Preventable Patient Harm: A Bundled Approach to Reducing *Clostridioides difficile* Infection

William A. Rutala, Ph.D., M.P.H., C.I.C

Director, Statewide Program for Infection Control and Epidemiology and Professor of Medicine, University of North Carolina at Chapel Hill, NC, USA

Former Director, Hospital Epidemiology, Occupational Health and Safety, UNC Health Care, Chapel Hill, NC (1979-2017)

DISCLOSURES

2018-2019

- **Consultations**
  - ASP (Advanced Sterilization Products), PDI
- **Honoraria**
  - PDI, ASP, 3M
- **Scientific Advisory Board**
  - Kinnos
- **Grants**
  - CDC, CMS

www.disinfectionandsterilization.org

Preventable Patient Harm: A Bundled Approach to Reducing *Clostridioides difficile* Infection

Schultz et al. J Clin Microbiol 2018;56

- *C. difficile* is now the most common healthcare-associated pathogen in the US
- *C. difficile* colitis is a serious disease especially in older adults with frequent morbidity and substantial mortality
- Our institution set an organizational goal to reduce our CDI rates by 10%

Preventable Patient Harm: A Bundled Approach to Reducing *Clostridioides difficile* Infection

Schultz et al. J Clin Microbiol 2018;56

- Multidisciplinary group met on a monthly basis to organize and coordinate our efforts
- Group included:
  - Hospital Epidemiology
  - Performance Improvement and Patient Safety
  - Clinical Microbiology
  - Antimicrobial Stewardship
  - Pharmacy
  - Infectious Diseases

Preventable Patient Harm: A Bundled Approach to Reducing *Clostridioides difficile* Infection

Schultz et al. J Clin Microbiol 2018;56

- Group included (continued):
  - Environmental Services
  - Nursing
  - Patient Equipment
  - Hospital Administration
- The group implemented multiple interventions and monitored the progress of each intervention with process measures

Preventable Patient Harm: A Bundled Approach to Reducing *Clostridioides difficile* Infection

Schultz et al. J Clin Microbiol 2018;56

The interventions fell into eight categories

- Diagnostic stewardship
- Electronic tools to enhance diagnostic stewardship
- Education
- Enhanced isolation precautions
- Hand hygiene
- Environmental cleaning and disinfection
- Antimicrobial stewardship
- Pharmaceutical interventions

Preventable Patient Harm: A Bundled Approach to Reducing *Clostridioides difficile* Infection

Schultz et al. J Clin Microbiol 2018;56

- Majority of the interventions were novel for our facility
- But some (e.g., hand hygiene) focused on sustained existing interventions that were already in place within our facility

Preventable Patient Harm: A Bundled Approach to Reducing *Clostridioides difficile* Infection

Schultz et al. J Clin Microbiol 2018;56

The interventions fell into eight categories

- Diagnostic stewardship
- Electronic tools to enhance diagnostic stewardship
- Education
- Enhanced isolation precautions
- Hand hygiene
- Environmental cleaning and disinfection
- Antimicrobial stewardship
- Pharmaceutical interventions

Preventable Patient Harm: A Bundled Approach to Reducing *Clostridioides difficile* Infection

Schultz et al. J Clin Microbiol 2018;56

- With the advent of highly sensitive nucleic acid amplification tests (NAATs), testing standards are necessary to ensure that the patient's clinical status warrants testing for CDI.
- Since 2009, use two-step glutamate dehydrogenase (GDH)/toxin immunochromatographic assay, if discordant, arbitrated by NAAT
- Microbiology enforced *C. difficile* testing only for unformed, liquid stool and restricted testing for children less than 12m with ped ID approval

Testing for C. *diff* when not indicated can harm your patient

Some patients are colonized with C. *diff* but do not have active infections. Testing a patient without symptoms may result in:

- Unnecessary antibiotics (and side effects)
- Avoidable isolation precautions
- Higher healthcare costs for patients (and hospitals)
- Increased lengths of stay

When should I test my patient for C. *diff*?

- ≥3 liquid stools within 24 hours, without another known medical reason
- No laxatives within past 48 hours*

*If patient has unexplained fever, abdominal pain, AND leukocytosis, testing may be indicated.

Follow Epic process instructions for timing after previous tests.

Testing not recommended for patients under age 2.

REMEMBER:

- **Wash hands with soap and water only**
- **Practice Antimicrobial Stewardship**
- **Follow Enteric Precautions**
- **Clean room & equipment with bleach wipes**
- **Ensure room cleaned with UV at discharge**

Visit the C. *diff* page on the Intranet (under Infection Prevention) for more info

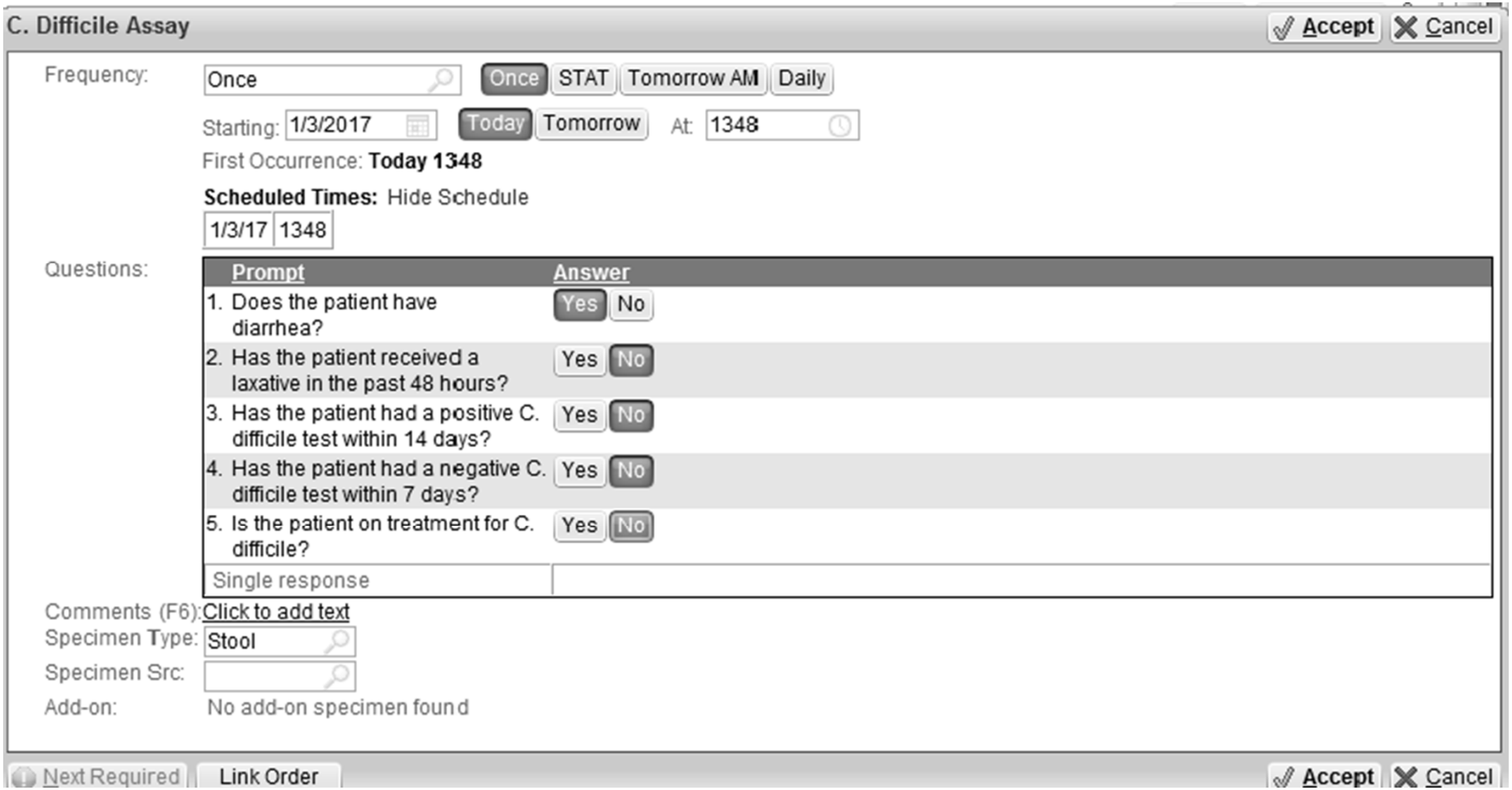
Preventable Patient Harm: A Bundled Approach to Reducing *Clostridioides difficile* Infection

Schultz et al. J Clin Microbiol 2018;56

The interventions fell into eight categories

- Diagnostic stewardship
- Electronic tools to enhance diagnostic stewardship
- Education
- Enhanced isolation precautions
- Hand hygiene
- Environmental cleaning and disinfection
- Antimicrobial stewardship
- Pharmaceutical interventions

Modified Electronic Record (Epic) To Create Automated Prompts Based on Lab Testing Standards for Clinicians Ordering *C. difficile* Testing (not hard stops, significant diarrhea)



Modified Electronic Record (Epic) To Create Automated Best Practice Advisories within Epic to Inform HCPs of the Lab Testing Standards

Schultz et al. J Clin Microbiol 2018;56

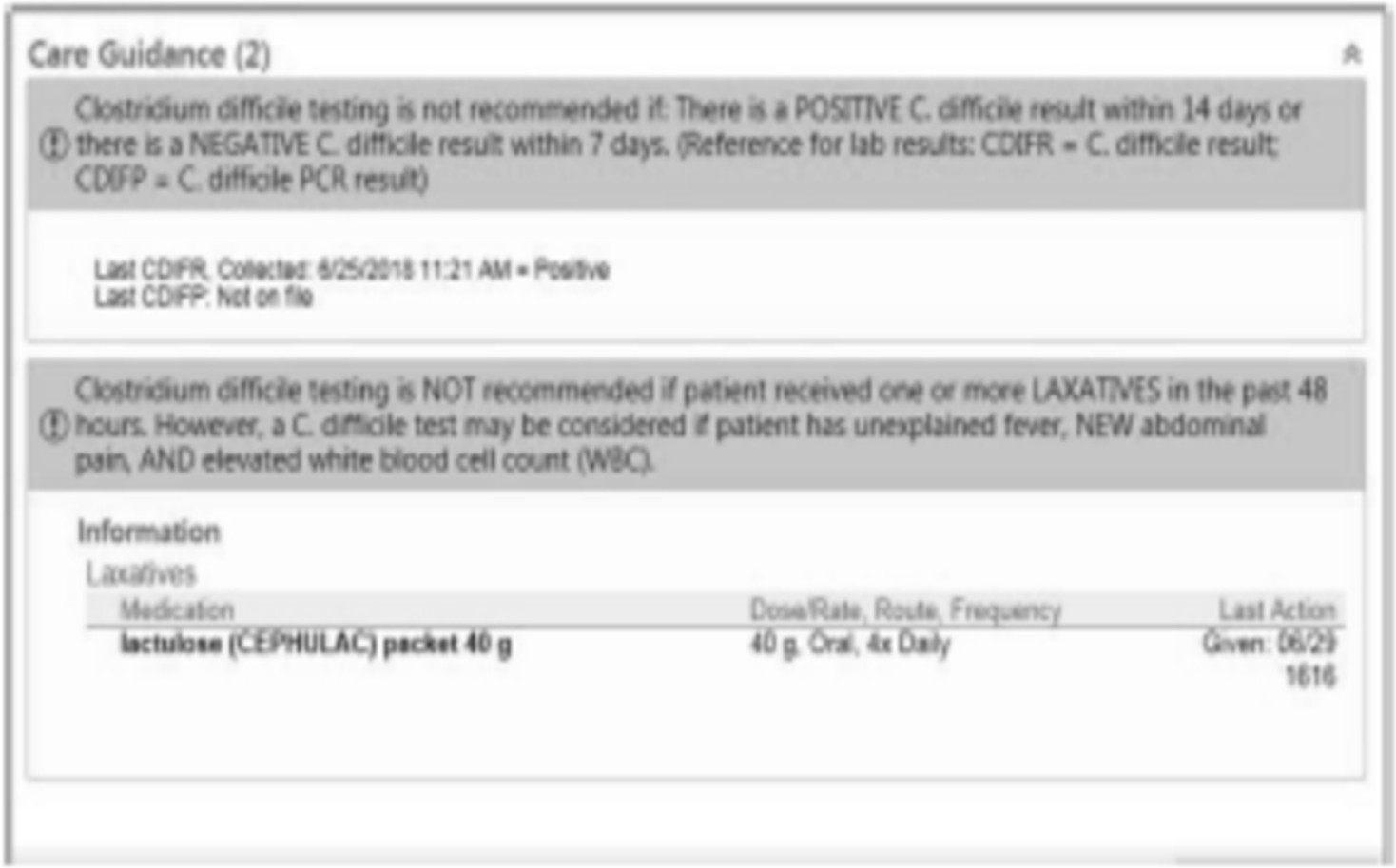


FIG 2 Electronic best practice advisories for *C. difficile* testing.

