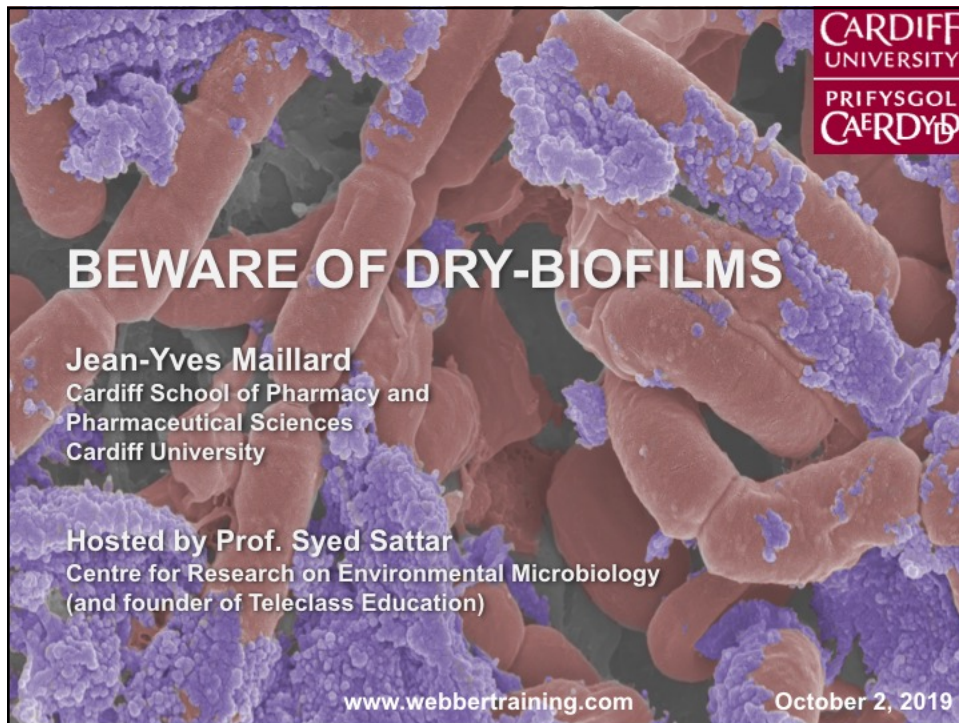


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Prof. Jean-Yves Maillard, Cardiff University, Wales
A Webber Training Teleclass



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BEWARE OF DRY-BIOFILMS


Jean-Yves Maillard
Cardiff School of Pharmacy and
Pharmaceutical Sciences
Cardiff University

Hosted by Prof. Syed Sattar
Centre for Research on Environmental Microbiology
(and founder of Teleclass Education)

www.webbertraining.com October 2, 2019

OVERVIEW

-  Context
-  Environmental surfaces in healthcare settings
-  Dry surface biofilms (DSB) in healthcare settings
-  Testing solutions against DSB
-  Conclusions



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CONTEXT - HAIs

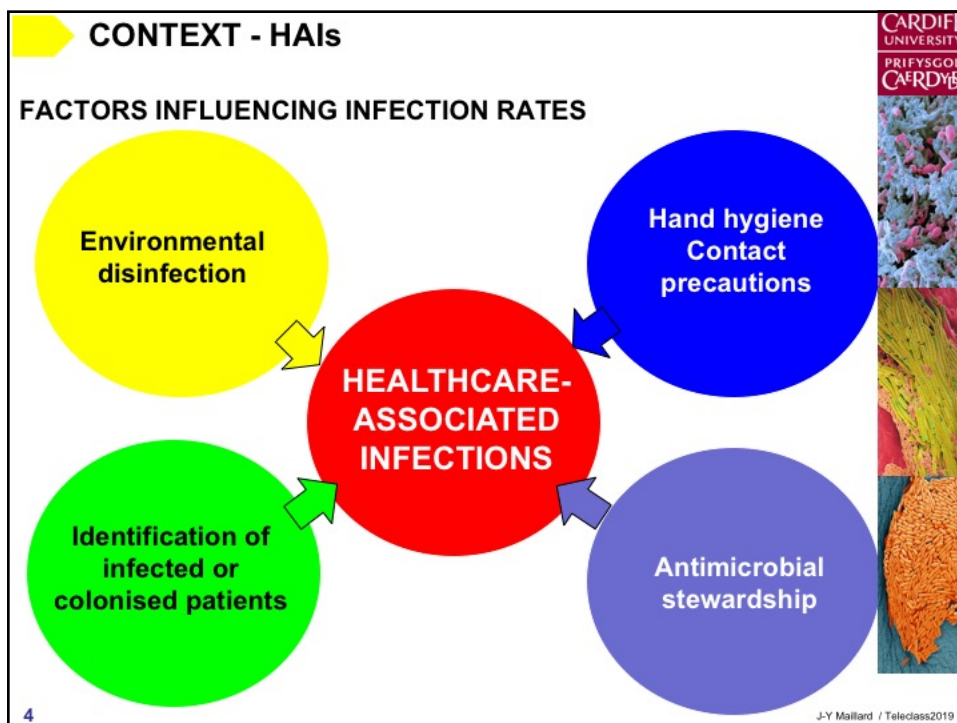
Cost of HAIs:

- **1 billion £ in the UK**
- **16 billions \$ in the US**



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CONTEXT – RISE OF AMR

Category	Value
AMR in 2050	10 million
AMR now (low estimate)	700,000
Cancer	8.2 million
Road traffic accidents	1.2 million
Diabetes	1.5 million
Diarrhoeal disease	1.4 million
Measles	130,000
Cholera	100,000 – 120,000
Tetanus	60,000

O'Neill. 2016. Tackling drug-resistant infections globally: Final report and recommendations. The Review Antimicrobial resistance. HM Government.

- NEW ANTIMICROBIALS
- DETECTION
- INFECTION CONTROL

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ENVIRONMENTAL SURFACES IN HEALTHCARE SETTINGS

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SURFACES & TRANSMISSION

- **1970s - 1990s: THE DARK AGES: AN ALMOST COMPLETE DENIAL!**

EVIDENCE

- **Microorganisms survival on surfaces proximal to patients (high-touch surfaces)**
- **Pathogens survival on surfaces at concentrations sufficient for transmission and transference to the hands of healthcare workers (inc. MRSA, *C. difficile*, norovirus, VRE...)**
- **Low infectious dose for some pathogens**
Otter et al. ICHE 2011;32:687-99.
 Lawley et al. AEM 2010;76L6895-900.
 Teunis et al. J Med Virol 2008;80:1468-76.
- **Ample evidence of the genotypic link between bacteria isolated from patients and surfaces proximal to patients**




