HOSPITAL LAUNDRY AND *C. DIFFICILE* SPORE INACTIVATION

Kevin McLaren
The American Reusable Textile Association (ARTA)

Hosted by Dr. Lynne Sehulster

Hospital Laundry and *C. difficile* Spore Inactivation

ARTA – The American Reusable Textile Association

- Founded in 1982 to Promote the Use of Reusable Textiles
- Membership is comprised of all facets of the textile maintenance industry: Textile Manufacturers, Chemical Suppliers, Machine Manufacturers, Professional Launderers, other support organizations
- Mission Statement is to Promote the Value & Need for Reusable Textiles through Education, Research, Legislative & Regulatory Action
- Supports the 3-R's (reduce, reuse, recycle) to promote the 3-C's(comfort, cost, conservation)
- Life Cycle Assessment (LCAs) studies on environmental & cost of use of Reusables vs. Disposables

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The ARTA C. diff Team

Brendan O'Neill -	London Hospital Linen Service
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Steve Tinker -	Gurtler Industries
Kevin McLaren –	Gurtler Industries
Lynne Sehulster –	Environmental Infection Prevention, LLC
Nancy Jenkins -	ARTA

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Healthcare Laundry-A Wide Array of Textiles

- Bed Linens
- Bath Towels & Washcloths
- Patient Gowns
- Scrubs
- Isolation & Barrier Gowns
- Surgical Towels
- Housekeeping Wipers & Mops
- Warming Blankets
- Baby Blankets
- Other

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The Historical Significance of Healthcare Laundry

1938 – A Sanitary Study of Commercial Laundry Practices.

American Journal of Public Health; Lloyd Arnold

Operation	Purpose	Temperature (oF)	Holding Time (minutes)	Ave. Bacterial Count per c.c. Wash Water
Flush	Wet cloth	110	5	200,428
Suds	Detergent-(soap-alkali)	125	10	94,314
Suds	Detergent-(soap-alkali)	135	10	42,518
Suds	Detergent-(soap-alkali)	140	10	8,382
Suds	Detergent-(soap-alkali) plus 1% Bleach	165-170	15	5
Rinse	Removes detergent	165	3	1
Rinse	Removes detergent	165	3	0.5
Rinse	Removes detergent	165	3	0.4
Rinse	Removes detergent	165	3	0.2
After Sour	Removes residue detergent	140	10	Sterile
Blue		110		

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The Historical Significance of Healthcare Laundry

1938 – A Sanitary Study of Commercial Laundry Practices.

American Journal of Public Health; Lloyd Arnold

- "The whole procedure consists of 4 detergency operations for cleaning the clothes and a similar number of rinsing operations to remove the detergent."
- "We were concerned only with the bacterial counts of the wash waters and the textiles in the laundry process."
- "A temperature of 165 ° to 175 ° F. with a chlorine (bleach) concentration of 0.01 per cent in the fourth suds, held for 15 minutes is an effective germicidal process."
- "Table IV gives the average number of bacteria cultured from wooden cylinders per sq. in. of surface before and after cleaning…"
- "It is apparent that the sanitary efficiency of the process is not satisfactory when the cylinder acts as a bacterial reservoir during the procedure.

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The Historical Significance of Healthcare Laundry

Published Studies and Their Role in our Beliefs

Often cited references specific to laundering

- Bacteriological Quality of Fabrics Washed at Lower-Than-Standard Temperatures in Hospital Laundry Facilities. Christian, Manchester & Mellor 1983
- Bacterial Survival in Laundered Fabrics. Walter & Schillinger 1974
- Detergent Systems on Bacterial Survival on Laundered Fabrics. Jaska & Fredell 1980
- Killing of Fabric-Associated Bacteria in Hospital Laundry by Low-Temperature Washing. Blaser, Smith, Cody, Wang, LaForce 1984
- Critical Analysis of the Microflora of Toweling. Wetzler, Quan, Schatzle 1971
- Antimicrobial disinfection effect of a laundering procedure for hospital textiles against various indicator bacteria and fungi using different substrates for simulating human excrements. Fijan, Koren, Cencic, Sostar-Turk. 2006
- Bacterial Contamination of Surgical Scrubs and Laundering Mechanisms: Infection Control Implications. Twomey, Beitz, Johnson. 2009

