Australia)	Contact plates	NR
Orenstein et al. 2011[94]	Germicidal bleach wipes	ATP bioluminescence, visual observation	NR
Sexton et al. 2011[80]	Steam vapor (VaporJet PC 2400 Steam Vapor System with the TANCS component from Advanced Vapor Technologies (Seattle, WA).)	Wipe/swatch cultures	NR
Wilson et al. 2011[83]	Detergent, alcohol spray, Actichlor Plus (Ecolab, Swindon, UK), steam cleaning, enhanced cleaning using microfiber cloths (Johnson Diversey Northampton, Northants, UK)	Agar slide cultures, contact plates, hand cultures	NR
Alfa et al. 2010[84]	Oxivir accelerated hydrogen peroxide (AHP) (Diversey, Sturtevant, WI) vs. PerDiem stabilized hydrogen peroxide (SHP) (Diversey, Sturtevant, WI)	Fluorescent/UV markers, contact plates	NR
Casey et al. 2010[99]	Copper surfaces	NR	NR
Hacek et al. 2010[96]	Bleach	NR	NR

Table C-3. Methods of cleaning and disinfection studies* (continued)

Author	Cleaning Method	Monitoring Method	Implementation Tools
Hamilton et al. 2010[98]	Ultramicrofiber cloths and mops, copper biocide	Agar slide cultures	NR
Hedin et al. 2010[97]	"Appeartex," an antimicrobial coating (Appeartex AB, Göteborg, Sweden)	Swab cultures, Agar slide cultures	NR
Rutala et al. 2010[95]	UV-C light emitting (Tru-D; Lumalier Corporation, Memphis, TN)	Agar slide cultures	NR
Andersen et al. 2009[85]	4 floor-mopping methods (dry, spray, moist and wet)	ATP bioluminescence, contact plates	NR
McMullen et al. 2007[100]	Bleach	NR	NR
Whitaker et al. 2007[59]	Bleach	NR	Education for staff, patients, and visitors
De Lorenzi et al. 2006[101]	Floor cleaning by dry, then wet mopping versus wet, then dry mopping	Agar slide cultures	NR
Wilcox et al. 2003[102]	Bleach	Swab cultures	NR
Byers et al. 1998[71]	Quaternary ammonium spray vs. bucket method (drenching surface)	Swab cultures	NR

*None of the studies discussed patient safety culture or sustainability of programs. For external factors, Mitchell et al. 2014[50] discussed the external quality control process undertaken by the manufacturer.

ATP=adenosine triphosphate; CDI=*Clostridium difficile* infection; HT=high touch; IPC=infection protection and control; NR=not reported; UV=ultraviolet; UV-C=ultraviolet light

Table C-4. Outcomes and conclusions of cleaning/disinfection studies

Author	Primary Outcome	Secondary Outcome of Interest	Authors Conclusions
Best et al. 2014[74]	Sites positive for *C. diff*, CDI incidence	*C. diff* ribotypes	"HPD, after deep cleaning with a detergent/chlorine agent, was highly effective for removing environmental C. difficile contamination. Long-term follow-up demonstrated that a CDI-symptomatic patient can rapidly recontaminate the immediate environment. Determining a role for HPD should include long-term cost-effectiveness evaluations."
Boyce et al. 2014[105]	Mean ACC	NR	"Cultures of surfaces obtained before daily cleaning with a quaternary ammonium disinfectant showed no significant residual antimicrobial activity of the organosilane products, although a modest reduction could not be excluded."
Haas et al. 2014[86]	Incidence rate of HAIs	NR	"During the time period UVD was in use, there was a significant decrease in overall hospital-acquired MDRO plus CD in spite of missing 24% of opportunities to disinfect contact precautions rooms. This technology was feasible to use in our acute care setting and appeared to have a beneficial effect."
Jinadatha et al. 2014[1]	ACC, total MRSA	Individual surface counts, cleaning time in minutes	"PPX-UV technology appears to be superior to manual cleaning alone for MRSA and HPC. Incorporating 15 minutes of PPX-UV exposure time to current hospital room cleaning practice can improve the overall cleanliness of patient rooms with respect to selected micro-organisms."
Mitchell et al. 2014[50]	Incidence of MRSA	NR	"Use of HP disinfection led to a decrease in residual MRSA contamination in patient rooms compared with detergent. It may also have encouraged the reduction in patient MRSA acquisition despite several confounders including staff feedback on terminal cleaning, additional MRSA screening and quicker laboratory methods. Infection control is best served by concurrent interventions targeting both the patient and healthcare environment."
Sjöberg et al. 2014[104]	Sites positive for culture	NR	"We demonstrated a moderate spread of CD spores to the environment despite routine cleaning procedures involving Vikron."
Wiemken et al.[106]	Compliance with room protocol	Time needed to clean	"In conclusion, this study supports the use of RTU CD wipes over the traditional bucket method. Enhancing environmental processes may reduce the environmental bioburden, leading to reductions in HAIs because of environmentally hardy pathogens."
Anderson et al. 2013[75]	Total number of CFU, median number of CFUs per sample	NR	"Our data confirm that automated UV-C-emitting devices can decrease the bioburden of important pathogens in real-world settings such as hospital rooms."
Boyce and Havill 2013[89]	CFU	RLU, adverse effects	"The activated hydrogen peroxide wipe product evaluated in our study proved to be an effective surface disinfectant, as reflected by ACC and ATP bioluminescence assays. ATP bioluminescence assays can be used as a tool to monitor the effectiveness of cleaning practices while using an activated hydrogen peroxide disinfectant. Additional studies are warranted to determine whether ATP and ACC cutoff points used to classify surfaces as clean should vary depending on the surface sampled."
Friedman et al. 2013[61]	VRE positive samples	VRE colonization rates, rate per 1,000 patient days	"During use of a chlorine-based, 3-staged protocol, significantly higher residual levels of VRE contamination were identified, compared with levels detected during use of a benzalkonium chloride based product for disinfection. This reduction in VRE may be due to a new disinfection product, more attention to the thoroughness of cleaning, or other supplementary efforts in our institution."
Gillespie et al. 2013[63]	RLU	NR	"Our pilot study supports using ultramicrofiber cloth and steam technology as an alternative to cleaning with chemicals."

Table C-4. Outcomes and conclusions of cleaning/disinfection studies (continued)

Author	Primary Outcome	Secondary Outcome of Interest	Authors Conclusions
Hess et al. 2013[90]	Contamination rates for health care worker gowns and gloves	NR	"Intense enhanced daily cleaning of ICU rooms occupied by patients colonized with MRSA or MDRAB was associated with a nonsignificant reduction in contamination of HCW gowns and gloves after routine patient care activities. Further research is needed to determine whether intense environmental cleaning will lead to significant reductions and fewer infections."
Levin et al. 2013[87]	Hospital-associated CDI rate per 10,000 patient days	HA-CDI attributable deaths, HA-CDI attributable colectomies	"In 2010, the HA-CDI rate was 9.46 per 10,000 patient-days; in 2011, the HA-CDI rates was 4.45 per 10,000 patient-days (53% reduction, P = .01). The number of deaths and colectomies attributable to hospital-associated C difficile infection also declined dramatically."
Mahida et al. 2013[88]	CFU	Disinfection times	"UV-C is an emerging decontamination technology that is effective in reducing bacterial contamination in the clinical environment. There are significant advantages to using UV-C, and, based on the results of this study we would recommend using Tru-D at the higher reflected dose setting of 22,000 mWs/cm^2 for terminal room disinfection in most healthcare settings."
Manian et al. 2013[103]	*C. diff*-associated diarrhea rate per 1,000 patient days	NR	"Implementation of an enhanced hospital-wide terminal cleaning program revolving around HPV decontamination of targeted hospital rooms was practical, safe, and associated with a significant reduction in the endemic rate of CDAD at our hospital. Further studies are needed to delineate better the role of HPV decontamination in reducing the endemic rate of transmission of other pathogens with significant environmental presence in hospitals."
Passaretti et al. 2013[77]	Adjusted incidence rate ratio	Proportion of contaminated rooms, MDRO matches/differs from the current room occupant	"HPV decontamination reduced environmental contamination and the risk of acquiring MDROs compared with standard cleaning protocols."
Salgado et al. 2013[73]	Rate of colonization	Length of stay, mortality	"Patients cared for in ICU rooms with copper alloy surfaces had a significantly lower rate of incident HAI and/or colonization with MRSA or VRE than did patients treated in standard rooms. Additional studies are needed to determine the clinical effect of copper alloy surfaces in additional patient populations and settings."
Schmidt et al. 2013[72]	Bacterial burden	NR	"Copper, when used to surface hospital bed rails, was found to consistently limit surface bacterial burden before and after cleaning through its continuous antimicrobial activity."
Sigler and Hensley 2013[76]	PCR positive for staph	NR	"Overall, genetic markers for several staphylococci known to colonize and infect humans remained ubiquitous in each room following daily disinfection practices."
Sitzlar et al. 2013[64]	Percent of targets cleaned	Disinfection as measured by cultures	"An intervention that included education as well as monitoring and feedback improved thoroughness of cleaning but did not significantly improve CDI room disinfection. The use of an automated UV device improved disinfection, but 35% of rooms remained culture positive after use. Disinfection was dramatically improved through formation of a dedicated daily disinfection team and implementation of a standardized process for clearing CDI rooms."
Goldenberg et al. 2012[57]	Number of contaminated sites	CDI rate	"The prevalence of environmental contamination was unaffected with a rate of 8% (9/120) before and 8% (17/212) following the change. Rates of patient infection were also unchanged during these periods."
Grabsch et al. 2012[91]	VRE colonization	Newly recognized VRE colonization, total burden of inpatient VRE colonization	"The Bleach-Clean programme was associated with marked reductions in new VRE colonizations in high-risk patients, and VRE bacteraemia across the entire hospital. These findings have important implications for VRE control in endemic healthcare settings."
Havill et al. 2012[93]	ACC	NR	"Both HPV and UVC reduce bacterial contamination, including spores, in patient rooms, but HPV is significantly more effective. UVC is significantly less effective for sites that are out of direct line of sight."