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SURFACES & TRANSMISSION

Environmental contamination with endemic and epidemic MRSA

	Outbreak		Endemic			Site estimated mean§
	Rampling et al ^{7*}	Boyce et al ^{8*}	Sexton et al ^{9†}	Lemmen et al ^{10‡}	French et al ^{6*}	
Floor	9%	50-55%	44-60%	24%	..	34.5%
Bed linen	..	38-54%	44%	34%	..	41%
Patient gown	..	40-53%	..	34%	..	40.5%
Overbed table	..	18-42%	64-67%	24%	..	40%
Blood pressure cuff	13%	25-33%	21%
Bed or siderails	5%	1-30%	44-60%	21%	43%	27%
Bathroom door handle	..	8-24%	..	12%¶	..	14%
Infusion pump button	13%	7-18%	..	30%	..	19%
Room door handle	11%	4-8%	..	23%	59%	21.5%
Furniture	11%	..	44-59%	19%	..	27%
Flat surfaces	7%	..	32-38%	21.5%
Sink taps or basin fitting	14%	33%	23.5%
Average quoted**	11%	27%	49%	25%	74%	37%

Dancer et al. Lancet ID 2008;8(2):101-13



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SURFACES & TRANSMISSION

Survival of pathogens on hospital surfaces

PATHOGEN	SURIVAL TIME
<i>S. aureus</i> (incl. MRSA)	7 days to >12 months
<i>Enterococcus</i> spp. (incl VRE)	5 days to >46 months
<i>Acinetobacter</i> spp.	3 days to 11 months
<i>C. difficile</i> (spores)	> 5 months
Norovirus (& feline calicivirus)	8 h to > 2 weeks
<i>Ps. aeruginosa</i>	6 h to 16 months
<i>Klebsiella</i> spp.	2h to 30 months

Hota *et al. Clin Infect Dis* 2004;39:1182-9
Kramer *et al. BMC Infect Dis* 2006;6:130




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SURFACES & TRANSMISSION

What is clean – visibly clean?

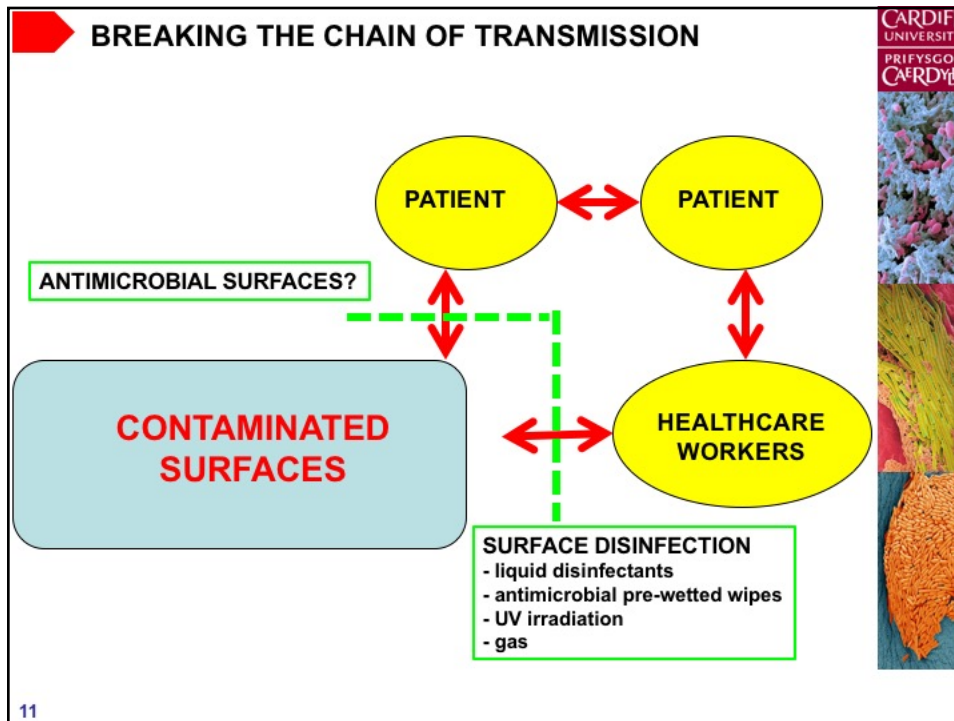
A number of authors proposed that aerobic colony counts on hand-touch sites should be set.

- **a value of < 2.5 CFU/cm² has been proposed based on risk based considerations**
 - Griffith *et al. J Hosp Infect* 2000;45:19-28.
 - White, *et al. AJIC* 2008;36:381-4.
 - Mulvey *et al. J Hosp Infect* 2011;77:25-30.
 - Meakin *et al. J Hosp Infect* 2012;80:122-7.
- **a value of <5 CFU/cm² based on ATP levels attainable values**
 - Dancer. *J Hosp Infect* 2004;56:10-5.
 - Griffith *et al. J Hosp Infect* 2000;45:19-28.
 - Meakin *et al. J Hosp Infect* 2012;80:122-7.
- **a zero tolerance approach for pathogens; 0 CFU/cm²?**



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- SURFACES & TRANSMISSION**
- **HCAIs cost the NHS: £1 billion annually (£3,154 per patient)**
 HPA 2012
 Plowman *et al.* *J Hosp Infect* 2001;47:198-209.
 National Audit Office, *The management and control of hospital acquired infection in acute NHS trusts in England.*, 2009, The Stationary Office: London
 IFIC 2011
 - **20-30% of HCAIs could be avoided with better application of existing knowledge and realistic infection control practices**
 National Audit Office 2009
 - **Enhanced cleaning practices are reported to save hospitals between £30,000–£70,000**
 Dancer *et al.* *BMC Med* 2009;7:28.
- 12
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SURFACES & TRANSMISSION





Antimicrobial Surfaces

<p>Silver</p> <ul style="list-style-type: none"> Electrical switches Flooring Keyboards Showers Waste bins Water machines Laptop screens Mobile phone screens Contact lenses Paper pens 	<p>Copper</p> <ul style="list-style-type: none"> Arms of chair Bed rails Door handles Door locks Door push plates Dressing trolleys Electrical switches Floor drains Handrails IV drip poles Keyboards Nurses' call devices Over bed tables Table tops Taps Toilet flush plates Toilet seats Towel rails 	<p>Triclosan</p> <ul style="list-style-type: none"> Cutting boards Plastic lunchboxes Refrigerators
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SURFACES & TRANSMISSION



Biocidal products for domestic market













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DRY SURFACE BIOFILMS

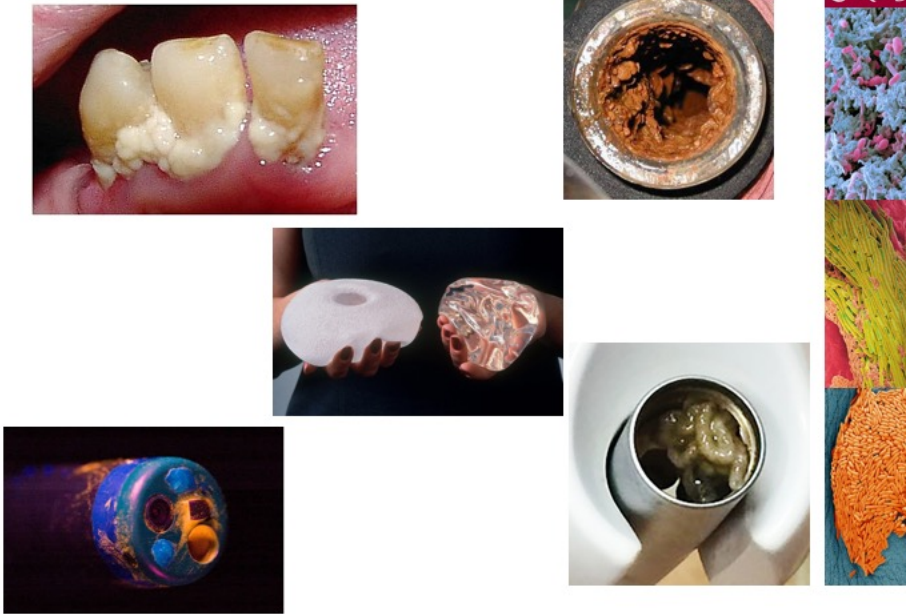


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Biofilms



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Environmental biofilms in hospitals



