Healthcare Textiles and Laundry
Dr. Lynne Sehulster, Centers for Disease Control, Atlanta
A Webber Training Teleclass

Healthcare Textiles and Laundry:
Important Trends That Can Impact Infection Prevention

Lynne Sehulster, PhD, M(ASCP)
Division of Healthcare Quality Promotion
Centers for Disease Control and Prevention

Hosted by Martin Kiernan
martin@webbertraining.com

Disclaimer

- The findings and conclusions in this presentation are those of the author and do not necessarily represent the views of the Centers for Disease Control and Prevention/Agency for Toxic Substances and Disease Registry.
- No financial conflicts of interest to disclose.

Let's Talk About…

- Healthcare textiles and laundry
  - Microbial burden, transfer
  - Hygienically clean concept
- Epidemiology of healthcare textiles and transmission of infection
- Laundry process and current standards
- Current developments re: healthcare textiles
  - Healthcare customer demands
  - Antimicrobial treatments for textiles

Textiles and the Laundry Process:

Basic Epidemiology, Microbiology, and Infectious Disease Transmission Principles

Laundry and Infectious Diseases

- Textiles contaminated with body substances can contain large numbers of microorganisms (10^6 – 10^8 cfu/100 cm^2 fabric)
- Few reports in the literature link laundry to disease transmission when proper procedures are followed
- Annual estimates for volume of laundry processed in U.S. health care: >10 billion lbs. (5 billion lbs. in the late 1980s)
- Continue current infection prevention practices

Some Observations About Textiles and Microorganisms in Health Care

- Perry C, et al. *J Hosp Infect* 2001; 48:238-241
  - Microbial sampling of HCW uniforms during normal wear
  - *Staphylococcus aureus* was the only bacterium to have high counts (e.g., 10-100 CFU and > 100 CFU)
  - Surgery uniforms – *S. aureus*; Medicine and renal uniforms – *S. aureus*, VRE, and *C. difficile*
  - Increasing numbers of *S. aureus* on uniforms when worn for more than one day
- Takashima M, et al. *Am J Infect Control* 2004; 32: 27-30
  - Binding ability: microorganisms to fibers (100 mg), high conc.
  - Cotton: *S. aureus* 2%, MRSA 1%, *Pseudomonas aeruginosa* 8.1%
  - Polyester: *S. aureus* 96.2%, MRSA 87.9%, *P. aeruginosa* 99.9%

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Observations from a Recent Study

- 135 personnel (45% physicians, 55% nurses) in surgical depts. (60%) and medical depts. (40%)
- Nonpathogenic skin organisms isolated from all attire tested
- Rate of contamination with pathogens higher in attire changed every 2 days compared to that for daily changes ($p<.05$)
- Isolated pathogenic bacteria:
  - *Acinetobacter* spp. 37% (89/238 cultures)
  - *Staphylococcus aureus* 13% (32/238 cultures)
  - Enterobacteriaceae 8% (18/238 cultures)
  - *Pseudomonas aeruginosa* 3% (8/238 cultures)
- Only skin bacteria isolated from 4 uniforms cultured immediately after receipt from the hospital laundry
  - Bacterial loads significantly lower than on uniforms being worn

Wiener-Well Y, et al. *Am J Infect Control* 2011; 39: 555-9

Microbial Burden on Textiles

- Blaser et al., JID 1984: ~10 – 100 cfu/cm^2
- Fijan et al., JHI 2005: < 100 cfu/dm^2
  - Quotes from German RAL-GZ 992 standard (Quality Assurance Standard for Textile Care of Hospital Laundry)
- Eriksson et al., JHI 1995: < 100 cfu/100 cm^2
- Barrie and Hoffman, JHI 1995: "While a bioburden of < 1 cfu/cm^2 is achievable, it is neither conveniently measured nor of proven significance."

