Environmental Cleaning and Decontamination to Prevent Clostridioides difficile Infection in Health Care Settings: A Systematic Review

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Objective: The aim of this systematic review was to examine the most effective and feasible methods for environmental cleaning and decontamination to prevent Clostridioides difficile infection (CDI) in health care settings.

Methods: A systematic search of the databases CINAHL and MEDLINE was conducted from 2008 to 2018 for English language articles with search terms including “Clostridium difficile,” and related medical subject headings, in combination with terms like “disinfection,” “decontamination,” and “no-touch decontamination.”

Results: Twelve studies and 2 systematic reviews were selected for inclusion in this review. The studies were primarily in hospitals (10/12) and used a before-after approach. The studied interventions included cleaning and decontamination with a chlorine-based agent (i.e., bleach; 2 studies), standard cleaning plus the use of hydrogen peroxide decontamination (3 studies), and standard bleach cleaning plus the use of ultraviolet light decontamination (6 studies), and there was 1 study about launderable bed covers. The interventions ranged in frequency, duration, and the area selected for cleaning and decontamination (e.g., all patient rooms versus only CDI patients’ rooms). Studies showed significant reductions in CDI associated with use of bleach (versus quaternary ammonium compound) and hydrogen peroxide decontamination (6 studies), and there was 1 study about launderable bed covers. The interventions ranged in frequency, duration, and the area selected for cleaning and decontamination (e.g., all patient rooms versus only CDI patients’ rooms).

Conclusions: The studied practices for environmental cleaning and decontamination were associated with significant decreases in facility-level CDI rates in most of the reviewed studies; however, study quality was low. Implementation challenges are worthy of further examination.

Key Words: Clostridioides difficile, Clostridium difficile, health care-associated infections, environmental cleaning, disinfection, decontamination, patient safety, HAIs, colitis, hospital, long-term care facility, nursing home

Preventing Clostridioides difficile (C. difficile) infection (CDI) in health care settings is an important U.S. public health priority. There are an estimated half a million incident CDIs per year as a result of CDI. The financial cost of CDI is also high; in recent years, CDI has resulted in approximately $5 billion a year in health care costs in the United States. A 2017 meta-analyses of 9 pooled study results found that cost incurred by a facility for an inpatient CDI case was $17,260 (95% confidence interval [CI], $9,341–$25,180). The health care environment is recognized as one of the primary sources of C. difficile transmission. In recent estimates, more than half of CDI cases are classified as health care associated (versus community associated). A review of multiple CDI prevention practices found that environmental cleaning and decontamination was the most cost-effective strategy. The C. difficile organism is spread through the feces of infected and colonized patients. Patients with contaminated hands may spread C. difficile through touching surfaces in the health care environment, and transmission can occur when other patients, health care staff, or visitors touch contaminated surfaces and ingest the organism (e.g., while eating). If a patient is taking antimicrobials, they are more susceptible to colonization or infection with C. difficile because antimicrobials alter gastrointestinal tract flora, destroying the bacteria that help to protect against C. difficile. Both symptomatic and asymptomatic C. difficile carriers have the potential to contaminate the environment.

Eliminating C. difficile from surfaces in the health care environment requires specialized practices. C. difficile produces spores that are especially robust and may remain viable for more than 7 days. Furthermore, the spores are resistant to alcohol and many hospital disinfectants. Among cleaning and decontamination agents for washing surfaces by hand, chlorine-releasing solutions (e.g., bleach), at sufficient concentration and with appropriate exposure time (at least 10 minutes), demonstrate the best evidence for killing C. difficile. Terminal (upon discharge) cleaning with a sporicidal agent is the currently recommended standard practice for C. difficile.

Manual cleaning under time pressures can result in failure to decontaminate all necessary surfaces. Automated no-touch methods have been developed and implemented to eliminate C. difficile and other pathogens that cause health care–associated infections. The 2 most commonly studied no-touch methods for C. difficile decontamination are hydrogen peroxide decontamination (HPD) and ultraviolet light decontamination (UVD). In controlled laboratory studies, both methods have shown effectiveness in almost entirely eliminating C. difficile. It is generally recommended that surfaces are precleaned before use of UVD or HPD, as organic matter is thought to reduce the efficacy of these methods.

Methods

The question of interest for this review is as follows: What are the most effective and feasible environmental cleaning and decontamination practices to prevent CDI? To answer this question, we searched the databases CINAHL and MEDLINE from 2008 to 2018 for “Clostridium difficile,” and related medical subject headings terms and synonyms in combination with terms like “disinfection,” “decontamination,” and “no-touch decontamination.” The search string also included a variety of health care settings, including “hospitals,” “long-term care,” and “transitional care.” The initial search yielded 121 original results. We excluded laboratory
studies, articles with insufficient study design or irrelevant outcomes, and studies in which environmental cleaning and decontamination was implemented with other CDI prevention interventions. Of these, 45 full-text articles were retrieved and screened. Reference lists of articles were also screened to ensure thoroughness, and 5 studies were retrieved by these means. A total of 12 studies and 2 systematic reviews were selected. (During the writing of this report, the Centers for Disease Control and Prevention transitioned from use of the name *Clostridium difficile* to *Clostridioides difficile*; for the purposes of this report, they are synonymous.)