Dry biofilms on hospital surfaces (DSB)

Wet/hydrated biofilms in drain systems

Semi-dry biofilms on medical devices

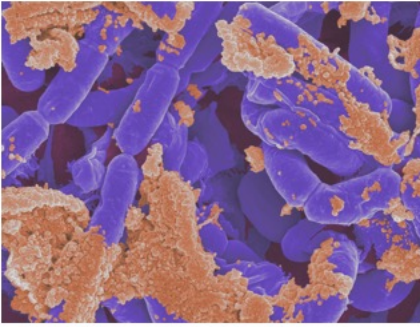


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What is dry surface biofilm (DSB)?

- Dry surface biofilms are **complex microbial communities** formed and grown in dry habitats.
- DSB colonize **various materials** from textile (chair), hard surfaces including plastic (PVC, PP), lacquered wood, wood, metal (stainless steel) to many others
- Dry biofilms have been isolated from diverse environmental conditions: **low moisture, varying temperature** and **nutrients levels**.
- Much **less attention** has been paid to dry biofilms compared to most commonly researched wet/hydrated biofilms



SEM image of DSB containing mixed hospital culture grown on stainless steel disc

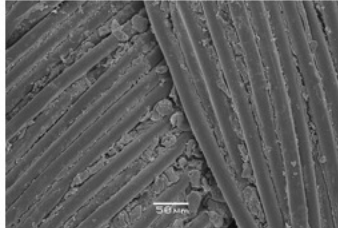
18

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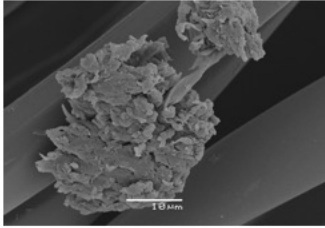
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Dry surface biofilms in healthcare settings

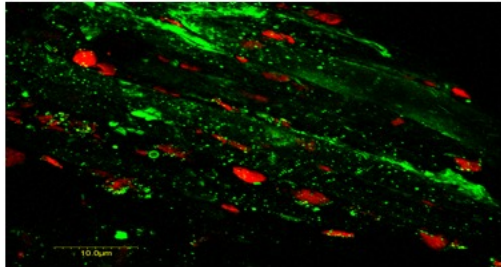
Venetian blind cord MRSA +ve



Curtain – MRSA +ve



Desiccation resistance



Courtesy of K Vickery, Macquarie University, Sydney, Australia




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Dry surface biofilms in healthcare settings

HOSPITAL SURFACE SAMPLES

Samples

Sample processing

- *Sterility* control
- Microbial recovery in enrichment broth
- Partial identification of pathogens on selective agar

Surface disinfection & recovery



- Exposure to chlorine (1,000 ppm) & peracetic acid (30 g/L) for 1 min
- Neutralisation in D/E neutralising broth & recovery at 37°C

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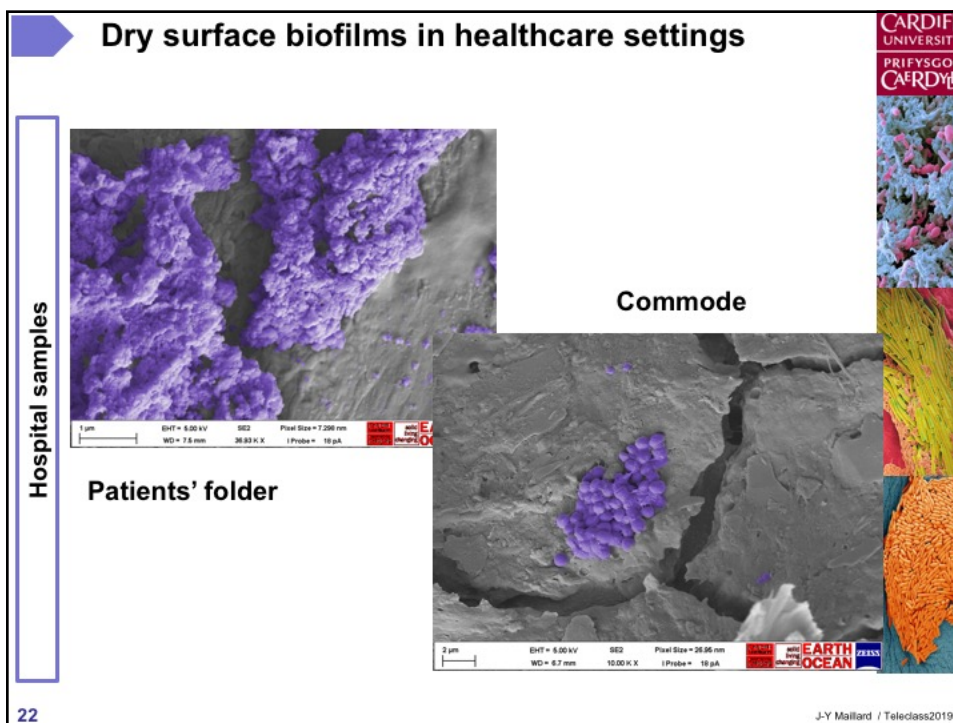
Dry surface biofilms in healthcare settings

Hospital samples	Samples	Colorex ^T M ^M MRSA Agar	Colorex TM VRE agar	Colorex TM Acinetobacter agar	Vogel Johnson Agar	MacConkey Agar
	Rubber tilt	× (0/3)	× (0/3)	× (0/3)	× (0/3)	× (0/3)
Bed frame	× (0/3)	× (0/3)	× (0/3)	× (0/3)	✓ (1/3)	✓ (3/3)
Side wheel	✓ (1/3)	× (0/3)	× (0/3)	× (0/3)	✓ (1/3)	× (0/3)
Folder-1	✓ (1/3)	× (0/3)	× (0/3)	× (0/3)	× (0/3)	× (0/3)
Folder-2	✓ (2/3)	× (0/3)	× (0/3)	× (0/3)	✓ (2/3)	✓ (2/3)

Treatment	Rubber tilt	Cable	Bed wheel	Folder-1	Folder-2
Control	✓	✓	✓	✓	✓
Chlorine (1,000 ppm)	✓	✓	✓	✓	✓
Peracetic acid (30g/L)	×	×	×	×	✓

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Dry surface biofilms in healthcare settings