Epidemiologic Observations: Healthcare Textiles and Infection

- Of all the surfaces in a hospital, a patient will have the greatest degree of contact with his gown and the bed linens
- Despite studies documenting presence of microbes on textiles, little documentation of actual transmission
  - *Rhizopus* outbreak in U.S., 2009
  - *Bacillus cereus* outbreaks in Japan, 2000 – 2005, 2006 (4 reports)
- Difficult to measure a rare event

Transfer of Microorganisms from Textiles to Other Surfaces

	Mean Log_{10} CFU		
	Starting Log_{10} CFU on Surface	Log_{10} CFU on Hands	Transfer Efficiency (%)
Micrococcus luteus			
Dishcloth	10.44	6.90	0.04
Faucet (tap)	6.13	5.59	40.03
Phone receiver	6.60	6.19	41.81
Laundry (100% cotton)	9.73	6.17	0.13
Laundry (50:50 cotton/ polyester	9.39	5.99	0.06

In general, the transfer of microbes from a porous material to another surface is not as efficient as the transfer from a nonporous material to another surface

Data: Rusin P, Maxwell S, Gerba CP. *J Appl Microbiol* 2002; 93: 585-92

Table Format Adapted From: Bloomfield SF, Exner M, Signorelli C, et al. The infection risks associated with clothing and household linens in home and everyday life settings, and the role of laundry. April 2011, International Scientific Forum on Home Hygiene www.ifh-homehygiene.org

Current Healthcare Textiles Standard in the U.S.

- Standard for reusable textiles: Hygienically clean
  - Not quantified for microorganisms, but assume textiles are generally rendered free of vegetative pathogens
  - Through a combination of soil removal, pathogen removal, pathogen inactivation, contaminated laundry is rendered hygienically clean
  - Carries negligible risk to healthcare workers and patients, provided that the clean textiles are not inadvertently contaminated before use
  - Sensory attributes: visual, tactile, olfactory
- Reusable surgical textiles: Sterilized

CDC Guidelines for Environmental Infection Control in Health-Care Facilities, 2003:
http://www.cdc.gov/hicpac/pdf/guidelines/eic_in_HCF_03.pdf
ANSI/AAMI ST79:2010 and A1; ANSI/AAMI ST65:2008

AAMI: Hygienically Clean

- Definition: "Free of pathogens in sufficient numbers to cause human illness." (ANSI/ AAMI ST 65:2008)
- No one has ever defined what "sufficient numbers" means

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Main Steps of Healthcare Laundry Processing

- Collection of soiled textiles at point of use
- Transport to laundry
- Wash cycle:
  - Flush, main wash, bleaching, rinsing, souring
- Dried and pressed
- Packaged, loaded into carts
- Delivery back to the hospital

Laundry Operations

- If using hot water washing, water temperature ≥71° C (≥160° F) is needed
  - Some healthcare facilities may not have access to water at this temperature
- Chlorine bleach (50 – 150 ppm) is effective laundry additive at various water temperatures
  - Follow manufacturer instructions for bleach use
- One of the rinses includes a mild acid (sour) to neutralize residual alkalinity from the wash
  - Helps to inactivate microorganisms
  - Reduces risk of skin reaction to alkali

Alternatives to Hot-water Laundry

- In-house laundries consume an average of 50% - 70% of the facility's hot water (10% - 15% of the total energy used)
- Water temperature may be regulated locally
- Lower temperature (e.g., 22° – 50° C) wash cycles can be used with appropriate detergents and laundry additives
- New detergents and processes (e.g., oxidative products) are being evaluated in Europe
- Current problems associated with bleach use:
  - Not all fibers and fabrics are compatible with bleach
  - Chlorine + residual chlorhexidine gluconate (CHG) = brown stains

Conventional Laundering: Log Reductions in Bioburden

- In the wash, rinse cycles:
  - Agitation: ~3 $\log_{10}$ unit reductions
  - Addition of bleach: ~ 3 $\log_{10}$ unit reductions
- In the dry cycle:
  - ~ 1 – 2 $\log_{10}$ unit reductions

From: Blaser MJ, et al. 1984; J Infect Dis 149: 48-57.

