Drains and dry surfaces; is anywhere safe from biofilm colonisation?

INFECTION PREVENTION IN ONE HEALTH AREAS

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COMBAT
Complex Biofilms and AMR Transmission

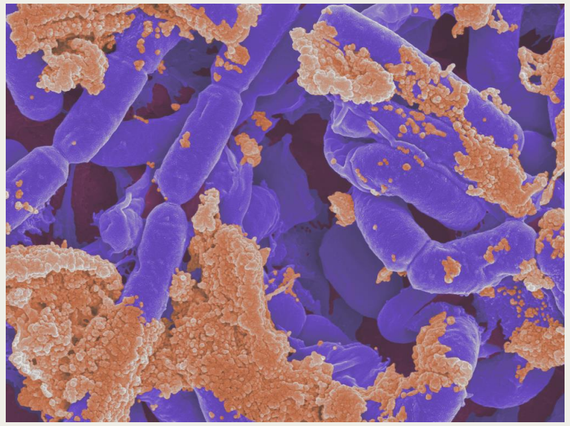
CARDIFF UNIVERSITY
PRIFYSGOL CAERDYDD

Overview 

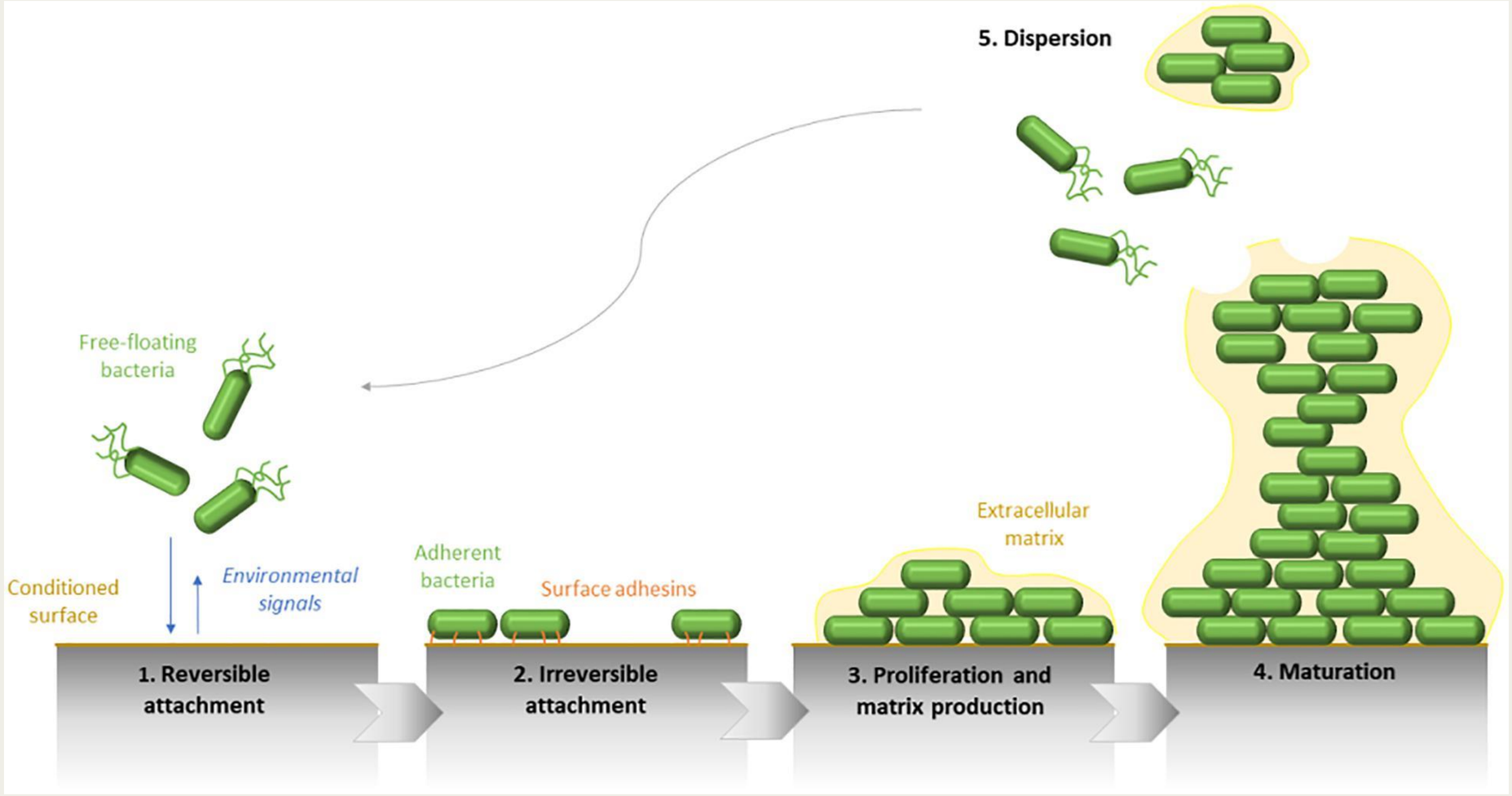
- Biofilms contamination in healthcare
- Introduction to dry surface and drain biofilms
  - Problems and current procedures
- Susceptibility of biofilms to current disinfection protocol
- Complex drain communities
- Future interventions and ways to combat DSB and drain biofilm

BIOFILMS

- Complex multispecies communities
- Exopolymeric substances to “stick” together
- Low metabolism
- Quorum sensing communication
- Form on a variety of abiotic and biotic surfaces
  - Teeth
  - Wounds
  - Ships

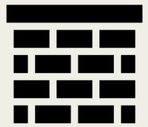


HOW ARE BIOFILMS FORMED?



Taken from Olivares et al 2020. Front Microbiol.

Biofilm resistance

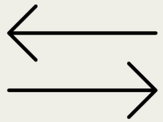


Barriers to penetration of antimicrobial substances

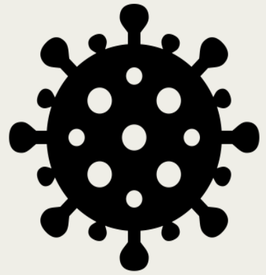
Persister cells – phenotypic variants, dormant, tolerant

Diversity of biofilms allowing for protection of certain species

Gene exchange and mutations



What's hiding on your surfaces? Dry surface biofilms; the unnoticed problem in healthcare facilities



IDENTIFICATION of dry surface biofilms (DSB)

Journal of Hospital Infection 80 (2012) 52–55

Available online at www.sciencedirect.com

Journal of Hospital Infection

journal homepage: www.elsevierhealth.com/journals/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. Jacombs [a], J. Allan [a], P. Valente [a], I.B. Gosbell [b,c]

[a] Surgical Infection Research Group, Australian School of Advanced Medicine, Macquarie University, New South Wales, Australia
[b] Antibiotic Resistance and Mobile Elements Group (ARMEG), Microbiology and Infectious Diseases Unit, School of Medicine, University of Western Sydney, New South Wales, Australia
[c] Department of Microbiology and Infectious Diseases, Sydney South West Pathology Service – Liverpool, New South Wales, Australia

Journal of Microbiological Methods 117 (2015) 171–176

Contents lists available at ScienceDirect

Journal of Microbiological Methods

journal homepage: www.elsevier.com/locate/jmicmeth

A new dry-surface biofilm model: An essential tool for efficacy testing of hospital surface decontamination procedures

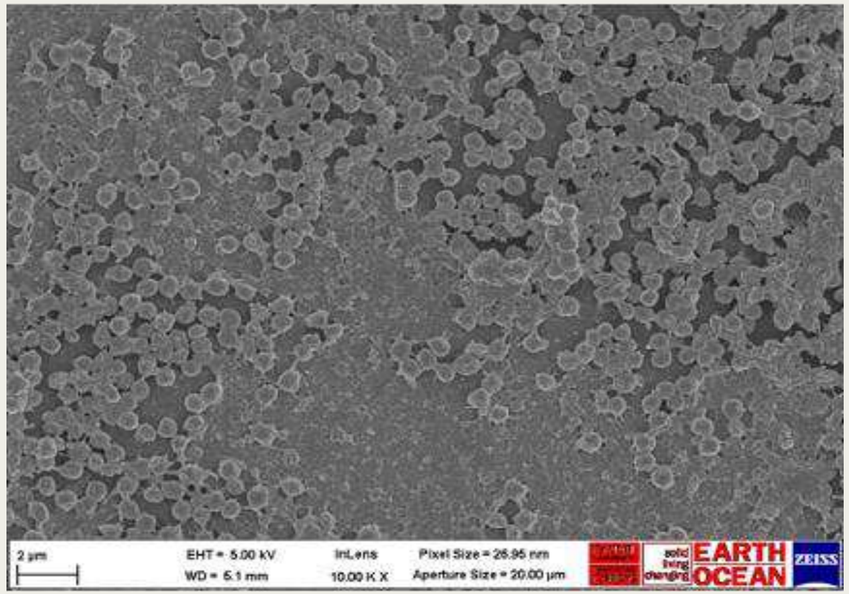
Ahmad Almatroudi [a,b], Honghua Hu [a], Anand Deva [a], Iain B. Gosbell [c,d,e], Anita Jacombs [a], Slade O. Jensen [c,e], Greg Whiteley [f], Trevor Glasbey [f], Karen Vickery [a,*]

[a] Surgical Infection Research Group, Faculty of Medicine and Health Sciences, Macquarie University, NSW 2109, Australia
[b] Department of Medical Laboratories, College of Applied Medical Sciences, Qassim University, Qassim, Saudi Arabia
[c] Molecular Medicine Research Group, Microbiology and Infectious Diseases Unit, School of Medicine, University of Western Sydney, Penrith, NSW 2715, Australia
[d] Department of Microbiology and Infectious Diseases, Sydney South-West Pathology Service, Liverpool, NSW, Australia
[e] Antimicrobial Resistance and Mobile Elements Group (ARMEG), Ingham Institute for Applied Medical Research, Liverpool, NSW 2170, Australia
[f] Whiteley Corporation, Tomago, Newcastle, NSW 2322, Australia

Initial naming of DSB from Karen Vickery (Australia)