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The Historical Significance of Healthcare Laundry

Authors	Publication Year	Washer Type	Bleach (if noted)
Wetzler et. al.	1971	W/E	Chlorine
Walter & Schillinger	1975	W/E - 35 lb	Chlorine
Jaska & Fredell	1980	W/E - 25 lb	N/A
Christian et. al.	1983	W/E 350 lb	Chlorine
Blaser et. al	1984	W/E 400 lb	Chlorine
Perenich & Wilkinson	1993	Home-Stlye	N/A
KAM	1994	W/E	Chlorine
Twomey et. al	2009	Home Style	ND

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The Historical Significance of Healthcare Laundry

What About Microbiological Studies Conducted in Modern Tunnel Washer Programs?

There is not much out there!

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The Historical Significance of Healthcare Laundry

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The Regulatory Guidance of Healthcare Laundry

- Guidelines for Environmental Infection Control in Health-Care Facilities – Section G. Laundry and Bedding. Centers for Disease Control & Prevention *(approx. 80 citation references)*
- Interpretive Guidelines for Long-Term Care Facilities F tag 441 Infection Control. Centers for Medicare & Medicaid Services (CMS)
- Department of Public Health. Multiple Individual States
- Guidelines for Surgical Scrubs or other Surgical/Procedural Attire. Joint Commission

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"Today's Healthcare Laundry"

- Highly Automated Production Environment; Sling Rail systems for soil sort
- Tunnel washers replacing washer/extractors
- Automated shuttle systems move textiles through drying/finishing
- Ironers, folders, stackers automate finishing operations
- Evolution of "green" wash chemistry/programs
- On Premise Laundries (OPL) being replaced by Co-Op Laundries
- Consolidation of Healthcare providers and shrinking profits, Hospital closings
- Evolution & variation in textiles being laundered
- Chlorhexidine Gluconate has become primary antiseptic

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"Today's Healthcare Laundry"

Why is "Today" different?

- Tunnel washers continue to replace washer/extractors as the machine of choice
- Tunnel washers retain water liquors and seldom run out "dry"
- Chlorine bleach use has diminished as the oxidizer of choice due to CHG
- Economic pressures have squeezed the use of wash chemistry
- Resource conservation efforts have introduced water recycle programs and reduced temperature
- Biodegradable surfactants have replaced more traditional NPE detergents

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The Start of a Research Project

ARTA 2016 Educational Conference

Presentation on *Clostridium difficile* (now *Clostridioides)*

- Pathogenicity
- Impact on the Hospital & Healthcare Industry
- Lack of published science specific to the role of the laundering process on C. diff spores
  (lots on vegetative microbes)
- Lack of EPA Germicide Testing Protocols for Laundry specific to bacterial spores

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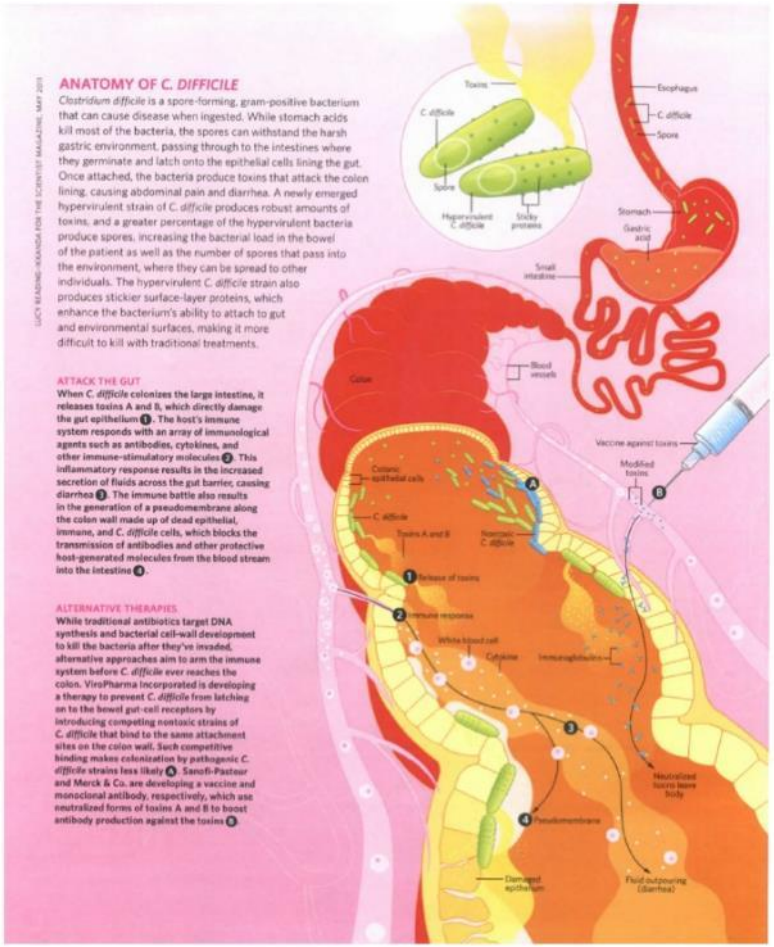
The Start of a Research Project