- Post wash microbial burden ~10 – 100 CFU/ cm^2
- Predominantly gram-positive organisms

The Laundry Process: Log Reductions

Process	Gram Positive LR	Gram Negative LR
Pre –wash at 35° C	0.73 – 2.47	0.70 – 1.16
Main wash at 45° C w/o pre-wash	0.97 – 2.58	1.11 – 2.66
Main wash at 60° C w/o pre-wash	1.34 - >5.56	3.71 - >5.6
E60 + 35: pre-wash at 35° C, main wash at 60° C	1.91 - >7.68	>5.6 - >7.76
Completed main wash at 75° C	>5.56 - >7.88	>5.6 - >7.76
Disinfecting only at 75° C	>5.56 - >7.88	>5.6 - >7.76
Complete 3-step cycle (with disinfection at 80° C)	>5.56 - >7.88	>5.6 - >7.76

- Detergent was mix of anionic and nonionic surfactants, phosphates
- Bleach: H_2O_2 agent; Disinfecting agent was peroxyacetic acid, H_2O_2, acetic acid
- Starting inocula: 10^6 – 10^7 CFU in 1 square cm
- The disinfecting step by itself could not remove stains
- *E. faecium* had the greatest survival; Gram positive > Gram negative

Fijan S, et al. *Diag Microbiol Infect Dis* 2007; 57: 251-257

U.S. EPA and Detergents, Laundry Additives

- OCSPP 810.2400: Fabrics and Textiles – efficacy data recommendations
- Efficacy testing for antimicrobial pesticides intended to be used on fabrics and textiles, and which bear label claims as disinfectants or sanitizers
- Sanitizers used on fabrics: 3 $\log_{10}$ reduction
- Disinfectants used in laundry facility: ≥ 59 carriers out of 60 – no growth (carriers inoculated with ≥ 10^6 microbes)

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CMS Questions to CDC

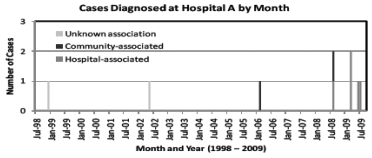
- Is hot-water laundering required?
- If a low-temperature laundry chemical is used, is a bleach rinse required?
- If an EPA-registered laundry sanitizer is used, must it bear label claims for key HAI pathogens (e.g., MRSA, VRE, *Klebsiella* spp)?
- Are laundry detergents EPA-registered?

Laundry Transport / Storage

- Separate clean textiles from contaminated textiles when transporting in a vehicle
- Physical barriers and/or space separation
- Clean, unwrapped textiles can be stored in a clean location for short periods of time
- Unwrapped textiles should be stored so to prevent inadvertent contamination by soil or body substances
- **This is the part of the overall process that is most vulnerable to outside contamination**

RESULTS

Cases Diagnosed at Hospital A by Month



- Five hospital-associated cases occurred in a cluster from August 2008 to July 2009

Characteristics of the Five Hospital-Associated Cases

Patient	1	2	3	4	5
Age	0 days	1 day	13 years	10 years	11 years
Date of diagnosis	8/22/2008	3/25/2009	3/11/2009	6/22/2009	7/2/2009
Admitting Diagnosis	Premature birth	Dextrocardia and TAPVR	Histiocytosis	Mitral valve insufficiency	Graft versus host disease
Zygomycosis risk factors	– Acidosis – Low birth weight	– Acidosis	– Acidosis – Chronic steroids	– Acidosis	– Chronic steroids – Bone marrow transplant
Location of cutaneous lesion	Groin	Upper back and posterior neck	Axila and sacrum	Face	Periumbilical
Length of stay at infection onset (days)	35	47	20	51	33
Ward	NICU	CCU	ICU	CCU	ICU