Table C-4. Outcomes and conclusions of cleaning/disinfection studies (continued)

Author	Primary Outcome	Secondary Outcome of Interest	Authors Conclusions
Kundrapu et al. 2012[78]	CFU	Frequency of health care worker hand contamination	"In a randomized nonblinded trial, we demonstrated that daily disinfection of high-touch surfaces in rooms of patients with Clostridium difficile infection and methicillin-resistant Staphylococcus aureus colonization reduced acquisition of the pathogens on hands after contacting high-touch surfaces and reduced contamination of hands of healthcare workers caring for the patients."
Schmidt et al. 2012[79]	CFU	Overall microbial burden	"There was no difference in effectiveness, with a mean relative reduction of microbial burden of 84% for the traditional method versus 88% for the PureMist method."
Schmidt et al. 2012[92]	CFU	NR	"The introduction of copper surfaces to objects formerly covered with plastic, wood, stainless steel, and other materials found in the patient care environment significantly reduced the overall MB on a continuous basis, thereby providing a potentially safer environment for hospital patients, health care workers (HCWs), and visitors."
Boyce et al. 2011[82]	Mean ACC (CFU per plate)	Proportion of surfaces yielding a positive culture result (more than 1 CFU); number of surfaces yielding >2.5CUs/cm^2 for the ACC	"The mobile UV-C light unit significantly reduced aerobic colony counts and C. difficile spores on contaminated surfaces in patient rooms."
Carter and Barry 2011[58]	CDI rate per 1,000 patients, overall rate of C diff infection	NR	"The introduction of sporicidal wipes resulted in a significant reduction in C. difficile rates. This supports the need to review and enhance traditional environmental cleaning regimens for preventing and controlling C difficile in acute settings."
Chan et al. 2011[81]	CFU	NR	"These results showed that dry hydrogen peroxide vapour room decontamination is highly effective on a range of surfaces, although the cleanliness data obtained by these methods cannot be easily compared among the different surfaces as recovery of organisms is affected by the nature of the surface."
Orenstein et al. 2011[94]	*C. diff* incidence rates	NR	"We found that daily room cleaning with 0.55% germicidal bleach wipes led to a sustained reduction in hospital-acquired CDI on units with high endemic incidence of CDI. Targeting the use of daily bleach wipe cleaning to units with an increased C. difficile colonization pressure is an effective method to wipe out healthcare-acquired CDI."
Sexton et al. 2011[80]	CFU	Log(10) reduction	"The steam vapor system reduced bacterial levels by >90% and reduced pathogen levels on most surfaces to below the detection limit. The steam vapor system provides a means to reduce levels of microorganisms on hospital surfaces without the drawbacks associated with chemicals, and may decrease the risk of cross-contamination."
Wilson et al. 2011[83]	Number of bed areas from which target pathogens were isolated at least once during a sampling day	Unpooled results of screening for the target pathogens in bed/communal areas, total ACC	"Enhanced cleaning reduced environmental contamination and hand carriage, but no significant effect was observed on patient acquisition of methicillin-resistant Staphylococcus aureus."
Alfa et al. 2010[84]	CFU	NR	"Our data indicate that the AHP formulation evaluated that has some sporicidal activity was significantly better than the currently used SHP formulation. This AHP formulation provides a one-step process that significantly lowers the C. difficile spore level in toilets during non-outbreak conditions without the workplace safety concerns associated with 5,000 ppm bleach."
Casey et al. 2010[99]	Median CFU/cm^2	NR	"The results of this trial clearly demonstrate that copper-containing items offer the potential to significantly reduce the numbers of micro-organisms in the clinical environment. However, the use of antimicrobial surfaces should not act as a replacement for cleaning in clinical areas, but as an adjunct in the fight against HCAI."

Table C-4. Outcomes and conclusions of cleaning/disinfection studies (continued)

Author	Primary Outcome	Secondary Outcome of Interest	Authors Conclusions
Hacek et al. 2010[96]	*C. diff* cases per 1,000 patient days	NR	"The implementation of a thorough, all-surface terminal bleach cleaning program in the rooms of patients with CDI has made a sustained, significant impact on reducing the rate of nosocomial CDI in our health care system."
Hamilton et al. 2010[98]	Total viable bacterial counts	NR	"Cleaning with UMF reduces TVC in the hospital environment and this effect is significantly enhanced (about two-fold) with additional CuWB50. The copper-based biocide has two beneficial effects: (i) a residual effect that requires 2-3 weeks of cleaning to establish, and (ii) an immediate effect on reducing TVC that is most evident shortly after cleaning."
Hedin et al. 2010[97]	Total ACC	NR	"Significantly fewer bacteria were found on Appeartex-treated surfaces compared with untreated surfaces."
Rutala et al. 2010[95]	Total CFUs per site	NR	"This UV-C device was effective in eliminating vegetative bacteria on contaminated surfaces both in the line of sight and behind objects within approximately 15 minutes and in eliminating C. difficile spores within 50 minutes."
Andersen et al. 2009[85]	CFU	CFU in air, ease of use of ATP	"Wet, moist and dry mopping seemed to be more effective in reducing bacteria on the floor, than the spray mopping (P=0.007, p=0.002 and p=0.011, respectively). The burden of bacteria in air increased for all methods just after mopping. The overall best cleaning methods seemed to be moist and wet mopping."
McMullen et al. 2007[100]	Cases of *C. diff* -associated diarrhea per 1,000 patient days	NR	"These findings are further evidence that use of sodium hypochlorite solution may be an effective means of reducing the occurrence of CDAD in acute care facilities where the disease is epidemic or hyperendemic."
Whitaker et al. 2007[59]	*C. diff* infection rate per 1,000 patient days	NR	"A combination of automated daily isolation reports, use of a standardized methodology for isolation rounds, as well as development of a 10% hypochlorite disinfection protocol resulted in a dramatic decrease in health care-associated C difficile cases. Weekly nursing director reports and daily rounds by nursing leadership keep the direct line supervisors abreast of infection control issues on their respective nursing units. The addition of the dual-chamber bleach container ensured that the proper dilution was achieved when disinfecting reusable equipment."
De Lorenzi et al. 2006[101]	ACC	NR	"Dry wiping followed by damp washing did not produce any significant reduction in the average bacterial load. However, damp washing followed by dry wiping reduced the bacterial load for both types of flooring. The difference was statistically significant."
Wilcox et al. 2003[102]	Incidence rate of *C. diff* infection	Surface colonization	"Our results provide some evidence that hypochlorite environmental cleaning may significantly reduce CDI incidence, but also emphasize the potential for confounding factors."
Byers et al. 1998[71]	Number of colonized sites	Cost of labor and supplies, cost of keeping room empty	"Sixteen percent of hospital room surfaces remained colonized by 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."

