



The Physics of Flying Feces

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Disclosure

- Jim was employed by Diversey from 2015-2023. He received salary and benefits from this company
- Jim has also consulted with Arjo, Baxter and Crede Technologies.
- None of these companies have had input into this presentation from a commercial interest
- Any images used in the presentation are for emphasis and do not imply a recommendation/endorsement



Objectives

At the end of the presentation, the participants will be able to:

1. List at least 5 common healthcare pathogens that can be present in feces
2. Recognize common sources of fecal pathogens within our healthcare settings
3. State at least two methods to limit the presence of fecal organisms within our healthcare settings

Feces*

- fe·ces fi siz/ [**fee**-seez] noun (used with a plural verb)
 - 1. Waste matter discharged from the intestines through the anus; excrement.
 - 2. Also, especially British, faeces.
 - Origin 1425-75; late middle English from Latin faecēs – grounds, dregs, sediment
- As a lab tech: ‘stool’
- As a grandparent: poopoo



*www.dictionary.com - Dictionary.com unabridged V1.0.1
<https://www.instagram.com/p/CxsxqpkxT-O/>

We All Defecate

- Bowel movements can be between 72 and 470 g!
(2.5-16.6 oz.) (Cummings 1992)
 - Scotland #1
 - USA #3 / 5 (New York / Hawaii)
 - Uganda – best!



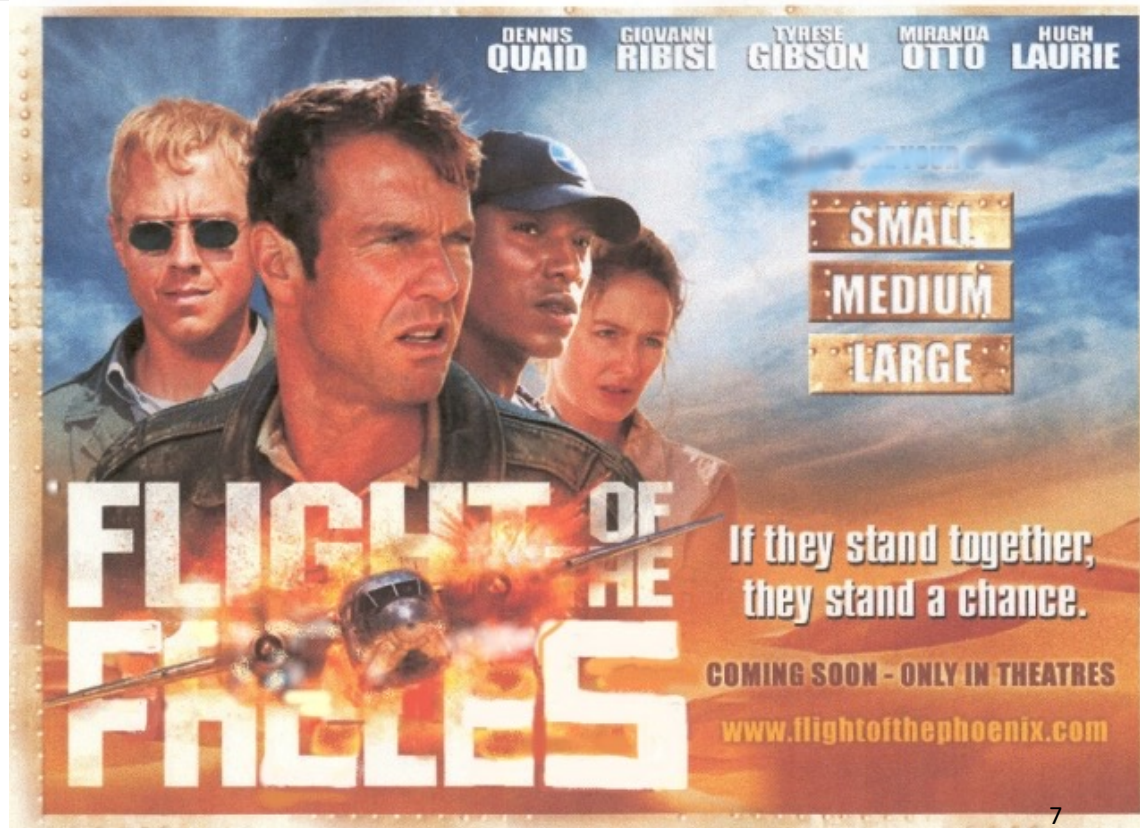
www.my.opera.com



More Stuff!

- 70-75% of what we pass per rectum is water
- 30% of solid remaining is bacteria (1×10^{12} per gram, dry weight)
- Defecation may occur from once every two or three days to several times per day

So, What is the Problem?



[https://en.wikipedia.org/wiki/Flight_of_the_Phoenix_\(2004_film\)#/media/File:Flightofthephoenix.PNG](https://en.wikipedia.org/wiki/Flight_of_the_Phoenix_(2004_film)#/media/File:Flightofthephoenix.PNG)

Global Healthcare Defecation

Table 1. Description of defecation in hospitals

Question	Answers	% (n)
Typical situation of defecation of patients (n=1,134 answers)	Open defecation outside	1% (13)
	Some sort of bog outside	1% (8)
	Bog inside or outside	1% (14)
	Toilet with water flushing system inside and/or outside	19% (213)
	Toilet with water flushing system inside only	78% (900)

North American Healthcare Handling of Feces

- Patients have a few choices
 - Use the toilet in the room
 - May be shared
 - Use a commode
 - Kept at bedside
 - May be shared
 - Use Bedpan
 - Kept in a variety of places
 - Not always single use



Handling of Feces



<https://myliberty.life/products/>

- Use Incontinent products
 - Briefs
- Use bed
 - May have an absorbent pad under them
 - Vented, unconscious ICU patients

Bedpan/Commode: Now What?