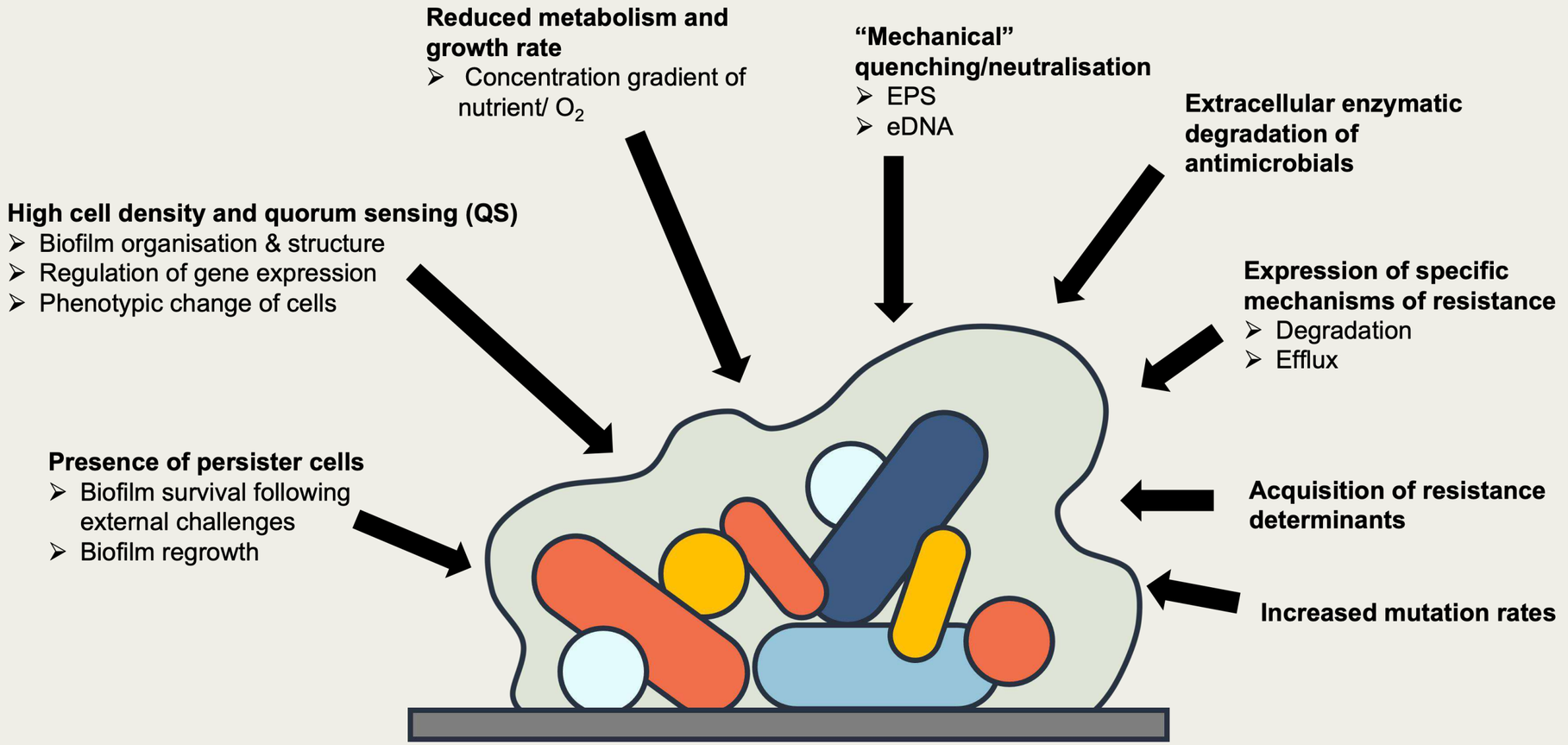
What are DSB?

- Complex communities exposed to repeated desiccation periods
  - Cleaning and disinfection protocols
- Exposed to lowered water potential, reduced nutrient sources and varied temperatures
- Colonise a variety of materials including woven textiles and plastics
- Thick exopolysaccharide layer
- Widespread
- Highly tolerant



Almatroudi et al., (2015); Ledwoch et al., (2018); Vickery et al., (2012)

DSB vs WET BIOFILM CHARACTERISTICS

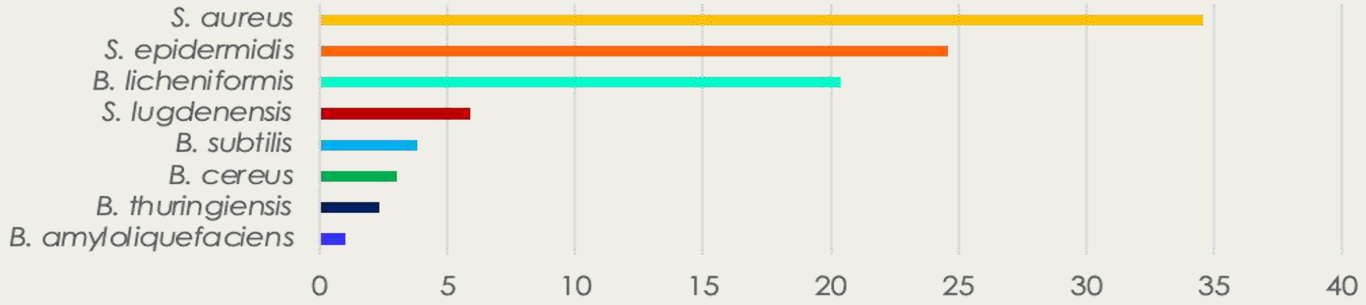


Taken from Maillard & Centeleghe, 2023. Antimicrob Resist Infect Control.

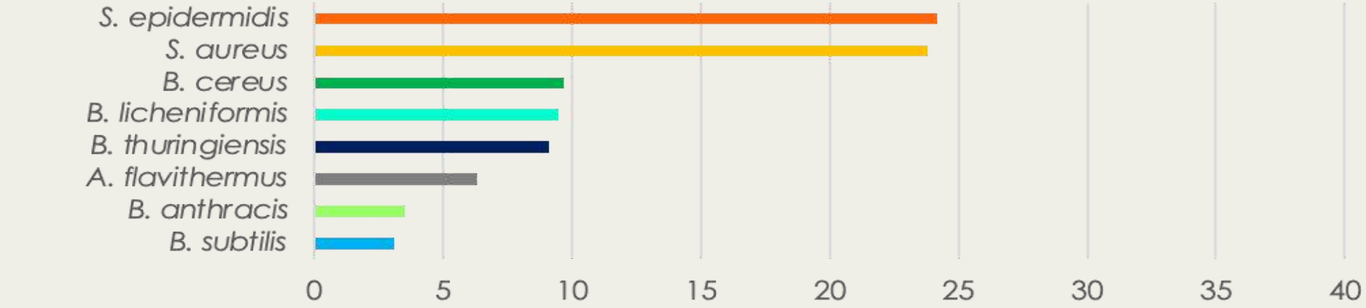
Multicentre study (Ledwoch et al 2018; J Hosp Infect)

3 hospitals / Species composition / 60 terminally clean items

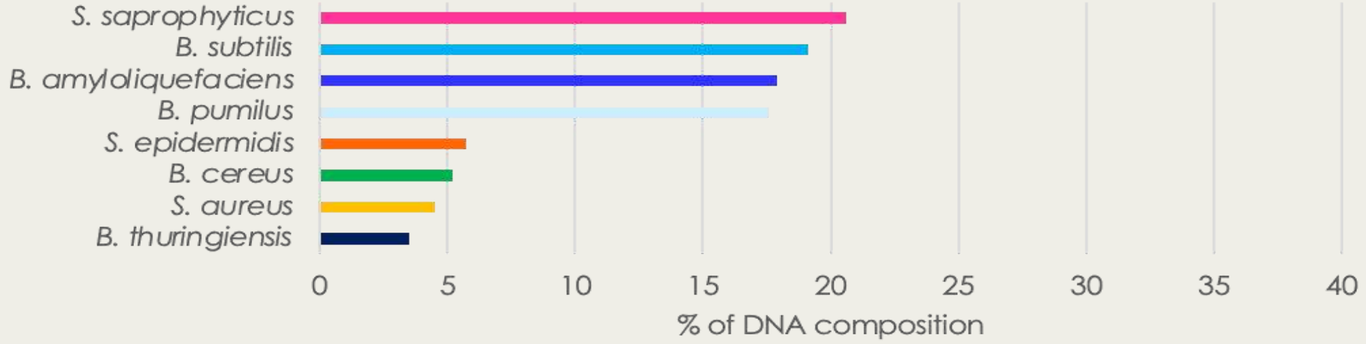
A



B

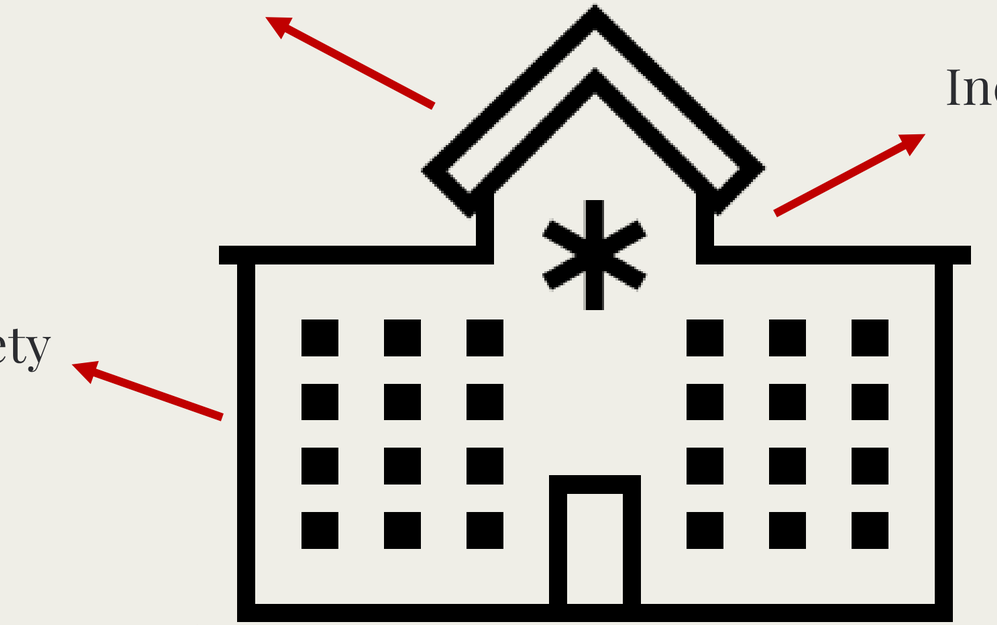


C



WHY ARE DSB A PROBLEM?