Journal of Hospital Infection 95 (2012) 10–19

Available online at www.elsevier.com/locate/jhin

Journal of Hospital Infection

Journal homepage: www.elsevier.com/locate/jhin

Presence of biofilm containing viable multiresistant organisms despite terminal cleaning on clinical surfaces in an intensive care unit

K. Vickery^{a,*}, A. Deva^a, A. Jacobs^a, J. Allan^a, P. Valente^a, I.B. Gobell^{b,c}

^aSurgical Infection Research Group, Australian School of Advanced Medicine, Macquarie University, New South Wales, Australia; ^bAntibiotic Resistance and Mobile Elements Group (ARMEG), Microbiology and Infectious Diseases Unit, School of Medicine, University of Western Sydney, New South Wales, Australia; ^cDepartment of Microbiology and Infectious Diseases, Sydney South West Pathology Service – Liverpool, New South Wales, Australia

ARTICLE INFO

Article history:
Received 15 March 2011
Accepted 3 July 2011
by J.A. Cook
Available online 4 September 2011

Keywords:
Biofilm
Environmental contamination
Healthcare-associated infections
Intensive care unit
Multiresistant organisms
Staphylococcus aureus

SUMMARY

Background: Despite recent attention to surface cleaning and hand hygiene programmes, multiresistant organisms (MROs) continue to be isolated from the hospital environment. Biofilms, consisting of bacteria embedded in exopolysaccharide (EPS) are difficult to remove due to their increased resistance to biocides and disinfectants, and potentially release free swimming planktonic bacteria back into the environment which may act as an infection source.

Aims: To establish whether reservoirs of MROs exist in the environment as biofilms.

Methods: Following terminal cleaning, equipment and furnishings were removed aseptically from an intensive care unit (ICU) and subjected to culture and scanning electron microscopy (SEM). Samples were placed in 5% of isopropyl alcohol, incubated for 5 min before plate culture on horse blood agar, Bactec MRSA and Brilliance VRE agar plates. Samples for SEM were fixed in 2.5 glutaraldehyde and hexamethyldisilazane (HMDS) prior to sputter coating with gold and examination in a scanning electron microscope.

Findings: Biofilm was demonstrated visually on the sterile supply basket, the opaque plastic door, the venetian blind cord, and the sink rubber, whereas EPS alone was seen on the curtain. Viable bacteria were grown from these samples, including MRSA from the venetian blind cord and the curtain.

Conclusions: Biofilm containing MROs persist on clinical surfaces from an ICU despite terminal cleaning, suggesting that current cleaning practices are inadequate to control biofilm development. The presence of MROs being protected within these biofilms may be the mechanism by which MROs persist within the hospital environment.

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Dry surface biofilms are **complex microbial communities** formed and grown in dry habitats.

Intensive care unit environmental surfaces are contaminated by multidrug-resistant bacteria in biofilms: combined results of conventional culture, pyrosequencing, scanning electron microscopy, and confocal laser microscopy

H. Hu^a, K. Johani^{b,c}, I.B. Gobell^{c,d}, A.S.W. Jacobs^a, A. Almatroudi^{e,f}, G.S. Whiteley^a, A.K. Deva^a, S. Jensen^a, K. Vickery^a

^aCentral Infection Research Group, Faculty of Medicine, Macquarie University, New South Wales, Australia; ^bDivision of Microbiology, Prince Sultan Military Medical City, Riyadh, Saudi Arabia; ^cAntibiotic Resistance and Mobile Elements Group (ARMEG), Microbiology and Infectious Diseases Unit, School of Medicine, University of Western Sydney, New South Wales, Australia; ^dDepartment of Microbiology and Infectious Diseases, Sydney South West Pathology Service – Liverpool, New South Wales, Australia; ^eDepartment of Medical Laboratories, College of Applied Medical Sciences, Quassim University, Quassim, Saudi Arabia; ^fIntervet Corporation, Torrance, Newcastle, NSW, Australia

ARTICLE INFO

Article history:
Received 17 March 2012
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Available online 23 June 2012

Keywords:
Intensive care unit
Healthcare-associated infections
Microbiology
Multidrug-resistant organisms
Staphylococcus aureus

SUMMARY

Background: Hospital-associated infections cause considerable morbidity and mortality, and an expense to track. Organisms causing these infections can be isolated from the immediate environment around a patient. Could the difficulty in eradicating these organisms from the environment be because they reside in dry surface biofilms?

Aims: The intensive care unit (ICU) of a tertiary referral hospital was decontaminated and the opportunity to colonise various critical surfaces was taken in order to investigate biofilm formation, measure of organisms present on the decontaminated surfaces, and whether they were present in biofilms.

Methods: The ICU had an 'openness' closer with 100µm free chlorine solution, items from bedding, curtains, and furnishings were then sampled with culturing impingers. Biofilms were washed to hygiene swabs and inoculated on to chromogenic plates to demonstrate MROs, which were confirmed with the Widal system. Genomic DNA was extracted directly from ICU surfaces, and subjected to pyrosequencing (454) for identification of species. Scanning electron microscopy (SEM) and confocal laser microscopy (CLM) were performed on environmental samples.

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Dry surface biofilms in healthcare settings

Journal of Hospital Infection 102 (2012) 447–454

Available online at www.elsevier.com/locate/jhin

Journal of Hospital Infection

Journal homepage: www.elsevier.com/locate/jhin

Multi-centre study on dry biofilms from several frequently touch surfaces

K. Ledwoch^a, S.J. Dancer^{b,c}, J.A. Otter^{d,e}, K. Kerr^f, D. Roposte^g, L. Rushton^h, R. Weiserⁱ, E. Mahenthiralingam^j, D.D. Mout^k, J.-Y. Maillard^{l,m}

^aCardiff University, UK; ^bSchool of Pharmacy and Pharmaceutical Sciences, Cardiff University, Cardiff, UK; ^cCardiff University, UK; ^dSchool of Applied Sciences, Edinburgh Napier University, Edinburgh, UK; ^ePublic Health Protection Research Unit (PHE) in Wills and Hall of Imperial College, London, UK; ^fImperial College Healthcare NHS Trust, Infection Prevention and Control, London, UK; ^gSchool of Biomedicine, Cardiff University, Cardiff, UK; ^hSchool of Earth and Ocean Sciences, Cardiff University, Cardiff, UK

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Article history:
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Keywords:
Biofilm
Environmental microbiology
Healthcare
Pathogens

Healthcare-associated infection

SUMMARY

Background: Wet biofilms associated with medical devices have been widely studied and their role with healthcare-associated infections (HCAIs) is well recognised. Little attention has been paid to the presence of dry biofilms on environmental surfaces in healthcare settings.

Aims: To investigate the occurrence, prevalence, and diversity of dry biofilms on hospital surfaces.

Methods: Sixty-one normally cleaned items were swabbed from three different UK hospitals. The presence of dry biofilms was investigated using culture-based methods and scanning electron microscopy (SEM). Biofilm diversity within biofilms was investigated using 16S rDNA sequencing, open-ended PCR, polymerase chain reaction (PCR) and gel electrophoresis.