RESULTS

Most studies (10/12) showed statistically significant reductions in CDI after the implementation of an environmental cleaning and decontamination intervention; however, study quality was low and studies were difficult to compare. These findings are similar to those of Lough et al in their examination of CDI prevention studies in acute care hospitals from 2009 to 2015. In another review, Khanafer et al cited mostly positive outcomes in a review that included 9 studies on environmental cleaning for CDI prevention published from 1982 to December 2013. Khanafer et al concluded that environmental cleaning with a 10:1 bleach solution is both practical and effective.

In this review, the cleaning and decontamination interventions fell into 4 categories: use of a chlorine-based (e.g., bleach) agent, use of HPD after standard cleaning, use of UVD after standard bleach cleaning, and 1 study about launderable bed covers. Within these categories there were different variables, such as the frequency of cleaning (e.g., daily or at discharge) and the area of cleaning (e.g., CDI patient rooms, all patient rooms, or patient rooms and communal spaces). The studies reviewed were primarily quasiexperimental with a before-after approach. One exception was a study by Anderson et al, which was the only randomized trial. Also of note, 2 of the studies on HPD no-touch decontamination methods received some financial support from the makers of the products, in the form of free use of equipment and reduced cost to use the products. Two UV studies had more than one author who was an employee of Xenex, the company that sells the machines that were studied in the intervention.

Studies: Cleaning With Bleach

Two studies examined patient outcomes after a period in which patient rooms were cleaned with bleach. In one of these studies, Hacek et al evaluated a cleaning intervention at 3 hospitals with a total of approximately 850 beds in which terminal cleaning of the rooms occupied by CDI patients was conducted with a bleach solution (5000 ppm) as a replacement for quaternary ammonium compound. In addition, walls were added to a checklist of surfaces to clean after patient discharge where there were periodic unannounced cleaning assessments by supervisory staff. After 2 years of the new procedures, the average number of CDI patients per 1000 patient days decreased from 0.85 to 0.45. There was a 48% reduction in the prevalence density of CDI (95% CI, 36%–58%; \( P < 0.0001 \)) when compared with the previous 10-month period. The researchers report that there were no other significant infection prevention practice changes during the cleaning intervention implementation period. Orenstein et al measured CDI outcomes after a cleaning and decontamination intervention on 2 hospital wards with high baseline incidences of CDI. The intervention consisted of switching from quaternary ammonium compound to germicidal bleach wipes (5000 ppm active chlorine) for daily and terminal cleaning of all patient rooms. After a year of the new procedures, there was a reduction in hospital-acquired CDI incidence of 85%, from 24.2 to 3.6 cases per 10,000 patient days \( (P < 0.001) \). The researchers conclude that daily bleach cleaning of all rooms on the wards with high incidence of CDI may be more effective than only terminal cleaning of the CDI rooms.

Studies: HPD

Three reviewed studies examined the use of HPD (as an addition to standard cleaning) for patient room decontamination. Best et al reported reduction in incident CDI cases in the months after a one-time deep clean with HPD. Boyce et al found that, after a deep cleaning of 5 wards with HPD, then 8 months of terminal cleaning of CDI-occupied rooms with bleach and HPD, the incidence of nosocomial CDI decreased from 2.28 to 1.28 cases per 1000 patient days \( (P = 0.047) \). Manian et al evaluated an intervention at a 900-bed community hospital, in which HPD was added to terminal cleaning of all rooms. When HPD decontamination was not possible, CDI rooms were cleaned with 4 rounds of bleach cleaning. After approximately 7 months, the rate of nosocomial CDI dropped significantly, from 0.88 cases/1000 patient days to 0.55 cases/1000 patient days (rate ratio, 0.63; 95% CI, 0.50–0.79; \( P < 0.0001 \)). Results are ambiguous because approximately half of the CDI rooms were cleaned with 4 rounds of bleach cleaning without HPD.

Studies: Ultraviolet Environmental Disinfection

Six studies selected for this review examined the use of UVD and CDI patient outcomes. Of these, 4 studies showed statistically significant decreases in CDI after a period of UVD added to standard terminal cleaning with bleach of CDI patient rooms. One study found borderline significant reductions in CDI, and one study found no change after UVD implementation. Vianna et al studied the addition of UVD to terminal cleaning with bleach in a 206-bed hospital. The terminal UV disinfection procedure was implemented for all room discharges in the intensive care unit (ICU) and for rooms occupied by patients with CDI in the rest of the hospital. After 21 months, there was a 41% decrease in CDI \( (P = 0.01) \). *C. difficile* infection reductions were greater in the ICU than in the rest of the hospital (61% versus 29%). The results indicate that UVD is effective when deployed to higher-risk/higher-acuity settings (e.g., the ICU) and/or when used in all room discharges (not just for patients with *C. difficile*).