Sluice Rooms

- Also known as
 - Dirty utility room
 - Soiled utility room
- May contain
 - Rim flushing sink/hopper
 - Hand hygiene sink
 - Clean/dirty area
 - Storage

<https://www.safeopedia.com/definition/7204/slucce-room>

Rim Flushing Sink



Jim Gauthier Personal Collection

2021

Wand

Plexiglass Shields



Jim Gauthier Personal Collection

Hoppers

- Plenty of good evidence that there is dispersal of bacteria around these sinks

(Moorefield 1998, Frederick 1997)

- Household studies showed aerosol can persist hours after a flush

(Gerba 1975)



Bed Pan Washing

- Pipe or wand on back of toilet
- Still in general use
- Huge risk of splashing
- Only rinses pan, no disinfection

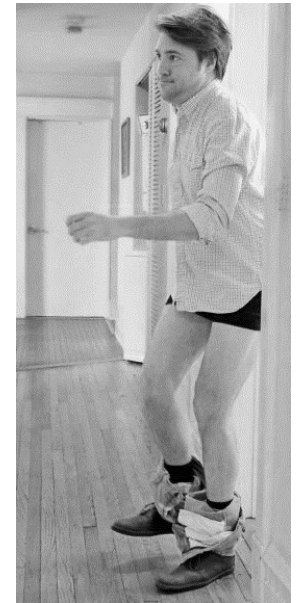


How Might Movement of Organisms Happen?

- Contamination of patient's clothing?
- Poor patient hand hygiene?
 - Sanitizer within stalls?



Do2learn¹⁷.org



theonion.com



Toilets and Pathogen Dissemination

- Most common bioaerosol droplet sizes <3 um
- Empty
 - bioaerosol droplets distances of up to 1 meter from the toilet
- Solid feces and toilet paper slows the movement of water less bioaerosol droplets generated.
- High velocity flushing toilets may be more at risk of creating bioaerosol droplets

What am I Worried About?





Viral Pathogens Enveloped

- Killed by hospital disinfectants
 - Coronavirus
 - Ebola



Viral Pathogens Large Non-enveloped

- May, or may not be killed by hospital disinfectants
 - Adenovirus
 - Rotavirus



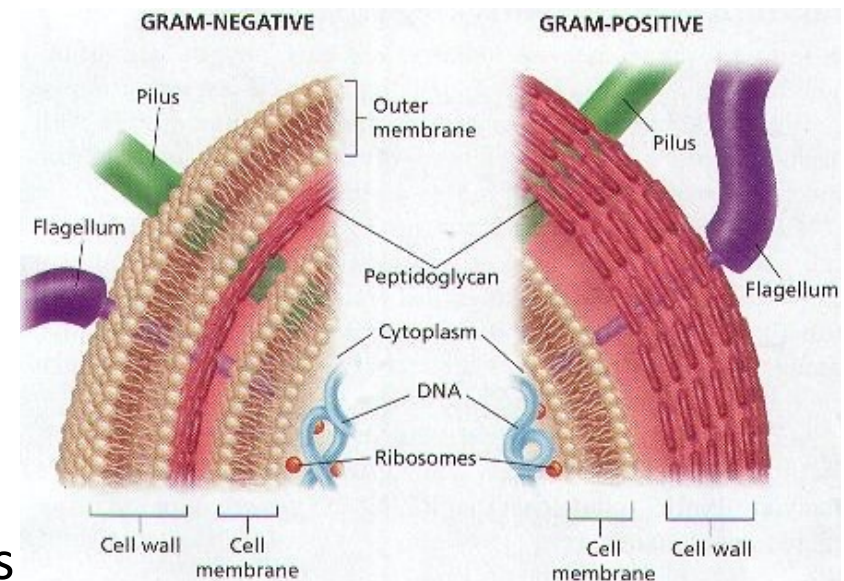
Viral Pathogens – Small, Non-enveloped

- May not be killed with hospital disinfectants
- Hepatitis A
- Enteroviruses
 - Poliovirus
 - Coxsackievirus
 - EV-D68
 - Rhinovirus
- Norovirus

Gram Negative Bacteria

- *E. coli*
- *Klebsiella pneumoniae*
- Enterobacter species
- Citrobacter species
- Proteus species
- Serratia species

With or without resistance genes
(ESBL*, CPE**)



sps.k12.ar.us/massengale/bacteria_notes_b1.htm

*Extended Spectrum Beta-lactamase, **Carbapenem producing Enterobacterales



Other Poop Pathogens

- Salmonella species
- Shigella species
- Yersinia species
- *E. coli* O157:H7 and others
- Campylobacter species
- Aeromonas / Vibrio species
- Acinetobacter*

*Can colonize feces – Aljindan 2015



Fascinating Fecal Fact (Gram Positive)

- Boyce 2007 - MRSA

- If present in 4+ => 10^7 - 10^9 Colony-Forming Units (cfu) per gram of stool
- **10,000,000 – 1,000,000,000**



Hospital Fecal Pathogens

- Vancomycin Resistant Enterococci (VRE)
 - Reasonably hardy in the environment
 - Susceptible to hospital disinfectants

Quantified

- Mayer 2003 – VRE
 - Colony forming units / gram stool

2,300- 1,600,000,000!