Findings: Multi-species dry biofilms were recovered from 95% of 41 samples. Abundance and complexity of dry biofilms were confirmed by SEM. 42 bacterial families (taxonomic position) bacteria including pathogens associated with HCAI, 95% of samples grew multiresistant Staphylococcus aureus. Dry biofilms had similar genetic composition regardless of the type of items sampled or the ward from which the samples originated. There were differences observed in the dominance of particular species: dry biofilms from the hospital contained mostly *Staphylococcus* DNA, whereas more *Bacteroides* spp. DNA was found on surfaces from the third hospital.

Beware biofilm! Dry biofilms containing bacterial pathogens on multiple healthcare surfaces; a multi-centre study

Trauma and orthopaedics, adult intensive care, joint assessment unit, acute admission unit, kidney and transplant, nephrology, cardiology, gastroenterology, intensive therapy unit, and haematology

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Dry surface biofilms in healthcare settings

The diagram features a central icon of a hospital building. Six lines radiate from this center to six light blue rectangular boxes, each containing a label: 'sanitising bottles', 'keyboards', 'patient folders', 'clipboards', 'DSB abundance', 'DSB diversity (NGS)', and 'DSB appearance (SEM)'. The 'DSB' labels are positioned at the bottom of the diagram.

Ledwoch et al (2018) J Hosp Infect 100:3:e47-e56

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Dry surface biofilms in healthcare settings

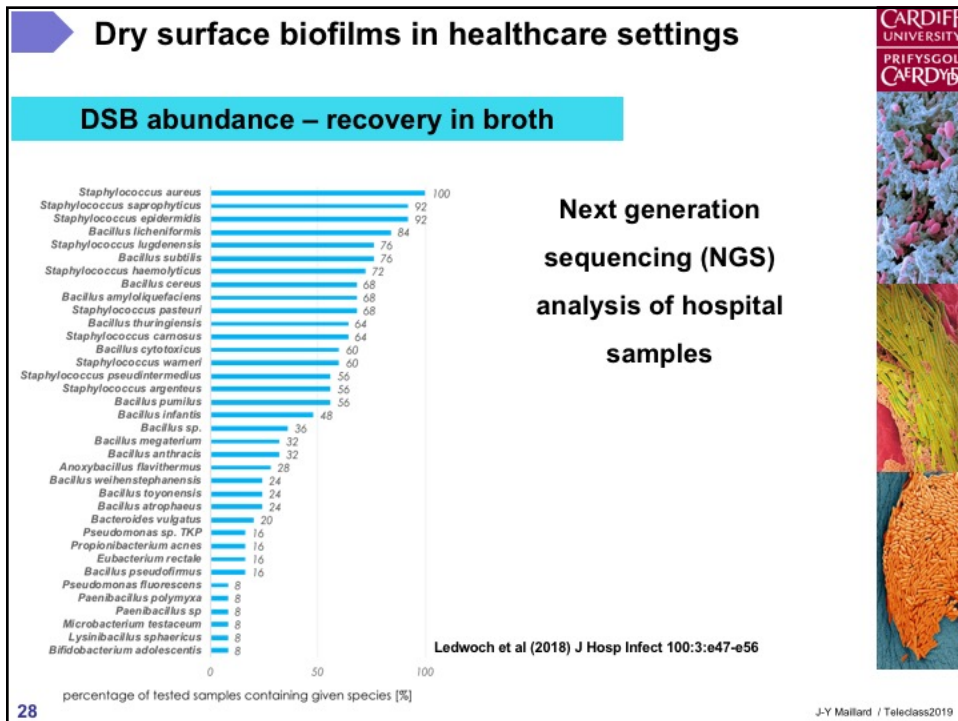
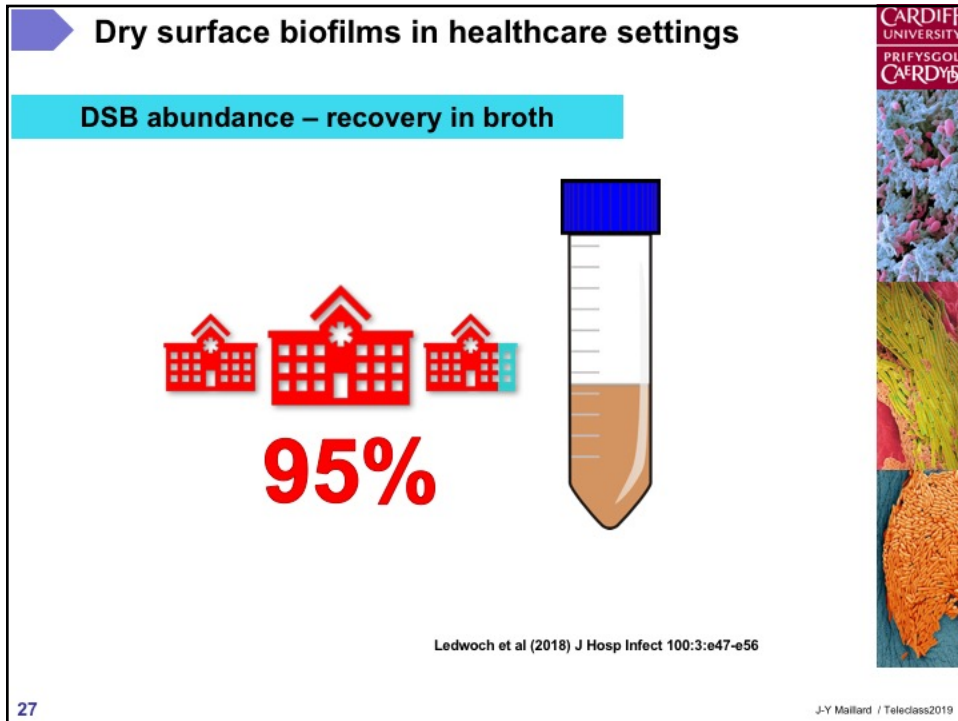
DSB abundance - swabbing

The diagram shows three hospital building icons on the left and a single keyboard key labeled 'A' on the right. A swab is shown touching the key. A large '0%' is displayed in the center, indicating zero DSB abundance after swabbing.