In a long-term acute care facility, Miller et al evaluated the addition of UVD to standard procedures for patient rooms at discharge and for common areas on an approximately weekly basis. For rooms occupied by *C. difficile* patients, standard procedures also included cleaning with a bleach solution. During a 15-month period of added UVD, CDI rates decreased from 19.3 per 1000 patient days to 8.3 per 1000 patient days, a 56.9% reduction \( (P = 0.02) \). It is important to note that in the prior year, the facility had implemented additional infection prevention measures and it is possible that the reductions in CDI rates reflect the longer-term impact of these measures.

Less favorable results were found in a broad cluster-randomized study of 9 hospitals, in which terminal cleaning with bleach of all rooms occupied by CDI patients was compared with terminal cleaning with bleach plus UVD. In this crossover trial, Anderson et al found that, comparing the strategies for 7 months each, the incidence of CDI infection among patients exposed to rooms previously occupied by patients with CDI was unchanged (n = 38 versus 36; 30.4 cases versus 31.6 cases per 10,000 exposure days; relative risk, 1.0; 95% CI, 0.57–1.75; \( P = 0.997 \)).
Study: Launderable Bed Covers

Contaminated mattresses and bed frames are difficult to clean and have been linked to HAI transmission. To address this problem, Hooker et al. examined CDI rates associated with the introduction of washable bed covers at 2 long-term acute care hospitals. The cleaning intervention consisted of introducing launderable bed covers that cover both the mattress and bed deck. The launderable covers were used on all patient beds, removed after every patient discharge, and replaced with a clean cover. After 14 months of use of the bed covers, the rate of CDIs at one hospital reduced 47.8% (95% CI, 47.1%-48.6%), controlling for the rate of handwashing compliance and length of stay in days. At the second hospital, the rate of CDIs decreased by 50% (95% CI, 47.5%-52.7%), controlling for the rate of handwashing compliance and length of stay in days. Data on antimicrobial use were not available so this variable was not factored into the analyses.

Implementation Challenges

There are several implementation challenges and concerns associated with environmental decontamination for C. difficile.3,13 Housekeepers have reported respiratory irritation when using bleach and other chlorine-based disinfectants.30 One reason provided to support terminal cleaning versus daily cleaning of CDI patient rooms is to avoid excessive exposure of bleach for environmental services staff.19 To address this problem, several studies have examined alternatives to bleach, including hydrogen peroxide and peracetic acid.31,32

Another challenge is compliance with manual cleaning procedures. Cleaning checklists can be effective,17 and the use of adenine triphosphate bioluminescence26 or fluorescent markers can be useful for auditing/monitoring the thoroughness of cleaning and a basis from which to provide feedback.34 Other guidelines from an earlier recommend frequent education for environmental service personnel in the primary language of the cleaning team.3

One of the challenges reported across several of the studies on HPD and UVD was being able to use the machines in all intended instances3,25,27,28 Both touchless methods require that rooms be vacant and items be placed in a manner to allow for adequate contact with the hydrogen peroxide mist or UV light. The HPD process can take approximately 3 to 4 hours per patient room.18 Haas et al.27 reported that the time for UVD light exposure in their study was around 6 minutes, but it took close to a half hour for setup (including setting up blackout curtains) depending on the room. Because of limited device availability, Levin et al.26 reported that only 56% of discharged contact precautions rooms received the UVD treatment. Discrepancies were attributed to limited device availability, a second room occupant who could not be moved, an urgent need for the room, and labor constraints.28,29

DISCUSSION

Most of the studies in this review show an association between environmental cleaning interventions and reductions in CDI. The strength of the studies was undermined by several weaknesses such as not including a control group or not controlling for important confounders such as antimicrobial use (e.g., Hooker et al.29). Because of the heterogeneity of approaches, questions remain about whether decontamination efforts should target CDI patient rooms, all patient rooms, and/or common areas outside the patient room, and whether terminal (versus daily) cleaning and decontamination is sufficient. Comparing these variables could provide better understanding of the most effective and feasible approach. Implementation research on manual and no-touch decontamination methods could focus on the most effective approaches to implementation, in the context of resource and time limitations.

CONCLUSIONS

Environmental cleaning and decontamination interventions for C. difficile were associated with significant decreases in facility-level CDI rates in most of the studies in this review; however, study design was generally weak and had potential for bias. Practices with positive outcomes include daily and terminal cleaning of CDI patients’ rooms with bleach solutions (typically 5000 ppm) and terminal bleach cleaning plus the use of no-touch decontamination methods such as hydrogen peroxide or UVD. Each method has implementation challenges. Touchless methods require the room or area be vacant and take time to complete.27,29 Studies suggest that manual cleaning is optimized by standardized cleaning protocols and training and observation of environmental cleaning services staff.

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