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The relationship between patient functional status and environmental contamination by *Clostridium difficile*: a pilot study

Rebekah Blakney^{1,2}, Unnur Gudnadottir¹, Simone Warrack², John C. O'Horo³, Michael Anderson², Ajay Sethi¹, Michelle Schmitz⁴, Jennifer Wang², Megan Duster², Emma Ide⁵, and Nasia Safdar^{1,2,5,6}

¹ Department of Population Health Sciences, University of Wisconsin, 5221 MFCB, 1685 Highland Avenue, Madison, WI 53705, USA

² Department of Medicine, University of Wisconsin, Madison, WI, USA

³ Department of Medicine, Mayo Clinic, Rochester, MN, USA

⁴ Departments of the Natural Sciences, University of Wisconsin, Madison, WI, USA

⁵ University of Wisconsin Hospitals and Clinics, Madison, WI, USA

⁶ William S. Middleton Memorial Veterans Hospital, Madison, WI, USA

Abstract

Introduction—Limited data exist on patient factors related to environmental contamination with *Clostridium difficile*.

Methods—We evaluated the association between the functional status of patients with *C. difficile* infection (CDI) and environmental contamination with *C. difficile*.

Results—Contamination of patient rooms was frequent and higher functional status was associated with contaminated surfaces remote from the bed. All but one environmental isolates matched the corresponding patient's stool isolate for the seven patients tested.

Conclusion—Functional status is a factor that influences environmental contamination with *C. difficile*. Future studies should evaluate strategies to reduce contamination in CDI patient rooms, taking into account the patient's functional status.

Keywords

Healthcare-associated infections; *Clostridium difficile*; Environmental contamination; Infection control

Introduction

Clostridium difficile is the most common infectious cause of healthcare-associated diarrhea. In recent years, a hyper virulent strain associated with increased toxin production and adverse clinical outcomes has become increasingly common [1]. *C. difficile* infection (CDI) is transmitted via spores in the stool, which are shed in large numbers. Contamination of surfaces is common and spores tend to persist in the environment for weeks after treatment [2]. Standard environmental decontamination products are largely ineffective in reducing *C. difficile* spore burden, requiring sporicidal compounds, or no touch environmental disinfection with products such as ultraviolet light or vaporized hydrogen peroxide [3].

Identifying predictors of increased risk for environmental contamination in patients with CDI would be useful for designing effective decontamination strategies. We sought to evaluate the potential association between patient functional status and environmental contamination with *C. difficile*. Although poor functional status is known to be a risk factor for poor clinical outcomes and severe infection [4], highly mobile, more functional patients may be more likely to shed spores in the wider environment and thus present a higher risk for infection transmission. Therefore, we hypothesized that high-patient functional status would be associated with more extensive environmental contamination in adults.

Methods

Setting and study population

Consecutive cases of CDI were chosen at our 566 bed, acute care tertiary referral hospital between February and May 2013. Cases were identified by reviewing all positive *C. difficile* tests daily at the hospital microbiology laboratory. All clinical testing for *C. difficile* is performed via polymerase chain reaction (PCR) at our institution.

Human subjects consideration

The University of Wisconsin Institutional Review Board deemed this project exempt as part of a quality improvement project. Subjects verbally consented to participate in this project.

Environmental cleaning practices

The department of environmental services at our facility manages daily cleaning using damp dusting followed by a one-step cleaning and disinfection process using Dispatch®, a germicidal cleaner combined with a 1:10 dilution of bleach. For a subset of units at our facility where *C. difficile* rates are higher, rooms are also cleaned at discharge using UV light disinfection (Xenex™).

Sampling

We selected 11 surfaces in the patient's room to be sampled based on recommendations of the Centers for Disease Control and Prevention environmental cleaning toolkit [5] and our own direct observations of surfaces that were frequently touched by patients or healthcare workers. The following areas were sampled: bed hand rails/bed controls (all controls and top and bottom of the bedrails), tray table (the entire tabletop), call button (front and back),

patient chair (hand rest and entire surface of seat), room sink (front and back of paddles), room inner door knob (entire surface including the plate), hand sanitizer dispenser (push button and back plate), bathroom handrails (entire surface of handrails adjacent to toilet), toilet seat (top and bottom, not bowl area), toilet flush handle (entire surface), and menu (front and back). The surfaces were dichotomized into surfaces far away from the patients' bed (patient needed to get out of the bed to reach these areas) and surfaces near the patients' bed. Surfaces sampled were broadly replicable between hospital units.