Cannot be detected on surface through swabbing



Increased mortality and outbreaks

Staff and patient safety

Less responsive to biocidal products

Increased hospitalisation costs

Controlling DSB

Improve hand hygiene

Improve cleaning protocols

Focus on disinfectants targeting DSB

Improve monitoring of contamination levels

Log reduction

Removal of bacteria from surface after treatment

Transferability

Bacterial transfer directly from the surface and to a new ”clean” surface

Regrowth

Time needed for bacteria in DSB to recover post treatment

DSB formation in our lab

DAY 0
- Wet phase (TSB + 3 g/L BSA)
- Orbital shaker room temp

DAY 2
- Media drained out
- Incubation at 37ºC

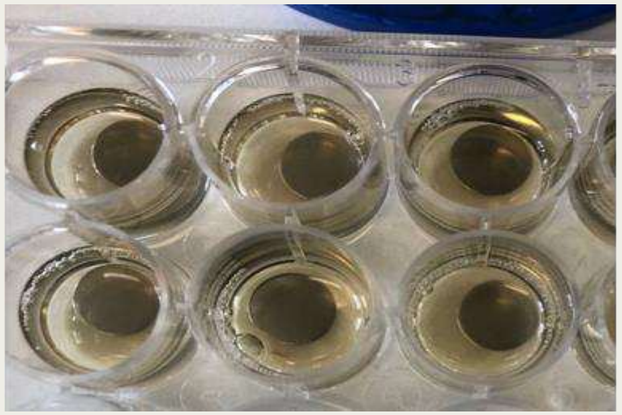
DAY 4
- Wet phase (TSB + 3 g/L BSA)
- Orbital shaker room temp

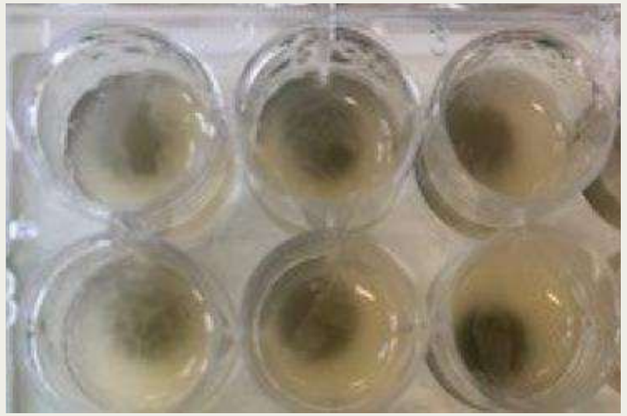
DAY 6
- Media drained out
- Incubation at 37ºC

DAY 8
- Wet phase (TSB + 3 g/L BSA)
- Orbital shaker room temp

DAY 10
- Media drained out
- Incubation at 37ºC

DAY 12
- DSB is ready for testing





METHODS TO TEST DSB

Carrier testing
1

Testing disinfectant solutions against DSB by submerging in liquid

Wipe testing
2

Using the wiperator to test commercially available wipe products

Culturability
3

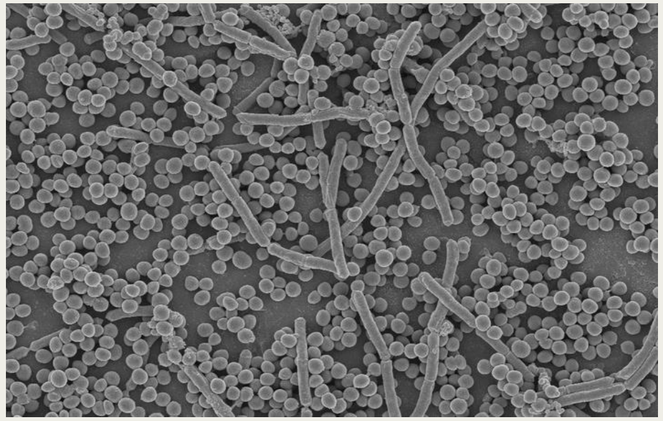
How long can bacteria in DSB survive on surfaces

Virulence
4

Testing pathogenicity of bacteria after being in a DSB state

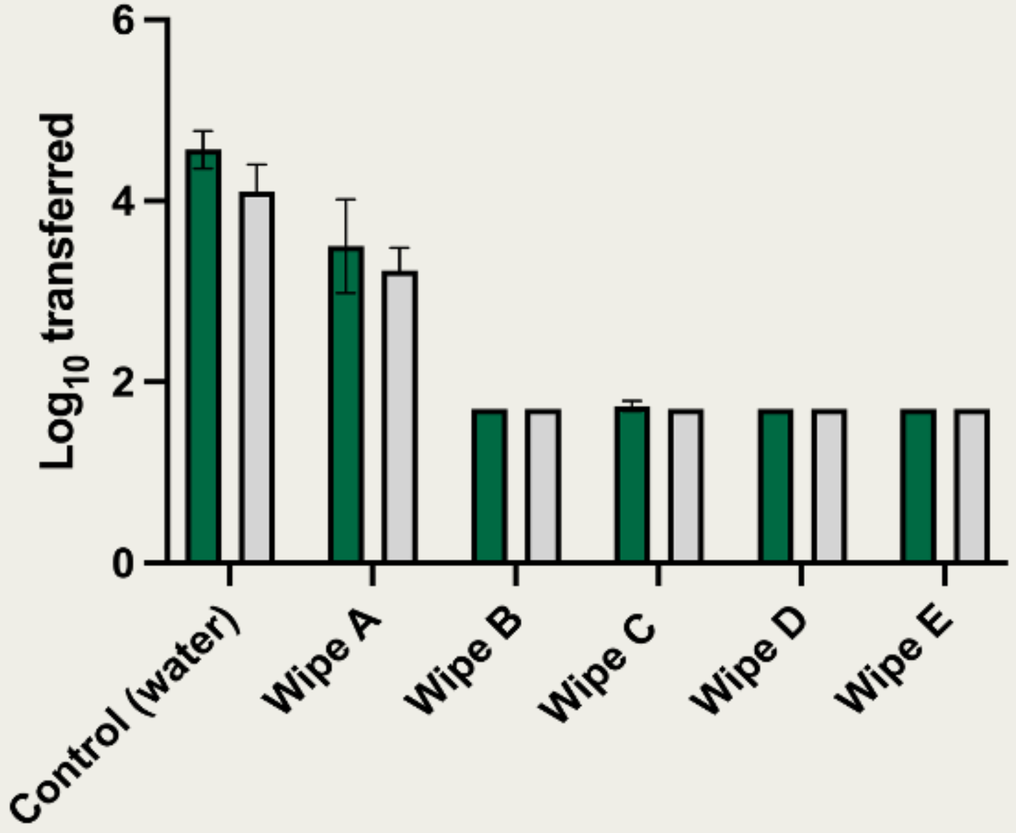
SEM imaging
5

Imaging of bacteria in DSB on surfaces

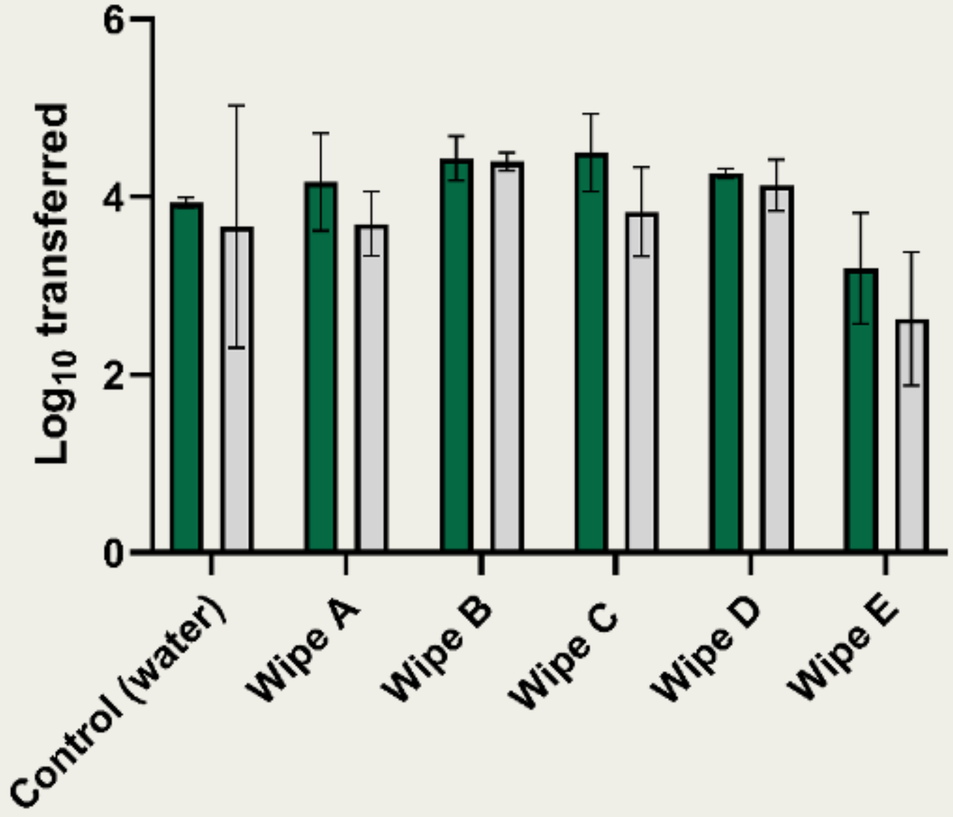


What quantity of bacteria are transferred by the wipe?

