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Environmental Spread of Multidrug-Resistant Pathogens in a Hospital Laundry Facility

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In an effort to evaluate the threat of antibiotic resistant bacteria in the U.S., the Centers for Disease Control (CDC) developed three classifications of pathogens; "urgent", "serious" and "concerning", based on the severity of the disease, cost of treatment and difficulty of treatment.[1] *Clostridium difficile* has been classified as an "immediate public health threat that requires urgent and aggressive action", even though it does not have clinically relevant antibiotic resistance at this time. Methicillin-resistant *Staphylococcus aureus* (MRSA) and vancomycin-resistant *Enterococcus faecalis* and *E. faecium* (VRE) were classified as "serious" threats which "require prompt and sustained action to ensure that the problems do not grow". All three pathogens have the ability to survive on fomites for extended periods of time and are difficult to remove from the environment by standard cleaning and disinfection protocols, increasing the chance that the next patient to occupy the room will be colonized. Personnel protective equipment is required when entering a patient's room with any of these three pathogens. However, no special precautions are taken with the soiled laundry once the patient has left and the room is cleaned. These contaminated linens are placed into dirty laundry bags with other soiled linens from the same ward and sent off to the laundry facility without any identification stating that they may be contaminated with high precaution pathogens.

Laundry facilities that process hospital and clinic linens should be considered an extension of the healthcare environment, even when the facility is not physically located on site.[2-5] It is estimated that 5 billion pounds of health care-associated fabrics are laundered in the U. S. annually, and heavily contaminated textiles can contain up to 10^6 to 10^8 cfu per 100 cm^2.[6] Limited studies have assessed the potential risk to exposed laundry workers who handle dirty hospital linens. A very few cases have documented illness (12 cases of hepatitis and eight cases of *Salmonella* poisoning) related to exposures to soiled linens.[4] Other reports of infections among laundry workers include *Staphylococcus aureus* infections and viral gastroenteritis—potentially Norovirus.[7] In Taiwan, a laundry worker was suspected to be the index case in a SARS viral epidemic within the community.[8] Laundry workers are also at physical risk of cuts and abrasions due to sharps and medical devices left in and among the linens. These medical devices may also be contaminated with infectious body fluids which can cause blood infections.

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We undertook a study of "soiled" and "clean area" surfaces in order to determine the level of contamination of *C. difficile*, MRSA, and VRE within the environment of a commercial laundry facility that services six Seattle area hospitals and 30 outpatient clinics.[9-11] Approximately 300,000 pounds of laundry are processed each week. Over 98% of the linens cleaned are owned by the laundry and processed in one line where they are sent down chutes to the 1st floor for cleaning. A 2nd processing

line is used for customer-owned goods [COG] (2%). These are sorted in a separate area of the facility, manually placed into washers on the 1st floor and washed in smaller batches. All clean laundry is dried, sorted, folded and packaged for delivery on the first floor "clean areas.