Preventable Patient Harm: A Bundled Approach to Reducing *Clostridioides difficile* Infection

Schultz et al. J Clin Microbiol 2018;56

The interventions fell into eight categories

- Diagnostic stewardship
- Electronic tools to enhance diagnostic stewardship
- Education
- Enhanced isolation precautions
- Hand hygiene
- Environmental cleaning and disinfection
- Antimicrobial stewardship
- Pharmaceutical interventions

Preventable Patient Harm: A Bundled Approach to Reducing *Clostridioides difficile* Infection

Schultz et al. J Clin Microbiol 2018;56

Education

- Update of *C. difficile* testing per hospital policy was disseminated to physician leadership
- RNs empowered to place an order for *C. difficile* testing for symptomatic patients
- Intended to expedite testing on symptomatic patients when appropriate in order to initiate isolation and treatment

Preventable Patient Harm: A Bundled Approach to Reducing *Clostridioides difficile* Infection

Schultz et al. J Clin Microbiol 2018;56

The interventions fell into eight categories

- Diagnostic stewardship
- Electronic tools to enhance diagnostic stewardship
- Education
- Enhanced isolation precautions
- Hand hygiene
- Environmental cleaning and disinfection
- Antimicrobial stewardship
- Pharmaceutical interventions

Preventable Patient Harm: A Bundled Approach to Reducing *Clostridioides difficile* Infection

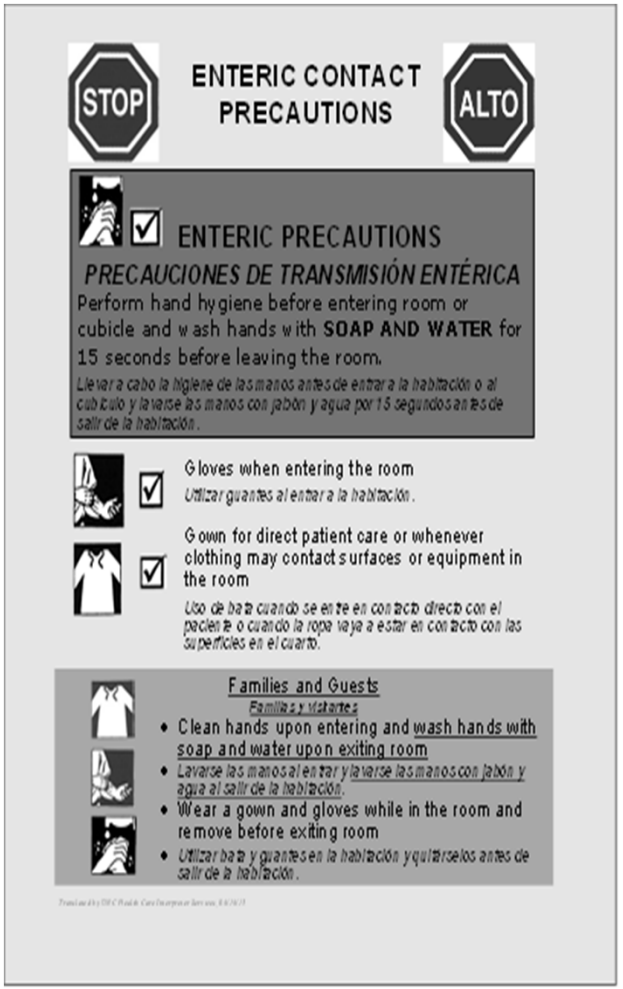
Schultz et al. J Clin Microbiol 2018;56

Enhanced Isolation Precautions

- Patients with known or suspected CDI are placed on Enteric Precautions (enhanced version of CP)
- Enteric Precautions requires a private room, gloves when entering the room, disposable gown/gloves for patient contact or clothing may contact room surfaces, and hand hygiene with soap and water
- Visitors are also required to wear a gown and gloves and perform hand hygiene require

UNC Health Care Isolation Sign for Patients with *C. difficile*

- Use term Contact-Enteric Precautions
- Requires gloves and gown when entering room
- Recommends hand hygiene with soap and water (instead of alcohol-based antiseptic)
- Information in English and Spanish



SURVIVAL
C. difficile

- Vegetative cells
  - Can survive for at least 24 h on inanimate surfaces

- Spores
  - Spores survive for up to 5 months. 10^6 CFU of *C. difficile* inoculated onto a floor; marked decline within 2 days. Kim et al. J Inf Dis 1981;143:42.

Microbiological Disinfectant Hierarchy

Rutala WA, Weber DJ, HICPAC. www.cdc.gov

Most Resistant

Most Susceptible

Spores (*C. difficile*)

Mycobacteria (*M. tuberculosis*)

Non-Enveloped Viruses (norovirus, HAV, polio)

Fungi (Candida, *Trichophyton*)

Bacteria (MRSA, VRE, *Acinetobacter*)

Enveloped Viruses (HIV, HSV, Flu)

DISINFECTANTS AND ANTISEPSIS

C. difficile spores at 20 min, Rutala et al, 2006

- No measurable activity (1 *C. difficile* strain, J9)
  - CHG
  - Phenolic
  - 70% isopropyl alcohol
  - 95% ethanol
  - 3% hydrogen peroxide
  - Disinfecting spray (65% ethanol, 0.6% QUAT)
  - Disinfecting spray (79% ethanol, 0.1% QUAT)
  - 0.06% QUAT; QUAT may increase sporulation capacity-Lancet 2000;356:1324
  - 10% povidone iodine
  - 0.5% hydrogen peroxide

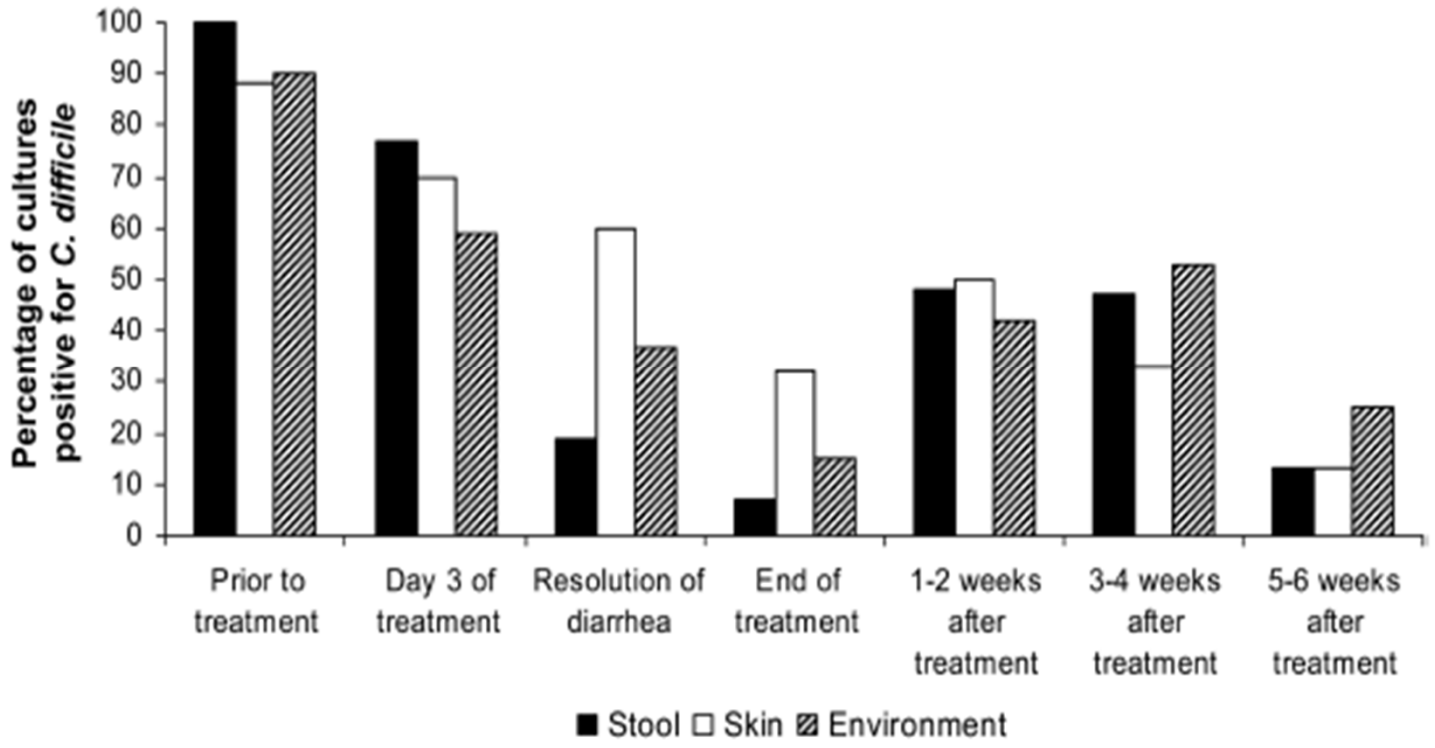
Preventable Patient Harm: A Bundled Approach to Reducing *Clostridioides difficile* Infection

Schultz et al. J Clin Microbiol 2018;56

Enhanced Isolation Precautions

- HE increased the duration of Enteric Precautions from cessation of antibiotic therapy to 30 days after the cessation of antibiotic therapy, based on persistent stool, skin and environmental contamination after CDI
- This change was periodically monitored staff and visitor compliance with point prevalence surveys

RATIONALE FOR PROLONGED CONTACT ENTERIC ISOLATION OF PATIENTS WITH CDI



Skin (chest and abdomen) and environment (bed rail, bedside table, call button, toilet seat)

Sethi AK, et al. ICHE 2010;31:21-27

Preventable Patient Harm: A Bundled Approach to Reducing *Clostridioides difficile* Infection