S. aureus



B. subtilis (environmental)

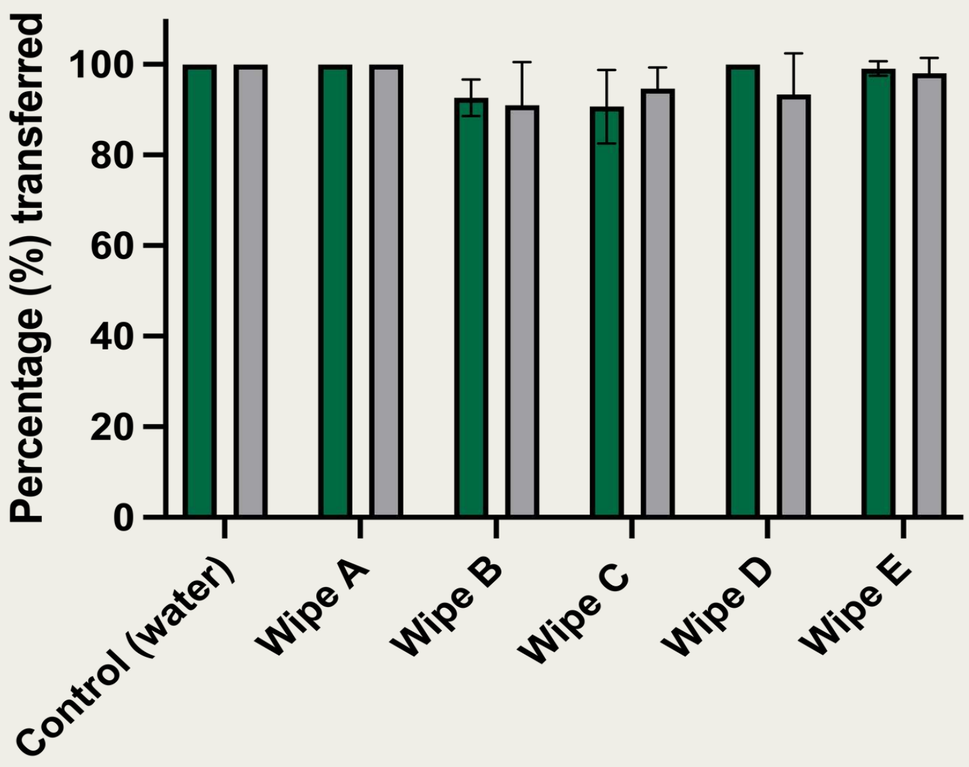


30 seconds

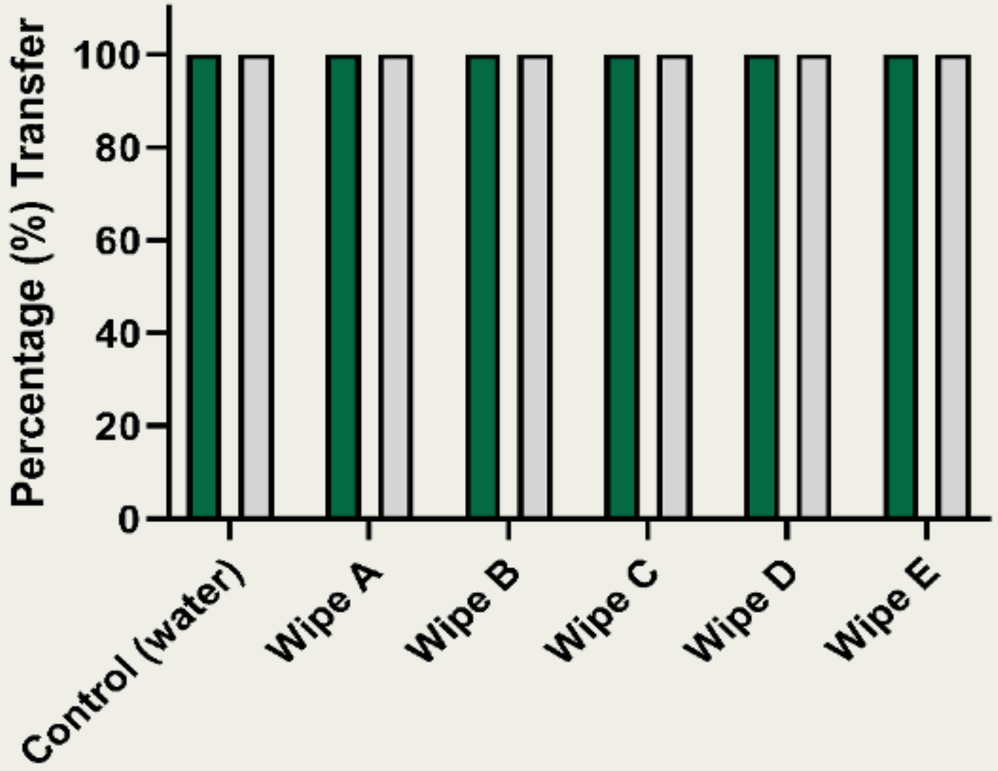
60 seconds

What quantity of bacteria remains on the surface?

S. aureus



B. subtilis (environmental)

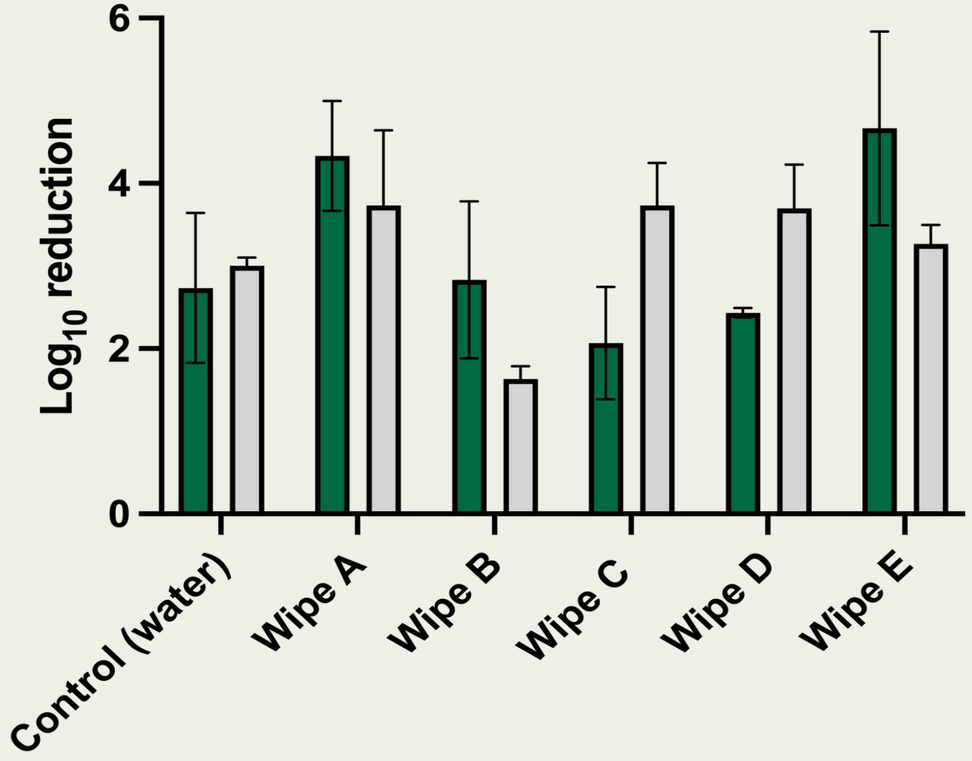


30 seconds

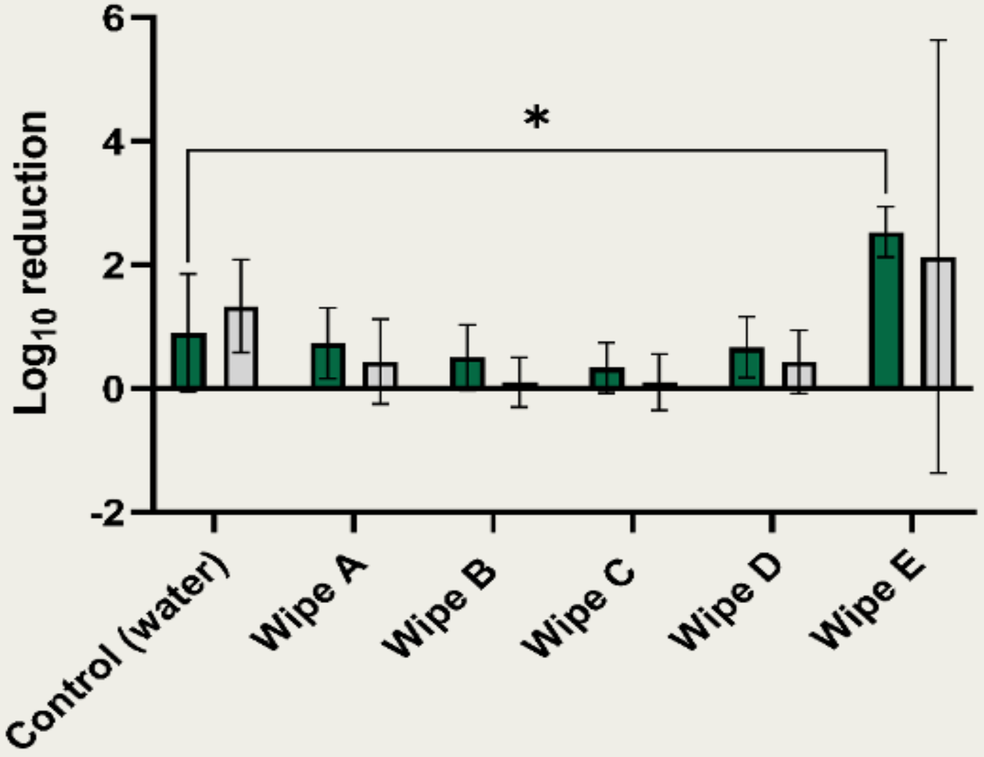
60 seconds

What quantity of bacteria are removed from the surface?

S. aureus



B. subtilis (environmental)



30 seconds

60 seconds

How long can DSB survive on a surface?

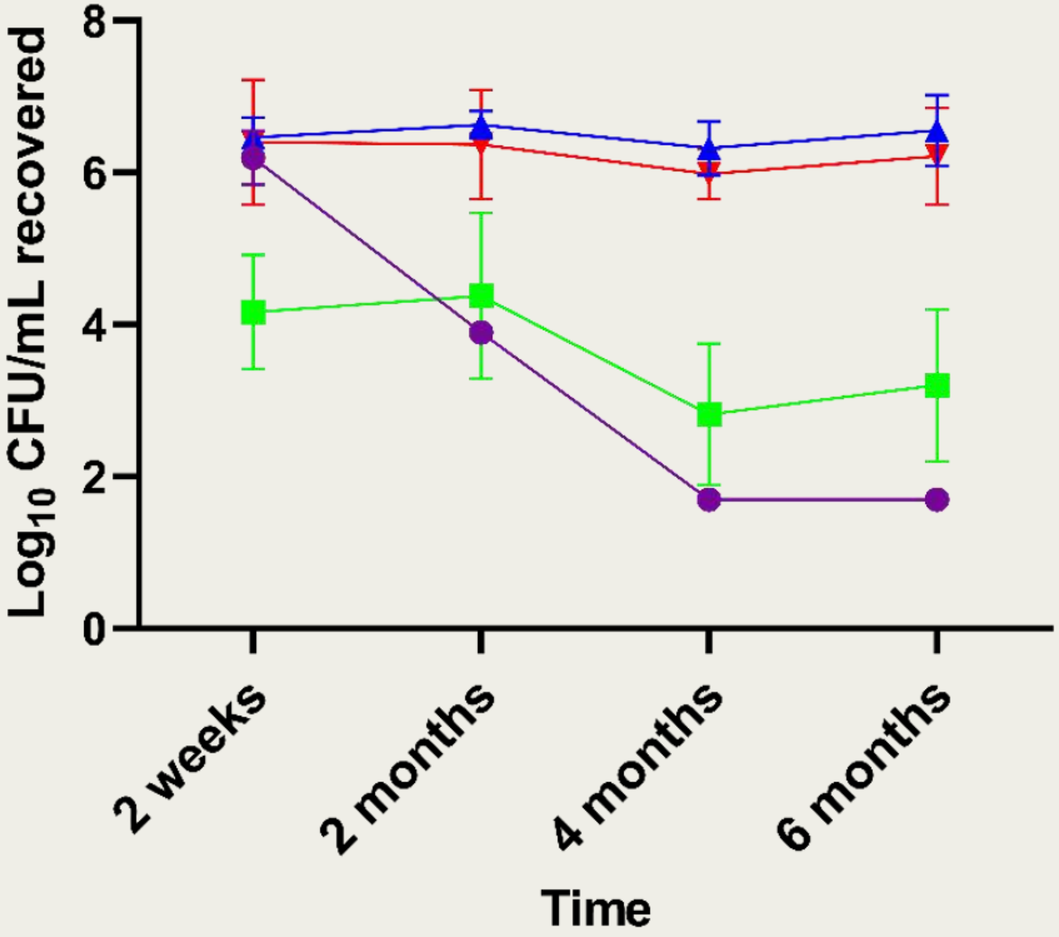
DSB remain a threat if they go unnoticed, but how long are they viable on a surface for?