1 g: 1 cm x 1 cm x 1 cm
1 μg: 1 mm x 1 mm x 1 mm





VRE and Environmental Soiling

- Donskey 2000
- 10 of 12 sets of cultures positive (83%)
 - $> 4 \text{ log/g}$
- 1 of 9 sets positive (11%)
 - $< 4 \text{ log/g}$

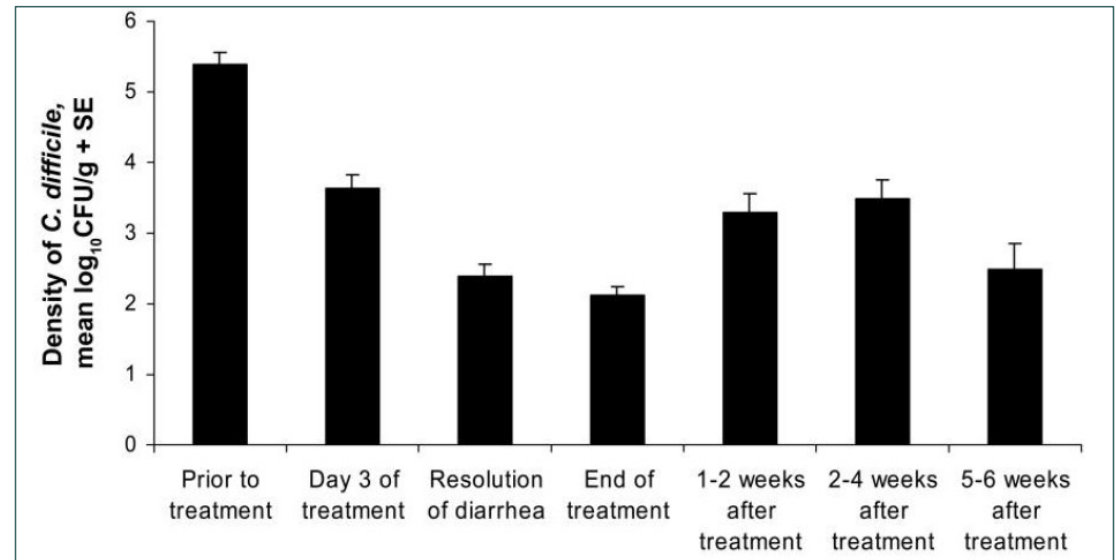


Hospital Pathogens

- *Clostridium/Clostridioides difficile*
 - Spore environmental survivor
 - Resistant to hospital disinfectants
 - Vegetative bacteria sporulate when under stress
 - Drying, antibiotics, temperature changes
 - Vegetative cells easy to kill with hospital disinfectants
 - Can excrete $1 \times 10^4 - 10^8$ spores per gram feces

C. difficile Excretion

- Sethi 2010
- Excretion detected throughout hospital stay



C. difficile in the Environment

Site	Known + CD Patient		No Known + CD Patient	
	After Routine	After Terminal	After Routine	After Terminal
Bedrails	50%	11.8%	7.4%	4.1%
Bedside Table	57.1%	22.2%	7.5%	5.9%
Bed Controls	42.9%	17.6%	3.7%	4.1%



Patient's Environment

Organism On Bedrail	References
VRE	Bhalla, Boyce (1994), Bonten, Ray, Duckro, Hayden, Mayer, Hota, Sample
MRSA	Calfee, Boyce (2007)
<i>Clostridioides difficile</i>	Yui
Resistant <i>Acinetobacter baumannii</i>	Rose, Thom, Choi
Resistant <i>K. pneumonia</i> (KPC)	Rock, Thurlow
MDRO	Hess
Bioburden/Bacteria	Sehulster, Anderson, Adams, Attaway
<i>C. auris</i>	Escandon, Welsh

Patient's Environment

Organisms on Overbed Table	References
VRE	Bhalla, Boyce (1994), Hota
<i>St. aureus</i> /MRSA	Bhalla, Boyce (2007), Calfee, Hess, Dancer (2009)
Resistant <i>Acinetobacter baumannii</i>	Enfield, Hess
<i>Clostridioides difficile</i>	Yui
Bioburden/Bacteria	Dancer (2008), Adams



Hardy Little Guys!