Ledwoch et al (2018) J Hosp Infect 100:3:e47-e56

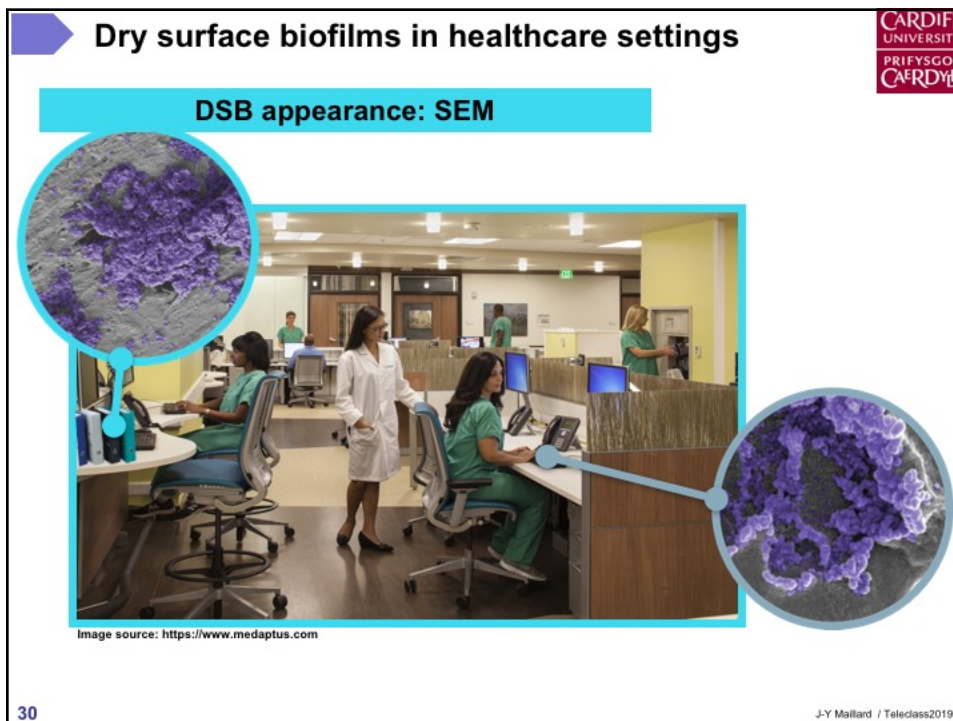
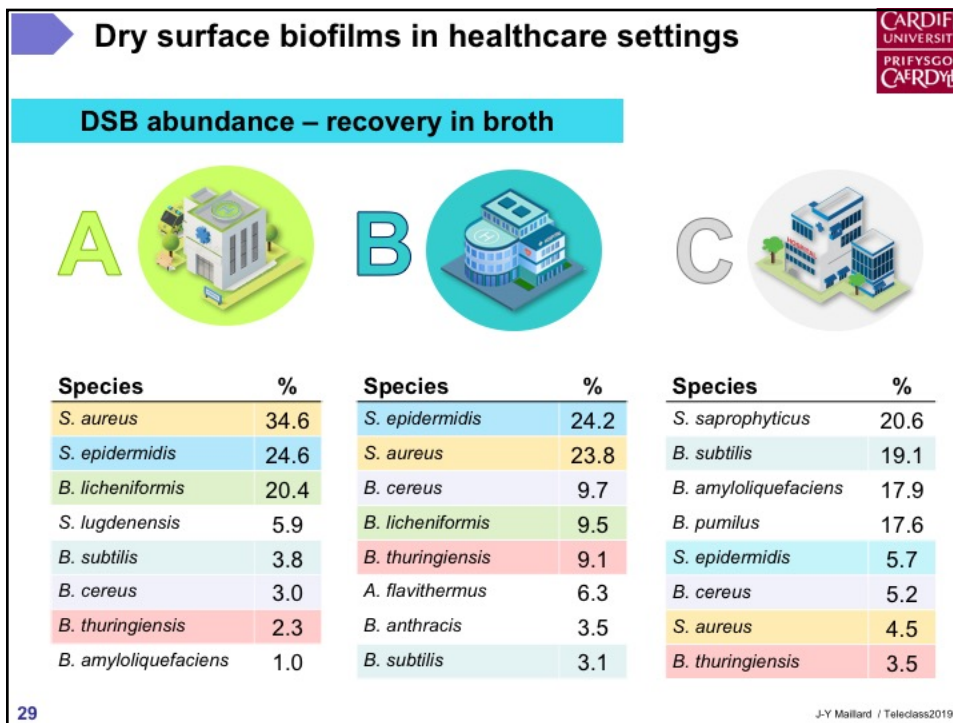
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Dry surface biofilms in healthcare settings





Image source: Unsplash

- Multi-species dry biofilms were recovered from **95%** of samples.
- All biofilms harbored **gram-positive bacteria** including pathogens associated with HCAs.
- Dry biofilms had complex composition. Community of 11-27 different microbial species

➤ **DNA of gram negative bacteria** was also identified in some of the samples: *Pseudomonas* spp., *Pseudomonas aeruginosa* and *Acinetobacter baumannii*.

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Dry surface biofilms in healthcare settings

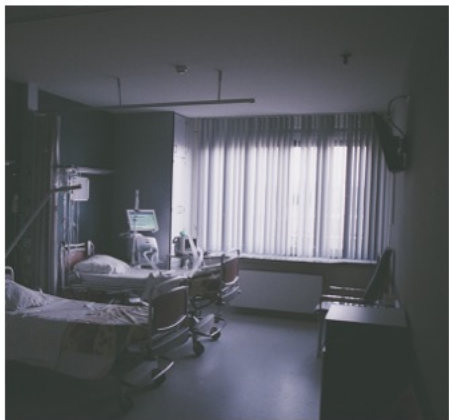



Image source: Unsplash

- Multi-species dry biofilms were recovered from **95%** of samples.
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➤ **DNA of gram negative bacteria** was also identified in some of the samples: *Pseudomonas* spp., *Pseudomonas aeruginosa* and *Acinetobacter baumannii*.

➤ **Dry biofilms could not be detected by swabbing**

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Why DSB can be a problem?

“(...) hand-touch sites are habitually contaminated by hospital pathogens, which are then delivered to patients on hands”
- Dancer (2009) J Hosp Infect 73: 378-385



“(...) current cleaning practices are inadequate to control biofilm development.”
- Vickery et al. (2012) J Hosp Infect 80: 52-55

“Contamination of the inanimate environment around patients constitutes an important reservoir of MRO with the risk of HAI (...)”
- Vickery et al. (2012) J Hosp Infect 80: 52-55

“In 2002, the estimated number of HAIs in U.S. hospitals, (...) was approximately 1.7 million (...). The estimated deaths (...) were 98,987.”
- Klevens R, et al. (2007) Public Health Rep 122:160-16



“(...) evaluating the clinical effectiveness of cleaning and disinfecting methods is challenging”
- Han et al. (2015) Ann Intern Med 163(8):598-607

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Why DSB can be a problem?





Hospital gowns retain superbugs even after being treated with disinfectant




Study links hospital Candida auris outbreak to reusable thermometers



The Latest Dirt on Hospital Cleanliness

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Why DSB can be a problem?

Dry surfaces are a major contributor of pathogens persistence on surfaces

Hospital gowns retain superbugs even after being treated with disinfectant

Many treatments fail to eradicate dry surface biofilms highlighting their high resistance and transferability



We hypothesize that dry surface biofilms play a significant role in Healthcare associated infections

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TESTING SOLUTIONS AGAINST DSB



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Solutions?