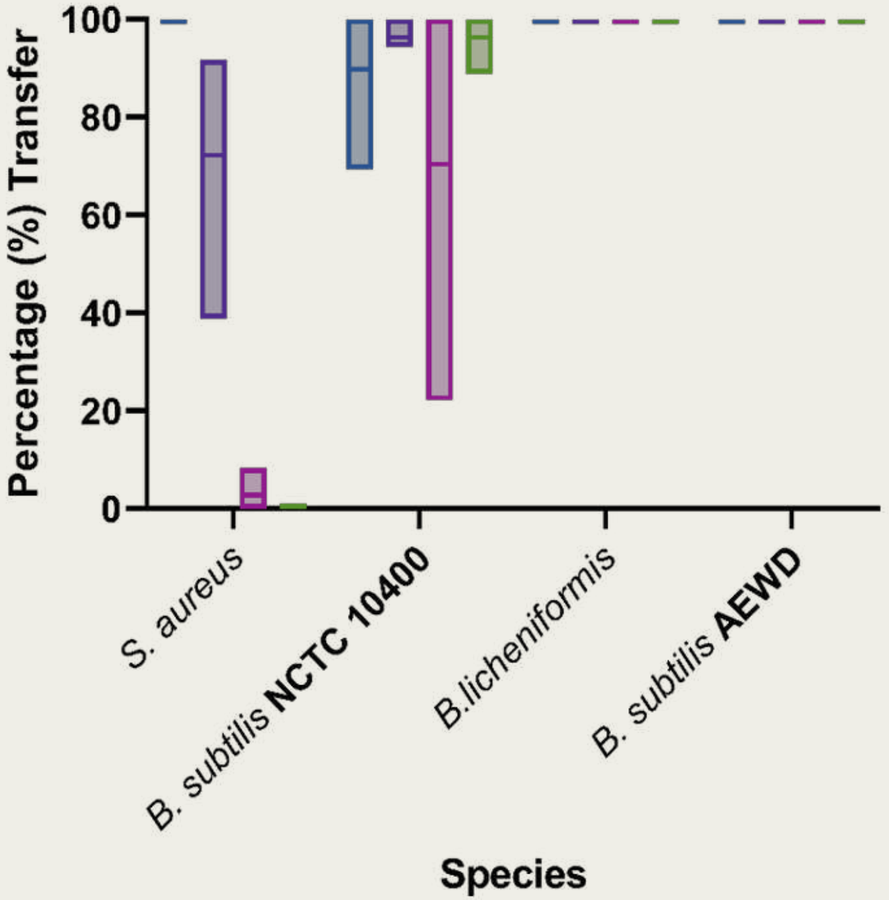
Testing post 12 day growth at 2 weeks, 2/4/6 months.

Culturability, transferability and SEM.

Culturability and transferability

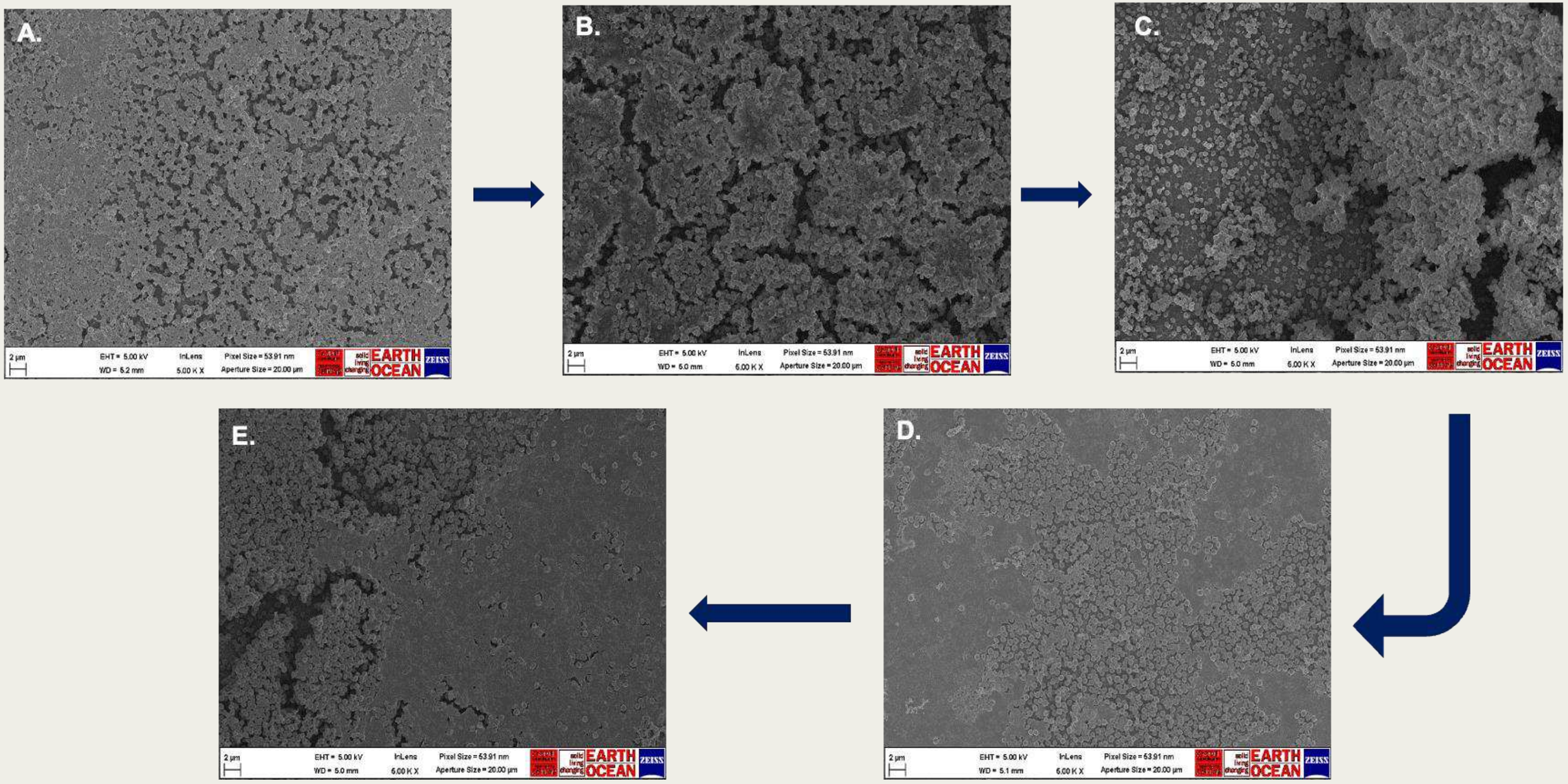
Are some species VBNC?





S. aureus
B. subtilis NCTC 10400
B.licheniformis
B. subtilis AEWD

2 weeks
2 months
4 months
6 months



SEM images of *S. aureus* at (A) 12 days, (B) 2 weeks, (C) 2 months, (D) 4 months and (E) 6 months

What do these results tell us?

Transferability and recovery of DSB post treatment are essential to measure disinfectant efficacy.

Many wipe products cannot prevent transferability of DSB to surfaces.

The importance of adhering to cleaning and disinfection guidelines.

Infection Prevention in Practice
Volume 6, Issue 2, June 2024, 100357

Infection prevention control in practice: a survey of healthcare professionals' knowledge and experiences

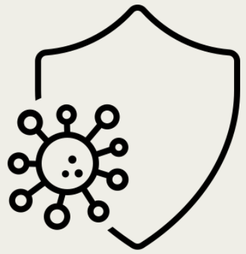
Isabella Centeleghe [a], Philip Norville [b], Jean-Yves Maillard [a], Louise Hughes [a]

…It appears areas HCPs believe to be “safe” might pose more threat than first thought…”

…*”Culture swabs*” was commonly chosen as a method for detection of surface contamination…”

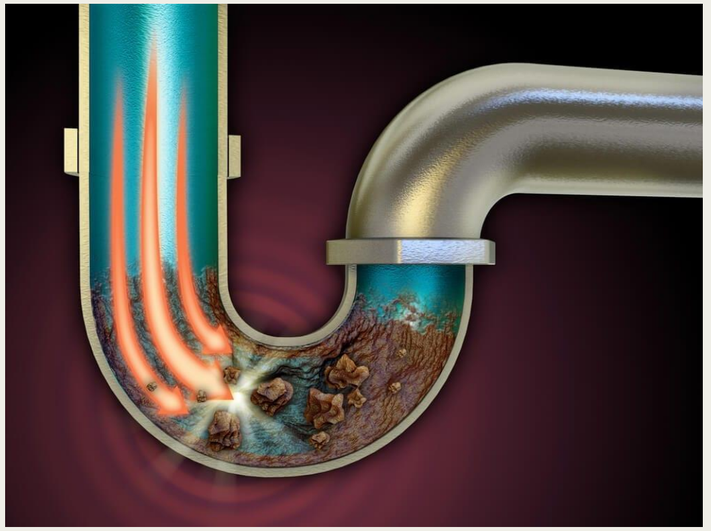
“Some survey participants chose “*visibly looks clean*” as one of the best methods for measuring cleanliness…”

“…“*Talking to colleagues*” was also amongst the most commonly reported methods of gaining knowledge on infection control topics.”



What's hiding in your drains? Pulling the plug on the sink drain

What are drain biofilms?



- Hydrated biofilm in P-trap
- Partially dry at the front and back sections of system
- Evidence for *in situ* effectiveness of products but lacking regrowth data
- *Pseudomonas aeruginosa* (a WHO list priority pathogen) commonly associated with water environment and drains
- Bacteria are able to travel back up the sink to the strainer

Kotay et al., (2017); Lalancette et al., (2017); Ledwoch et al., (2020)

Health

Sinks suspected in Toronto hospital outbreak

Potential hygiene risk highlighted

The Canadian Press · Posted: Jul 25, 2012 11:09 AM EDT | Last Updated: July 25, 2012

Infectious Disease

Dangerous Bacteria May Lurk in Hospital Sinks

Sink-traps are a major source for carbapenemase-producing *Enterobacteriaceae* transmission

Published online by Cambridge University Press: **27 December 2023**

Gili Regev-Yochay, Ili Margalit, Gillian Smollan, Rotem Rapaport, Ilana Tal, William P. Hanage, Nani Pinas Zade, Hanaa Jaber, Bradford P. Taylor and You Che ...Show all authors Show author details

Identification of carbapenem-resistant organism (CRO) contamination of in-room sinks in intensive care units in a new hospital bed tower

Published online by Cambridge University Press: **19 January 2024**

Bobby G. Warren, Becky A. Smith, Aaron Barrett, Amanda M. Graves, Alicia Nelson, Erin Gettler, Sarah S. Lewis and Deverick J. Anderson Show author details

HOSPITALS

Hospitals installed more sinks to stop infections. The sinks can make the problem worse

By Helen Branswell Oct. 25, 2016 Reprints

February 28, 2024 | 2 min read

Sinks located in newly constructed ICU rooms contaminated quickly

An intensive care unit outbreak with multi-drug-resistant *Pseudomonas aeruginosa* – spotlight on sinks

V. Schärer [a], M-T. Meier [a], R.A. Schuepbach [b], A.S. Zinkernagel [a], M. Boumasmoud [a], B. Chakrakodi [a], S.D. Brugger [a], M.R. Fröhlich [b c], A. Wolfensberger [a], H. Sax [a d], S.P. Kuster [a], P.W. Schreiber [a]