- The hospital wards involved are served by different air handling units / air intakes located on opposite sides of the building, making airborne dissemination of mold from a common source unlikely
- All five case-patients died

Hospital A Pre-Intervention Environmental Cultures

Linen Related Areas and Items Cultured		
Category	*Rhizopus* Positive	Samples Tested
Linen storage room	6	8
Clean linen delivery bins	10	22
Clean linen in bins	1	3
Linen delivery truck (inside)	1	1
Linen bin holding area	1	1
Ward A linen closet	2	4
Ward B linen closet	3	4
Ward C linens	0	9
OR linen closet	2	10
Linen rewashed in hospital	0	3
Total	26 (40%)	65

Non-linen Related Areas and Items Cultured		
Category	*Rhizopus* Positive	Samples Tested
Skin adhesives	0	9
Wound cleaner	0	1
Ward C	0	8
Pharmacy	0	2
Respiratory equipment room	1	2
Air handling unit	0	1
Service entrance	0	1
Total	1 (4%)	24

Intervention: Initial Control Measures

- Based on the results of the initial investigation, Hospital A implemented the following interventions seven days after the case triggering the investigation was diagnosed
  - changed to a different linen supply company
  - started using a different entrance for linen deliveries and a different linen bin holding area
  - removed all linen in use at the time
  - disinfected the linen storage room

Conclusions From the Outbreak Investigation

- Hospital linens were the most likely vehicle to have brought *Rhizopus* in contact with the patients
- Genetic subtyping of fungal isolates supported this epidemiologic hypothesis
- Contamination of clean linens with *Rhizopus* happened repeatedly, but might have been intermittent
- Hospital linens should be laundered, shipped, and stored in a manner that minimizes exposure to environmental contaminants

Current Standards and Developing Trends

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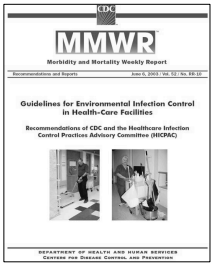
CDC / HICPAC Guidelines: Laundry and Bedding

From the "Guidelines for Environmental Infection Control in Health-Care Facilities" (2003):

Epidemiology and General Aspects of Infection Control
Collecting, Transporting, and Sorting Contaminated Textiles and Fabrics
Parameters of the Laundry Process
Special Laundry Situations
Surgical Gowns, Drapes, and Disposable Fabrics
Antimicrobial-Impregnated Articles and Consumer Items Bearing Antimicrobial Labeling
Standard Mattresses, Pillows, and Air-Fluidized Beds



Process Certification Programs

- European Standard EN 14065
  - Process approach to quality management consistent with ISO 9001
- Australian/New Zealand
  - AS/NZS 4146:2000
- United States
  - ANSI/AAMI ST65: 2008 Standard
  - HLAC

Potential CDC Concerns

- Piecemeal sampling not statistically valid
- No standards, no consensus
- Post-process product sampling does not "certify" the effectiveness of the process
- No epidemiologic evidence of an existing infectious disease transmission problem with hygienically clean textiles
- Why have an expensive program to solve a problem that has not been detected
- Numbers generated without context
- Better approach: parametric monitoring of the laundry process

OR Pack Room

Questions Raised

- Customers are beginning to question the standard
  - Is hygienically clean good enough? Should we be doing something different?
  - Should we be incorporating more antimicrobials into the laundry process on a routine basis?
- Reports of customers asking laundry operators to do ATP sampling of laundry facility surfaces, cleaned textiles
  - What does this mean?
  - Should microbial sampling of clean textiles be implemented?
  - Use of ATP monitoring of hard sufaces in a HACCP approach

A Short List of Antimicrobial Chemicals for Textiles

- Quaternary ammonium compounds plus acrylic copolymer fluid repellent
- Chitosans and chitooligosaccharides
- Quaternary ammonium compounds plus organosilane (forming a silicon-nitrogen carbon polymer)
- Hydrophobic N-alkyl plus benzophenone containing polyethylenimine
- Silver (Ag) nanoparticles
- Copper (Cu) nanoparticles
- Gold (Au) nanoparticles
- Siloxane sulfipropylbetaine (SSPB)
- Titanium dioxide (TiO_2)
- Ag nanocomposite with TiO_2 and citric acid as a crosslinker
- Triclosan