Pathogen	Survival (Kramer)	Survival (Porter)
<i>Campylobacter jejuni</i>	Up to 6 days	
<i>Clostridium difficile</i> spores	5 months	140 days
<i>E. coli</i>	1.5 hrs – 16 months	<1 min – 56
Enterococcus spp.	5 days – 4 months	0.02 - 287
Klebsiella spp.	>30 months	0.57 - 600
<i>Salmonella typhimurium</i>	10 days – 4.2 years	0.29 – 5
<i>Serratia marcescens</i>	3 days – 2 months	0.29 – 20
Shigella spp.	2 days – 5 months	
Adenovirus	7 days – 3 months	
HAV	Up to 60 days	
Norovirus	8 hours – 7 days	

Kramer 2006. Porter 2024

Patient Examination

TABLE 2. Sensitivity of Culture of Different Anatomic Sites for *Klebsiella pneumoniae* Carbapenemase–Producing Enterobacteriaceae

	No. of positive cultures (<i>N</i> = 24)	Sensitivity, % (95% CI)
Skin sites		
Inguinal	19	79 (58–93)
Axillary	18	75 (53–90)
Upper back	6	25 (10–47)
Antecubital fossae	6	25 (10–47)
Nonskin sites		
Rectal ^a	21	88 (68–97)
Urine (<i>N</i> = 19) ^b	10	53 (29–76)
Oropharyngeal/tracheal secretions	10	42 (22–63)
Combined sites		
Rectal and inguinal	24	100 (86–100)
Rectal and axillary	23	96 (79–100)
Axillary and inguinal	22	92 (73–99)

NOTE. CI, confidence interval.



Is it Just Incontinent Patients?

- 14 colonized VRE, continent – Mock exam rooms
- Chair cultures positive
 - 36% outpatient, 58% hemodialysis
- Couch cultures positive
 - 48% outpatient, 42% radiology, 45% hemodialysis

(Grabsch 2006)



Basin Bathing and Fecal Bacteria

- “Standard plate count bacteria ranged from 10^5 to 10^{10} (cfu) per 100 ml for shower and bath water, and an average of 10^4 to 10^6 cfu per 100 ml for total coliforms.”



What Are We Seeing?

- *C. difficile* Floor Contamination
 - Especially washrooms, sluice rooms
 - Moved by feet hypothesized
 - High rate of colonization in Geriatrics

(McCoubrey 2003)

Non-slip Socks

- Mahida (2016) cultured 54 pairs of socks and 35 floor samples
 - VRE was found on 85% of socks and 69% of floor samples
 - MRSA was found on 9% of socks and 17% of floor samples
 - *C. diff* was not detected on socks or floor samples



Table I

Recovery of multidrug-resistant organisms from socks and floor samples; and numbers of patients known to have carriage from hospital administration system

	Vancomycin-resistant enterococci	Meticillin-resistant <i>Staphylococcus aureus</i>	<i>Clostridium difficile</i>
Used socks (54 samples)	46 (85%)	5 (9%)	0
Floor (35 samples)	24 (69%)	6 (17%)	0
Patients with carriage on hospital system	3	2	4

Floors

- Deshpande et al (2017) cultured floors and observed what touched the floor
- Recommends staff education on possible role of floor in pathogen movement



The frequency of contamination was similar for each of the 5 hospitals and from room and bathroom floor sites