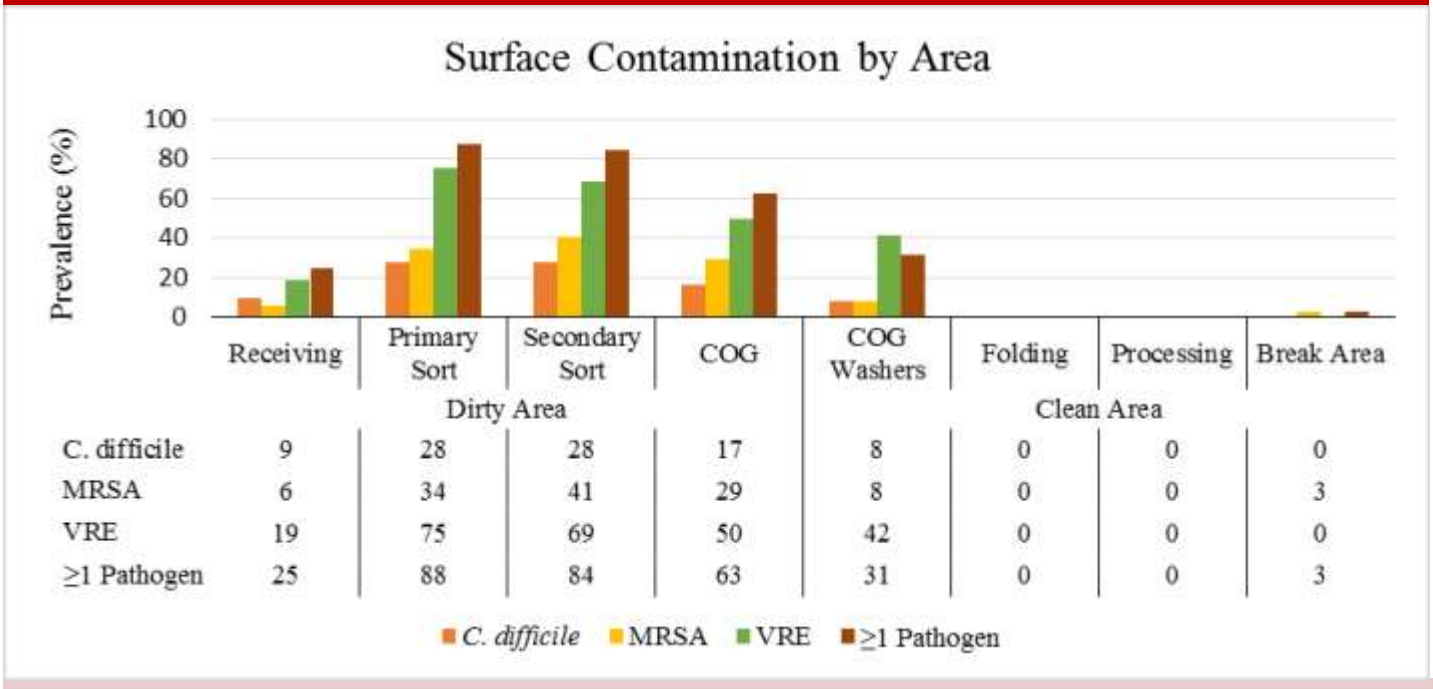
To build on the limited knowledge base available for these critical pathogens in the laundry processing environment, we collected and evaluated 240 surface samples from both "dirty" and "clean area" sites at four time points in 2015—thirty-five samples at each time point from a single surface; and 25 samples from 2 or more surfaces. Three parallel enrichment processes were utilized to independently target one of the three pathogens (*C. difficile*, MRSA and VRE) from each surface sample.

Of the 120 samples collected from the dirty areas, 21% (n=25) were positive for *C. difficile*, 28% (n=33) were positive for MRSA and 53% (n=64) were positive for VRE. On the clean side 2% (n=2) were positive for *C. difficile*, 3% (n=3) were positive for MRSA and 8% (n=10) were positive for VRE. The dirty area had statistically higher contamination rates than the clean area for contamination with ≥1 pathogen (65% dirty area vs 9% clean area, $p<0.001$). Dirty vs. clean areas rates were as follows: *C. difficile* (21% vs 2%, $p<0.001$), MRSA (28% vs. 3%, $p<0.001$) and VRE (53% vs. 8%, $p<0.001$).

The primary and secondary sort dirty areas showed the highest prevalence of positive samples for all pathogens, both overall and for individual pathogen. Overall, contamination was highest at 87.5% in both the primary and secondary sort, 62.5% in the COG area, 45.8% in the COG washers, 28.3% in the receiving area, 9.2% in the break area and 0% in the folding and processing areas (Fig 1). There were significant correlations among pathogens. Ten out of 240 (4.2%) samples contained all three pathogens. Seventeen (7.1%) samples contained both MRSA and VRE. The strongest correlations were between MRSA and VRE (0.6357, $p<0.0001$), followed by *C. difficile* and VRE (0.6120, $p<0.0001$), with a moderate correlation between *C. difficile* and MRSA (0.4880, $p<0.0005$). The odds of observing contamination with one or more pathogens in the dirty area was 18.0 times higher than in the clean areas (Table1).

Seasonal variation was observed in the dirty area for *C. difficile*. *C. difficile* toxins A and/or B were present in 64%

Figure 1. Contamination of a hospital laundry



COG=Customer owned goods, MRSA= Methicillin-resistant *S. aureus*, VRE=Vancomycin-resistant *Enterococcus*

Table 1. Probability (Odds Ratio) of Contamination in Dirty Area Compared to Clean Area

Location	Any Pathogen		*C. difficile*		MRSA		VRE	
	OR	CI	OR	CI	OR	CI	OR	CI
Clean Area	1	--	1	--	1	--	1	--
All Dirty Areas	18.0*	8.9-36.5	15.5*	3.6-67.2	14.8*	4.4-49.8	12.6*	6.0-26.3
Receiving	3.3**	1.2-9.1	6.1	1.0-38.2	2.6	0.4-16.3	2.5	0.8-7.6
Primary Sort	69.4*	20.5-234.3	23.1*	4.7-113.9	20.4*	5.3-79.5	33.0*	11.8-92.4
Secondary Sort	53.0*	17.1-166.9	23.1*	4.7-113.9	26.7*	6.9-102.5	24.2*	9.0-65.1
COG	16.5*	5.9-46.4	11.8**	2.0-68.7	16.1*	3.8-68.1	11.0*	3.9-30.8

* $p<0.001$, ** $p<0.05$

of all isolates from the dirty area. Of these, 10 isolates carried both genes.