ACC=aerobic colony counts; AHP=accelerated hydrogen peroxide; ATP=adenosine triphosphate; CD=cleaning and disinfection; CDAD=Clostridium difficile-associated diarrhea; CDI=Clostridium difficile infection; CFU=colony-forming unit; C diff=Clostridium difficile; HA-CDI=hospital-associated Clostridium difficile infection; HAI=hospital-associated infection; HCAI=healthcare-associated infection; HCW=healthcare worker; HP=hydrogen peroxide; HPC=heterotrophic plate counts; HPD=hydrogen peroxide decontamination; HPV=hydrogen peroxide vapor; ICU=intensive care unit; MB=microbial burden; MDRAB= multidrug-resistant Acinetobacter baumannii; MDRO=multiple-drug-resistant organisms; MRSA=methicillin-resistant staphylococcus aureus; PPX-UV=pulsed xenon ultraviolet light; RLU=relative light unit; RTU=ready-to-use; SHP=stabilized hydrogen peroxide; TVC= total viable (bacterial) counts; UMF=ultramicrofiber; UVD= ultraviolet environmental disinfection; VRE=vancomycin-resistant enterococci

Table C-5. Study characteristics of monitoring studies

Author	Country	Study Design	Monitoring Method	Study Length	Sample Size	Primary Setting	Pathogens	High Touch Object(s)
Luick et al. 2013[111]	United States	Non-randomized controlled	ATP bioluminescence, fluorescent/UV markers, visual observation	2 months	50 rooms, 250 total surfaces	Ward not specified	NR	Bed rail, call button, toilet, tray table, telephone
Smith et al. 2013[115]	United States	Non-randomized controlled	ATP bioluminescence, visual observation, swab cultures	Not reported	10 rooms	Ward not specified	Various pathogens including: *C. diff*, MRSA, VRE	Bed rail, call button, light switch, side table, toilet, sink, telephone, door handle
Snyder et al. 2013[9]	United States	Non-randomized controlled	ATP bioluminescence, fluorescent/UV markers, visual observation	3 months	20 rooms, 290 surfaces	Ward not specified	NR	Bed rail, call button, light switch, side table, toilet, tray table, door knob, telephone, sink
Mulvey et al. 2011[10]	United Kingdom	Non-randomized controlled	ATP bioluminescence, visual observation, Agar slide cultures	4 weeks	90 samples	General medical and surgical wards	MRSA	Bed, bed rail, floor, tray table
Munoz-Price et al. 2011[62]	United States	ITS	Fluorescent/UV markers	20 weeks	284 rooms, 2,292 surfaces	ICU	Various pathogens	Bed rail, bed control, call button, light switch, monitor control panel, remote control, side table, toilet, tray table
Carling et al. 2010[117]	United States	Before/after	Fluorescent/UV markers	Not reported	260 rooms, 3,532 samples, 27 hospitals	ICU	NR	NR
Alfa et al. 2008[110]	Not specified	Descriptive	Fluorescent/UV markers	8 months	20 patients, 201 samples	Ward not specified	*C. diff*	Toilet
Alhamad and Maxwell 2008[112]	United Kingdom	Before/after and correlation of two monitoring methods	Agar slide cultures, "wipe-rinse method," used an assay	4 weeks	130 samples	Intensive care unit and “high dependency unit”	MRSA	Bed rail, monitor control panel, cabinet, door handle, telephone, keyboard
Blue et al. 2008[109]	Canada	Before/after	Fluorescent/UV markers	4 months	364 samples	Ward not specified	VRE	Bed rail, call buttons light switch, toilet, tray table, doorknob
Carling et al. 2008[113]	United States	Descriptive study of UV fluorescent monitoring	Fluorescent/UV markers	12 weeks	1,119 rooms, 13,369 “high risk-objects”	ICU and other units	NR	Bed rail, call button, light switch, side table, toilet, tray table, sink, telephone, doorknob
Carling et al. 2006[114]	United States	Descriptive study of fluorescent marker monitoring	Fluorescent/UV markers	Not reported	157 rooms, 1,404 samples	Ward not specified	NR	Bed rail, call button, side table, toilet, tray table, sink, doorknob, telephone
Malik et al. 2003[116]	United Kingdom	Non-randomized controlled	ATP bioluminescence, visual observation, Agar slide cultures	Not reported	8 hospital wards	Ward not specified	NR	Not specified

ATP=adenosine triphosphate; C-diff=Clostridium difficile; HTO=High touch object; ICU=Intensive care unit; ITS=interrupted time series; MRSA=methicillin-resistant staphylococcus aureus; NR=Not reported; UV=ultraviolet; VRE=vancomycin-resistant enterococci

Table C-6. Methods for monitoring studies*

Author	Monitoring Methods	Implementation Tools	Discusses Sustainability
Luick et al. 2013[111]	ATP bioluminescence, fluorescent/UV markers, visual observation	Not reported	No
Smith et al. 2013[115]	ATP bioluminescence, visual observation, swab cultures	Not reported	No
Snyder et al. 2013[9]	ATP bioluminescence, fluorescent/UV markers, visual observation	Not reported	No
Mulvey et al. 2011[10]	ATP bioluminescence, visual observation, Agar slide cultures	Not reported	No
Munoz-Price et al. 2011[62]	Fluorescent/UV markers	Feedback of UV-powder surveillance to environmental services, hospital leadership, and unit administrators.	Yes
Carling et al. 2010[117]	Fluorescent/UV markers	Feedback and education to staff	No
Alfa et al. 2008[110]	Fluorescent/UV markers	Not reported	No
Alhamad and Maxwell 2008[112]	Agar slide cultures, "wipe-rinse method," uses an assay	Not reported	No
Blue et al. 2008[109]	Fluorescent/UV markers	Includes regular feedback to EVS personnel	No
Carling et al. 2008[113]	Fluorescent/UV markers	Not reported	No
Carling et al. 2006[114]	Fluorescent/UV markers	Not reported	No
Malik et al. 2003[116]	ATP bioluminescence, visual observation, Agar slide cultures	Not reported	No

Cleaning methods, external factors, and patient safety culture were not reported.
ATP=adenosine triphosphate; CDI=Clostridium difficile infection; EVS=environmental services

Table C-7. Outcomes and conclusions for monitoring studies

Author	Primary Outcome	Secondary Outcome of Interest	Authors' Conclusions
Luick et al. 2013[111]	Sensitivity to detect pathogens	Specificity of tests, PPV, NPV	"In a simultaneous assessment of 250 environmental surfaces after terminal cleaning using aerobic cultures as a gold standard, both fluorescent marker and an adenosine triphosphate bioluminescence assay system demonstrated better diagnosticity compared with subjective visual inspection."
Smith et al. 2013[115]	RLU/cm^2; CFU/cm^2	NR	"Although quantitative microbiology and ATP detection measure somewhat different aspects of environmental contamination, they both generally agree in distinguishing clean from dirty surfaces."
Snyder et al. 2013[9]	Percent of targets cleaned	Test characteristics of UV, ATP, and visual inspection	"In assessing the effectiveness of PDC, there was poor correlation between the two most frequently studied commercial methods and a microbiologic comparator. Visual inspection performed at least as well as commercial methods, directly addresses patient perception of cleanliness, and is economical to implement."

Table C-7. Outcomes and conclusions for monitoring studies (continued)

Author	Primary Outcome	Secondary Outcome of Interest	Authors' Conclusions
Mulvey et al. 2011[10]	Cleaning rate	Surface contamination (measured by ATP and dipslides)	"Microbiological and ATP monitoring confirmed environmental contamination, persistence of hospital pathogens and measured the effect on the environment from current cleaning practices. This study has provided provisional benchmarks to assist with future assessment of hospital cleanliness. Further work is required to refine practical sampling strategy and choice of benchmarks."
Munoz-Price et al. 2011[62]	Cleaning rate	NR	"We found that regular surveillance using an inexpensive technology coupled with regular feedback of results produced sustained improvements in environmental cleaning, which may explain the coincident reduction in hospital-acquired infections. The ability of this brief (12 weeks) intervention to produce rapid benefits (within 4 weeks) and prolonged benefits (more than 20 weeks) speaks to its efficacy. Further studies aimed at optimizing reintroduction of the intervention to optimize cleaning rates should be considered."
Carling et al. 2010[117]	Percent of targets cleaned	NR	"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."
Alfa et al. 2008[110]	Cleaning rate	NR	"Our data demonstrated the value of UVM for monitoring the compliance of housekeeping staff with the facility's toilet cleaning protocol. In addition to providing good physical cleaning action, agents with some sporicidal activity against C. difficile may be needed to effectively reduce the environmental reservoir."
Alhamad and Maxwell 2008[112]	Number of samples with positive culture	Overall cfu/cm^2	"There was no direct correlation between the findings of total aerobic count and MRSA isolation. We suggest, however, that combining both standards will give a more effective method of assessing the efficacy of cleaning/disinfection strategy. Further work is required to evaluate and refine these standards in order to assess the frequency of cleaning required for a particular area, or for changing the protocol or materials used."
Blue et al. 2008[109]	Percent of targets cleaned	VRE infection rate	"The GlitterBug product is an effective tool to evaluate environmental cleaning and adherence to policies and procedures and this method was superior to previous visual inspection methods. The use of GlitterBug potion improved physical cleaning and enhanced staff contribution. The Brevis GlitterBug product was incorporated into the CSS environmental cleaning program at Hamilton Health Sciences as a quality indicator to monitor environmental cleaning practices."
Carling et al. 2008[113]	Cleaning rate	NR	"We identified significant opportunities in all participating hospitals to improve the cleaning of frequently touched objects in the patient's immediate environment. The information obtained from such assessments can be used to develop focused administrative and educational interventions that incorporate ongoing feedback to the environmental services staff, to improve cleaning and disinfection practices in healthcare institutions."
Carling et al. 2006[114]	Percent of targets cleaned	NR	"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."
Malik et al. 2003[116]	RLU, CFU/cm^2	NR	"The data suggest that visual assessment is a poor indicator of cleaning efficacy and that the ACE audit gives a better assessment of cleaning programs compared with the other 2 audit methods in relation to microbial surface counts. It is recommended that hospital cleaning regimes be designed to ensure that surfaces are cleaned adequately and that efficacy is assessed with use of internal auditing and rapid hygiene testing."