ARTA 2016 Educational Conference

http://www.the-scientist.com/images/PDF/Anatomy-of-C.-Difficile.pdf

This is an easy to understand distillation of *Clostridium difficile* infection.



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The Start of a Research Project

Developing a Study Objective / Goal:

- Work with the actual C. diff spores, not an indicator organism
- Identification of a Laboratory proficient in work with C. diff spores
- The lab needs to be proficient in microbiology & have ability to run “laundry” testing
- The lab needs to be proficient in anaerobic microbiology
- The lab needs to be agreeable to a customized testing protocol

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The Start of a Research Project

Selecting – Developing Test Methods

- ASTM, AOAC, AATCC, other

Focus on the Tunnel Washer laundry model

- Tunnel Washers are the predominant washer style in the Healthcare Laundry market
- Transfer rate will dictate exposure time

Conduct a feasibility test to prove that C. diff spores can be recovered from a cloth swatch

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The Research Project

Select ASTM E 2406 "Evaluation of Laundry Sanitizers & Disinfectants" as a base protocol

Goal is to evaluate the alkaline Break and five (5) different bleaching conditions

All durations/exposures to be 8 minutes (very conservative, 2 x 4 minute "modules")

Agree to use 100% cotton test cloth based on history of this cloth, in this method, and data submission to the EPA

Test for C. diff spore survivors in both cloth & working solution

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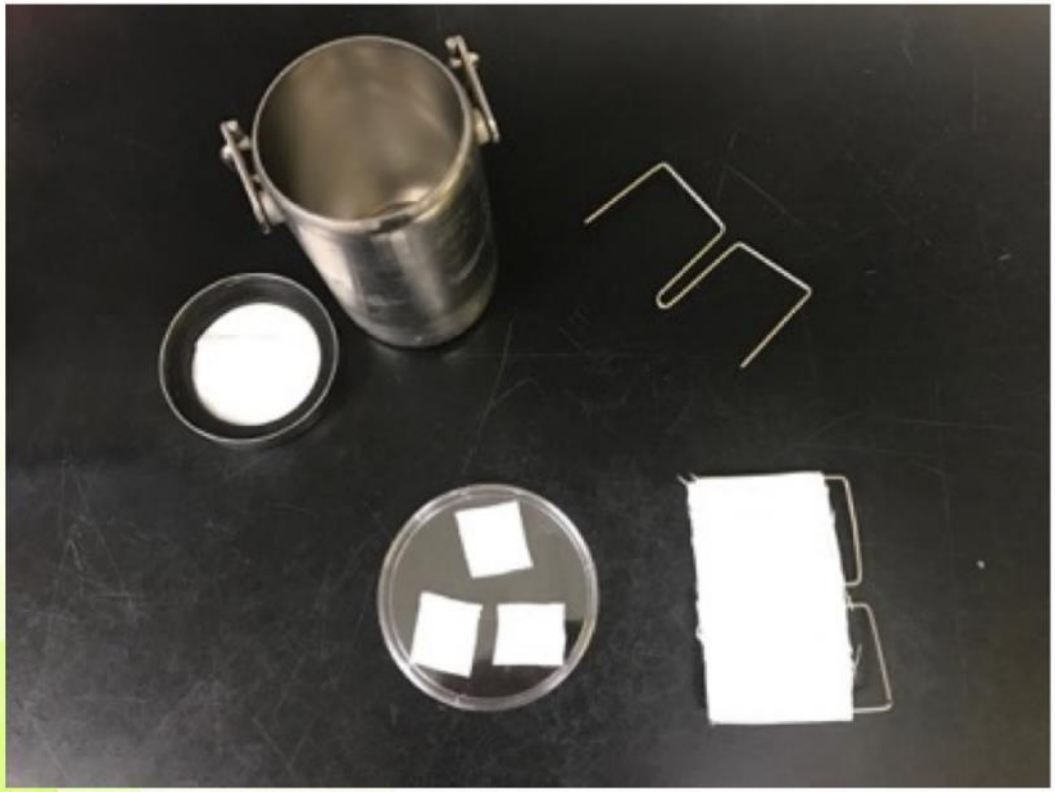
The Research Project