Schultz et al. J Clin Microbiol 2018;56

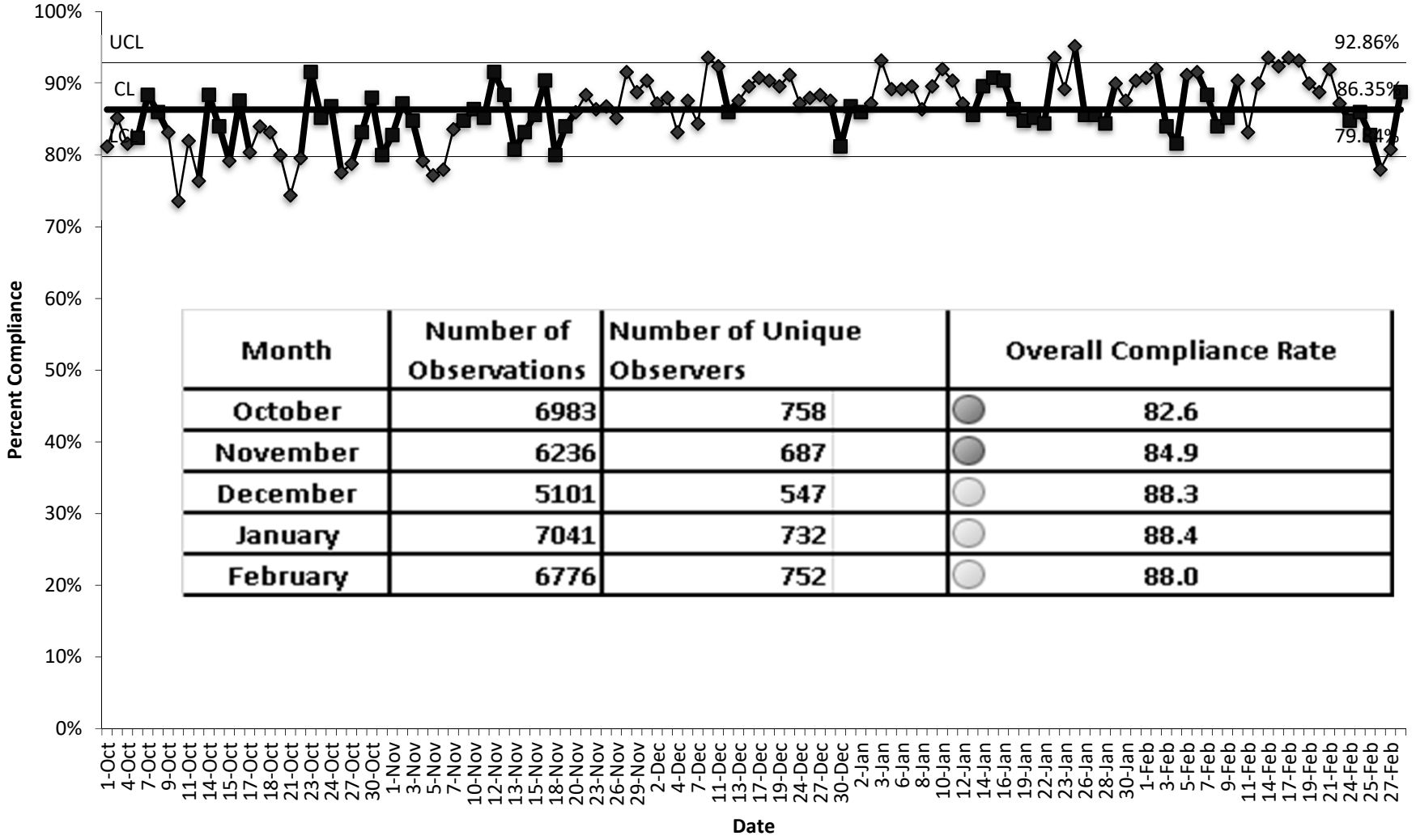
The interventions fell into eight categories

- Diagnostic stewardship
- Electronic tools to enhance diagnostic stewardship
- Education
- Enhanced isolation precautions
- Hand hygiene
- Environmental cleaning and disinfection
- Antimicrobial stewardship
- Pharmaceutical interventions

CLEAN IN, CLEAN OUT

Hand Hygiene Compliance Program Update

Overall Clean In, Clean Out Compliance
Shewhart Control Chart



Month	Number of Observations	Number of Unique Observers	Overall Compliance Rate
October	6983	758	82.6
November	6236	687	84.9
December	5101	547	88.3
January	7041	732	88.4
February	6776	752	88.0

Hand hygiene remained consistently high (>90%) hand hygiene compliance

Preventable Patient Harm: A Bundled Approach to Reducing *Clostridioides difficile* Infection

Schultz et al. J Clin Microbiol 2018;56

The interventions fell into eight categories

- Diagnostic stewardship
- Electronic tools to enhance diagnostic stewardship
- Education
- Enhanced isolation precautions
- Hand hygiene
- Environmental cleaning and disinfection
- Antimicrobial stewardship
- Pharmaceutical interventions

Environmental Contamination

- 25% (117/466) of cultures positive (<10 CFU) for *C. difficile*. >90% of sites positive with incontinent patients. (Samore et al. AJM 1996;100:32)
- 31.4% of environmental cultures positive for *C. difficile*. (Kaatz et al. AJE 1988;127:1289)
- 9.3% (85/910) of environmental cultures positive (floors, toilets, toilet seats) for *C. difficile*. (Kim et al. JID 1981;143:42)
- 29% (62/216) environmental samples were positive for *C. difficile*. 29% (11/38) positive cultures in rooms occupied by asymptomatic patients and 49% (44/90) in rooms with patients who had CDAD. (NEJM 1989;320:204)
- 10% (110/1086) environmental samples were positive for *C. difficile* in case-associated areas and 2.5% (14/489) in areas with no known cases. (Fekety et al. AJM 1981;70:907)

C. difficile Environmental Contamination

Rutala, Weber. SHEA. 3rd Edition. 2010

- Frequency of sites found contaminated~10->50% from 13 studies-stethoscopes, bed frames/rails, call buttons, sinks, hospital charts, toys, floors, windowsills, commodes, toilets, bedsheets, scales, blood pressure cuffs, phones, door handles, electronic thermometers, flow-control devices for IV catheter, feeding tube equipment, bedpan hoppers
- *C. difficile* spore load is low-7 studies assessed the spore load and most found <10 colonies on surfaces found to be contaminated. Two studies reported >100; one reported a range of "1->200" and one study sampled several sites with a sponge and found 1,300 colonies *C. difficile*.

FREQUENCY OF ENVIRONMENTAL CONTAMINATION AND RELATION TO HAND CONTAMINATION

- Study design: Prospective study, 1992
- Setting: Tertiary care hospital
- Methods: All patients with CDI assessed with environmental cultures
- Results
  - Environmental contamination frequently found (25% of sites) but higher if patients incontinent (>90%)
  - Level of contamination low (<10 colonies per plate)
  - Presence on hands correlated with prevalence of environmental sites

Samore MH, et al. Am J Med 1996;100:32-40

Frequency of Cultures Positive for *Clostridium difficile* From Different Environmental Sites Within the Hospital Room

Site	All Rooms	Double Rooms	
	No. Positive/ No. Tested (%)	Index Side (%)	Roommate Side (%)
Floor	15/31 (48)	NA	NA
Commode	7/17 (41)	NA	NA
Windowsill	6/16 (38)	NA	NA
Toilet	15/45 (33)	NA	NA
Buzzer	11/57 (19)	6/19 (32)	1/17 (6)
Bedsheets	12/56 (21)	4/20 (20)	2/14 (14)
Bedrails	15/81 (18)	7/26 (27)	2/25 (8)
Totals	81/303 (27)	17/65 (26)*	5/56 (9)

*P = 0.02 by Fisher's exact test, index side versus roommate side.
NA = not applicable.

Correlation Between Proportion of Positive Environmental Sites and Isolation of *Clostridium difficile* From Hands of Hospital Personnel

Environmental Sites Positive (%)	No. of Index Cases With Environmental Sites and Personnel Cultured	No. of Positive Personnel/ No. of Personnel Cultured (%)
0	12	0/25
1–25	5	0/11
[illegible]	[illegible]	[illegible]
>50	6	9/25 (36)*

*Chi-square test for linear trend in proportions: P <0.01.

Proving That Environmental Contamination Is Important in *C. difficile* Transmission

- Environmental persistence (Kim et al. JID 1981;14342)
- Frequent environmental contamination (McFarland et al. NEJM 1989;320:204)
- Demonstration of HCW hand contamination (Samore et al. AJM 1996;100:32)
- Environmental $\Rightarrow$ hand contamination (Samore et al. AJM 1996;100:32)
- Person-to-person transmission (Raxach et al. ICHE 2005;26:691))
- Transmission associated with environmental contamination (Samore et al. AJM 1996;100:32)
- CDI room a risk factor (Shaughnessy et al. IDSA/ICAAC. Abstract K-4194)
- Improved disinfection $\Rightarrow \Downarrow$ epidemic CDI (Kaatz et al. AJE 1988;127:1289)
- Improved disinfection $\Rightarrow \Downarrow$ endemic CDI (Boyce et al. ICHE 2008;29:723)

Factors Leading to Environmental Transmission of *Clostridioides difficile*

- Stable in the environment
- Relatively resistant to disinfectants
- Frequent contamination of the environment
- Low inoculating dose
- Common source of infectious gastroenteritis
- Susceptible population (limited immunity)

Preventable Patient Harm: A Bundled Approach to Reducing *Clostridioides difficile* Infection

Schultz et al. J Clin Microbiol 2018;56

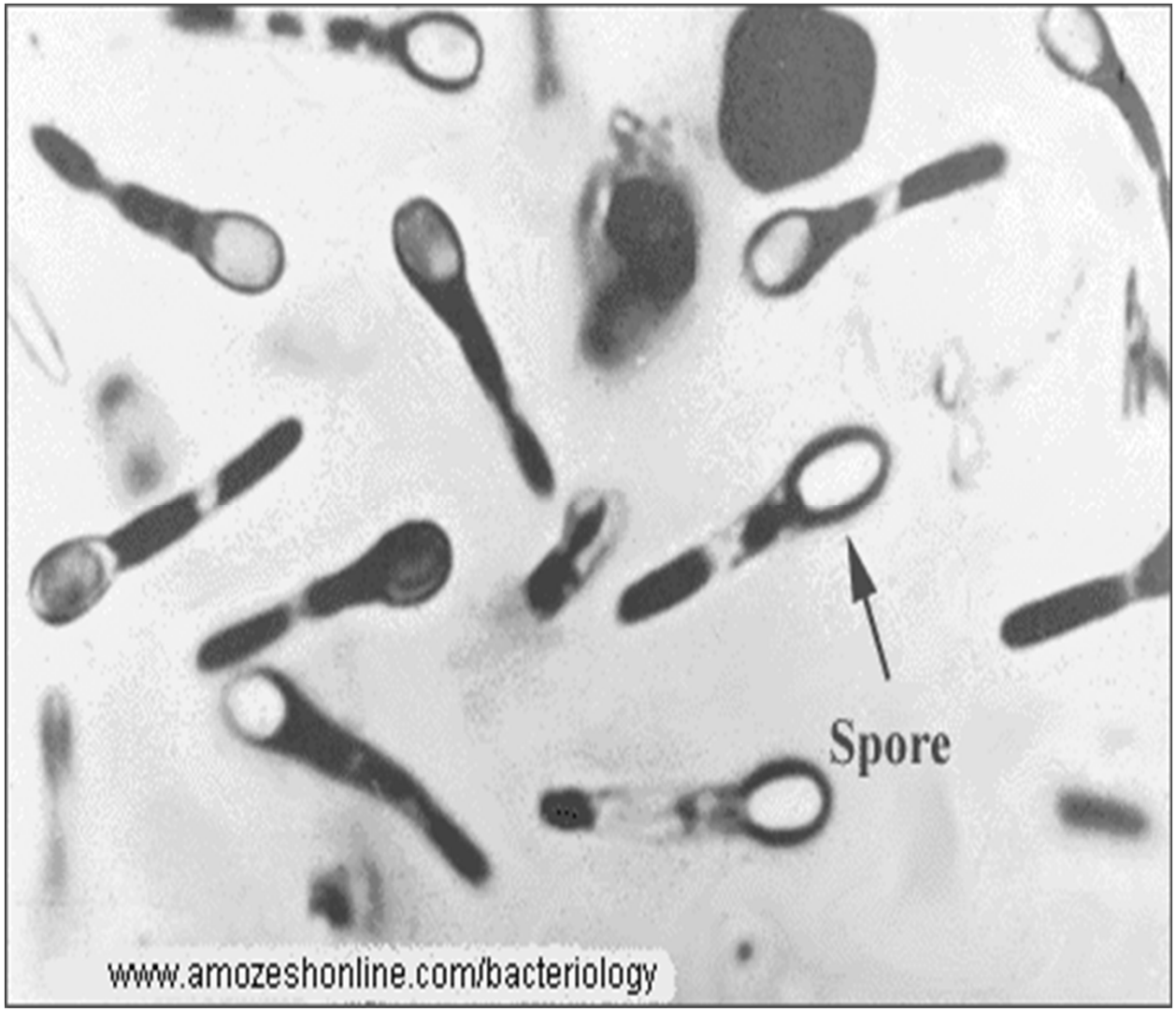
Environmental cleaning and disinfection (CD)