ACC=aerobic colony count; ACE=audit for cleaning efficacy; ATP=adenosine triphosphate; CDI=Clostridium difficile infection; CFU=colony-forming unit; CSS=infection control and customer support services; MRSA=methicillin-resistant staphylococcus aureus; NPV=negative predictive value; NR=Not reported; PDC=post-discharge cleaning; PPV=positive predictive value; RLU=relative light unit; UVM=ultraviolet visible marker

Table C-8. Study characteristics of implementation studies

Author	Country	Study Design	Study Length	Single or Multicomponent Strategy	Sample Size	Primary Setting	Pathogen(s) Described	High Touch Object(s)
Branch-Elliman et al. 2014[31]	United States	Before/after	2 months	Single	820 surfaces, 210 rooms	Ward not specified	MRSA, VRE	Side rail, over-bed rail, toilet seat
Koll et al. 2014[32]	United States	ITS	22 months	Multicomponent/infection prevention bundle, including contact precautions for patients with diarrhea and sign placement for patients with confirmed/suspected CDI	35 hospitals	Burn, telemetry and medical surgical unit	*C. diff*	Over 20 HTOs, including bed, bed rail, call button, floor, toilet, tray table, over 20 HTOs
Ramphal et al. 2014[33]	United States	ITS	14 months	Multicomponent/hand hygiene, improved kits for line-changing procedures	3,185 HTOs	Ward not specified	Various pathogens, including *C. diff*	20 HTOs, including bed rail, call button, remote control, and tray table
Rupp et al. 2014[34]	United States	Before/after	4 years	Single	90 rooms, 1,117 surface measurements	Medical/surgical critical care units	NR	Bed rail, tray table, room door handle, thermometer, monitor, bed rail, release button, nurse call monitor, and other items
Rupp et al. 2014[35]	United States	Observational	4 months	Single	292 rooms, 17 housekeepers	Surgical/medical ICU	NR	18 HTOs, including bed rail, call button, light switch, and toilet
Smith et al. 2014[36]	United States	Non-RCT	20 months	Single	13,345 sites	5 units including telemetry, ICU, medical/surgical, and cardiac	*C. diff*, MRSA, VRE	16 HTOs, including toilet seat, light switch, call light, mattress and bedrail
Brakovich et al. 2013[37]	United States	ITS	7 months	Multicomponent/a tiered approach that included environmental cleaning and disinfection, diagnostics and surveillance, and infection control measures including antibiotic stewardship	50 beds	Long-term acute care hospital	*C. diff*	Not specified
Trajtman et al. 2013[39]	Canada	Non-RCT	24 weeks	Single	7,680 sites	General medical ward	*C. diff*	Bathroom
Ragan et al. 2012[40]	Canada	Before/after	8 weeks	Single	823 HTO	ICU	*C. diff*, MRSA, VRE	Light switch, toilet, tray table, IV pole, drawer handle, door knob and other items
Datta et al. 2011[41]	United States	Retrospective cohort	19 months	Single	17,652 patients	ICU	MRSA, VRE	Not specified

Table C-8. Study characteristics of implementation studies (continued)

Author	Country	Study Design	Study Length	Single or Multicomponent Strategy	Sample Size	Primary Setting	Pathogen(s) Described	High Touch Object(s)
Murphy et al. 2011[38]	Australia	Before/after	17 weeks	Single	37 rooms, 986 HTOs	Ward not specified	MRSA, VRE	Light switch, toilet, bedroom door handle, bedroom soap dispenser, bedroom tap handle, paper towel dispenser
Hota et al. 2009[42]	United States	Before/after	25 weeks	Single	2,901 sites for thoroughness of cleaning, 1,472 sites for contamination	ICU	VRE	Bed rail, tray table, infusion pump; countertop; soap dispenser, and other items
Po et al. 2009[43]	United States	ITS	9 months	Single	16 bed	ICU	*C. diff*, VRE	Computer keyboard on wheels
Carling et al. 2008[44]	United States	Before/after	NR	Single	20,646 HTOs	General medical ward, special care areas	*C. diff*, MRSA, VRE	14 HTOs including bed rail, toilet, and tray table
Goodman et al. 2008[45]	United States	Before/after	8 months	Single	85 rooms, 1,121 surfaces	Respiratory step down unit	MRSA, VRE	15 HTOs, including bed rail, curtain, light switch, and toilet
Eckstein et al. 2007[46]	United States	Before/after	16 weeks	Single	17 rooms	Surgical ward	*C. diff*, VRE	Bed rail, call button, side table, toilet, and door knob
Hayden et al. 2006[47]	The Netherlands	Before/after	255 days	NR	485 cleaning episodes	ICU	VRE	Bed rail, infusion pump, countertop, door handle, telephone, and other items

CDI=Clostridium difficile infection; C diff=Clostridium difficile; HTO=high touch object; ICU=intensive care unit; ITS=interrupted time series; IV=intravenous; MRSA=methicillin-resistant staphylococcus aureus; non-RCT=nonrandomized controlled trial; NR=not reported; VRE=vancomycin-resistant enterococci

Table C-9. Methods for implementation studies

Author	Cleaning Methods	Monitoring Methods	External Factors	Patient Safety Culture	Implementation Tools	Discusses Sustainability
Branch-Elliman et al. 2014[31]	NR	ATP bioluminescence	NR	NR	Education, monitoring, feedback	Yes
Koll et al. 2014[32]	Hypochlorite-based disinfectant	NR	NR	NR	Cleaning checklists	NR
Ramphal et al. 2014[33]	NR	Fluorescent/UV markers	NR	NR	Education, training, "blinded monitoring with transparent reporting of the results in a positive, engaging manner"	Yes
Rupp et al. 2014[34]	NR	Fluorescent/UV markers	NR	Department of infection control	43-point room cleaning checklist, housekeeper educational program, training DVD, face-to-face meetings with housekeeping	Yes

Table C-9. Methods for implementation studies (continued)

Author	Cleaning Methods	Monitoring Methods	External Factors	Patient Safety Culture	Implementation Tools	Discusses Sustainability
Rupp et al. 2014[35]	Routine	ATP bioluminescence	NR	NR	NR	NR
Smith et al. 2014[36]	Quaternary ammonium	ATP bioluminescence	NR	NR	Educational interventional activities such as hands-on training and education with ATP devices, education via "Clean Sweep" electronic game, laminated pocket-size cleaning order, and high-touch surface lists in both English and Spanish	Yes
Brakovich et al. 2013[37]	Microfiber mops, HPV	NR	Outside contractor provided HPV devices and services for follow-up decontamination of rooms formerly occupied by patients with CDI	IP Registered Nurse, members of the Quality and Safety Committee, Clinical Quality Outcomes Coordinator	Lipstick challenge, checklists, training on use of chemicals, color-coded microfiber cloths, database output of quarterly reports	Yes
Trajtman et al. 2013[39]	NR	Fluorescent/UV markers	NR	NR	Feedback and UVM audit tool	Yes
Ragan et al. 2012[40]	NR	Fluorescent/UV markers	NR	NR	Audit and feedback, check list for HTOs	NR
Datta et al. 2011[41]	Quaternary ammonium, change in application of disinfectant to bucket immersion of cloths	Fluorescent/UV markers	NR	NR	Education	NR
Murphy et al. 2011[38]	NR	Fluorescent/UV markers	NR	EVS management from 2 participating hospitals were given advice to better understand and improve cleaning	Audit and feedback, education to EVS staff, survey of EVS staff	Yes
Hota et al. 2009[42]	Quaternary ammonium	Swab cultures	NR	NR	Education, intensified monitoring	NR
Po et al. 2009[43]	NR	Fluorescent/UV markers	NR	NR	Education and feedback, process improvement interventions (e.g., assigned 1 specific individual to clean COWS), modification to cleaning protocols	Yes