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The Research Project: *Test Conditions*

- Chemical solutions for evaluation: (all solutions made in potable softened water)
  - 3 mls/liter Liquid sodium hydroxide builder + 2 mls/liter liquid nonionic surfactant blend (to be provided by study company) (approx. 800 ppm Na_2O)
  - 5 mls/liter sodium hypochlorite bleach 10% solution (500 ppm active)
  - 2 mls/liter sodium hypochlorite bleach 10% solution (200 ppm active)
  - 2 mls/liter hydrogen peroxide 32% bleach solution, adjusted to pH 11 w 1 N NaOH (approx 640 ppm)
  - 2 mls/liter peracetic acid (15/10/30 PAA/H_2O_2/Acid) bleach solution
  - 2 mls/liter peracetic acid (15/10/30 PAA/H_2O_2/Acid) bleach solution adjusted to pH 9 with 1 N NaOH
  - Potable water control

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The Research Project: *Target Test Conditions*

Solution	Solution Description	pH of Solution	Operational test temperature	Time of Exposure
A	Alkaline Detergent	11.0-12.0	160 °F	8 minutes
B	500 ppm Chlorine Bleach	10.0-10.5	150 °F	8 minutes
C	200 ppm Chlorine Bleach	10.0-10.5	150 °F	8 minutes
D	640 ppm Hydrogen Peroxide	11.0-12.0	170 °F	8 minutes
E	2000 ppm PAA soln-acidic	As made	140 °F	8 minutes
F	2000 pp. PAA soln- pH adjusted	9.0 +/- 0.25	140 °F	8 minutes
G	Potable water control	7.0 +/- 1.0	100 °F	8 minutes

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The Research Results:

	Test Substances	% C diff Spore Reduction: Cloth	% C diff Spore Reduction: Wash Solution
A	Alkaline Detergent	No Reduction	No Reduction
B	500 ppm Chlorine Bleach	>99.9%	>99.9%
C	200 ppm Chlorine Bleach	>99.9%	>99.9%
D	640 ppm Hydrogen Peroxide-Alkaline	No Reduction	No Reduction
E	300 ppm Peracetic acid - Acidic	No Reduction	48.7 %
F	300 ppm Peracetic acid - Alkaline	No Reduction	No Reduction

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The Research Results Analysis:

- A simulated alkaline detergent wash step did not kill spores
- Simulated chlorine bleach baths, both 200 & 500 ppm, kills spores
- A simulated alkaline peroxide bleach bath did not kill spores
- A simulated alkaline peracetic acid bleach bath did not kill spores
- An acidic solution of dilute peracetic acid showed some potential to kill spores dislodged from the cloth, though spore remaining in the cloth were unaffected

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So does this mean my laundry process kills C. diff?

- If your laundry process is using chlorine bleach, you are probably killing C. diff spores
- If your laundry is using hydrogen peroxide bleach, you may not be killing C. diff spores
- If your laundry is using peracetic acid bleach, you may not be killing C. diff spores
- If your laundry processes colored textiles, without an oxidizing bleach, you may not be killing C. diff spores

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But we only tested steps, right?

We didn't actually test a full simulated wash process, did we?