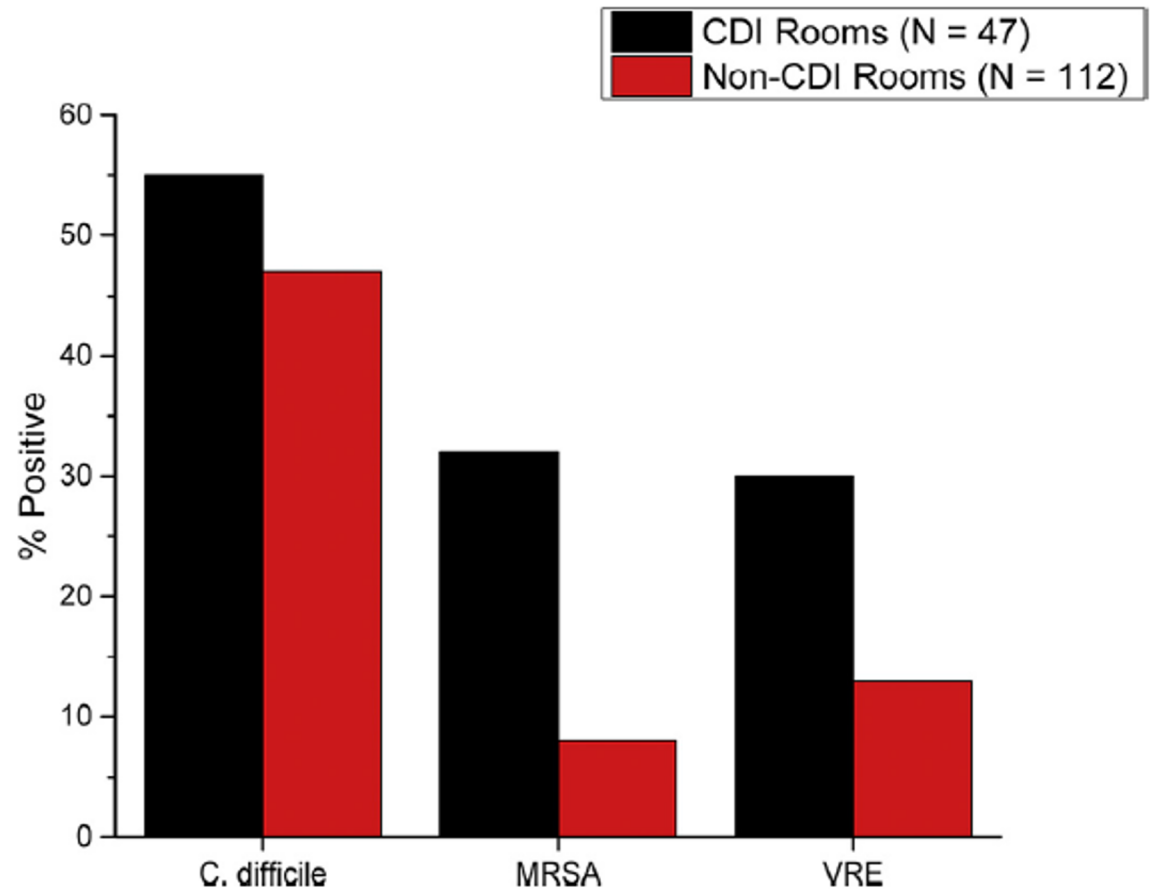


Fig 1. Recovery of *Clostridium difficile*, methicillin-resistant *Staphylococcus aureus*, and vancomycin-resistant enterococci from floors in patient rooms from 5 hospitals in northeast Ohio.



High Touch Objects on Floors

- 41% of rooms surveyed (n=100) had HTO on floor
 - Personal items
 - clothing, canes, and cellular telephone chargers
 - Medical devices or supplies
 - pulse oximeter, call button, heating pad, urinal, blood pressure cuff, wash basin, and heel protector
 - Bed linen or towels
 - bed sheets, pillow, and towels



Can We Move the Bacteria?

- Hand or glove culture after picking up object (n=31)
 - MRSA – 18%
 - VRE – 6%
 - CD – 3%

What is on Surfaces?



How much *C. difficile*?

Ali et al. cultured for *C. difficile* on floors and 'higher' areas

- Floors almost 3 times as contaminated

Surface	Mean CFU/cm ²	Surface	Mean CFU/cm ²
Room Corner	0.87±1.45	Toilet Floor	1.87± 2.40
Bed Rail	0.17± 0.35	Toilet Grab Bar	0.17±0.32
Bed Controls	0.33± 0.74	Toilet Flush	0.01±0.02
Bedside Table	0.01± 0.03	Toilet Seat	0.76 ±1.76

Areas Tested

Surface	Mean CFU/cm ²	Area Tested (cm ²)	Surface	Mean CFU/cm ²	Area Tested cm ²
Room Corner	0.87±1.45	225	Toilet Floor	1.87± 2.40	225
Bed Rail	0.17± 0.35	180	Toilet Grab Bar	0.17±0.32	150
Bed Controls	0.33± 0.74	225	Toilet Flush	0.01±0.02	50
Bedside Table	0.01± 0.03	300	Toilet Seat	0.76 ±1.76	800



Room Contamination – *C. difficile*

Control (17 rooms), Carrier (70), active *C. diff* (30)

Sponge-wipe (5x20 cm)

Patient Room: high touch surfaces

- floor, bedrail, patient table, armchair, call button

Bathroom

- floor, toilet handrail, toilet seat, toilet flush button, door handle

	Control (n=17)	Carrier (n=70)	CDI (n=30)	p Value
Incontinent	70.6% (12)	56.7 (38)	46.2 (12)	0.29
Total CFU/room	13	2060	276	
Mean (\pm SD)	0.8 (2.6)	29.9 (71.5)	9.2 (17.9)	0.004-0.007
%No Growth (n)	88.2 (15)	40.0 (32)	46.7 (14)	NA
CFU/contam. Site*	2.8 (\pm 3.9)	18.3 (\pm 39.2)	9.2 (\pm 9.3)	Not Sign.

Most contaminated site (CFU) in all sampling was floors:

○ **Carrier**

- Room Floors: 19 (27%)
- Bathroom Floor: 15 (21%)
- Bedrail: 19 (27.1%)

○ **CDI group**

- Room Floor: 7 (23%)
- Bathroom Floor: 5 (16%)
- Bedrail: 5 (16.7%)

*MEAN

Gilboa 2020



Is *C. difficile* Spread Within Hospitals?

- A much larger follow-up study by Eyre (2013) conducted over 3.6 years and using whole genome sequencing (WGS) found that only 35% of HO-CDI cases were genetically associated with previous cases. Of 957 cases of HO-CDI, 624 (65%) were genetically distinct and thus not related to healthcare exposure

Assessment of the Overall and Multidrug-Resistant Organism Bioburden on Environmental Surfaces in Healthcare Facilities

Alicia M. Shams, MPH;¹ Laura J. Rose, MS;¹ Jonathan R. Edwards, MStat;¹ Salvatore Cali, MPH;²

- Composite of TV remote, telephone, call button and bedrails most contaminated (100 cm²)
 - MRSA, VRE, *C. difficile*, *A. baumannii*, *K. pneumoniae*
MRSA, VRE, *C. difficile*, *A. baumannii*, *K. pneumoniae*
Most Common
- 40% of rooms sampled positive for MDRO



Other Reservoirs for Gram Negative?