Table C-9. Methods for implementation studies (continued)

Author	Cleaning Methods	Monitoring Methods	External Factors	Patient Safety Culture	Implementation Tools	Discusses Sustainability
Carling et al. 2008[44]	NR	Fluorescent/UV markers	NR	Hospital directors at all participating hospitals reviewed evaluation of terminal room cleaning practices with EVS management and subsequently presented this information to frontline staff; active interhospital networking	Audit and feedback	Yes
Goodman et al. 2008[45]	Quaternary ammonium (change from pour bottles to immersing cloth in bucket)	ATP bioluminescence, swab cultures	NR	NR	Education, monitoring, and feedback	NR
Eckstein et al. 2007[46]	NR	Swab cultures	NR	Infection Control Department meets monthly with housekeeping to provide feedback on culture results and to reconfirm importance of housekeeping in controlling pathogens	Audit and feedback, education, housekeeping staff asked for input on additional resources needed to perform job well	NR
Hayden et al. 2006[47]	Quaternary ammonium	Visual observation, VRE cultures	NR	NR	Educational in services, increased monitoring, audit, and feedback	NR

ATP=adenosine triphosphate; CDI=Clostridium difficile infection; COW=computer on wheels; EVS=environmental services; HPV=hydrogen peroxide vapor; HTO=high touch objects; IP=Infection prevention; NR=not reported; UVM=ultraviolet visible marker; VRE=vancomycin-resistant enterococci

Table C-10. Outcomes and conclusions for implementation studies

Author	Primary Outcome	Secondary Outcome of Interest	Authors' Conclusions
Branch-Elliman et al. 2014[31]	Proportion of surfaces cleaned	NR	"We successfully implemented a quality improvement and education project to improve environmental cleaning in our hospital. Our study demonstrates that quality-assessment tools, such as the ATP luminometer, can be used at the point of cleaning to improve cleaning performance. Use of the tool in a positive feedback loop directly with front-line EMS staff resulted in enhanced collaboration, communication, and education among services."
Koll et al. 2014[32]	Compliance with room cleaning protocol	CDI rates	"The use of a collaborative model to implement a multifaceted infection prevention strategy was temporally associated with a significant reduction in hospital-onset CDI rates in participating New York metropolitan regional hospitals."
Ramphal et al. 2014[33]	Percent of targets cleaned	*C. diff* rate per 1,000 patient days	"The percentage of cleaned surfaces improved incrementally between the three trials—with values of 20%, 49%, and 82%—showing that repeat training favorably changed behavior in the staff (P = 0.007). During the study period, during which other infection control interventions were also introduced, there was a decline from 0.27 to 0.21 per 1000 patient days for Clostridium difficile infection, 0.43 to 0.21 per 1000 patient days for ventilator-associated infections, 1.8% to 1.2% for surgical site infections, and 1.2 to 0.7 per 1000 central venous line days for central line–associated bloodstream infections."

Table C-10. Outcomes and conclusions for implementation studies (continued)

Author	Primary Outcome	Secondary Outcome of Interest	Authors' Conclusions
Rupp et al. 2014[34]	Compliance with room cleaning protocol	NR	"Over a 4-year period, we observed that monthly feedback of performance data in face-to-face meetings with frontline personnel was crucial in maintaining environmental-cleaning effectiveness in adult critical care units."
Rupp et al. 2014[35]	Housekeeper efficiency and effectiveness based on RLUs	NR	"A subgroup of housekeepers was identified who were significantly more effective and efficient than their coworkers. These optimum outliers may be used in performance improvement to optimize environmental cleaning."
Smith et al. 2014[36]	Cleaning score measures over time	Trends in HAIs	"The ATP detection device combined with educational feedback for EVS workers resulted in significant improvement in cleaning efficacy of the hospital room environment."
Brakovich et al. 2013[37]	Incidence rate of CDI	Cost	"This program was successful in decreasing the incidence of CDI in the LTACH creating a safe and cost-effective environment for patients, families, and the community."
Trajtman et al. 2013[39]	Compliance with room cleaning protocol	NR	"The use of UVM as an audit tool combined with weekly feedback of results to housekeeping staff resulted in significant, sustained improvement in the overall level of cleaning compliance of housekeeping staff."
Ragan et al. 2012[40]	Percent of targets cleaned	NR	"We demonstrate that auditing with fluorescent targeting can be implemented in both the ward and intensive care unit settings using only modest resources, resulting in rapid improvements in cleaning thoroughness."
Datta et al. 2011[41]	Infection rate: MRSA and VRE	Acquisition by prior occupant status	"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."
Murphy et al. 2011[38]	Compliance with room cleaning protocol	Percent of targets cleaned	"The [fluorescent marker] was useful to assess HTO cleaning thoroughness. It facilitated relevant feedback and education and motivated staff to strive for continual improvements in environmental cleaning. Without on-going education, preliminary improvements were unsustained. However, investigators better understood flaws in cleaning and policy/procedure conflicts."
Hota et al. 2009[42]	Percent of targets cleaned	Contamination of sites post-cleaning, VRE prevalence	"These findings suggest that surface contamination with VRE is due to a failure to clean rather than to a faulty cleaning procedure or product."
Po et al. 2009[43]	Cleaning rate	NR	"Following a series of educational and programmatic interventions, we were able to improve the thoroughness of cleaning to 100%."
Carling et al. 2008[44]	Percent of targets cleaned	NR	"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."
Goodman et al. 2008[45]	Positive cultures	Number of rooms with positive culture	"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 the frequency of MRSA and VRE contamination."

Table C-10. Outcomes and conclusions for implementation studies (continued)

Author	Primary Outcome	Secondary Outcome of Interest	Authors' Conclusions
Eckstein et al. 2007[46]	Percent of positive cultures	NR	"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."
Hayden et al. 2006[47]	Colonization with VRE	Time to clean, antibiotic use	"Decreasing environmental contamination may help to control the spread of some antibiotic resistant bacteria in hospitals."

ATP=adenosine triphosphate; CDI=Clostridium difficile infection; EVS=environmental services; HAI=hospital-associated infection; HTO=high touch object; LTACH=long-term acute care hospital; MRSA=methicillin-resistant staphylococcus aureus; RLU=relative light unit; UVM=ultraviolet visible marker; VRE=vancomycin-resistant enterococci

Appendix D. Clinical Practice Guidelines and Ongoing Clinical Trials

Table D-1. Clinical practice guidelines

#	Organization	Reference	Country	Methods (Evidence-based or Consensus/narrative-based)
1	American College of Gastroenterology	Surawicz CM et al. Guidelines for diagnosis, treatment, and prevention of Clostridium difficile infections. *Am J Gastroenterol*. 2013 Apr;108(4):478-98.[118]	USA	Evidence-based
2	Association for the Healthcare Environment (AHE), formerly known as the American Society for Healthcare Environmental Services (ASHES) (part of the American Hospital Association)	Association for the Healthcare Environment. Practice guidance for healthcare environmental cleaning, 2nd edition. Chicago (IL): American Hospital Association; 2010.[119]	USA	Evidence-based
3	Association for Healthcare Research and Quality (AHRQ)	Collins AS. Chapter 41. Preventing health care–associated infections. In: Hughes RG, editor. Patient safety and quality: An evidence-based handbook for nurses. Rockville (MD): Agency for Healthcare Research and Quality (AHRQ); 2008. p. 547-75. Also available: http://www.ncbi.nlm.nih.gov/books/NBK2683/pdf/ch41.pdf.[120]	USA	Evidence-based
4	Association for Professionals in Infection Control and Epidemiology (APIC)	Association for Professionals in Infection Control and Epidemiology (APIC). APIC position on mandatory public reporting of HAIs. Washington (DC): Association for Professionals in Infection Control and Epidemiology (APIC); 2005 Mar 14. 3 p. Also available: http://www.apic.org/Resource_/TinyMceFileManager/Position_Statements/MandRpt_posnPaoper_2005.pdf.[121]	USA	Consensus/narrative
5	APIC	Greene LR et al. APIC Position Paper: The importance of surveillance technologies in the prevention of healthcare-associated infections (HAIs). Washington (DC): 2009 May 29. 7 p.[122]	USA	Evidence-based
6	APIC	Cardo D et al. Moving toward elimination of healthcare-associated infections: a call to action. [White paper]. Am J Infect Control. 2010 Nov;38(9):671-5.[123] "a joint white paper between APIC, Society for Healthcare Epidemiology of America (SHEA), Infectious Diseases Society of America (IDSA), Association of State and Territorial Health Officials, Council of State and Territorial Epidemiologists, Pediatric Infectious Diseases Society, and the Centers for Disease Control and Prevention."	USA	Consensus/narrative
7	APIC	Friedman C et al. APIC/CHICA-Canada infection prevention, control, and epidemiology: Professionals and practice standards. Washington (DC): Association for Professionals in Infection Control and Epidemiology (APIC); 2008. 5 p.[124]	Canada	Consensus/narrative