Improved hand hygiene



Image source: Unsplash

Improved cleaning



Image source: <http://resistancecontrol.info>

Disinfectants targeting DSB



Image source: Unsplash




Image source: Unsplash

Improved monitoring of contamination level

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Dry surface biofilm model



Day 0	Day 2	Day 4	Day 6	Day 8	Day 10	Day 12
<ul style="list-style-type: none"> • Inoculation • Wet phase (TSB/TSB + BSA) • Rotary shaker at room temperature 	<ul style="list-style-type: none"> • Dry phase (media drained out) • Incubation at 37°C/25°C in incubator 	<ul style="list-style-type: none"> • Wet phase (TSB/TSB + BSA) • Rotary shaker at room temperature 	<ul style="list-style-type: none"> • Dry phase (media drained out) • Incubation at 37°C/25°C in incubator 	<ul style="list-style-type: none"> • Wet phase (TSB/TSB + BSA) • Rotary shaker at room temperature 	<ul style="list-style-type: none"> • Dry phase (media drained out) • Incubation at 37°C/25°C in incubator 	<ul style="list-style-type: none"> • Dry biofilm is ready for testing

NOW

- *Staphylococcus aureus*
- *Candida auris*
- *Bacillus subtilis*
- *Bacillus linchenformis*
- *Klebsiella pneumoniae*

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Dry surface biofilm model

Environmental biofilm

Dry artificial biofilm

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Dry surface biofilm model – *S. aureus*

Without organic load

X2,500 x5,000

With organic load

X2,500 x5,000

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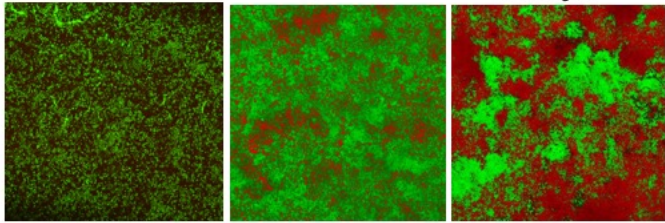
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Dry surface biofilm model – *S. aureus*

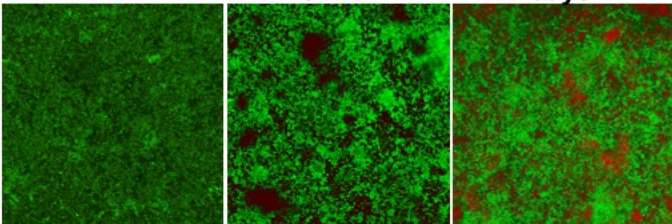
Without organic load

4 8 12 days



With organic load

4 8 12 days


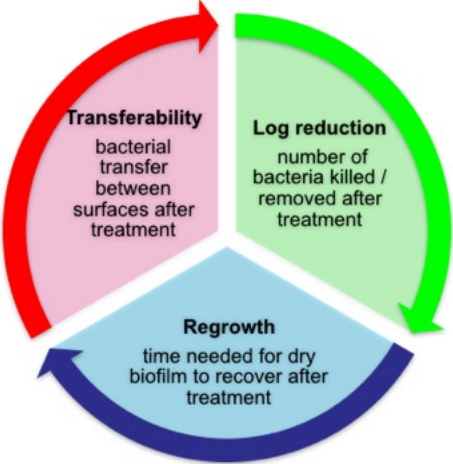


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Testing against dry surface biofilm

➤ **ASTM International E2967-15**

Transferability
bacterial transfer between surfaces after treatment

Log reduction
number of bacteria killed / removed after treatment

Regrowth
time needed for dry biofilm to recover after treatment

Ledwoch and Maillard (2019) Materials (Basel) 12(1):18 ; Ledwoch et al (2019) Lett Appl Microbiol 68(4): 329-336

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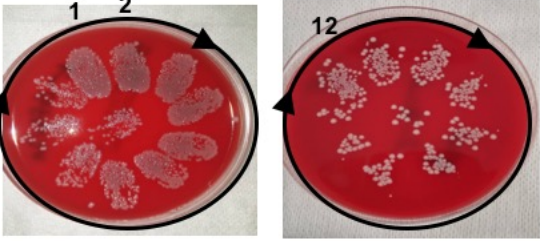
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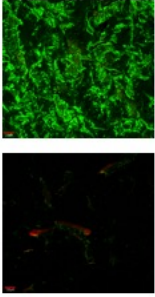
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Testing against dry surface biofilm

Effect of chlorine on dry biofilm




- 1000 and 5000ppm – recovered 1 day
- 10,000ppm – Recovered after 8 days
- 20,000ppm – Recovered after 12 days





Courtesy of K Vickery, Macquarie University, Sydney, Australia

Transmission following touching a dry biofilm



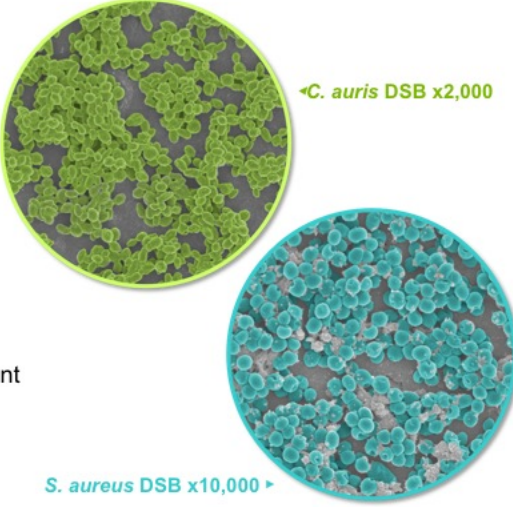
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Testing against dry surface biofilm

- AISI 430 stainless steel sterile discs
- 10^6 CFU/ml *S. aureus* NCTC 10788
- 10^6 CFU/ml *C. auris* DSM 21092
- 1ml of inoculum per disc
- TSB/MEB + 3 g/L BSA

- 48h wet/dry cycles for of 12 days
- High uniformity ensuring testing repeatability

- More resistant to disinfection treatment than dried bacterial suspension






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Treatment efficacy against *S. aureus* DSB

Log₁₀ reduction: number of bacteria killed / removed after treatment




Treatment	Log ₁₀ reduction	
	No OL	OL
Commercial wipe A	3.54	2.68
Commercial wipe B	6.73	3.55
Commercial wipe C	0.25	4.97
Commercial wipe D	6.87	>8.45
Commercial wipe E	4.65	1.08
NaOCl 1,000ppm	5.76	5.05
NaDCC 1,000ppm	0.51- 4.07	1.58- 5.91
ClO ₂ 200ppm	0	1.69
VH ₂ O ₂	3.08	0.71
Cold gas plasma	6.27	0.84

OL: organic load

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Treatment efficacy against *S. aureus* DSB

Transferability: determines how well bacteria in a dry biofilm can transfer between surfaces post treatment



Treatment	Log ₁₀ reduction		Transferability	
	No OL	OL	No OL	OL
Commercial wipe A	3.54	2.68	75%	78%
Commercial wipe B	6.73	3.55	31%	33%
Commercial wipe C	0.25	4.97	100%	85%
Commercial wipe D	6.87	>8.45	8%	1%
Commercial wipe E	4.65	1.08	39%	50%
NaOCl 1,000ppm	5.76	5.05	44%	100%
NaDCC 1,000ppm	0.51- 4.07	1.58- 5.91	100%	69- 100%
ClO ₂ 200ppm	0	1.69	100%	100%
VH ₂ O ₂	3.08	0.71	67%	100%
Cold gas plasma	6.27	0.84	19%	100%

OL: organic load


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Treatment efficacy against *S. aureus* DSB