ELSEVIER

American Journal of Infection Control

Volume 42, Issue 5, May 2014, Pages 554-555

Brief report

The important role of sink location in handwashing compliance and microbial sink contamination

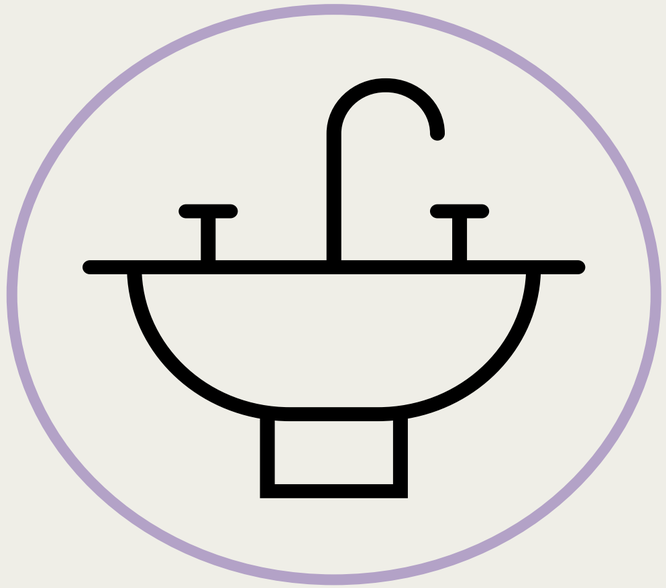
Elaine Cloutman-Green MRes, MSc [a], Oya Kalaycioglu MSc [b], Hedieh Wojani BArch [c d], John C. Hartley BSc, MBBS, DTM&H, MSc [a], Serge Guillas PhD [b], Deirdre Malone BSc [a], Vanya Gant PhD [e], Colin Grey MPhil, MCIOB [d], Nigel Klein PhD [c]

Why are drain biofilms a problem?

Increased hospitalisation costs

Less responsive to biocidal products

Sinks/drains are widespread and a necessity



Patient and staff safety

Increased infrastructure costs

Biofilms able to regrow after disinfection

Regular use of disinfectants could select for certain pathogens

Sinks, drains and infection

NEED

- Hand hygiene is an essential part of IPC practice
- Campaigns to promote hand hygiene led to more sinks

ISSUES

- Aerosols and splash zones up to 2m away from sinks
- Gram-negative bacteria found in aerosols produced by running water in up to 93% sinks

RISK

- Contamination of equipment and critical care environment from sink splash zones
- Sub-optimal room and sink designs put patients and staff at risk

Sinks and handwashing

ELSEVIER

American Journal of Infection Control

Volume 42, Issue 5, May 2014, Pages 554-555

Brief report

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- Increasing sink visibility increased handwashing episodes
- Increased usage = contamination within sink bowl
- Contamination of soap dispensers inversely related to sink usage
- Enterobacteriaceae detected at all sites except soap/alcohol dispensers
- Stapyhlococcal species detected at all sites

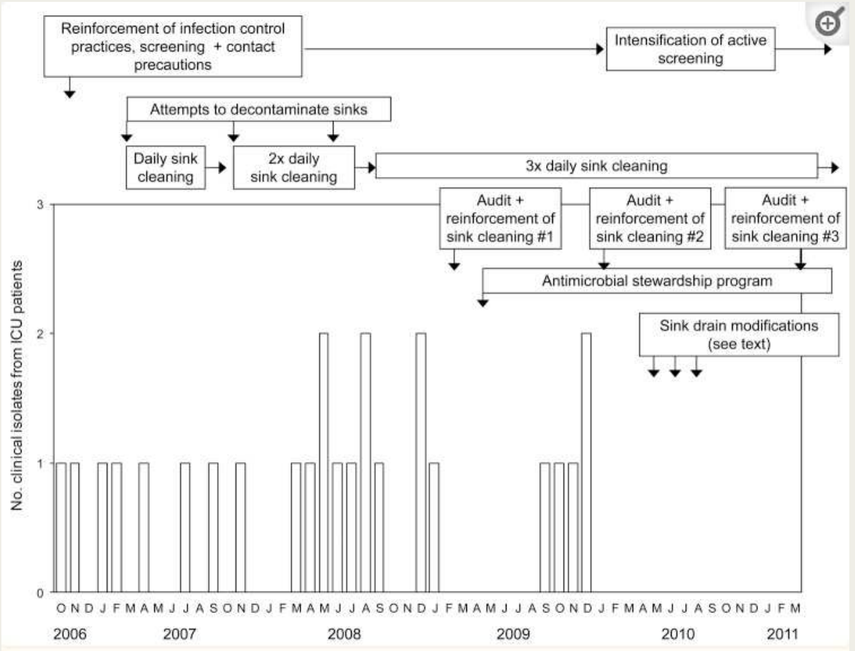
Sinks as a reservoir for infection

- Patients acquired *Klebsiella oxytoca* whilst in hospital
- Extended beta-lactamase strain
- New cases after reinforcement of current IPC practices
- Infections stopped occurring after;
  - Sink cleaning 3 x per day
  - Sink modifications
  - Antimicrobial stewardship programme

Emerg Infect Dis. 2012 Aug; 18(8): 1242–1247.
doi: 10.3201/eid1808.111268
PMCID: PMC3414015
PMID: 22841005

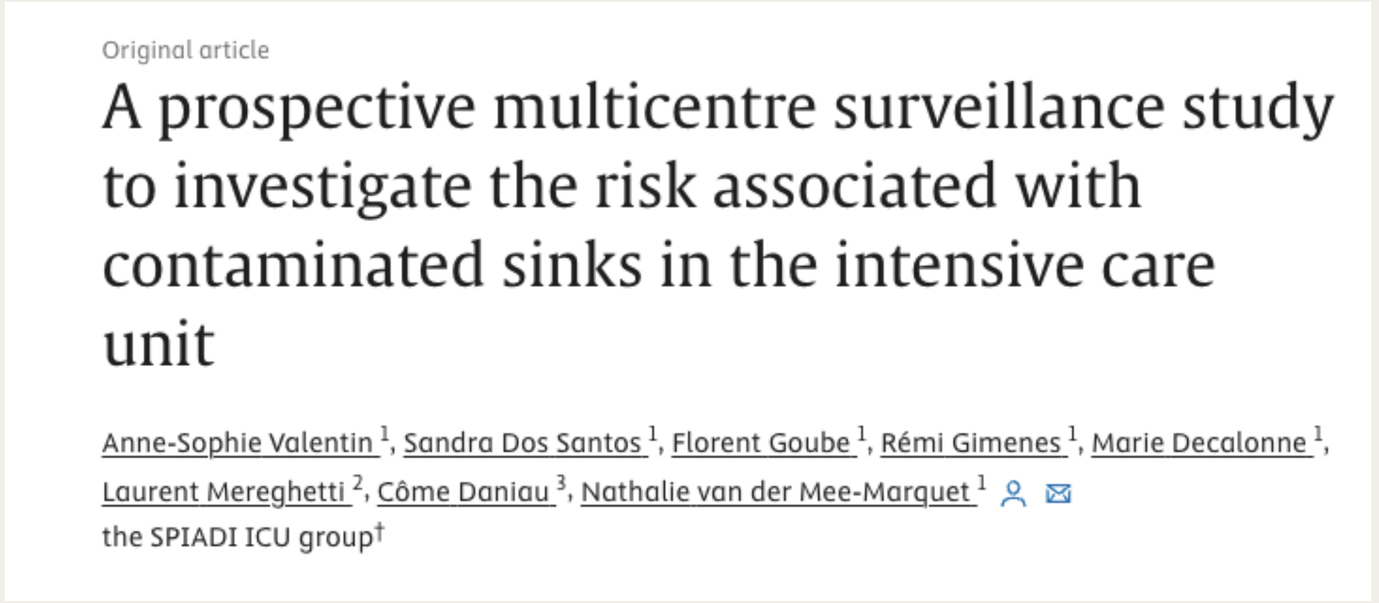
Outbreak of Extended-Spectrum β-Lactamase–producing *Klebsiella oxytoca* Infections Associated with Contaminated Handwashing Sinks[1]

Christopher Lowe, Barbara Willey, Anna O'Shaughnessy, Wayne Lee, Ming Lum, Karen Pike, Cindy Larocque, Helen Dedier, Lorraine Dales, Christine Moore, Allison McGeer,[✉] and the Mount Sinai Hospital Infection Control Team



Sinks as a reservoir for infection

- 73 ICUs participated - multicentre
- 50.9% (606/1191) of sinks were contaminated with MDR bacteria
  - 41% of these used for handwashing
  - 55.3% for waste disposal
  - 23% were bleached daily
  - 59.1% exposed to QACs
  - 62% untreated



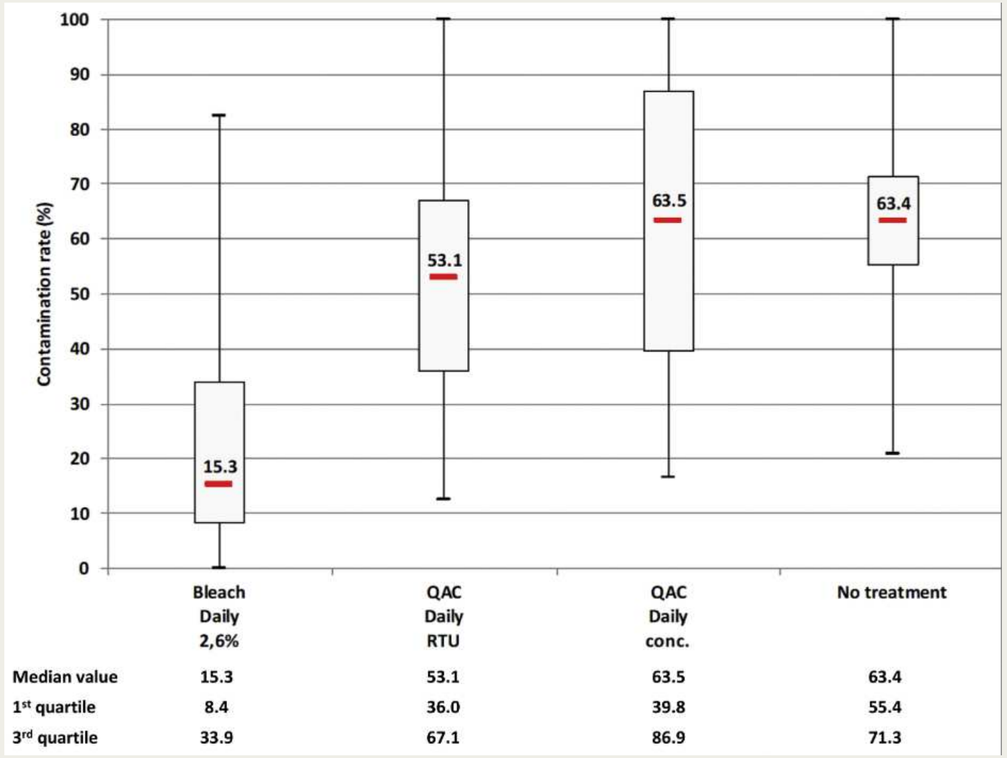
Original article

A prospective multicentre surveillance study to investigate the risk associated with contaminated sinks in the intensive care unit