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ARTA's C. Diff Research Continues: Study 2

- In the absence of an approved EPA Test Method: Study 1 has shown that C. diff spores can be recovered from a cloth carrier similar to vegetative bacteria
- Study 1 has also shown that chlorine bleach based laundry baths can kill C. diff spores in 8 minutes under "normal" operational conditions
- Study 1 suggests that it might be possible to kill C. diff spores with peracetic acid

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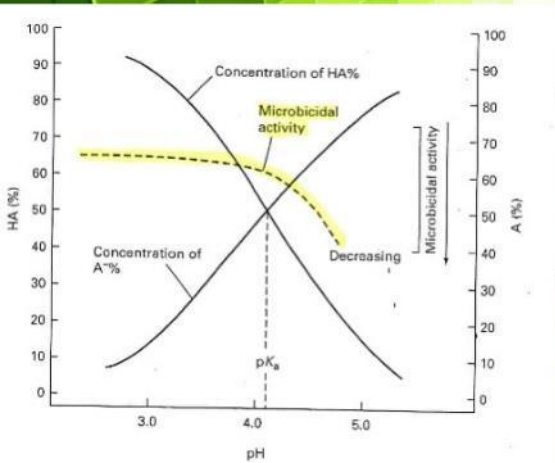
ARTA's C. Diff Research Continues: Study 2

- A second study was designed to evaluate a simulated tunnel washer process
- This study was designed to mimic a 24 minute wash cycle
- This study was designed to incorporate a second/different grade of peracetic acid as the bleaching agent
- This study *was intentionally designed* to evaluate the PAA Bleach bath under a pH profile which is known to be more biocidal, pH 7
- This study was designed with as sequential transfer of the spindle wound cloth carriers through 5 test solutions.



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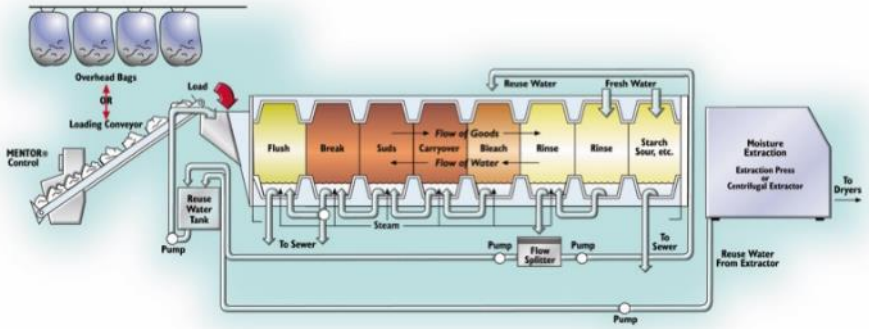
ARTA's C. Diff Research Continues: Study 2



Pictorial of a Milnor brand traditional counter-flow tunnel washer. Courtesy of Pellerin Milnor Corporation

Pictorial of simulated wash sequence, transfer of C. diff spore inoculated cloth carriers through laundry wash baths.

Canister	A	B	C	D	E	Spore recovery
Solution	1 ml/l alkali	3 ml/l alkali + 2 ml/l detergent	2 ml/l Peracetic acid – 15% (300 ppm PAA)		0.2 ml/l acid "sour" TBD	
Time/Temp/pH	115 °F/3 min/ 10 pH (approx)	160 °F/ 6 min 11 pH	160 °F/ 6 min 7 pH	115 °F/6 min pH TBD	115 °F/3 min 5-7 pH	
Theoretical Wash Cycle Time & Zone	3 minutes-Flush	9 minutes-Wash	15 minutes-Bleach	21 minutes-Rinse	24 minutes-Sour	

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ARTA's C. Diff Research Continues: Study 2

- Prior to conducting this study, a feasibility test was performed to predict compliance to time and temperature targets
- Prior to conducting this study, a simulated "walk-through" was conducted to predict the pH profile of the bleaching canister.
- A gentle tweezer "ringing" of the fabric wound spindle was conducted between canisters 2 & 3 in order to minimize carryover of alkali
- This study also utilized a variation of the peracetic acid bleach composition containing 15/22/16 peracetic acid/hydrogen peroxide/acetic acid
- A mechanical action was also imparted via the inclusion of 5 stainless steel balls as per AATCC Laundrometer test methods