- Garcia, 2005 AJIC, Good review concerning healthcare pneumonia
 - Gastric Colonization
 - Upper Respiratory Tract is colonized
 - Fibronectin helps streptococci to adhere
 - Drying or inflammation will decrease this
 - Reduces streptococci binding sites and allows for overgrowth of Gram negative bacilli



There's More!

- In one ICU, 60% of all patients colonized after 5 days and 85% by tenth day
 - Gram negative microorganisms predominated during this period
- Vented patients
 - Heavily colonized by gram negative
 - Can occur in a little as 24 hours after intubation

Gram negative movement

H. Alhmidi et al. / American Journal of Infection Control 48 (2020) 1336–1340

1339

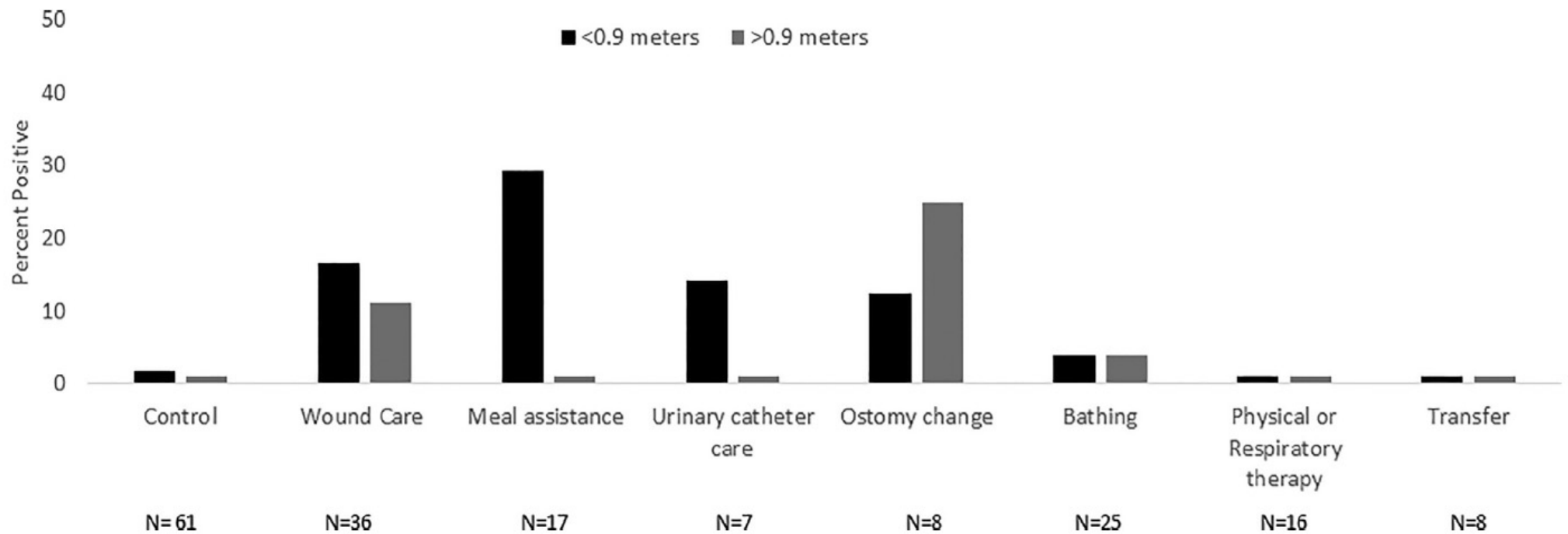


Fig 2. Frequency of environmental shedding of extended-spectrum beta-lactamase-producing and carbapenem-resistant gram-negative bacilli during medical procedures and patient care activities for 34 colonized or infected patients with positive perirectal and/or skin or wound contamination.



What Should We Do?

- Every patient has skin, feces and mucous membranes!
- Routine Practices/Standard Precautions
 - If they are leaking, limit their movement and protect yourself. If it is dirty or you used it, clean it!
 - 20 words



The Environment

- I do recognize that we live in a buggy world
 - I only want clean equipment
 - I only want clean hands
 - I only want to limit the movement of those who soil the environment!



Cleaning and Disinfecting

- Disinfecting is not as important as effective cleaning
(Dettenkofer 2004)
- Housekeeping has been cut too far in many institutions
 - Or lowest bidder!
 - Florence Nightingale recognized that cleaning was vital in 1850's
(Dancer 1999)



Cleaning and Disinfecting

- We need to clean better
 - Microfiber – can have issues
 - Single Dip Methods
 - Remove dirt, organisms, spores
- We need to clean effectively
 - Well trained
 - Check the work (fluorescent concept)

(Dettenkofer 2004, Carling 2006, Buntrock 2005)



Proposal: Any Fecal Clean Up

1. Wipe up gross spill with disposable product or launderable cloth
2. Disinfect 'area' with disinfectant/sporicidal wipe, repeat if wipe is soiled on first pass. Allow contact time for disinfection
3. Use sporicidal wipe on 'area', and allow contact time for sporicidal action



C. *diff* issues? Jim's First Question

- What do you do with bedpans/commode buckets?
 - Disposable Plastic (single use)
 - Thermal Disinfection (bedpan washer)
 - Macerator (single use)
 - Liner bags that solidify waste
 - Regular waste stream



Risk to Staff

- Nursing needs, perceptions, and satisfaction related to patient bodily waste management
 1. Nurse knowledge of risk of exposure
 2. Reporting and mitigation of exposure
 3. Satisfaction and Morale