Anne-Sophie Valentin [1], Sandra Dos Santos [1], Florent Goube [1], Rémi Gimenes [1], Marie Decalonne [1], Laurent Mereghetti [2], Côme Daniau [3], Nathalie van der Mee-Marquet [1]
the SPIADI ICU group†

Sinks as a reservoir for infection

- 38.5% of sinks had signs of visible splashes
- 30.%% of sinks were close to patient beds (<2m) with no physical barrier
- MDR associated bloodstream infections incidence rates 0.7/1000 patient days
- 38.4% reported lack of sink disinfection
- After implementation of sink disinfection, 68.9% performed daily used bleach and QAC



Controlling drain biofilms

Cover drains

Sink replacement/removal

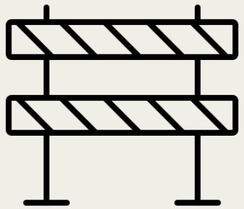
Enhanced disinfection procedures

Improve monitoring of contamination levels

Reducing infection from sinks

Remove handwashing sinks from critical care units

- Implementation of wipes and alcohol hand gel
- Problems of rapid recolonization



Physical barriers or modifications

- Splash screens
- Sinks away from patient area

Engineering design modifications

- Drain covers
- Self disinfecting siphons
- Waste disposal to remove drain contamination
- Automated trap disinfection devices

Reducing infection from sinks

Disinfection formulations

- Bleach/PAA/QAC
- Frequency of disinfection
- Compliance from staff

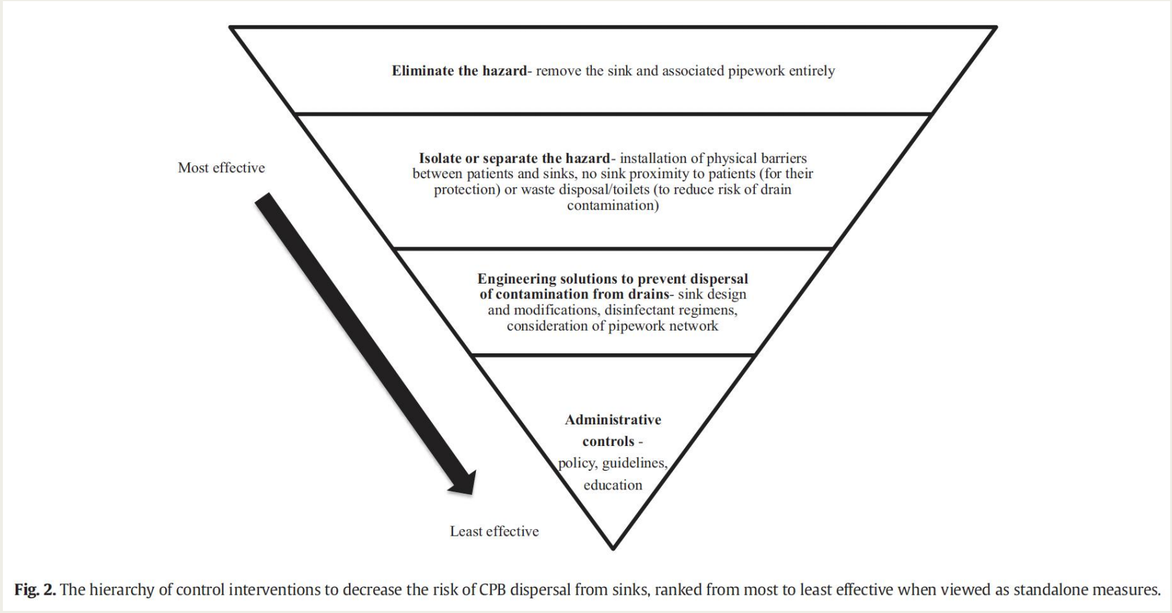
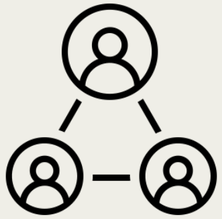


Fig. 2. The hierarchy of control interventions to decrease the risk of CPB dispersal from sinks, ranked from most to least effective when viewed as standalone measures.



Administrative controls

- Policy making
- Hygiene services
- Education and training for staff

The development of a drain biofilm model at Cardiff

Journal of Hospital Infection 106 (2020) 757–764

Available online at www.sciencedirect.com

Journal of Hospital Infection

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

It's a trap! The development of a versatile drain biofilm model and its susceptibility to disinfection

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Log reduction

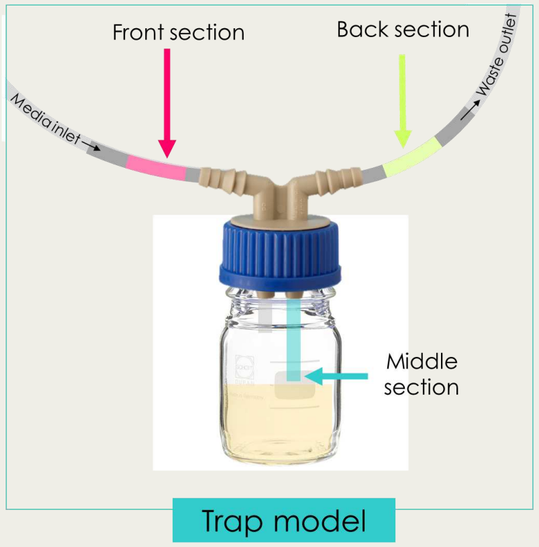
Removal of bacteria from drain tubing after treatment

Regrowth

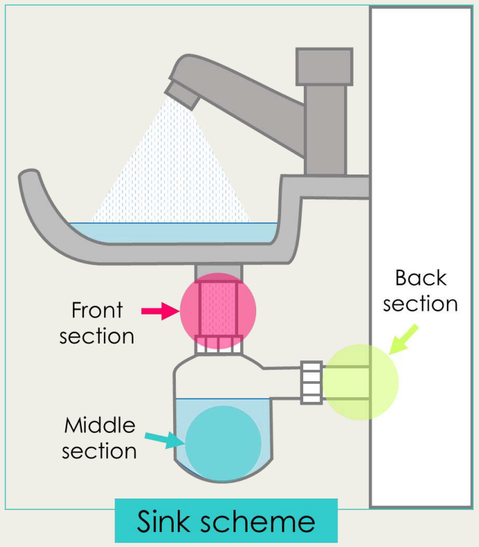
Time of bacteria remaining in the drain to recover post treatment

The development of a drain biofilm model at Cardiff

- Mixed species drain culture taken from trap
- Taken from One Health areas – veterinary, healthcare and home environments
- Peristaltic pump used to grow biofilm and allow disinfectant into the system



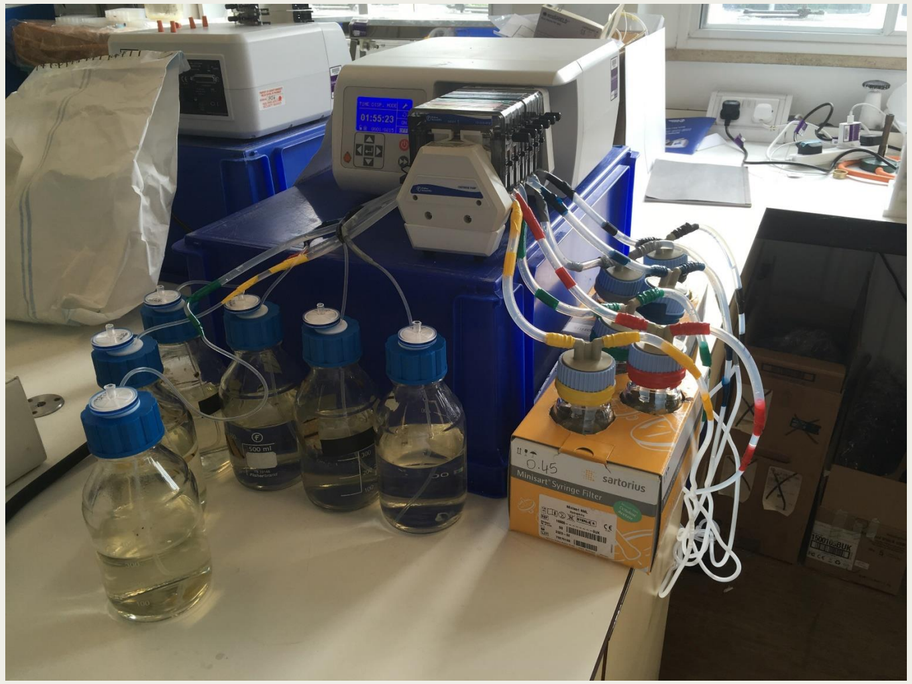
Trap model



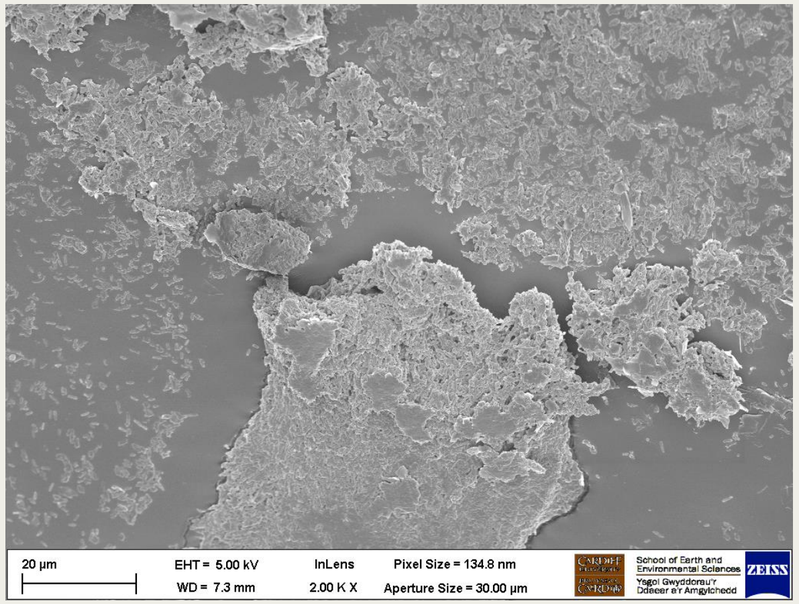
Sink scheme

The development of a drain biofilm model at Cardiff

- Drain biofilm is inoculated in tubes for 2 days
- Tubes are connected to peristaltic pump with a 1:10 TSB media supply
- Drain biofilm is flushed every 2 hours for 10 seconds
- After 6 days the drain biofilm is ready for testing