Table D-1. Clinical practice guidelines (continued)

#	Organization	Reference	Country	Methods (Evidence-based or Consensus/narrative-based)
8	APIC	Association for Professionals in Infection Control and Epidemiology, Inc. Guide to preventing Clostridium difficile infections. Washington (DC): Association for Professionals in Infection Control and Epidemiology, Inc.; 2013 Feb;100 p. Also available: http://www.apic.org/Resource_/EliminationGuideForm/59397fc6-3f90-43d1-9325-e8be75d86888/File/2013CDiffFinal.pdf.[55]	USA	Consensus/narrative
9	APIC	Association for Professionals in Infection Control and Epidemiology, Inc. Guide to the elimination of methicillin-resistant Staphylococcus aureus (MRSA) transmission in hospital settings, 2nd edition. Washington (DC): Association for Professionals in Infection Control and Epidemiology, Inc.; 2010. 65 p. Also available: http://www.apic.org/Resource_/EliminationGuideForm/631fcd91-8773-4067-9f85-ab2a5b157eab/File/MRSA-elimination-guide-2010.pdf.[125]	USA	Evidence-based
10	APIC	Infection Control and Epidemiology, Inc. Guide to the elimination of methicillin-resistant Staphylococcus aureus (MRSA) transmission in hospital settings. California supplement 2009. Washington (DC): Association for Professionals in Infection Control and Epidemiology, Inc.; 2009 Apr 3. 12 p. Also available: http://www.apic.org/Resource_/EliminationGuideForm/16c7a44f-55fe-4c7b-819a-b9c5907eca72/File/APIC-MRSA-California.pdf.[126]	USA	Consensus/narrative
11	APIC	Association for Professionals in Infection Control and Epidemiology, Inc. Guide to the elimination of methicillin-resistant Staphylococcus aureus (MRSA) in the long-term care facility. Washington (DC): Association for Professionals in Infection Control and Epidemiology, Inc.; 2009. 74 p. Also available: http://www.apic.org/Resource_/EliminationGuideForm/08b12595-9f92-4a64-ad41-4afdd0088224/File/APIC-MRSA-in-Long-Term-Care.pdf.[127]	USA	Evidence-based
12	Association of periOperative Registered Nurses (AORN)	Association of periOperative Registered Nurses (AORN). Recommended practices for environmental cleaning. In: 2014 perioperative standards and recommended practices. Denver (CO): Association of perioperative Registered Nurses (AORN); 2013 Sep. p. 255-76.[128] NGC summary.	USA	Evidence-based
13	AORN	Allen G. Implementing AORN recommended practices for environmental cleaning. *AORN J.* 2014 May;99(5):570-82. Also available: http://dx.doi.org/10.1016/j.aorn.2014.01.023.[129]	USA	Evidence-based
14	Australasian Society for Infectious Diseases (ASID)	Stuart RL et al. ASID/AICA position statement: Infection control guidelines for patients with Clostridium difficile infection in healthcare settings. Healthc Infect. Mar 2011;16(1):33-9. Also available: http://dx.doi.org/10.1071/HI11011.[130]	Australia	Consensus/narrative

Table D-1. Clinical practice guidelines (continued)

#	Organization	Reference	Country	Methods (Evidence-based or Consensus/narrative-based)
15	ASID	Cheng AC et al. Australasian Society for Infectious Diseases guidelines for the diagnosis and treatment of Clostridium difficile infection. Med J Aust. 2011 Apr 4;194(7):353-8.[131]	Australia	Evidence-based
16	Center for International Blood and Marrow Transplant Research (CIBMTR)	Tomblyn M et al. Guidelines for preventing infectious complications among hematopoietic cell transplantation recipients: A global perspective. Biol Blood Marrow Transplant. 2009 Oct;15(10):1143-238.[132]	Multinational	Evidence-based
17	Centers for Disease Control and Prevention (CDC), including the Healthcare Infection Control Practices Advisory Committee (HICPAC)	Rutala WA, Weber DJ, Healthcare Infection Control Practices Advisory Committee. Guideline for disinfection and sterilization in healthcare facilities, 2008. Atlanta (GA): Centers for Disease Control and Prevention; 2008. 158 p. Also available: http://www.cdc.gov/hicpac/Disinfection_Sterilization/17_00Recommendations.html.[12] See also: Recommendations for disinfection and sterilization in health-care facilities.	USA	Evidence-based
18	CDC, including HICPAC	Centers for Disease Control and Prevention (CDC). Antibiotic resistance threats in the United States, 2013. Atlanta (GA):Centers for Disease Control and Prevention (CDC); 2013. 114 p. Also available: http://www.cdc.gov/drugresistance/threat-report-2013/pdf/ar-threats-2013-508.pdf.[133]	USA	Evidence-based
19	CDC, including HICPAC	Guh A. Carling P, Environmental Evaluation Workgroup. Division of Healthcare Quality Promotion; National Center for Emerging, Zoonotic and Infectious Diseases. Options for evaluating environmental cleaning. [Toolkit]. 2010. Atlanta (GA): Centers for Disease Control and Prevention (CDC); 2010 Dec.15 p. Also available: http://www.cdc.gov/HAI/pdfs/toolkits/Environ-Cleaning-Eval-Toolkit12-2-2010.pdf.[53] Note: Additional resources.	USA	Consensus/narrative
20	CDC, including HICPAC	McGKibben L et al. Guidance on public reporting of healthcare-associated infections: Recommendations of the Healthcare Infection Control Practices Advisory Committee. Am J Infect Control. 2005 May;33(4):217-26.[134]	USA	Consensus/narrative
21	CDC, including HICPAC	Recommendations for Preventing the Spread of Vancomycin Resistance Recommendations of the Hospital Infection Control Practices Advisory Committee (HICPAC). MMWR Recomm Rep. 1995 Sep 22;44(RR-12):1-13.[135]	USA	Consensus/narrative

Table D-1. Clinical practice guidelines (continued)

#	Organization	Reference	Country	Methods (Evidence-based or Consensus/narrative-based)
22	CDC, including HICPAC	Sehulster L et al. Guidelines for environmental infection control in healthcare facilities. Recommendations of CDC and the Healthcare Infection Control Practices Advisory Committee (HICPAC) [Published errata appear in MMWR Recomm Rep 2003 Oct 24;52(42):1025-6]. MMWR Recomm Rep. 2003 Jun 6;52(RR-10):1-42.[56]	USA	Evidence-based
23	CDC, including HICPAC	Siegel J et al. Guideline for isolation precautions: preventing transmission of infectious agents in healthcare settings. Atlanta (GA): Centers for Disease Control and Prevention (CDC); 2007 Jun. 219 p.[136]	USA	Evidence-based
24	CDC, including HICPAC	Siegel JD et al. Management of multidrug-resistant organisms in healthcare settings. 2006. 74 p.[137]	USA	Evidence-based
25	CDC, including HICPAC	Umscheid C et al. Updating the Guideline Methodology of the Healthcare Infection Control Practices Advisory Committee (HICPAC). Atlanta (GA): Centers for Disease Control and Prevention (CDC); 31 p. Also available: http://www.cdc.gov/hicpac/pdf/guidelines/2009-10-29HICPAC_GuidelineMethodsFINAL.pdf.[138] Publication date not available.	USA	Evidence-based
26	European Centre for Disease Control and Prevention (ECDC)	Vonberg RP et al. Infection control measures to limit the spread of Clostridium difficile. Clin Microbiol Infect. 2008 May;14:2-20. Also available: http://dx.doi.org/10.1111/j.1469-0691.2008.01992.x.[139]	Europe	Evidence-based
27	European Society of Clinical Microbiology and Infectious Diseases (ESCMID)	European Society of Clinical Microbiology and Infectious Diseases. ESCMID consensus statements. [internet]. Basel (Switzerland): European Society of Clinical Microbiology and Infectious Diseases; MRSA expert consensus documents, 2013 Feb 14 [accessed 2014 Oct 07]. [2 p]. Available: https://www.escmid.org/escmid_library/medical_guidelines/escmid_consensus_statements/.[140] Note: See Humphreys H et al. Workshop 2 for cleaning.	Europe	Consensus/narrative
28	Environmental Protection Agency (EPA)	U.S. Environmental Protection Agency. Antimicrobial testing program – guideline methodology. [internet]. Washington (DC): U.S. Environmental Protection Agency; 2014 Aug 21 [accessed 2014 Oct 07]. [2 p]. Available: http://www.epa.gov/oppad001/antimicrobial-testing-program.html..[141] Note: includes test results from August 2014. See also: The antimicrobial testing program. hospital disinfectant and tuberculocidal products tested or pending testing. [List of products]. 2014 Aug 21.	USA	Evidence-based