- Enhanced cleaning practices in enteric precautions included the use of an EPA-registered disinfectant with sporicidal during daily cleans and at patient discharge.
- ES staff also used UV-C machines to terminally disinfect patient rooms after CD following patient discharge.
- The thoroughness of CD was monitored on a regular basis with the application of fluorescent dye on surfaces
- A second multidisciplinary group created to standardize CD plan for both patient rooms and pieces of patient equipment throughout the hospital.

Effective Surface Decontamination

Product and Practice = Perfection

C. difficile spores



C. difficile Spores
EPA-Registered Products

- List K: EPA's Registered Antimicrobials Products Effective Against *C. difficile* spores, April 2014
- http://www.epa.gov/oppad001/list_k_clostridium.pdf
- 34 registered products; most chlorine-based, some HP/PA-based, PA with silver
- New 4% hydrogen peroxide

LOW-LEVEL DISINFECTION FOR NONCRITICAL EQUIPMENT AND SURFACES

Rutala, Weber. Infect Control Hosp Epidemiol. 2014;35:855-865; Rutala, Weber. AJIC 2019;47:A3-A9

Exposure time ≥ 1 min

Germicide	Use Concentration
Ethyl or isopropyl alcohol	70-90%
Chlorine	100ppm (1:500 dilution)
Phenolic	UD
Iodophor	UD
Quaternary ammonium (QUAT)	UD
QUAT with alcohol	RTU
Improved hydrogen peroxide (HP)	0.5%, 1.4%
PA with HP, 4% HP, chlorine (*C. difficile*)	UD

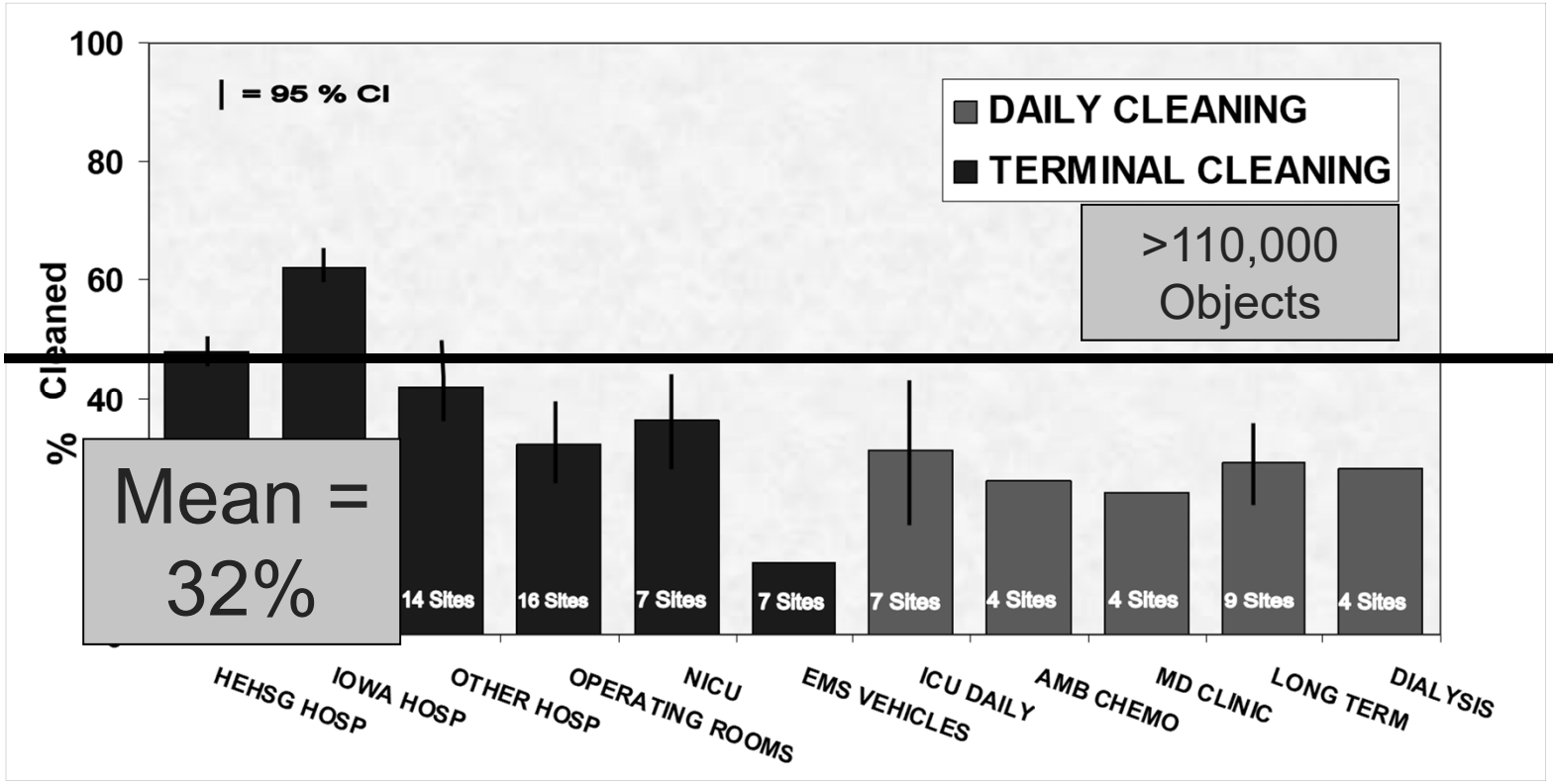
UD=Manufacturer's recommended use dilution; others in development/testing-electrolyzed water; polymeric guanidine; cold-air atmospheric pressure plasma (Boyce Antimicrob Res IC 2016. 5:10)

Effective Surface Decontamination

Product and Practice = Perfection

Thoroughness of Environmental Cleaning

Carling et al. ECCMID, Milan, Italy, May 2011



EVALUATION OF HOSPITAL ROOM ASSIGNMENT AND ACQUISITION OF CDI

- **Study design: Retrospective cohort analysis, 2005-2006**
- **Setting: Medical ICU at a tertiary care hospital**
- **Methods: All patients evaluated for diagnosis of CDI 48 hours after ICU admission and within 30 days after ICU discharge**
- **Results (acquisition of CDI)**
  - **Admission to room previously occupied by CDI = 11.0%**
  - **Admission to room not previously occupied by CDI = 4.6% (p=0.002)**

TABLE 3. Multivariate Analysis of Risk Factors for Acquisition of *Clostridium difficile* Infection (CDI)

Risk factor	HR (95% CI)	*P*
Prior room occupant with CDI	2.35 (1.21–4.54)	.01
Greater age	1.00 (0.99–1.01)	.71
Higher APACHE III score	1.00 (1.00–1.01)	.06
Proton pump inhibitor use	1.11 (0.44–2.78)	.83
Antibiotic exposure		
Norfloxacin	0.38 (0.05–2.72)	.33
Levofloxacin	1.08 (0.67–1.73)	.75
Ciprofloxacin	0.49 (0.15–1.67)	.23
Fluoroquinolones	1.17 (0.72–1.91)	.53
Clindamycin	0.45 (0.14–1.42)	.17
Third- or fourth-generation cephalosporins	1.17 (0.76–1.79)	.48
Carbapenems	1.05 (0.63–1.75)	.84
Piperacillin-tazobactam	1.31 (0.82–2.10)	.27
Other penicillin	0.47 (0.23–0.98)	.04
Metronidazole	1.31 (0.83–2.07)	.24
Vancomycin		
Oral	1.38 (0.32–5.89)	.67
Intravenous	1.55 (0.88–2.73)	.13
Aminoglycosides	1.27 (0.78–2.06)	.35
Multiple (≥3 antibiotic classes)	1.28 (0.75–2.21)	.37

NOTE. APACHE, Acute Physiology and Chronic Health Evaluation; CI, confidence interval; HR, hazard ratio.

Shaughnessy MK, et al. ICHE 2011;32:201-206

Wipes

Cotton, Disposable, Microfiber, Cellulose-Based, Nonwoven Spunlace

Wipe should have sufficient wetness to achieve the disinfectant contact time (e.g. >1 minute)

SURFACE DISINFECTION

Effectiveness of Different Methods

Rutala, Gergen, Weber. ICHE 2012;33:1255-58

Technique (with cotton)	*C. difficile* Log_{10} Reduction (1:10 Bleach)
Saturated cloth	3.90
Spray (10s) and wipe	4.48
Spray, wipe, spray (1m), wipe	4.48
Spray	3.44
Spray, wipe, spray (until dry)	4.48
5500 ppm chlorine pop-up wipe	3.98
Non-sporicidal wipe	$\geq$2.9

Daily Disinfection of High-Touch Surfaces

Kundrapu et al. ICHE 2012;33:1039

Daily disinfection of high-touch surfaces (vs cleaned when soiled) with sporicidal disinfectant (PA) in rooms of patients with CDI and MRSA reduced acquisition of pathogens on hands after contact with surfaces and of hands caring for the patient