Two to three trained personnel collected samples from each room in a standardized fashion. A sterile 2×2 gauze pad was placed in a sterile specimen cup with ~ 0.75 mL of sterile 0.9 % saline. During specimen collection, the gauze pad was removed from the cup with a sterile hemostat or sterile surgical gloves and rubbed over the surface of interest. Each surface was rubbed with the gauze in the same manner; horizontal, vertical, and diagonally (two times, once from adjunct corners). Hemostat or gloves were changed between each sample. Because of limited resources and time constraints, we did not time our sampling efforts with room cleaning. Environmental services were not notified of our study.

Stool sample processing

According to our hospital policy, stools are eligible for *C. difficile* testing only if the stool specimen is unformed and there have been three or more loose stools in a 24 h period. Stool samples were available from 14 patients and these were collected from the clinical microbiology laboratory for culture in order to obtain isolates for comparison to the environmental sample isolates from the patients' room. 0.1 g of stool were placed into 1 mL of prerduced *C. difficile* *Brucella* broth, incubated at 24 h anaerobically at 36° centigrade then plated to cycloserine cefoxitin fructose agar and incubated at 48 h anaerobically at 36 °C.

Environmental sample processing

Environmental samples were brought to the Infectious Disease Research Laboratory within 1 h of collection and processed as described previously in Dumford et al. [6] with the following modifications. Prerduced *C. difficile* *Brucella* broth with neutralizer [7] was added to specimen cups. 50 μ L was plated to cycloserine cefoxitin fructose agar plates (Anaerobe System, Morgan Hill, CA). An in-house PCR was developed to confirm the isolate was *C. difficile* and to evaluate presence of the following toxin genes; *tcdA*, *tcdB*, and *cdtB*. Pulsed field gel electrophoresis (PFGE) was performed on all confirmed clinical and environmental *C. difficile* isolates.

Clinical data collection and variables

We collected the following information on the subjects: gender, age, unit, room number, underlying medical diseases/conditions, length of hospitalization, number of days in isolation, hospitalization within the previous 6 months, severity of CDI, current treatment for CDI, number of days in treatment for CDI, hospital- or community-acquired CDI, previous episodes of CDI, current medications, use of antibiotics within the previous 3 months, use of probiotics, immunosuppressing condition, and functional status. The information was either collected from electronic medical records or by querying the patient or nursing staff.

The modified University of Illinois index score was used to categorize the severity of CDI. Patients with a score of two points or above are considered to have severe infection. One point each is given for age above 60 years, temperature over 38.3 °C, albumin level lower than 2.5 mg/dL, or peripheral WBC count over 15,000 cells/mm³. Two points are given for evidence of pseudomembranous colitis or treatment in the intensive care unit [8].

We measured functional status using the Barthel index of activities of daily living with a modified score from 0 to 20, with lower scores indicating increased disability [9]. Patients were categorized as having higher functional status if they were above the mean for this group (mean score = 12), and lower functional status if below this cutoff. The Barthel index was validated for stroke patients. However, it is widely used in geriatrics settings, and is recommended for older adults. We used the Collin version of the Barthel index [9].

All data were obtained prospectively. The data were analyzed using Excel (Microsoft Corp, Redmond, WA), SPSS version 20 (SPSS Inc., Chicago, IL), and SAS software (SAS Institute Inc., Cary, NC). The Spearman's rank correlation test was used to identify correlation between variables, and an independent sample *t* test was used to explore statistically significant difference between the means of two unrelated groups. Relative risk for environmental contamination by functional status was calculated, and a Chi-square test was used to determine significance. A *p* value of 0.05 was considered statistically significant.