Regrowth: time needed for a dry biofilm to recover after treatment



Treatment	Log ₁₀ reduction		Transferability		Regrowth (days)	
	No OL	OL	No OL	OL	No OL	OL
Commercial wipe A	3.54	2.68	75%	78%	3.9	2
Commercial wipe B	6.73	3.55	31%	33%	6.2	5
Commercial wipe C	0.25	4.97	100%	85%	1.3	2
Commercial wipe D	6.87	>8.45	8%	1%	>2	4.3
Commercial wipe E	4.65	1.08	39%	50%	>1.5	1.3
NaOCl 1,000ppm	5.76	5.05	44%	100%	4.8	3.9
NaDCC 1,000ppm	0.51- 4.07	1.58- 5.91	100%	69- 100%	1.3-1.7	1-2
ClO ₂ 200ppm	0	1.69	100%	100%	1	1
VH ₂ O ₂	3.08	0.71	67%	100%	1.4	1.1
Cold gas plasma	6.27	0.84	19%	100%	2.5	1


OL: organic load

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Development of a dry biofilm model – *C. auris*

Materials 2019, 12(1), 18; <https://doi.org/10.3390/ma12010018> Open Access Article

Candida auris Dry Surface Biofilm (DSB) for Disinfectant Efficacy Testing

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(This article belongs to the Special Issue Microbial Biofilms in Healthcare: Formation, Prevention and Treatment)


[Full-Text](#) | [PDF](#) (1428 KB, uploaded 21 December 2018) | [Figures](#) | [Review Reports](#)

Abstract

Candida auris is an emerging pathogen that needs to be controlled effectively due to its association with a high mortality rate. The presence of biofilms on dry surfaces has been shown to be widespread in healthcare settings. We produced a *C. auris* dry surface biofilm (DSB) on stainless steel surfaces following sequential hydration and desiccation cycles for 12 days. The ASTM2967-15 was used to measure the reduction in viability of 12 commercially wipe-based disinfectants and sodium hypochlorite (1000 ppm) against *C. auris* DSB. We also evaluated *C. auris* transferability and biofilm regrowth post-treatment. A peracetic acid (3500 ppm) product and two chlorine-based products (1000 ppm available chlorine) were successful in reducing *C. auris* viability and delaying DSB regrowth. However, 50% of the products tested failed to decrease *C. auris* viability, 56% failed to prevent its transferability, and 75% did not delay biofilm regrowth. Using three different parameters to measure product efficacy provided a practical evaluation of product effectiveness against *C. auris* DSB. Although log₁₀ reduction in viability is traditionally measured, transferability is an important factor to consider from an infection control and prevention point of view as it allows for determination of whether the surface is safe to touch by patients and hospital staff post-treatment. [View Full-Text](#)

Keywords: *Candida auris*; dry-biofilm; disinfection; peracetic acid; sodium hypochlorite; chlorine dioxide; sodium dichloroisocyanurate; transferability; regrowth

▼ [Figures](#)



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Development of a dry biofilm model – *C. auris*

Day 0

- Inoculation
- Wet phase (TSB/TSB + SA)
- Rotary shaker at room temperature

Day 2

- Dry phase (media drained out)
- Incubation at 37°C/25°C in incubator

Day 4

- Wet phase (TSB/TSB + SA)
- Rotary shaker at room temperature

Day 6

- Dry phase (media drained out)
- Incubation of 37°C/25°C in incubator

Day 8

- Wet phase (TSB/TSB + SA)
- Rotary shaker at room temperature

Day 10

- Dry phase (media drained out)
- Incubation of 37°C/25°C in incubator

Day 12

- Dry biofilm is ready for testing

With organic load

X2,500

x5,000

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Treatment efficacy against *C. auris* DSB

Log₁₀ reduction / removal

Disinfectant	Log ₁₀ reduction/removal
BK	~4.0
CO2-1	~2.0
CO2-2	~1.5
NuCC-1	~3.5
NuCC-2	~2.5
NuCC-3	~1.5
NuCC-4	~3.5
NuCC-5	~7.5
NuCC-6	~7.5
NuCC-7	~2.5
NuCC-8	~7.5
PA-1	~7.5
PA-2	~1.5
Water	~2.0

Transferability

Disinfectant	Transferability (%)
BK	~25
CO2-1	~100
CO2-2	~100
NuCC-1	~75
NuCC-2	~75
NuCC-3	~75
NuCC-4	~100
NuCC-5	~100
NuCC-6	~100
NuCC-7	~100
NuCC-8	~100
PA-1	~100
PA-2	~100
Water	~100
Untreated	~100


Regrowth


Disinfectant	Regrowth (days)
BK	~1.5
CO2-1	~1.5
CO2-2	~1.5
NuCC-1	~1.5
NuCC-2	~1.5
NuCC-3	~1.5
NuCC-4	~5.0
NuCC-5	~4.5
NuCC-6	~4.5
NuCC-7	~1.5
NuCC-8	~1.5
PA-1	~6.5
PA-2	~1.5
Water	~1.5
Untreated	~1.5


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 **DSB KNOWLEDGE**



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 **BEWARE OF DRY BIOFILMS**

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Dry biofilms on hospital surfaces (DSB)



- Widespread on environmental (dry) surfaces
- Cannot be detected by swabbing (of dry surfaces)
- Less susceptible to biocidal products if no mechanical removal
- Can easily be transferred post-treatment (when wet)
- Product formulation matters

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BEWARE OF DRY BIOFILMS






Dry biofilms on hospital surfaces (DSB)


- Contribute to HCAI?
- Difficult to eradicate
- Patients and staff directly exposed
- Harbor pathogens
- Require improved control measures

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THANK YOU

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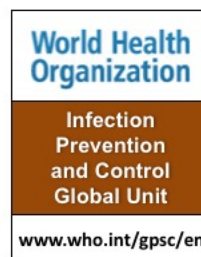
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October 10, 2019	ENDOSCOPE REPROCESSING: PARADIGM SHIFT Speaker: Dr. Michelle Alfa , University of Manitoba <i>(South Pacific Teleclass)</i>
October 16, 2019	SELF-REPORTED BEHAVIORS AND PERCEPTIONS OF AUSTRALIAN PARAMEDICS IN RELATION TO HAND HYGIENE AND GLOVING PRACTICES IN PARAMEDIC-LED HEALTHCARE Speaker: Prof. Nigel Barr , University of the Sunshine Coast, Australia
October 24, 2019	INFECTION CONTROL ISSUES IN HEALTHCARE CONSTRUCTION, PART 2 – NEW BUILDS Speaker: Andrew Streifel , University of Minnesota
November 7, 2019	HEALTHCARE-ASSOCIATED PNEUMONIA THAT IS NOT VENTILATOR-ASSOCIATED: BIG PROBLEM, BUT GUIDELINE-FREE ZONE Speaker: Martin Kiernan , University of West London <i>(FREE European Teleclass)</i>
November 12, 2019	THE ROLE OF CLEANERS IN INFECTION PREVENTION - NEGLECTED FRONT LINE WORKERS IN HEALTHCARE FACILITIES Speaker: Prof. Wendy Graham , London School of Hygiene & Tropical Medicine
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