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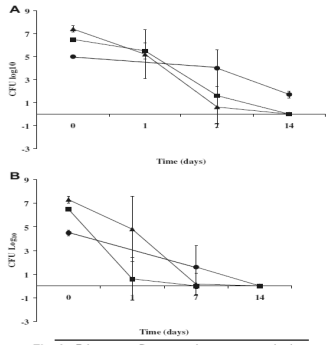

Treatment of Fabric with Quaternary Ammonium/Organo-silane During the Wash Process

Baxa D, et al. *Am J Infect Control* 2011; 39: 483-7

Fig 1. Fabric test. Patient isolates were applied to fabric treated with GS: MRSA (■), EC (●), and PA (▲). Viable recovery of bacteria from untreated (A) and treated (B) materials. Fabric was sampled every 7 days, with plated samples incubated at 35°C for 48 hours. Results are expressed as the mean for the number of isolates tested.

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Log Reductions on Untreated Fabric (Control) and Silver Treated Fabric

Table 1 Average inhibition[a] of clinical and reference strains of ten bacterial species on bioactive and control fabrics depending on the contact time

	No. of strains	CS (cfu/ml)	3 h		24 h		48 h		72 h	
			CF	BTF	CF	BTF	CF	BTF	CF	BTF
A. baumannii	3	3.5×10^6	0	0	0	2.6	0	4.1	0.8	5
E. aerogenes	3	5.8×10^6	0	1.5	0	3.4	2.2	4.3	4	5
E. coli	4[b]	5.5×10^6	0	0	0	4	2	5	4.5	5
E. faecalis	3	3.8×10^6	0	0	1.8	3.1	2	4	4	4.8
K. pneumoniae	3	4.0×10^6	0	0.6	0	5	4	5	4	5
M. morganii	4[b]	4.5×10^6	0	0	0	4	4	5	5	5
P. aeruginosa	4[b]	4.2×10^6	0	0.3	0	4	2	4	5	5
P. aeruginosa mucous	3	3.5×10^6	0	3.8	4.2	5	4.5	5	5	5
P. mirabilis	3	3.5×10^6	0	1.1	0	4	3	4.6	4	5
S. aureus	4[b]	2.8×10^6	0	1.3	1.5	4.2	3	5	3	5
S. epidermidis	3	3.2×10^6	0	0	1.6	4	3	5	3.2	5

CS, cell suspensions of inoculums as an average of cfu/ml;CF, control fabric;BTF, Bioactive® -treated fabric

[a] Inhibition expressed as average $\log_{10}$ reductions (LR) in relation to the inoculum size ($5\log_{10}$ cfu)

[b] Three clinical strains and a reference strain are included

Mariscal A, et al. *Eur J Clin Microbiol Infect Dis* 2011; 30: 227-32

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Effect of Artificial Sweat on Silver Leaching from Treated Fabrics

Table 3: Initial silver content and total silver release in standard formulas of artificial sweat for 24 h