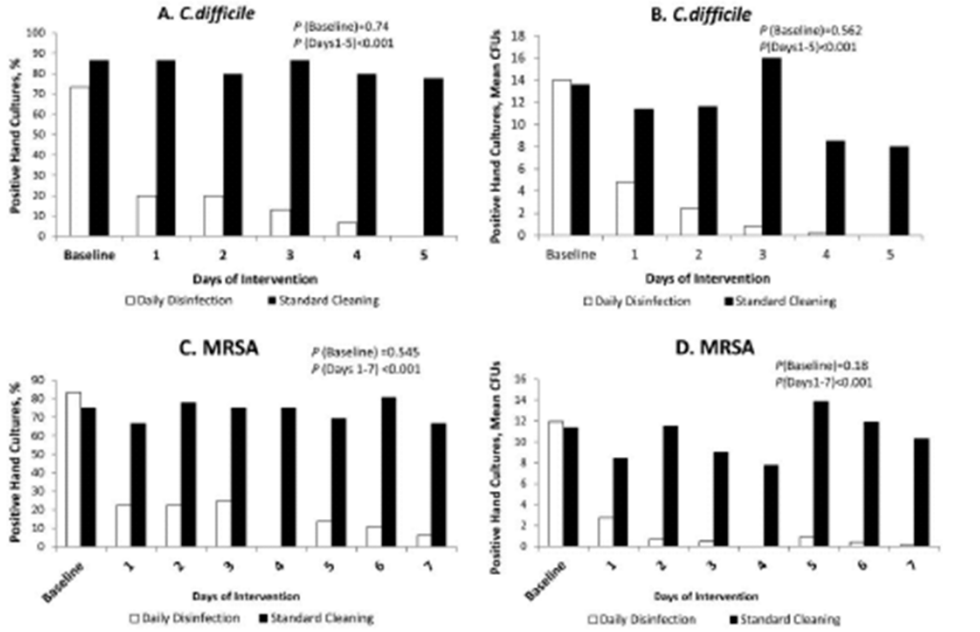
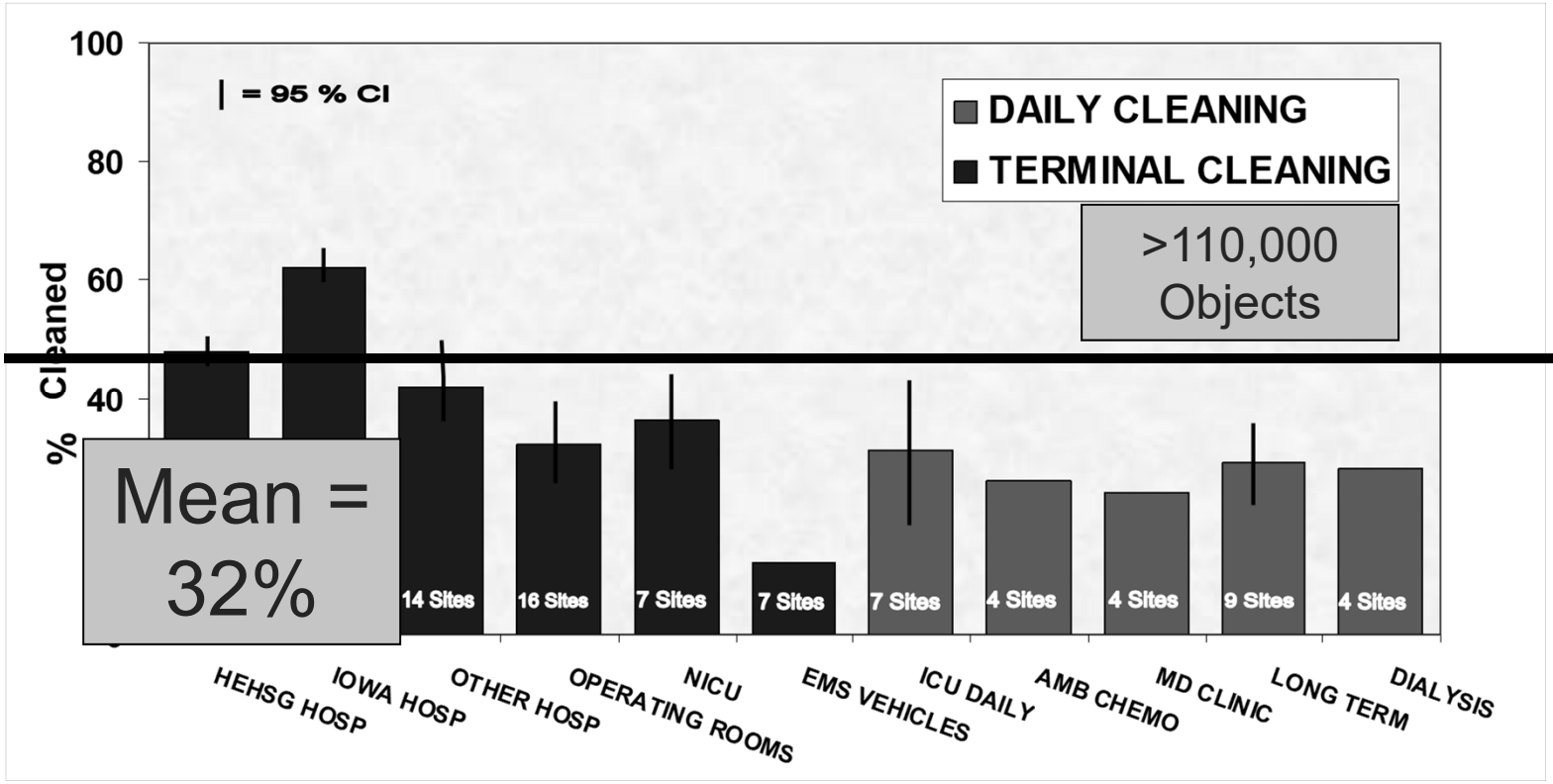


FIGURE 1. Effect of daily disinfection of high-touch environmental surfaces on acquisition of *Clostridium difficile* and methicillin-resistant *Staphylococcus aureus* (MRSA) on gloved hands of investigators after contact with the surfaces. *A*, Percentage of positive *C. difficile* cultures; *B*, mean number of *C. difficile* colony-forming units acquired; *C*, percentage of positive MRSA cultures; *D*, mean number of MRSA colony-forming units acquired.

Thoroughness of Environmental Cleaning

Carling et al. ECCMID, Milan, Italy, May 2011



MONITORING THE EFFECTIVENESS OF CLEANING

Cooper et al. AJIC 2007;35:338

- Visual assessment-not a reliable indicator of surface cleanliness
- ATP bioluminescence-measures organic debris (each unit has own reading scale, <250-500 RLU)
- Microbiological methods-<2.5CFUs/cm^2-pass; can be costly and pathogen specific
- Fluorescent marker-transparent, easily cleaned, environmentally stable marking solution that fluoresces when exposed to an ultraviolet light (applied by IP unbeknown to EVS, after EVS cleaning, markings are reassessed)

Thoroughness of Environmental Cleaning

Carling and Herwaldt. Infect Control Hosp Epidemiol 2017;38:960–965

Hospitals can improve their thoroughness of terminal room disinfection through fluorescent monitoring

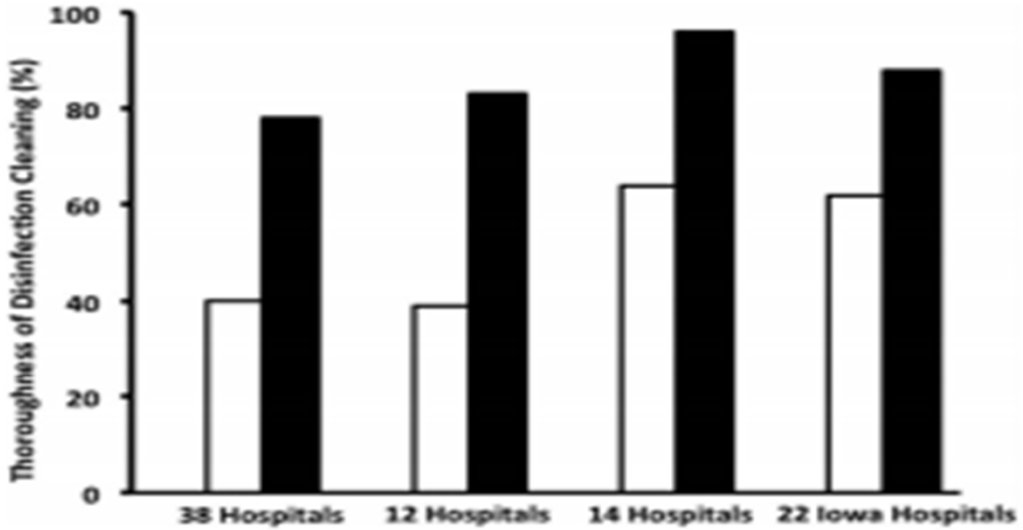
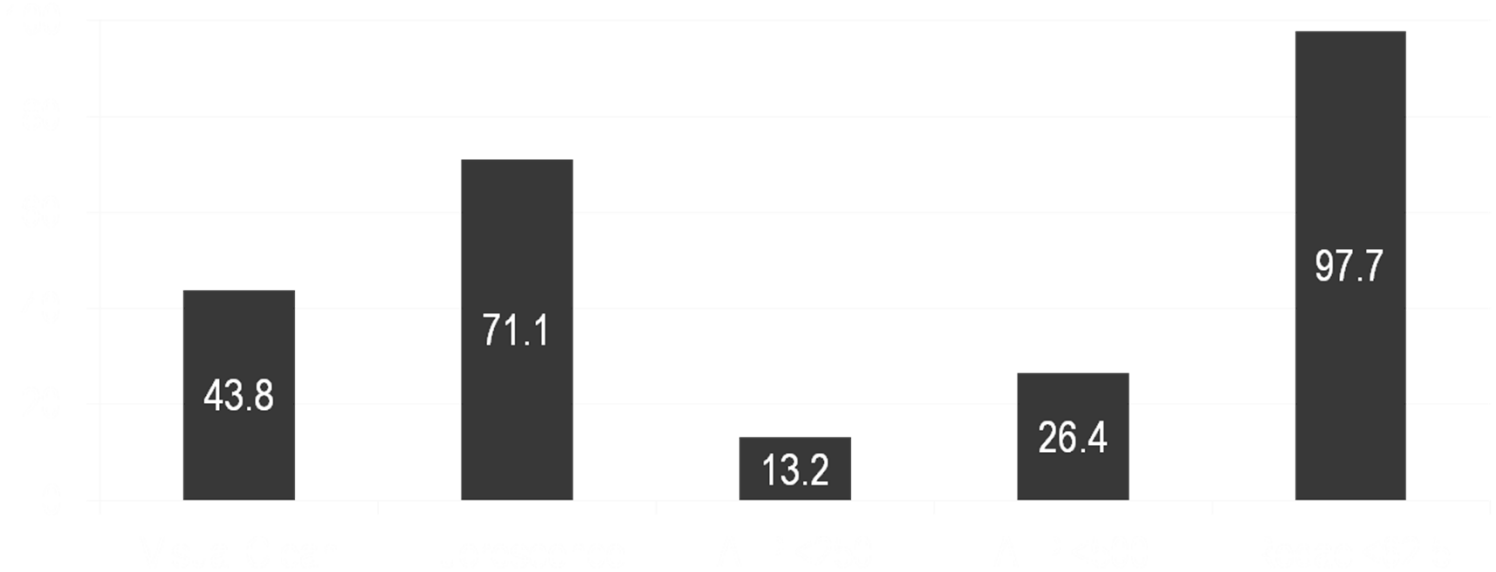


FIGURE 4. A comparison of the results of the 3 previously published multisite studies compared with results from the Iowa project. White bars represent the average baseline TDCs and black bars represent the average final TDCs for sites that completed each study.

Percentage of Surfaces Clean by Different Measurement Methods

Rutala, Kanamori, Gergen, Sickbert-Bennett, Huslage, Weber. APIC 2017.