Contamination in the dirty area was highest in April with a prevalence of 40% (n=12) and was statistically higher than both January (10%, p=0.012) and July (13%, p=0.025), but not October (20%, p>0.05). MRSA contamination was highest in July (40%, n=12) and VRE had the highest levels of contamination in April (57%, n=17), but no statistical difference by sample date was observed for either pathogen (p>0.05). In the clean areas, the number of positive samples were very low and showed very little seasonal difference in prevalence.

Inherent limitations, such as the difficulty in culturing specific bacteria (i.e., *C. difficile* spores), and differences in incubation times and media used, may have led to an underestimation of the true prevalence for each of the pathogens.[9-11] Additional studies will be needed to demonstrate if there is a clear risk to facility workers. Future studies comparing the whole genomes of both the human and environmental isolates would help to elucidate the relationship between the strains from the contaminated laundry environment and those isolated from laundry personnel. In addition, whole genome analysis would allow one to determine if isolates from different areas and different times within the facility were genetically related, as some of our data suggests. As a result of this study, the laundry facility implemented new protocols in an effort to reduce the level of contamination and potential for occupational exposure.[11] These protocols include the use of EPA registered disinfectants on high touch surfaces, guard rails to physically block clean carts from getting underneath soiled linen chutes, color coding of carts (certain colors are used only for soiled linen), providing additional PPE (such as gloves and face shields) available at the point of use, and clearly posted PPE donning and doffing guidelines. Further studies involving collection of health records of employees, including immunological function and other exposures would need to be done in order to characterize the risk of infection due to exposure in the laundry. Ideally an exposure limit to each of the three pathogens would be developed. This would help determine if the risk of exposure is high enough to warrant changes in the handling and transportation of soiled clinical linens.

References

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CDC updates "best practices" for hospital laundry

As hospitals seek to control the scourge and excessive costs incurred by superbug outbreaks, all vectors of possible pathogen transmission must come under scrutiny. The processing of healthcare laundry is a complex operation, involving factors such as ventilation, transport, appropriate chemicals and equipment. Frequently, this task is outsourced to healthcare laundry services, and an increasing number of these facilities are proactively seeking certification or accreditation to ensure the highest possible standards. According to Nancy Jenkins, executive director of the American Reusable Textile Association, "training employees and clients in the proper handling and storage of linens is of paramount importance". Nonetheless, while many laundry services offer in-service training for the best practices in handling, clients have not been particularly receptive. Additional training may soon become mandatory.

In a 2015 review (ICHE 36:1073-88), Lynne M. Sehulster of the CDC has set forth a compilation of the findings and recommendations of peer-reviewed studies on the handling of healthcare fabrics. View a Q&A with Sehulster and also high-lights of the CDC review in this power point slide presentation.

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Upcoming Events

February 23-25, 2017:
Antimicrobials 2017 Australian Society for Antimicrobials 18th Annual Scientific Meeting. Adelaide, Australia

February 26 - March 3, 2017:
Antimicrobial Peptides Gordon Research Conference. Ventura, California

February 27, 2017:
7th Clinical Microbiology Conference. Amsterdam, The Netherlands

March 7-8, 2017:
Second Semmelweis CEE Conference, Budapest, Hungary

March 20-21, 2017:
SMI's 19th Annual Conference: Superbugs and Superdrugs - a focus on antibacterials. London, UK

March 22–25, 2017:
ASM Conference on Innovative Microbial Ecology for Mitigation of Antibiotic Resistance and Bacterial Diseases, Crystal City, VA

April 22-23, 2017:
Global Health and Innovation Conference.
Yale University, New Haven, Connecticut

April 22-25, 2017:
27th European Congress of Clinical Microbiology and Infectious Diseases (ECCMID). Vienna, Austria

June 1-5, 2017:
ASM Microbe 2017. New Orleans, LA, USA

June 14-16, 2017:
Association for Professionals in Infection Control and Epidemiology (APIC) Annual Conference. Portland, Oregon

June 20 – 23, 2017: ICPIC 2017, 4th International Conference on Prevention and Infection Control, Geneva Switzerland

July 31-August 01, 2017
3rd World Congress and Exhibition on Antibiotics and Antibiotic Resistance**;** The Future of Antibiotics: Key Opportunities & Emerging Therapies. Milan, Italy

Sep 25, 2017
7th Annual Congress on Clinical Microbiology, Chicago, Illinois, USA

October 4 – 8, 2017: ID Week 2017, San Diego, California