

## Short Communication

# Cleanliness of Linen and Clothing Items Professionally Laundered or Dry-Cleaned

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**SUMMARY:** We asked 14 professional cleaners (laundry services) to clean various unused (new) linen and clothing items with a microbial contamination level of <1 cfu/cm<sup>2</sup> and then evaluated the bacterial/fungal contamination of the laundered or dry-cleaned items. After laundering, 6 (21.4%) of the 28 samples from 4 of the 14 cleaners (28.6%) were contaminated (1–1,200 cfu/cm<sup>2</sup>). After dry-cleaning, 2 (7.1%) of the 28 samples from 2 (14.3%) of the 14 cleaners were contaminated (7–10 cfu/cm<sup>2</sup>). The main contaminant was *Bacillus cereus*. No sample of the laundered or dry-cleaned items showed *Staphylococcus aureus*, *Escherichia coli*, or *Pseudomonas aeruginosa* contamination. All 14 cleaners investigated in this study used batch-type washing machines. Therefore, batch-type washing machines can cause contamination of linen and clothing items with *B. cereus*.

Previous studies have clarified that *Bacillus cereus* contamination of hospital linen such as towels for wiping and sheets, causes bloodstream infection, meningitis, and pseudo-infection (1–4). Therefore, maintaining the cleanliness of linen is important. However, the cause of *B. cereus* contamination of linen has not been adequately clarified, although its contamination of washing machines or rinse water reused in washing machines, its multiplication on used, damp linen, and environmental contamination have all been suggested (1,2,5–7). We asked professional cleaners (laundry services) to wash or dry-clean unused linen and clothing items and evaluated the subsequent bacterial/fungal contamination.

Commercially available bath towels (100% cotton), sheets (100% cotton), cardigans (70% wool and 30% acrylic), and slacks (100% polyester) were purchased. We asked 14 professional cleaners in Tokyo and Yamaguchi prefecture to clean these items and then evaluated their bacterial and fungal contamination. Bath towels and sheets were laundered, while cardigans and slacks were dry-cleaned. All 14 professional cleaners used batch-type washing machines. None of the cleaners recycled rinse water in the washing machines. The investigation period was from September to December 2009.

Microorganisms were detected using liquid extraction methods (6,8). After cleaning, samples (100 cm<sup>2</sup>: 10 × 10 cm) were obtained from the items by cutting with sterilized scissors. The samples were then placed in glass bottles (500 mL) containing 200 mL of sterile physiological saline and ultrasonicated at 37 kHz for 10 min. Bacteria and fungi in the solution were identified and quantified to evaluate microorganisms attached to the

samples.

To count viable microbial cells, 0.5 mL of the undiluted solution from each sample and its 10-fold dilution were spread using glass ‘hockey sticks’ over Trypticase soy agar (TSA, Nippon Becton Dickinson, Tokyo, Japan), Salt egg yolk agar (Nissui Pharmaceutical, Tokyo, Japan), and Sabouraud dextrose agar (Nikken Seibutsu, Kyoto, Japan). For each linen and clothing sample, 8 TSA plates, 4 salt egg yolk agar plates, and 4 Sabouraud dextrose agar plates were used. In addition, all volumes of the remaining solution were filtrated using 0.45- $\mu$ m filters (Nalgene Thermo Scientific, New York, NY, USA), and the filters were cultured to count viable cells. Organisms were identified by Gram staining, morphological examination, the oxidation fermentation test, the cytochrome-oxidase test, and use of the API System (bioMérieux SA, L’Etoile, France).

Table 1 shows the microbial contamination levels of linen and clothing samples after cleaning. Items were considered to be contaminated when the viable cell count was  $\geq 1$  cfu/cm<sup>2</sup> (8–10). After laundering, 3 (21.4%) of the 14 bath towel samples were contaminated with 1–1,200 cfu/cm<sup>2</sup> of microorganisms such as *B. cereus* or coagulase-negative staphylococci. After laundering, 3 (21.4%) of the 14 sheet samples were contaminated with 8–190 cfu/cm<sup>2</sup> of *Bacillus* spp. Six contaminated samples were obtained from 4 (28.6%) of the 14 professional cleaners.

After dry-cleaning, 2 (14.2%) of the 14 samples were contaminated with 7–10 cfu/cm<sup>2</sup> of *B. cereus*, although none of the 14 samples from the slacks was contaminated. After dry-cleaning, 2 contaminated samples were obtained from 2 (14.2%) of the 14 professional cleaners. No sample showed *Staphylococcus aureus*, *Escherichia coli*, or *Pseudomonas aeruginosa* contamination after either cleaning method. The microbial level before sending the unused linen and clothing items (total 56 samples) to the cleaners was less than 1 cfu/cm<sup>2</sup>.