Fluorescent marker is a useful tool in determining how thoroughly a surface is wiped and mimics the microbiological data better than ATP



These interventions (effective surface disinfection, thoroughness indicators) not enough to achieve consistent and high rates of cleaning/disinfection

No Touch

(supplements but do not replace surface cleaning/disinfection)

“NO TOUCH” APPROACHES TO ROOM DECONTAMINATION

(UV/VHP~20 microbicidal studies, 12 HAI reduction studies; will not discuss technology with limited data)

Weber, Kanamori, Rutala. Curr Op Infect Dis 2016;29:424-431; Weber, Rutala et al. AJIC; 2016:44: e77-e84; Anderson et al. Lancet 2017;389:805-14; Anderson et al. Lancet Infect Dis 2018;June 2018.

Table 2. Clinical trials of 'no touch' methods: UV devices and hydrogen peroxide systems

Year, author	Device/system	Study design	Setting	Selected results[a]
2016, Vianna *et al.* [44]	UV-PX	Before–after	Community hospital	Facility wide: ↓*C. difficile*, ↓all MDROs (MRSA, VRE, CDI)
2015, Horn and Otter [45]	HP vapor	Before–after	Hospital	↓CDI, ↓VRE, ↓ESBL GNB
2015, Anderson *et al.* [46]	UV-C	RCT	9 hospitals	↓All MDROs (MRSA, VRE, CDI)
2015, Pegues *et al.* [47]	UV-C	Before–after	Academic center	↓CDI
2015, Nagaraja *et al.* [48]	UV-PX	Before–after	Academic center	↓CDI
2015, Miller *et al.* [49]	UV-PX	Before–after	Nursing home	↓CDI
2014, Mitchell *et al.* [50]	Dry HP vapor	Before–after	Hospital	↓MRSA colonization and infection
2014, Haas *et al.* [51]	UV-PX	Before–after	Academic center	↓CDI, ↓MRSA, ↓VRE, ↓MDRO GNB, all MDROs
2013, Manian *et al.* [52]	HP vapor	Before–after	Community hospital	↓CDI
2013, Passaretti *et al.* [53]	HP vapor	Prospective cohort	Academic center	↓VRE, ↓all MDROs (MRSA, VRE, CDI)
2013, Levin *et al.* [54]	UV-PX	Before–after	Community hospital	↓CDI, ↓MRSA,
2011, Cooper *et al.* [55]	HP vapor	Before–after (2 cycles)	Hospitals	↓CDI (cases; incidence not significant)
2008, Boyce *et al.* [56]	HP vapor	Before–after	Community hospital	↓CDI

CDI, *Clostridium difficile* infection; ESBL, extended spectrum beta-lactamase producers; GNB, Gram negative bacteria; HP, hydrogen peroxide; MDRO, multidrug-resistant organism; MRSA, methicillin-resistant *Staphylococcus aureus*; UV-C, ultraviolet light – C; UV-PX, ultraviolet light – pulsed xenon; VRE, vancomycin-resistant *Enterococcus*.

[a]All listed results were statistically significant (see reference for more details)

Weber DJ, Rutala WA, et al. Curr Opin Infect Dis 2016;29:424-31.

EFFICACY OF UVC AT TERMINAL DISINFECTION TO REDUCE HAIs

(A = *C. difficile*, B = VRE; UV effective in preventing VRE and *C. difficile*)

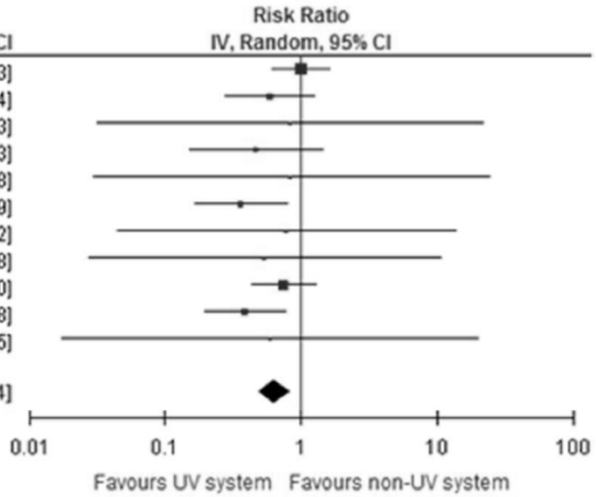
Marra AR, et al. ICHE 2018;39:20-31

A

Study or Subgroup	log[Risk Ratio]	SE	Weight	Risk Ratio IV, Random, 95% CI
Anderson 2017	0	0.25	29.0%	1.00 [0.61, 1.63]
Bernard 2015	-0.53	0.38	12.6%	0.59 [0.28, 1.24]
Haas 2014	-0.19	1.67	0.7%	0.83 [0.03, 21.83]
Levin 2013	-0.76	0.57	5.6%	0.47 [0.15, 1.43]
McMullen 2016	-0.17	1.71	0.6%	0.84 [0.03, 24.08]
Miller 2015	-1.02	0.4	11.3%	0.36 [0.16, 0.79]
Nagajara 2015	-0.25	1.46	0.9%	0.78 [0.04, 13.62]
Napolitano 2015	-0.62	1.52	0.8%	0.54 [0.03, 10.58]
Pegues 2017	-0.29	0.28	23.2%	0.75 [0.43, 1.30]
Sampathkumar 2016	-0.94	0.35	14.8%	0.39 [0.20, 0.78]
Vianna 2016	-0.52	1.8	0.6%	0.59 [0.02, 20.25]
Total (95% CI)			100.0%	0.64 [0.49, 0.84]

Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 7.98$, df = 10 (P = 0.63); $I^2 = 0\%$

Test for overall effect: Z = 3.29 (P = 0.0010)

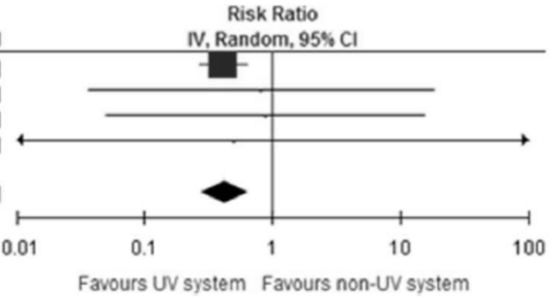


B

Study or Subgroup	log[Risk Ratio]	SE	Weight	Risk Ratio IV, Random, 95% CI
Anderson 2017	-0.89	0.22	95.5%	0.41 [0.27, 0.63]
Haas 2014	-0.2	1.58	1.9%	0.82 [0.04, 18.12]
Napolitano 2015	-0.13	1.46	2.2%	0.88 [0.05, 15.36]
Vianna 2016	-0.69	2.97	0.5%	0.50 [0.00, 169.20]
Total (95% CI)			100.0%	0.42 [0.28, 0.65]

Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 0.45$, df = 3 (P = 0.93); $I^2 = 0\%$

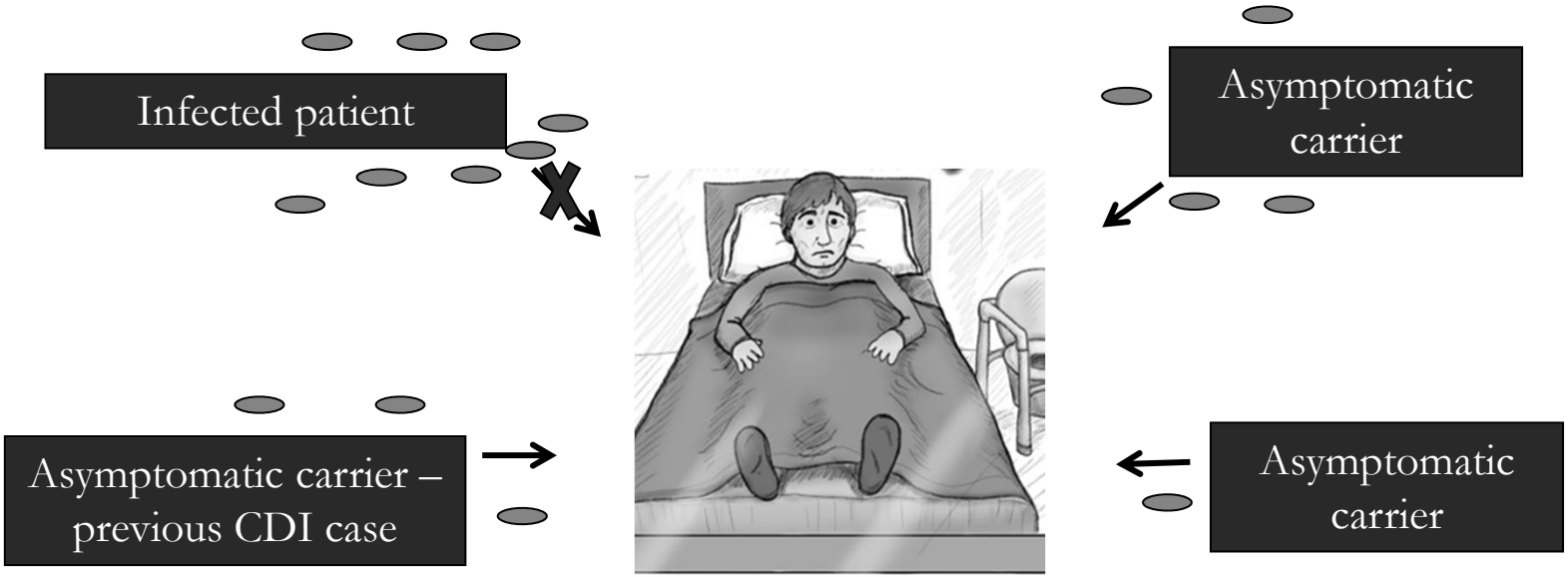
Test for overall effect: Z = 4.00 (P < 0.0001)



New Strategy

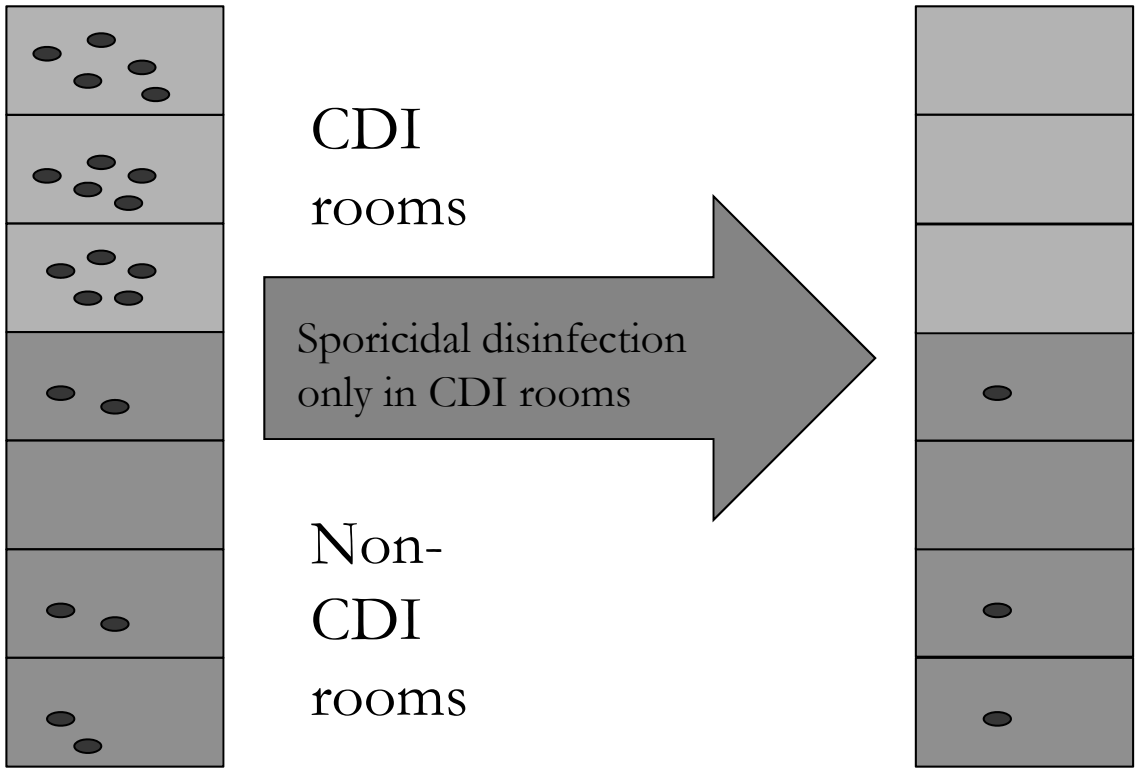
(not employed in referenced paper)