Results

Patient characteristics

Thirty single patients' rooms were assessed. The rooms were located in twelve different units. Ten rooms were located in medical units, eight in surgery, seven in medical and surgery units, and four in the medical and surgical intensive care unit. The participants' ages ranged from 27 to 98 years with a mean age of 61.6 (SD 14.8) years. Eighteen patients were over the age of 60 years. Sixteen were men and 14 were women. Two of the participants had CDI caused by the NAP1 strain. Participants' average functional status, measured with the Barthel index, was 12.4 (SD 7.7), ranging from 0 (completely dependent) to 20 (completely independent). Sufficient data were available to calculate severity scores for 23 patients. CDI severity scores ranged from 0 to 6, with an average score of 2.61 (SD 1.88). On average, patients' rooms were sampled 4.6 days (SD 1.2) after the patient tested positive for CDI. There was no statistically significant difference in the timing of room sampling relative to CDI diagnosis between low and high functional status patients. Of the 30 patients, 26.7 % had a history of a previous CDI episode. All patients were treated with antibiotics on average for 16 days (SD 5.1), with treatment ranging from 5 to 31 days. Average hospital stay was 12.2 days (SD 9.1), ranging from 3 to 33 days.

Environmental contamination

Of the 30 rooms sampled, 15 (50.0 %) had at least one *C. difficile* contaminated surface. The number of *C. difficile* contaminated areas in each room ranged from 1/11 (9.1 %) to 6/11 (54.5 %). *C. difficile* was most frequently cultured from the bathroom handrails (24.1 %),

the toilet seat (13.8 %), and the tray Table (17.2 %) (Table 1). Twenty-one out of 145 surfaces (14.5 %) sampled near the patient's bed tested positive for *C. difficile*, while 16 out of 177 surfaces (9.0 %) sampled far away from the bed tested positive.

Stool isolates

Of the 14 patients for whom stool isolates were available for our study after clinical laboratory testing, seven also had *C. difficile* environmental contamination in their room. The seven patients all had at least one environmental isolate that matched their stool isolate, though one patient (08) had an isolate that did not match. Figure 1 presents the PFGE results for the stool isolates of the seven patients as well as one isolate from a matching environmental sample. There was no epidemiological relationship between both clinical and environmental isolates between cases suggesting the presence of multiple strains of *C. difficile* in patients and their environment.

Relationship between functional status and CDI room contamination

Patient functional status was not related to the frequency of contaminated areas in the patient's room ($r = 0.07$, $p = 0.70$). However, higher functional status was positively correlated to the position of the contaminated areas in the room ($r = 0.37$, $p = 0.047$). Surfaces far away from higher functional status patients' beds were more likely to be contaminated than those surfaces in rooms with patients with lower functional status [$t(28) = -2.54$, $p = 0.02$]. The relative risk of a high functional status patients contaminating surfaces far from the bed compared to low functional status patients was 9.58, and the risk for low functional status patients compared to high functional status patients was 0.10 ($p = 0.006$) (Table 2).

Functional status and number of contaminated areas in patients' room were not statistically associated with any patient demographic variables. However, low functional status was negatively associated, though not statistically significantly, with higher severity score ($r = -0.36$, $p = 0.09$).

Discussion

Our results show that half of CDI patients' rooms had at least one contaminated surface and the most commonly contaminated surfaces were the bathroom handrails, toilet seat, and the tray table. A previous multisite study found that 75 % of sites within a CDI room were positive for *C. difficile* [10]. Since these were both cross-sectional studies where cleaning practices were not altered as part of the study, the timing of sampling, variation in cleaning practices, and patient condition may all have influenced the degree of environmental contamination.