Table D-1. Clinical practice guidelines (continued)

#	Organization	Reference	Country	Methods (Evidence-based or Consensus/narrative-based)
29	Government Accounting Office (GAO)	Bascetta CA. Health-care-associated infections in hospitals: Leadership needed from HHS to prioritize prevention practices and improve data on these infections: Report to the Chairman, Committee on Oversight and Government Reform, House of Representatives. Washington (DC): U.S. Government Accountability Office; 2008 Mar. 61 p. Also available: http://www.gao.gov/assets/280/274314.pdf.[142]	USA	Evidence-based
30	Healthcare-Associated Infection Working Group of the Joint Public Policy Committee. APIC, CDC, Council of State and Territorial Epidemiologists (CSTE), and Society for Healthcare Epidemiology of America (SHEA)]	Healthcare-Associated Infection Working Group of the Joint Public Policy Committee. Essentials of public reporting of HAIs, Healthcare-Associated Infection Working Group of the Joint Public Policy Committee toolkit. 4 p. Also available: http://www.apic.org/Resource_/TinyMceFileManager/Position_Statements/Essentials_Tool_Kit.pdf.[143] Publication date not provided.	USA	Evidence-based
31	Healthcare Infection Society (UK) (formerly, the Hospital Infection Society)	Coia JE et al. Guidelines for the control and prevention of methicillin-resistant Staphylococcus aureus (MRSA) in healthcare facilities. J Hosp Infect. 2006 May;63:1-44. Also Available: http://dx.doi.org/10.1016/j.jhin.2005.10.014.[144]	UK	Evidence-based
32	Healthcare Infection Society (UK)	Cookson BD et al. Guidelines for the control of glycopeptide-resistant enterococci in hospitals. J Hosp Infect. 2006 Jan;62(1):6-21. Also available: http://dx.doi.org/10.1016/j.jhin.2005.02.016[145]	UK	Evidence-based
33	Healthcare Infection Society (UK)	Loveday HP et al. epic3: national evidence-based guidelines for preventing healthcare-associated infections in NHS Hospitals in England. J Hosp Infect. 2014 Jan;86. Also available: http://dx.doi.org/10.1016/S0195-6701(13)60012-2.[146]	UK	Evidence-based
34	Healthcare Infection Society (UK)	National Clostridium difficile Standards Group: Report to the Department of Health. J Hosp Infect. 2004 Feb;56 Suppl 1:1-38.[147]	UK	Evidence-based
35	Healthcare Infection Society (UK)	Pratt RJ et al. epic2: National Evidence-Based Guidelines for Preventing Healthcare-Associated Infections in NHS Hospitals in England. J Hosp Infect. 2007 Feb;65. Also available: http://dx.doi.org/10.1016/S0195-6701(07)60002-4.[148]	UK	Evidence-based
36	Healthcare Infection Society (UK)	Steer JA et al. Guidelines for prevention and control of group A streptococcal infection in acute healthcare and maternity settings in the UK. J Infect. 2012 Jan;64(1):1-18. Also available: http://dx.doi.org/10.1016/j.jinf.2011.11.001[149]	UK	Evidence-based
37	Infection Control Working Group	Neely AN et al. Computer equipment used in patient care within a multihospital system: recommendations for cleaning and disinfection. Am J Infect Control. 2005 May;33(4):233-7. Also available: http://dx.doi.org/10.1016/j.ajic.2005.03.002.[150]	USA	Evidence-based

Table D-1. Clinical practice guidelines (continued)

#	Organization	Reference	Country	Methods (Evidence-based or Consensus/narrative-based)
38	Infection Prevention Society (IPS), formerly the Infection Control Nurses Association (ICNA)	Infection Prevention Society. Care setting process improvement tool in & out patient areas / departments. Bathgate (Scotland): Infection Prevention Society; 44 p. Also available: http://www.ips.uk.net/files/8213/8044/9268/In_-_Out_Patient_Area_Departments_PIT.pdf.[151] No publication date.	USA	Evidence-based
39	Institute of Medicine (IOM)	Institute of Medicine (IOM). Initial national priority for comparative effectiveness research. [book online]. Washington (DC): National Academies Press; 2009 Jan 01. [accessed 2010 Mar 03] [various].[152]	USA	Evidence-based
40	International Federation for Infection Control (IFIC)	Damani N. Information resources in infection control, 6th edition. Armagh (Ireland): International Federation of Infection Control; 2009. 96 p. Also available: http://www.theific.org/pdf_files/resource_IFIC_Sept_2009.pdf.[153]	UK	Evidence-based
41	JHPIEGO Corporation, an affiliate of Johns Hopkins University	Tietjen L et al. Infection prevention guidelines for healthcare facilities with limited resources**.** JHPIEGO Corporation; 2003. 419 p. Also available: http://pdf.usaid.gov/pdf_docs/PNACT433.[154]	USA	Evidence-based
42	Joint Commission	It's all the on the surface: establishing protocols for cleaning and disinfecting environmental surface areas. Environ Care News. 2010 Mar;13(3):6-11. Also available: http://www.jointcommission.org/assets/1/18/Its_All_on_the_Surface.pdf.[155]	USA	Evidence-based
43	Joint Commission	The Joint Commission. National patient safety goals effective January 1, 2014. Hospital accreditation program. Oakbrook Terrace (IL): The Joint Commission; 2013. 17 p. Also available: http://www.jointcommission.org/assets/1/6/HAP_NPSG_Chapter_2014.pdf.[156]	USA	Evidence-based
44	Massachusetts Nurses Association	Massachusetts Nurses Association. Exposure to environmental cleaning chemicals in healthcare settings. [internet]. Canton (MA): Massachusetts Nurses Association; 2007 Oct 01 [accessed 2014 Oct 07]. [5 p]. Available: http://www.massnurses.org/nursing-resources/position-statements/env-cleaning-chem.[157]	USA	Consensus/narrative
45	Mehta et al.	Mehta Y et al. Guidelines for prevention of hospital acquired infections**.** Indian J Crit Care Med. 2014 Mar;18(3):149–63. Also available: http://dx.doi.org/10.4103/0972-5229.128705.[158]	India	Evidence-based

Table D-1. Clinical practice guidelines (continued)

#	Organization	Reference	Country	Methods (Evidence-based or Consensus/narrative-based)
46	National Institute for Health and Care Excellence	Prevention and control of healthcare-associated infections: quality improvement guide. PH36. [internet]. London (UK: National Institute for Health and Care Excellence (NICE); 2011 Nov 01 [accessed 2013 Oct 01]. [5 p]. Available: http://publications.nice.org.uk/prevention-and-control-of-healthcare-associated-infections-ph36.[159] See: Quality improvement statement 5: Environmental cleanliness.	UK	Evidence-based
47	National Patient Safety Agency (NPSA) UK	National Patient Safety Agency (NPSA). National specifications for cleanliness: primary medical and dental premises. London (UK): National Patient Safety Agency (NPSA); 2010 Aug. 44 p. Also available: http://www.nrls.npsa.nhs.uk/EasySiteWeb/getresource.axd?AssetID=75245%20.[160]	UK	Consensus/narrative
48	NPSA	National Patient Safety Agency. The revised healthcare cleaning manual. London: National Patient Safety Agency; 2009 Jun. 174 p. Also available: http://www.nrls.npsa.nhs.uk/EasySiteWeb/getresource.axd?AssetID=61814.[161]	UK	Evidence-based
49	Public Health Ontario, Provincial Infectious Diseases Advisory Committee (PIDAC)	Provincial Infectious Diseases Advisory Committee (PIDAC). Routine practices and additional precautions in all health care settings, 3rd edition. Ottawa (Ontario): Public Health Ontario; 2012 Nov.113 p. Also available: http://www.publichealthontario.ca/en/eRepository/RPAP_All_HealthCare_Settings_Eng2012.pdf.[162]	Canada	Evidence-based
50	PIDAC	Provincial Infectious Diseases Advisory Committee (PIDAC). Best practices for environmental cleaning for prevention and control of Infections In all health care settings - 2nd edition. Ottawa (Ontario): Public Health Ontario; 2012 May.183 p.[163]	Canada	Evidence-based
51	PIDAC	Provincial Infectious Diseases Advisory Committee (PIDAC). Review of literature for evidence-based best practices for VRE control. Ottawa (Ontario): Public Health Ontario; 2012. 24 p. Also available: http://www.publichealthontario.ca/en/eRepository/PIDAC-IPC_VRE_Evidence-based_Review_2012_Eng.pdf.[164]	Canada	Evidence-based
52	Public Health Agency of Canada	Public Health Agency of Canada. Clostridium difficile infection - infection prevention and control guidance for management in acute care settings. [internet]. Ottawa (Ontario): Public Health Agency of Canada; 2013 Jan 01. [accessed 2014 Oct 07]. [13 p]. Available: http://www.phac-aspc.gc.ca/nois-sinp/guide/c-dif-acs-esa/index-eng.php.[165] See the section: 14. Environmental cleaning.	Canada	Evidence-based
53	Public Health Agency of Canada	Public Health Agency of Canada. Routine practices and additional precautions for preventing the transmission of infection in healthcare settings. Ottawa (ON): Public Health Agency of Canada; 2012. 195 p. Also available: http://publications.gc.ca/collections/collection_2013/aspc-phac/HP40-83-2013-eng.pdf.[166]	Canada	Evidence-based