Asymptomatic carriers contribute to *C. difficile* transmission



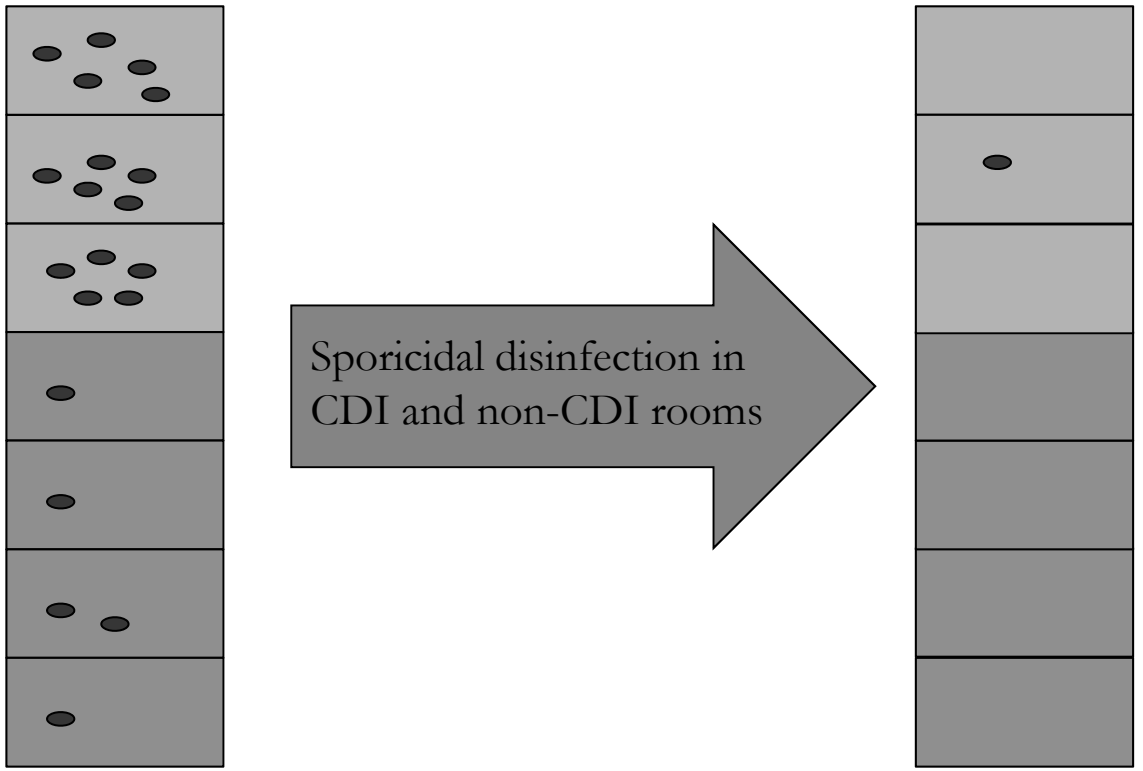
1. Curry SR. Clin Infect Dis 2013 (29% of hospital-associated CDI cases linked to carriers by MLVA); 2. Blixt T. Gastroenterol 2017;152:1031 (exposure to carriers increased CDI risk); 3. Longtin Y. JAMA Int Med 2016 (screening for and isolating carriers reduced CDI by 63%); 4. Samore MH. Am J Med 1996;100:32 (only 1% of cases linked to asymptomatic carriers - roommates and adjacent rooms - by PFGE/REA); 5. Eyre DW. PLOS One 2013;8:e78445 (18 carriers: no links to subsequent CDI cases); 6. Lisenmyer K. Clin Infect Dis 2018 (screening and isolation of carriers associated with control of a ward outbreak); 7. Paquet-Bolduc B. Clin Infect Dis 2018 (unit-wide screening and isolation of carriers not associated with shorter outbreak durations vs historical controls); 8. Donskey CJ. Infect Control Hosp Epidemiol 2018 (14% of healthcare-associated CDI cases linked to LTCF asymptomatic carriers); 9. Kong LY. Clin Infect Dis 2018 (23% of healthcare-associated CDI linked to carriers vs 42% to CDI cases and 35% to carriers or cases)

Interventions focused on CDI rooms



Curry SR, et al. Clin Infect Dis 2013;57:1094-102; Kong LY, et al. Clin Infect Dis 2018; Longtin Y, et al. JAMA Intern Med 2016;

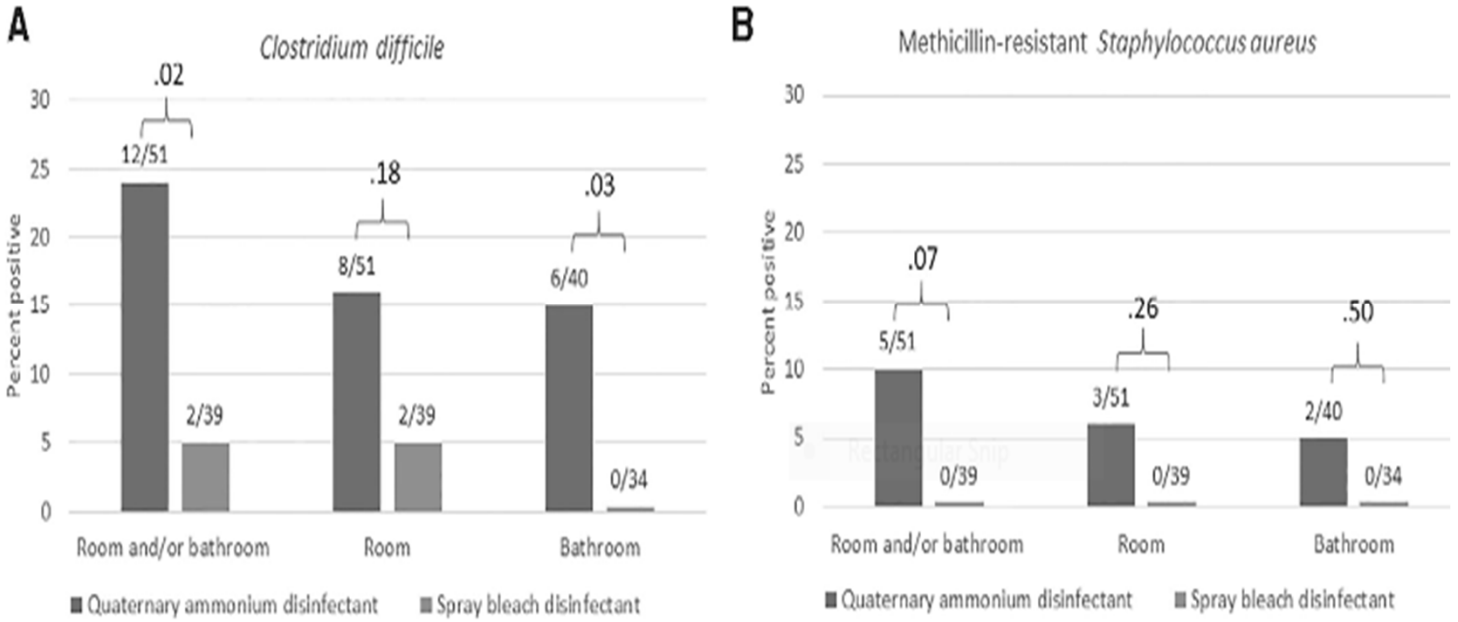
Interventions addressing CDI cases and asymptomatic carriers



Use of Sporicidal Disinfectant on *C. difficile* spore Contamination in non-*C. difficile* Infection Rooms

Wong et al. AJIC, 2019

The percentage of rooms contaminated with *C. difficile* was significantly reduced during the period with a sporicidal product was used 5% vs 24%. Results suggest sporicidal disinfectant in all postdischarge rooms could potentially be beneficial in reducing the risk *for C. difficile* transmission from contaminated surfaces



Preventable Patient Harm: A Bundled Approach to Reducing *Clostridioides difficile* Infection

Schultz et al. J Clin Microbiol 2018;56

The interventions fell into eight categories

- Diagnostic stewardship
- Electronic tools to enhance diagnostic stewardship
- Education
- Enhanced isolation precautions
- Hand hygiene
- Environmental cleaning and disinfection
- Antimicrobial stewardship
- Pharmaceutical interventions

Preventable Patient Harm: A Bundled Approach to Reducing *Clostridioides difficile* Infection

Schultz et al. J Clin Microbiol 2018;56

Antimicrobial stewardship (AS) and pharmacy intervention

- Reducing the use of unnecessary antibiotics is crucial in preventing CDI
- AS program (ID MD, ID PharmD, CM) provided support through antimicrobial surveillance, audits and feedback
- AS program worked to reduce 3rd and 4th generation cephalosporins and fluoroquinolones
- Guidelines for proton pump inhibitors (lowest dose possible for shortest time) presented to pharmacists, ICU MDs and nurse leaders

Antimicrobial Stewardship and Pharmacy Interventions

- Antimicrobial stewardship goal was to reduce the days of therapy per 1,000 patients days of third and fourth generation
- Cefepime, ceftazidime, and levofloxacin use all decreased significantly.
- Clindamycin days of therapy were also reduced

Preventable Patient Harm: A Bundled Approach to Reducing *Clostridioides difficile* Infection

Schultz et al. J Clin Microbiol 2018;56

The interventions fell into eight categories

- Diagnostic stewardship
- Electronic tools to enhance diagnostic stewardship
- Education
- Enhanced isolation precautions
- Hand hygiene
- Environmental cleaning and disinfection
- Antimicrobial stewardship
- Pharmaceutical interventions