Harris 2024 Survey Results

- Waste management devices can decrease costs of HAI
- 88% did not report stool splash or spill events
- 80% use PPE – 99% only use gloves
- Mitigation Mechanisms:

	No	Maybe	Yes
Macerators	202 (80%)	39 (15%)	12 (4.7%)
Bedpan Liners	162 (63%)	27 (11%)	68 (26%)
Splash Screens	175 (68%)	22 (8.5%)	62 (24%)
Bedpans	101 (39%)	64 (24%)	97 (37%)



Popp 2015

- Single Use Bedpan
 - Macerators: Australia (73%) and UK (89%)
- Multi-Use Bedpan
 - Thermal Disinfection: Germany (100%)
- Liner bags:
 - Canada/US (but low %)

Apple 2016

Table 1. Overview of Bedpan Types and Washing Methods.

Category:	Disposable	Disposable	Reusable	Reusable
Medium:	Plastic bag with liner	Paper mâché/ cardboard	Plastic or steel	Plastic or steel
Infrastructure required:	Waste receptacle	Macerator machine	Washer–disinfector machine	Manual spray wand/nozzle
Bedpan handling time:	Low	Low to high ^a	Low to high ^a	High to very High ^b
Start-up costs:	Low	High	High	Medium
Materials usage:	High	High	Low	Low
Energy usage (washing):	None	Low	Medium	Low
Equip. maintenance:	None	Low to medium	Medium to high	Low
Waste output quantity:	High	High	Low	Low
Risk of infection:	Low	Low	Low to medium ^c	High

^aLess time if the machine is located in or next to the patient room. More time if the machine is located in a central soiled utility room. ^bHigh time due to manual washing. Very high time (more walking) if washing is only done in the soiled utility room.

^cGenerally low risk, but some pathogens may remain after washing.



Bedpan Classification

- Spaulding/CDC noncritical item (CDC 2024)
 - Low Level Disinfection
- Van Knippenberg-Gordebeke (2012)
 - Netherlands classify as semi-critical
 - High Level Disinfection



The Soiling of the Environment

- How do we change incontinent patient's briefs?
 - How many patients, today, are incontinent? (Popp 2015)
- How do we change beds?
 - Number of glove changes?
 - Disinfection?
- How do we handle bed pans? (Popp 2015)
 - Bedpan with red paint all over it...
- Commode Chairs?
 - Who cleans what?



Staff Training

- N'Guyen 2018
 - 1 washer/disinfector for every 21 beds
 - >50% emptied container in patient bathroom
 - >30% used hand shower to rinse
- “lack of proper practices for excreta management could be linked to a high incidence of Extended spectrum B-lactamase producing Enterobacteriaceae in healthcare settings, especially in surgical units”



Targeted Moments of Environmental Disinfection

1. Before placing a food/drink on an over-bed table
2. Before/after any aseptic practice (wounds, lines, etc.)
3. After any procedure involving feces or respiratory secretions within the patient bed space
4. After patient bathing (within bed space)
5. After any object used by/on a patient touches the floor

Gram Negative Movement

H. Alhmidi et al. / American Journal of Infection Control 48 (2020) 1336–1340

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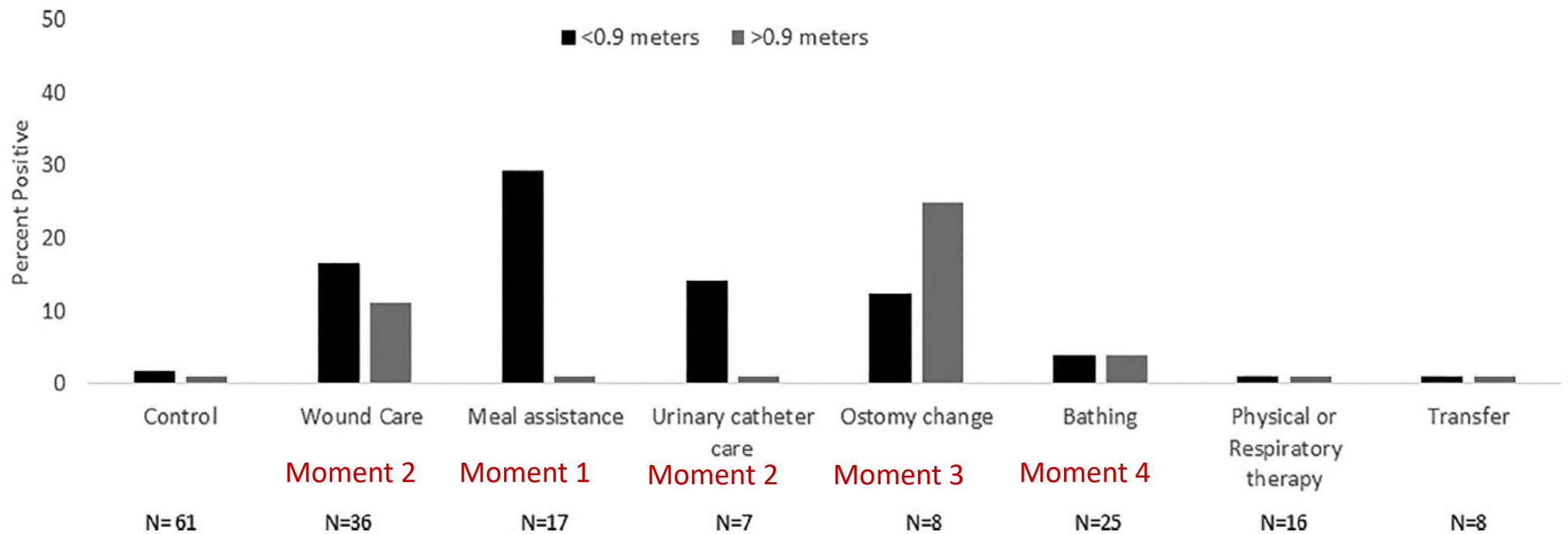