Sample	Initial silver content (mg/kg)	Silver released in artificial sweat (mg/kg)			
		AATCC Ph 4.3	ISO Ph 5.5	ISO Ph 8.0	EN Ph 6.5
A0	n.d.	n.d.	n.d.	n.d.	n.d.
A1	36.12 ± 22.42	21.01 ± 4.13	15.53 ± 3.62	34.27 ± 2.88	35.83 ± 19.68
A2	56.57 ± 34.28	33.39 ± 15.80	28.81 ± 10.34	66.54 ± 46.29	77.96 ± 23.80
A3	95.12 ± 33.12	70.15 ± 37.29	72.69 ± 11.99	82.22 ± 26.99	152.20 ± 36.54
A4	425.21 ± 93.73	217.61 ± 81.32	177.13 ± 57.13	268.31 ± 131.15	322.21 ± 87.00
B	n.d.	n.d.	n.d.	n.d.	n.d.
C	n.d.	n.d.	n.d.	n.d.	n.d.
D	n.d.	n.d.	n.d.	n.d.	n.d.
E	15.16 ± 9.90	0.08 ± 0.05	0.01 ± 0.01	0.50 ± 0.30	0.36 ± 0.10
F	1.22 ± 0.87	n.d.	n.d.	n.d.	0.05 ± 0.00
G	0.99 ± 1.53	n.d.	n.d.	n.d.	n.d.

Data are mean ± SD of three independent experiments.
n.d. = not detected

Kulthong K, et al. *Part Fib Toxicol* 2010; 7: 8

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Quality Issues for Consideration

- Conduct risk-benefit analysis
- Potential toxicologic and allergic side effects
  - Does exposure alter the microbial ecology of the skin, skin integrity?
- Potential selection for resistant microorganisms with long-term use
- Potential environmental issues
  - Biodegradability, toxicity to plants, marine life
- Persistence of the antimicrobial effect
  - Is recharge needed, or is another treatment necessary?
- Can consistent adherence to existing infection prevention practices achieve similar results?
- **Need to document an impact on healthcare-associated infection (HAI) rates while using antimicrobial treatment of textiles**

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EPA: Treated Article Exemption

- According to FIFRA, "treated articles" refer to articles or products that are treated with an antimicrobial pesticide to protect the article or product themselves.
- Treated Articles Exemption:
  - An article or substance treated with or containing a pesticide to protect the article or substance, if the pesticide is registered for such use
  - The Treated Articles Exemption is available only for the protection of the product and not for public health uses
    - Odor control, prevention of deterioration
- Products bearing a public health claim must be registered in addition to the registration of the antimicrobial pesticide

http://www.epa.gov/pesticides/factsheets/treatart.htm

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Resources for More Information

- CDC:
  - Guidelines for Environmental Infection Control in Health-Care Facilities: http://www.cdc.gov/hicpac/pdf/guidelines/eic_in_HCF_03.pdf
  - Guidelines for Disinfection and Sterilization in Healthcare Facilities: http://www.cdc.gov/hicpac/pdf/guidelines/Disinfection_Nov_2008.pdf
  - HAI Prevention Tool Kit: http://www.cdc.gov/HAI/prevent/prevention_tools.html
    - Options for Evaluating Environmental Cleaning
    - Appendices to the Conceptual Program Model for Environmental Evaluation
    - CDC Environmental Checklist for Monitoring Terminal Cleaning
    - CDC Environmental Checklist
    - Environmental Cleaning Evaluation Worksheet (Excel format)
    - CDI Prevention Tool Kit
- EPA:
  - Selected EPA-Registered Disinfectants: http://www.epa.gov/oppad001/chemregindex.htm
  - Pesticide Product Label System: http://www.epa.gov/pesticides/pestlabels/index.htm

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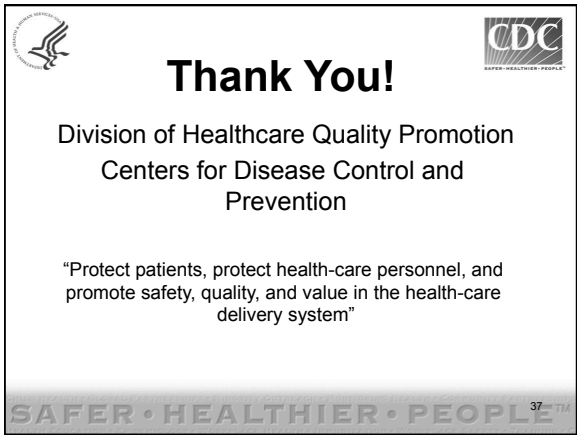

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