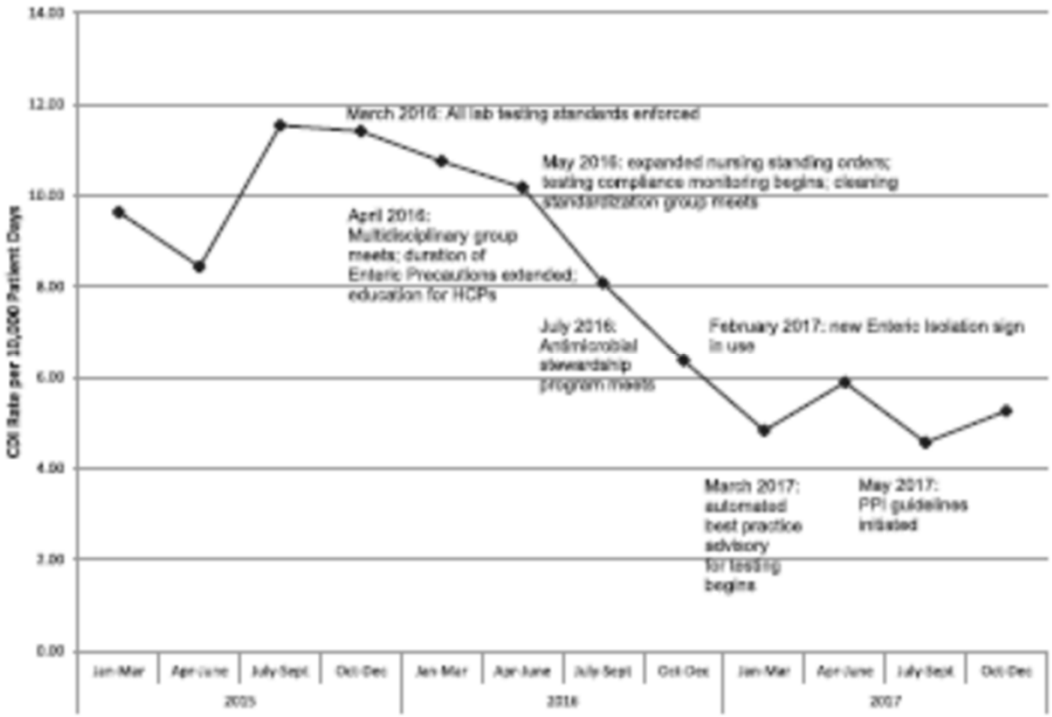
Preventable Patient Harm: A Bundled Approach to Reducing *Clostridioides difficile* Infection

Schultz et al. J Clin Microbiol 2018;56

Results

- 11.0 infections per 10,000 patient days → 6.30 infections per 10,000 patient days
- Decrease of 42.7%
- 100 fewer infections potentially saved our facility >$300,000
- None of the interventions implemented in this bundle required an additional financial investment

Health-Care Facility-Onset *C. difficile* LabID Rates and Novel Interventions, 2015-2017



Preventable Patient Harm: A Bundled Approach to Reducing *Clostridioides difficile* Infection

Schultz et al. J Clin Microbiol 2018;56

Eight interventions:

- Diagnostic stewardship
- Electronic tools to enhance diagnostic stewardship
- Education
- Enhanced isolation precautions
- Hand hygiene
- Environmental cleaning and disinfection
- Antimicrobial stewardship
- Pharmaceutical interventions

Achieved a statistically significant reduction of 42.7% in our healthcare-facility onset *C. difficile* infections by forming a multidisciplinary group to implement and monitor eight key categories of infection prevention

THANK YOU!

www.disinfectionandsterilization.org

Preventable Patient Harm: A Bundled Approach to Reducing *Clostridioides difficile* Infection

Schultz et al. J Clin Microbiol 2018;56

Audits and surveys

- Increased compliance with use of UVC at discharge CD for Enteric Precautions rooms
- ES audits of CD compliance with fluorescent dye on inpatient room touchpoints showed high monthly compliance
- High HCP compliance (93%) with PPE in Enteric Precaution rooms
- Reduced days of therapy per 1000 patient days of 3rd, 4th generation cephalosporin and fluoroquinolone

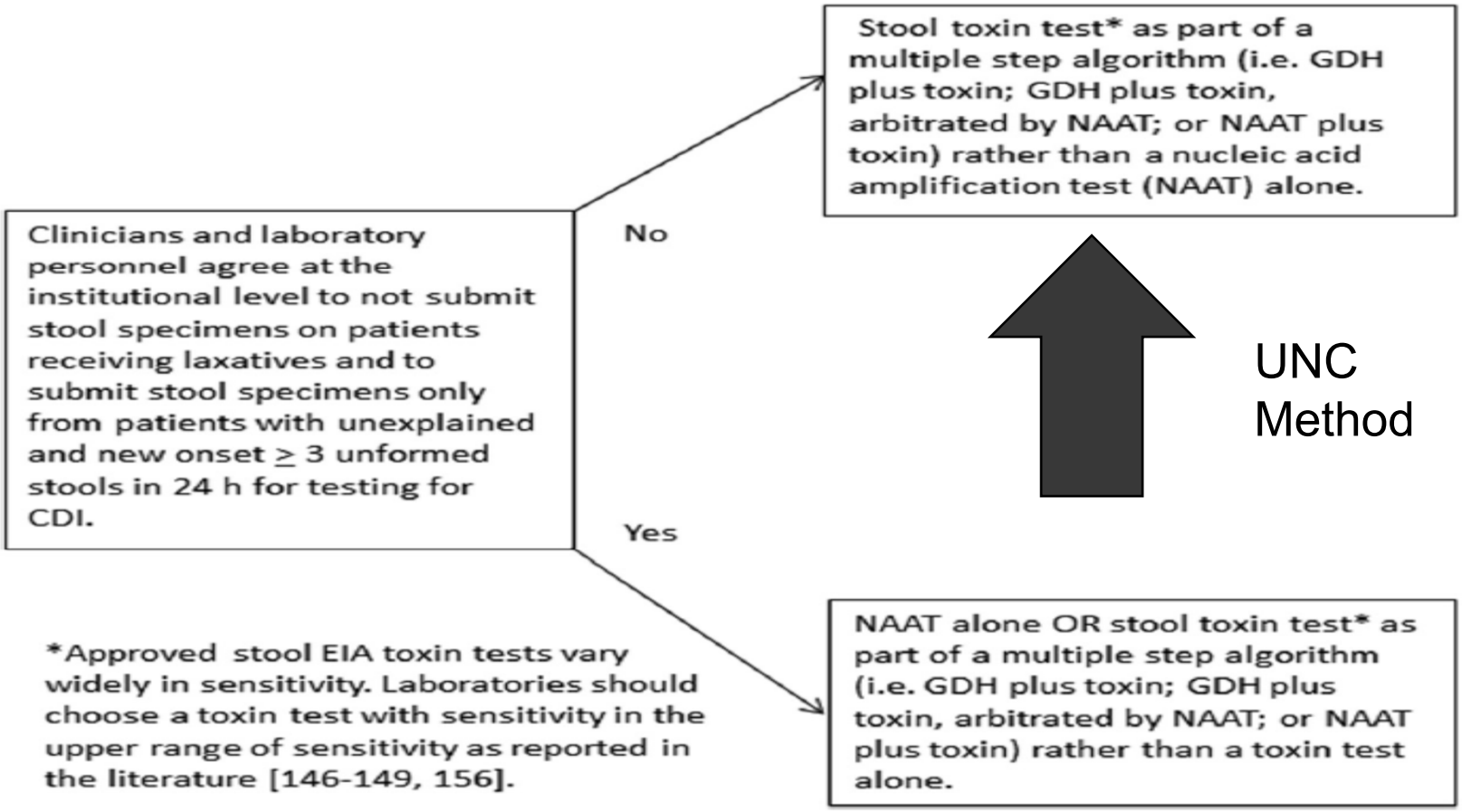
Preventable Patient Harm: A Bundled Approach to Reducing *Clostridioides difficile* Infection

Schultz et al. J Clin Microbiol 2018;56

Provider Compliance (abstracted from EMR)

- No previous positive test in the last 14 days
- No previous negative test in the last 7 days
- No laxatives or stool softeners administered in the 48 hours prior to testing
- Loose stools documented

CDI LAB TEST RECOMMENDATIONS



McDonald LG, et al. Clin Infect Dis 2018;66:e1-e48

CONTROL MEASURES

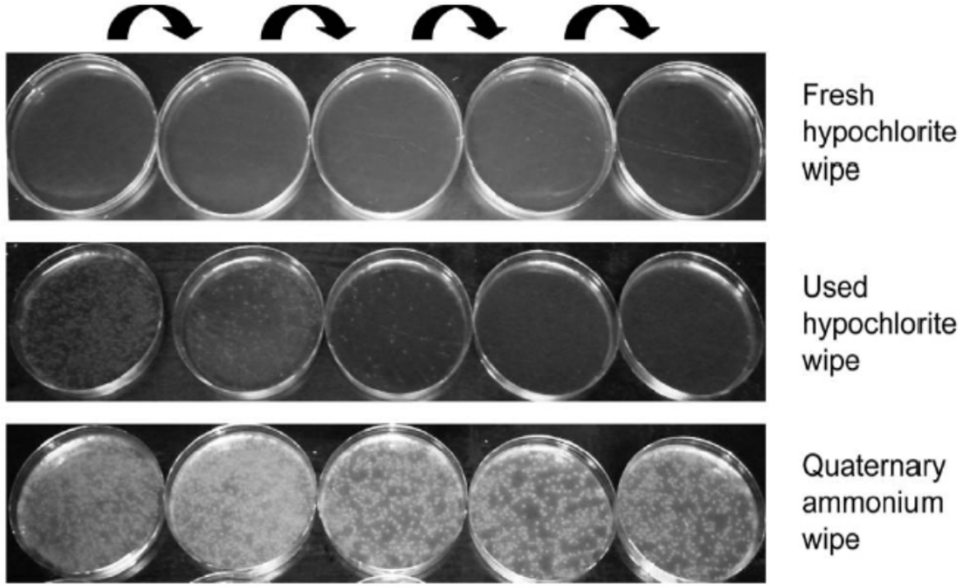
C. difficile Disinfection

- In units with high endemic *C. difficile* infection rates or in an outbreak setting, use dilute solutions of 5.25-6.15% sodium hypochlorite (e.g., 1:10 dilution of bleach) for routine disinfection. (CDC and SHEA).
- We now use chlorine solution in all CDI rooms for routine daily and terminal cleaning (formerly used QUAT in patient rooms with sporadic CDI). One application of an effective product covering all surfaces to allow a sufficient wetness for > 1 minute contact time. Chlorine solution normally takes 1-3 minutes to dry.
- For semicritical equipment, glutaraldehyde (20m), OPA (12m) and peracetic acid (12m) reliably kills *C. difficile* spores using normal exposure times

TRANSFER OF *C. DIFFICILE* SPORES BY NONSPORICIDAL WIPES AND IMPROPERLY USED HYPOCHLORITE WIPES

- Study design: *In vitro* study that assessed efficacy of different wipes in killing of *C. difficile* spores (5-$\log_{10}$)
  - Fresh hypochlorite wipes
  - Used hypochlorite wipes
  - Quaternary ammonium wipes
- Results (4th transfer)
  - Quat had no efficacy (3-$\log_{10}$ spores)
  - Fresh hypochlorite worked
  - Used hypochlorite transferred spores in lower concentration (0.4-$\log_{10}$ spores)

Practice + Product = Perfection



Cadnum JL, et al. ICHE 2013;34:441-2

DIAGNOSTIC TESTS FOR CDI

Table 3. Summary of Available Tests for *Clostridium difficile* Infection, in Decreasing Order of Sensitivity

Test	Sensitivity	Specificity	Substance Detected
Toxigenic culture	High	Low[a]	*Clostridium difficile* vegetative cells or spores
Nucleic acid amplification tests	High	Low/moderate	*C. difficile* nucleic acid (toxin genes)
Glutamate dehydrogenase	High	Low[a]	*C. difficile* common antigen
Cell culture cytotoxicity neutralization assay	High	High	Free toxins
Toxin A and B enzyme immunoassays	Low	Moderate	Free toxins

[a]Must be combined with a toxin test.

McDonald LG, et al. Clin Infect Dis 2018;66:e1-e48