Fig 2. Frequency of environmental shedding of extended-spectrum beta-lactamase-producing and carbapenem-resistant gram-negative bacilli during medical procedures and patient care activities for 34 colonized or infected patients with positive perirectal and/or skin or wound contamination.

UV Impact on Floors

- Evaluated 2 UV-C devices impact on *C. diff*, MRSA and VRE
- Cultured 5 high touch surfaces and floors to measure before and after manual cleaning and after UV-C treatment

Wong 2016

American Journal of Infection Control 44 (2016) 416-20

Contents lists available at ScienceDirect

 American Journal of Infection Control

journal homepage: www.ajicjournal.org



Major article

Postdischarge decontamination of MRSA, VRE, and *Clostridium difficile* isolation rooms using 2 commercially available automated ultraviolet-C-emitting devices 

Titus Wong MD, MHSc, FRCPC ^{a,b,1}, Tracey Woznow BSc, BEd(Sec) ^a, Mike Petrie ^c, Elena Murzello BScN, MBA ^d, Allison Muniak MSc ^d, Amin Kadora MBA ^e, Elizabeth Bryce MD, FRCPC ^{a,b,*}



UV Impact on Floors

- Neutral detergent, solution and mop head were changed after every third room.
- “Neutral detergent solutions or mops can act as reservoirs for bacteria, and these results emphasize the need for use of a disinfectant or alternatively to change neutral detergent solutions and mops heads after every room use”
- UVC disinfection mitigated against flaws in the execution of manual cleaning

Aerobic Colony Forming Units - Floors

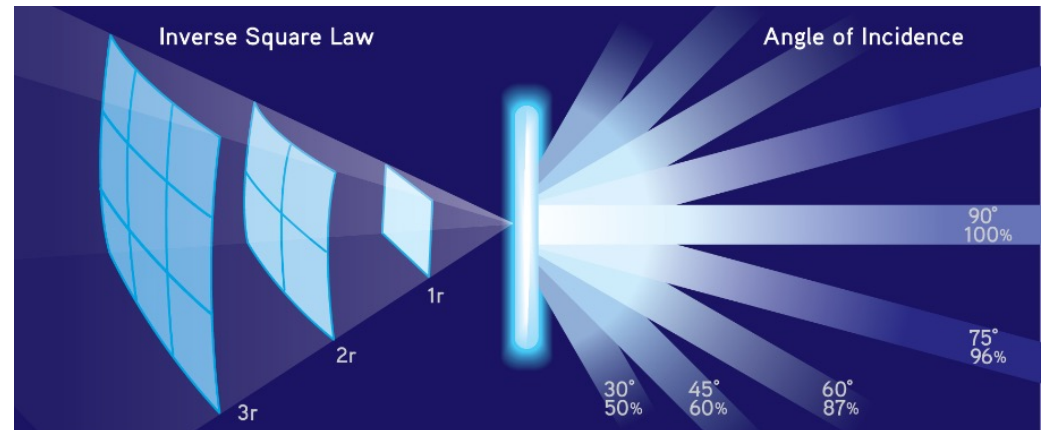
Site	Before Manual	After Manual	After UVC	P Value
Floors	241.4±184.6	590.0±97.7	8.8±9.5	<0.00001

2.38 log

2.77 log

0.94 log

(Value is mean±SD)



Wong 2016



Other Possible Solutions

- Cooper 2016
- UV-C in used, empty bathrooms
 - Showed reduction in surface and air contamination



Suggestions

- Any new hospital construction or renovation
 - Single rooms
 - Thermal flusher/disinfector
 - Macerators
 - Use of liner bags
- Incontinent Rooms
- Multi-use washrooms
 - For continent and incontinent



Suggestions

- Staff and visitor hands
- Patient hands
 - Can patients perform their own hand hygiene?
- Further look at the food link
 - Speculated in 1991 (Zaleznik 1991)
 - Investigated for Gram neg in 1971 (Shooter 1971)
 - CD found in sausages, ground beef, veal, turkey (Tan 2022)
- Other Environmental Sources? (Teska 2021)

In Summing Up

- I have a problem
 - Fecal fascination
- I really do not think it is right to feed feces to patients
 - Okay, pretty harsh, but...
- We need to handle excrement better than our great-great-great grandparents did!





Additionally, Going Forward

- Hand Hygiene and PPE
- High Touch surface cleaning and disinfection
- Train on management of handling human waste
- Manual cleaning and emptying of waste containers must be avoided

Questions?





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