We evaluated microbial contamination of linen and clothing items after cleaning by 14 professional cleaners and observed contamination ( $\geq 1$  cfu/cm<sup>2</sup>) of items laundered at 4 cleaners (28.5%) and 2 dry-cleaners

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Table 1. Microbial contamination of linens and clothing items after cleaning

Item	Cleaning method	Sample No.	Contamination level <sup>1)</sup> (cfu/cm <sup>2</sup> )	Major contaminant <sup>2)</sup>
Bath towel	Laundering	1	1,200	<i>Bacillus cereus</i>
		2	41	<i>Staphylococcus warneri</i> , <i>B. cereus</i>
		3	1	<i>B. cereus</i>
		4-14	<1	
Sheet	Laundering	1	190	<i>B. cereus</i>
		2	68	<i>B. cereus</i>
		3	8	<i>Bacillus amyloliquefaciens</i>
		4-14	<1	
Cardigan	Dry-cleaning	1	10	<i>B. cereus</i>
		2	7	<i>B. cereus</i>
		3-14	<1	
Slacks	Dry-cleaning	1-14	<1	

<sup>1)</sup>: Contamination was considered to be present when the viable count was  $\geq 1$  cfu/cm<sup>2</sup>.

<sup>2)</sup>: The contamination levels of *Staphylococcus aureus*, *Escherichia coli*, and *Pseudomonas aeruginosa* were <1 cfu/100 cm<sup>2</sup>.

(14.2%). Although no pathogens such as *S. aureus*, *E. coli*, or *P. aeruginosa* were identified, our results showed that contamination of linen and clothing with microorganisms such as *B. cereus* at cleaners is not rare.

For linen, batch- or continuous-type washing machines are used. Batch-type washing machines are widely used by professional cleaners for laundering and dry-cleaning of clothes brought by general consumers, while continuous-type washing machines are widely used by linen suppliers for sheets and wet towels used in hospitals and hotels. Previous studies, which suggested washing machines as the cause of linen contamination with *B. cereus*, identified continuous-type washing machines as the contamination source (1,2). However, all 14 cleaners investigated in this study used batch-type washing machines. Therefore, batch-type washing

machines can also cause contamination of linen and clothing with *B. cereus*. However, the *B. cereus* contamination level was not high. This may have been because even cleaners using *B. cereus*-contaminated batch-type washing machines also cleaned and disinfected the machines at a certain frequency. To prevent linen and clothing contamination when either continuous- or batch-type washing machines are used, cleaning and disinfection of the washing machine drums at regular intervals, such as twice a year, may be important.

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**Conflict of interest** None to declare.

## REFERENCES

1. Dohmae S, Okubo T, Higuchi W, et al. *Bacillus cereus* nosocomial infection from reused towels in Japan. J Hosp Infect. 2008; 69:361-7.
2. Sasahara T, Hayashi S, Morisawa Y, et al. *Bacillus cereus* bacteremia outbreak due to contaminated hospital linens. Eur J Clin Microbiol Infect Dis. 2011;30:219-26.
3. Barrie D, Wilson JA, Hoffman PN, et al. *Bacillus cereus* meningitis in two neurosurgical patients: an investigation into the source of the organism. J Infect. 1992;25:291-7.
4. Ohsaki Y, Kuroki M, Tachibana M, et al. Use of sodium hypochlorite (NaOCl) in laundering stops cross-contamination of *Bacillus cereus*. J Infect. 2007;55:283-4.
5. Balm MN, Jureen R, Teo C, et al. Hot and steamy: outbreak of *Bacillus cereus* in Singapore associated with construction work and laundry practices. J Hosp Infect. 2012;81:224-30.
6. Barrie D, Hoffman PN, Wilson JA, et al. Contamination of hospital linen by *Bacillus cereus*. Epidemiol Infect. 1994;113: 297-306.
7. Hernaiz C, Picardo A, Alos JJ, et al. Nosocomial bacteremia and catheter infection by *Bacillus cereus* in an immunocompetent patient. Clin Microbiol Infect. 2003;9:973-5.
8. Eriksson B, Hoborn J, Nyström B. The contact plate technique is inappropriate for bioburden determination on textiles. J Hosp Infect. 1995;30:73-4.
9. Walter WG, Schillinger JE. Bacterial survival in laundered fabrics. Appl Microbiol. 1975;29:368-73.
10. Christian RR, Manchester JT, Mellor MT. Bacteriological quality of fabrics washed at lower-than-standard temperatures in a hospital laundry facility. Appl Environ Microbiol. 1983;45:591-7.