Table D-1. Clinical practice guidelines (continued)

#	Organization	Reference	Country	Methods (Evidence-based or Consensus/narrative-based)
54	Royal College of Nursing	Royal College of Nursing. Creating a safe environment for care: Defining the relationship between cleaning and nursing staff. London: Royal College of Nursing; 2013. 11 p. Also available: http://www.rcn.org.uk/__data/assets/pdf_file/0007/548719/004492.pdf.[167]	UK	Consensus/narrative
55	Royal College of Nursing	Royal College of Nursing. Essential practice for infection prevention and control: Guidance for nursing staff. London: Royal College of Nursing; 2012. 36 p. Also available: http://www.rcn.org.uk/__data/assets/pdf_file/0008/427832/004166.pdf.[168] Note: See sections: 3.2 Decontamination of equipment; and 3.3 Achieving and maintaining a clean clinical environment.	UK	Consensus/narrative
56	Royal College of Nursing	Royal College of Nursing. Selection and use of disinfectant wipes. RCN guidance. London: Royal College of Nursing; 2011. 20 p. Also available: http://www.rcn.org.uk/__data/assets/pdf_file/0011/382538/003873.pdf.[169]	UK	Evidence-based
57	Public Health England/Department of Health	Department of Health, Health Protection Agency. Clostridium difficile infection: how to deal with the problem. [Guidance]. London (UK): Healthcare Associated Infection and Antimicrobial Resistance, Department of Health; 2008 Dec.140 p.[170] Note: See chapter 6: Prevention through environmental cleaning and disinfection.	UK	Evidence-based
58	Public Health England/Department of Health	Wilcox M. Updated guidance on the management and treatment of C. difficile infection. London: Public Health England; 2013. 29 p. Also available: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/321891/Clostridium_difficile_management_and_treatment.pdf.[171]	UK	Evidence-based
59	Rudolf Schuelke Foundation (Germany)	Gebel J et al. The role of surface disinfection in infection prevention. [Consensus paper]. GMS Hyg Infect Control. 2013;8(1):Doc10. Also available: http://dx.doi.org/10.3205/dgkh000210.[172]	Germany	Evidence-based
60	Society for Healthcare Epidemiology of America (SHEA)	Society for Healthcare Epidemiology of America (SHEA). Compendium of strategies to prevent healthcare-associated infections in acute care hospitals – overview page. [internet]. Arlington (VA): Society for Healthcare Epidemiology of America (SHEA); 2014 Jan 01. [accessed 2014 Oct 07]. [2 p]. Available: http://www.shea-online.org/PriorityTopics/CompendiumofStrategiestoPreventHAIs.aspx.[173] Note: This is an overview page. The recommendation sections related to this Technical Brief are listed in the next two documents.	USA	Evidence-based
61	SHEA	Calfee DP et al. Strategies to prevent methicillin-resistant staphylococcus aureus transmission and infection in acute care hospitals: 2014 update. Infect Control Hosp Epidemiol. 2014 Jul;35(7):772-96. Also available: http://dx.doi.org/10.1086/676534.[174] Note: from the 2014 Compendium.	USA	Evidence-based

Table D-1. Clinical practice guidelines (continued)

#	Organization	Reference	Country	Methods (Evidence-based or Consensus/narrative-based)
62	SHEA	Dubberke ER et al. Strategies to prevent Clostridium difficile infections in acute care hospitals: 2014 update. Infection control and hospital epidemiology: the official journal of the Society of Hospital Epidemiologists of America. 2014 Jun;35(6):628-45. Also available: http://dx.doi.org/10.1086/676023.[175] Note: from the 2014 Compendium.	USA	Evidence-based
63	SHEA	Calfee DP et al. Strategies to Prevent Transmission of Methicillin-Resistant Staphylococcus aureus in Acute Care Hospitals. Infect Control Hosp Epidemiol. 2008 Oct;29 Suppl 1:S62-80.[176] Note: from the 2008 Compendium.	USA	Evidence-based
64	SHEA	Dubberke ER et al. Strategies to Prevent Clostridium difficile Infections in Acute Care Hospitals. Infect Control Hosp Epidemiol. 2008 Oct;29 Suppl 1:S81-92.[177] Note: from the 2008 Compendium.	USA	Evidence-based
65	SHEA	Cohen SH, et al. Clinical practice guidelines for Clostridium difficile infection in adults: 2010 Update by the Society for Healthcare Epidemiology of America (SHEA) and the Infectious Diseases Society of America (IDSA). Infect Control Hosp Epidemiol. 2010 May;31(5):431-55.[178]	USA	Evidence-based
66	SHEA	Muto CA, et al. SHEA guideline for preventing nosocomial transmission of multidrug-resistant strains of Staphylococcus aureus and Enterococcus. Infect Control Hosp Epidemiol. 2003 May;24(5):362-86. Also available: http://www.journals.uchicago.edu/doi/pdf/10.1086/502213.[179]	USA	Evidence-based
67	U.S. Centers for Medicare and Medicaid Services (CMS)	U.S. Centers for Medicare and Medicaid Services (CMS). State operations manual: Appendix A—survey protocol, regulations and interpretive guidelines for hospitals. (Rev. 116, 06-06-14). Baltimore (MD): U.S. Centers for Medicare and Medicaid Services (CMS); 2014 Jun 6. 471 p. (CMS State Operations Manuals; Also available: http://www.cms.gov/Regulations-and-Guidance/Guidance/Manuals/downloads/som107ap_a_hospitals.pdf.[180] Also may be of interest: Peasah SK et al. Medicare non-payment of hospital-acquired infections: infection rates three-years post-implementation. MMWR 2013;3(3).	USA	Consensus/narrative
68	U.S. Department of Health and Human Services (HHS)	U.S. Department of Health and Human Services (HHS). National action plan to prevent health care-associated infections: road map to elimination. [internet]. Washington (DC): U.S. Department of Health and Human Services (HHS); [accessed 2014 Oct 07]. [7 p]. Available: http://www.health.gov/hai/prevent_hai.asp#hai_plan.[181]	USA	Evidence-based

Table D-1. Clinical practice guidelines (continued)

#	Organization	Reference	Country	Methods (Evidence-based or Consensus/narrative-based)
69	World Health Organization (WHO)	Ducel G et al. Prevention of hospital-acquired infections: A practical guide. 2nd edition. Geneva (Switzerland): World Health Organization (WHO); 2002. 72 p. Also available: http://www.who.int/csr/resources/publications/drugresist/en/whocdscsreph200212.pdf?ua=1.[182]	International	Evidence-based

Table D-2. Ongoing clinical trials

Clinicaltrials.gov Identifier	Sponsor	Study Design	Purpose	Start Date	Expected Completion Date	Estimated Enrollment	Relevance to Guiding Questions
NCT01579370	Duke University	Randomized controlled	To determine the efficacy and feasibility of enhanced terminal room disinfection strategies to prevent HAIs and to determine the impact of environmental contamination on acquisition of multidrug-resistant pathogens among hospitalized patients. The intervention arm includes quaternary ammonium; bleach; quaternary ammonium and ultraviolet-C (UV-C) light; and bleach and UV-C light	April 2012	October 2014	50,000	Cleaning and disinfection
NCT01349192	University of North Carolina, Chapel Hill	Randomized controlled	To determine whether an early eradication protocol is effective for eradicating MRSA and will provide an opportunity to obtain data regarding early clinical impact of new isolation of MRSA. The intervention arm includes an environmental decontamination component, including wiping down high-touch surfaces and medical equipment with surface disinfecting wipes daily for 21 days.	April 2011	July 2015	80	Cleaning & Disinfection

MRSA = Methicillin-resistant *Staphylococcus aureus*; UV-C = Ultraviolet-C