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ARTA's C. Diff Research Continues: Study 2

Cloth Carrier Results:

	Blank Control Carriers			Test Carriers		
	#1	#2	#3	#1	#2	#3
cfu/carrier	$2.14 * 10^5$	$1.41 * 10^5$	$1.79 * 10^5$	$<1 * 10^1$	$<1 * 10^1$	$<1 * 10^1$
cfu/carrier (ave.)	$1.78 * 10^5$			$<1 * 10^1$		
% Reduction vs. Population Control	No Reduction			>99.9%		

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ARTA's C. Diff Research Continues: Study 2

Test Solution Results:

	Blank Canisters					Test Canisters				
	#1 3 min	#2 6 min	#3 6 min	#4 6 min	#5 3 min	#1 3 min (alkali)	#2 6 min (alk & det)	#3 6 min (PAA)	#4 6 min (rinse)	#5 3 min (sour)
cfu/ml (wash water)	$1.3*10^4$	$1.0*10^3$	$7.1*10^2$	$5.9*10^2$	$5.5*10^2$	$1.7*10^4$	$4.8*10^3$	$<2.0*10^1$	$<2.0*10^1$	$<2.0*10^1$
% Reduction vs. Population Control	45.6%	95.8%	97.0%	97.5%	97.7%	28.9%	79.9%	>99.9%	>99.9%	>99.9%

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ARTA's C. Diff Research Continues: Study 2 *Results*

1. At the conclusion of the simulated wash process, there were no detected C. diff spores in the cloth carriers
2. At the conclusion of the simulated wash process, there were no detected C. diff spores in the final wash waters
3. At the conclusion of the Blank Control, there were C. diff spores recovered from the cloth carriers
4. At the conclusion of the Blank Control, there were C. diff spores recovered from the final wash waters

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ARTA's C. Diff Research Continues: Integrity & Validity of this Work

- These studies were conducted by an EPA and FDA Regulated Testing Laboratory
- These studies included all pertinent Spore Suspension Controls, Numbers Controls, Neutralization Controls and Temperature, Time & Blank Controls
- The testing was not conducted under GLP conditions due to infancy of this research
- ARTA's Out of Pocket expenditures approximate $29,000.^{00}$

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Path Forward

- A Research Manuscript detailing this study has been published. (AJIC – November 2019)
- There is need for additional research as it relates to other fabric types.
- There is need for additional research on the pH – Temperature – Time lethality of peracetic acid laundry bleach baths.
- Validation of the use of existing EPA protocols for work with bacterial spores.
- Funding for additional research requires additional stakeholders.

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Path Forward

- Future work needs to be mindful of potential corrosion to equipment
- Spore removal & kill under conditions of “cold water” washing should be studied to complement prior work on vegetative bacteria.
- This type of research has a direct patient touch

Thank you for your time!

Questions?

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www.webbertraining.com/schedulep1.php

September 10, 2020	**LOOK AT WHAT THE CAT SCRATCHED IN - PET ASSOCIATED ZOONOSES, WHAT'S NEW AND RELEVANT FOR INFECTION PREVENTION AND CONTROL** Speaker: **Prof. Jason Stull**, University of Prince Edward Island, and Ohio State University
September 17, 2020	**REPROCESSING OF CRITICAL FOOT CARE DEVICES** Speaker: **Clare Barry**, Infection Control Consultant, Canada, and **Merlee Steele-Rodway**, Canadian Association of Medical Device Reprocessing
September 24, 2020	**WATERBORNE PATHOGENS: WHY IS THEIR PROFILE CHANGING?** Speaker: **Prof. Syed A Sattar**, Professor Emeritus of Microbiology, University of Ottawa
October 15, 2020	*(FREE Teleclass)* **THE VALUE OF CERTIFICATION - "WHAT'S IN IT FOR ME?** Speaker: **Sandra Callery**, Certification Board of Infection Control
October 20, 2020	*(European Teleclass)* **CAN WE HALVE GRAM-NEGATIVE BLOODSTREAM INFECTIONS? A DEBATE** Speaker: **Prof. Jon Otter**, Imperial College Healthcare NHS Trust, and **Martin Kiernan**, University of West London
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