We did not find a relationship between a patient's functional status and the extent of contamination in the patient's room. However, patient functional status was related to the location of the contaminated areas within the room. Surfaces categorized as far away from the patient's bed were more likely to be contaminated if the patient had above average functional status. It appears that patients with higher functional status may be more prone to shed spores around their room than patients with low functional status, possibly indicating a

higher risk of *C. difficile* transmission. To our knowledge, this is the first study to investigate the association between location of contaminated surfaces and functional status. Several frequently touched surfaces, including the room inner doorknob and sink handles, rarely tested positive. Such surfaces are widely known to be at high risk of contamination and people therefore may take precautions when touching these areas and/or cleaning staff may disinfect them more thoroughly. This shows that frequently touched areas traditionally identified as high risk are not necessarily the most likely to be contaminated. Therefore, we believe a potential *C. difficile* prevention strategy is hospitals and hospital units tailoring daily cleaning protocols based on their own observations and patient characteristics.

Previous research has shown several strains of *C. difficile* can be found in a single hospital environment [10]. We correlated strains identified from patients to environmental strains and determined that active patient episodes were related to the environmental contamination. Further studies are needed to define this relationship, particularly changes in functional status over time, as ours was a cross-sectional study.

Our results have potential implications for housekeeping protocols in hospitals, especially identification of high touch surfaces, including non-traditional surfaces like the menu, which is currently not on the cleaning protocol. The high percentage of contaminated rooms also highlights the importance of multifaceted prevention strategies for *C. difficile*, including antimicrobial stewardship, appropriate isolation, and compliance with contact isolation protocols.

The most significant limitation of our study was that we could not control for the timing of sample collection relative to cleaning, as this may significantly decrease the degree to environmental surfaces, at least transiently, and lead us to underestimate the total spore burden. Our study is also limited by small sample size and cross-sectional design with no follow-up sampling. We did not collect data on incontinence or the number of unformed bowel movements per patient at the time of sampling. The small sample size may limit the generalizability of our findings, especially as we only had stool isolates for half of the patients for correlation. Further research is needed to confirm these findings.

In conclusion, we found that environmental contamination with *C. difficile* is a frequent occurrence and the surfaces affected may vary according to the patient's functional status. Efforts addressing environmental contamination should take these findings into consideration when tailoring local decontamination protocols to individual settings. Furthermore, it is important that people entering the rooms of CDI patients adhere to contact isolation protocols by wearing gowns and gloves since contamination of the environment is not restricted to the area immediately surrounding the patient.

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Fig. 1.

Pulsed field gel electrophoresis (PFGE) results from seven patients' stool isolates and seven corresponding environmental isolates. For example, CD 05 Tray table represents an environmental isolate and CDE 05 stool isolate shows the stool *C. difficile* results for the same patient. The isolates from the stool and the environment for all the patients in this figure are identical by PFGE

Table 1Frequency of *C. difficile* cultured from surfaces within the patient room by functional status

Surface (N [*])	Low functional status Positive (%)	High functional status Positive (%)	Total Positive (%)
Near patient bed			
Bed rails (30)	2 (16.7)	3 (16.7)	5 (16.7)
Tray table (29)	3 (25.0)	2 (11.1)	5 (17.2)
Call button (30)	2 (16.7)	2 (11.1)	4 (16.7)
Chair (27)	3 (25.0)	1 (6.25)	4 (14.8)
Menu (29)	1 (9.1)	1 (5.6)	2 (6.9)
Further away from patient bed			
Room inner door knob (30)	0	0	0
Hand sanitizer dispenser (30)	0	0	0
Sink handles (30)	0	1 (5.6)	1 (3.3)
Bathroom handrails (29)	0	7 (38.9)	7 (24.1)
Toilet flush handle (29)	0	1 (5.6)	1 (3.4)
Toilet seat (29)	1 (9.1)	3 (16.7)	4 (17.2)
Total positive	12	21	33

* Number of times each surface was sampled

Table 2

Relative risk of surface contamination by distance and functional status

	Low functional status Relative risk (95 % CI)	High functional status Relative risk (95 % CI)	P value
Surfaces near patient bed	1.65 (0.75, 3.63)	0.61 (0.22, 1.41)	0.2348
Surfaces distant from patient bed	0.10 (0.01, 0.77)	9.58 (1.30, 70.92)	0.0055 [*]
All surfaces	0.74 (0.38, 1.41)	1.36 (0.71, 2.60)	0.378

^{*} Significant at $p = 0.05$