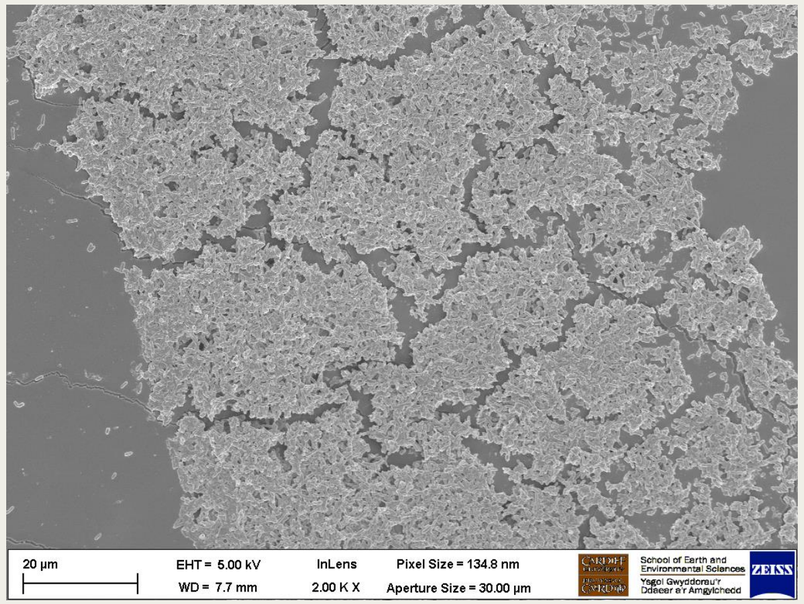


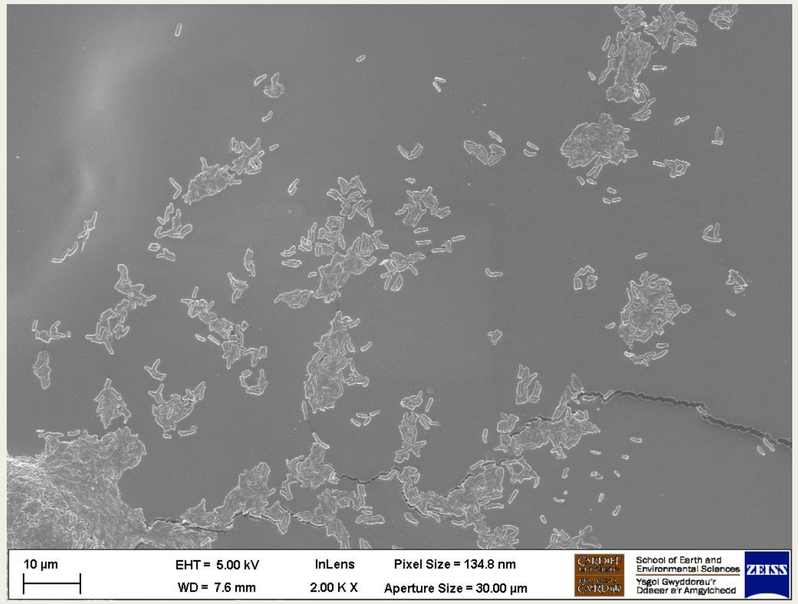
SEM imaging of drain biofilm



Front

Middle

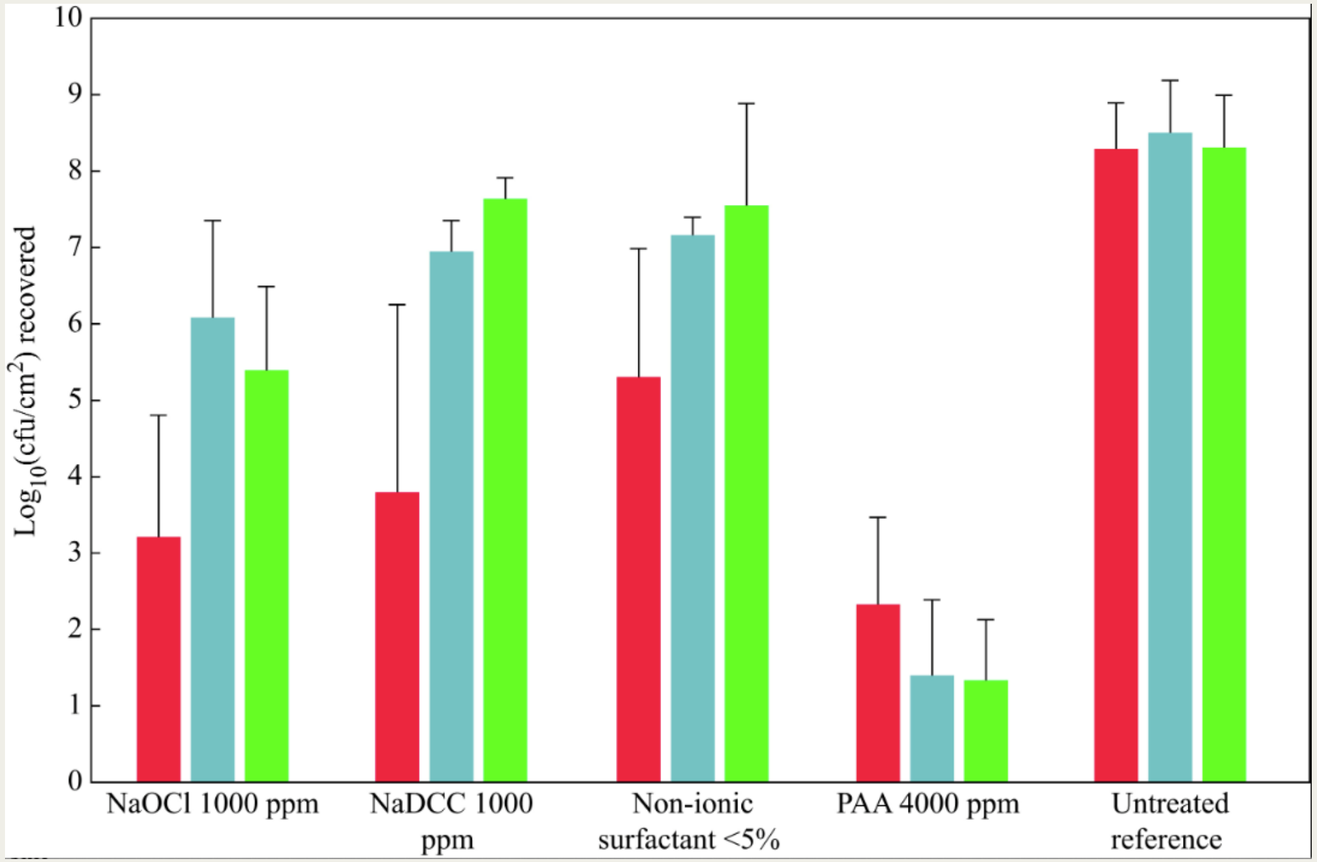


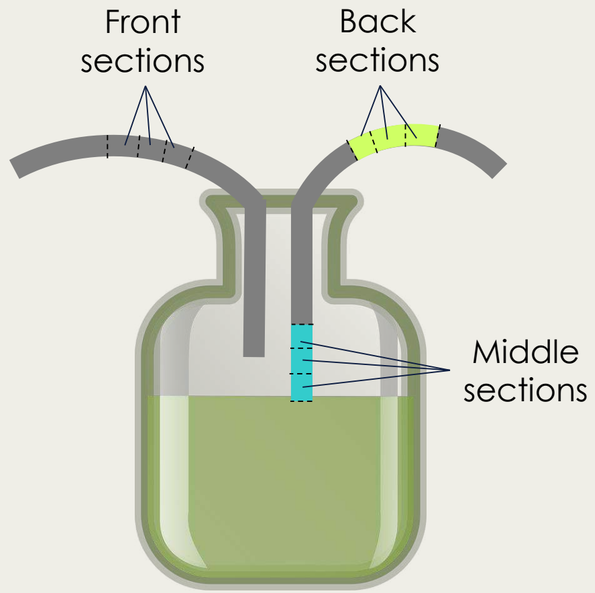


Back

Previous research (Ledwoch et al. 2020)

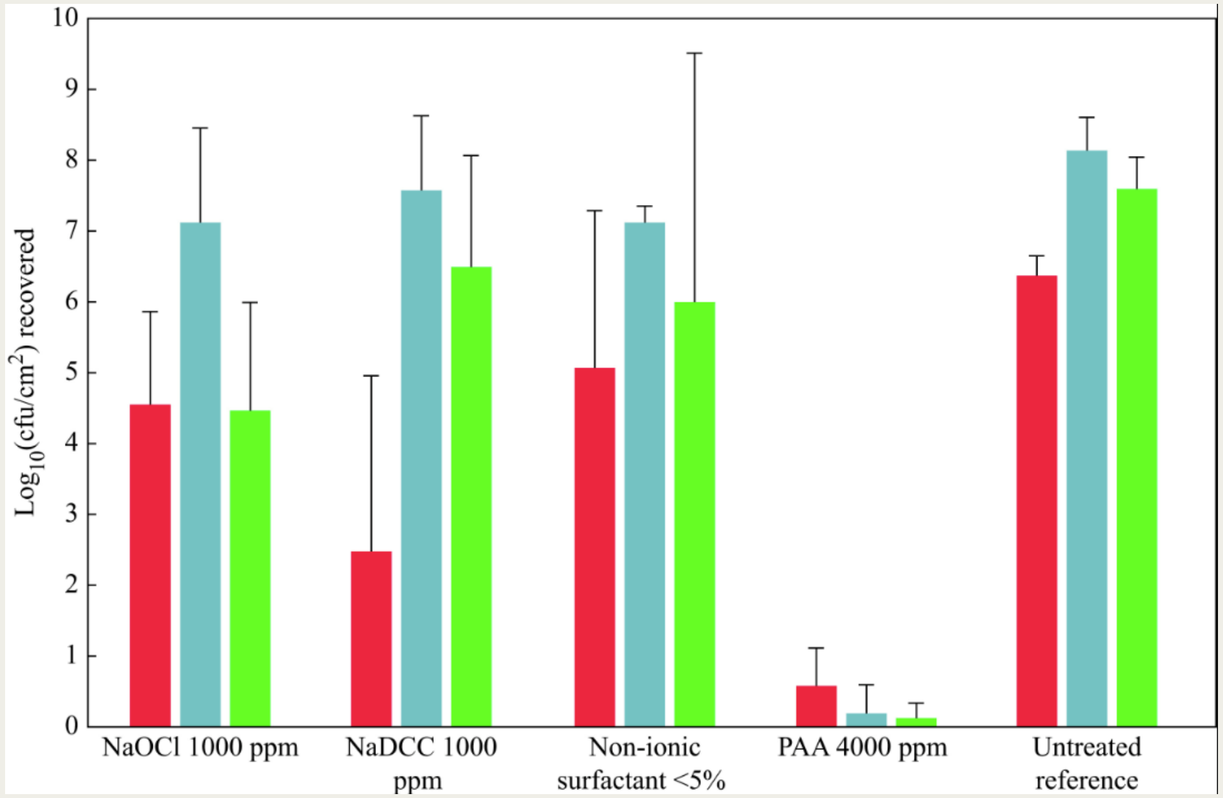
- Drain biofilm recovered following 3 x 15 minute doses of disinfectant treatment
- Red = front section, blue = middle section, green = back section

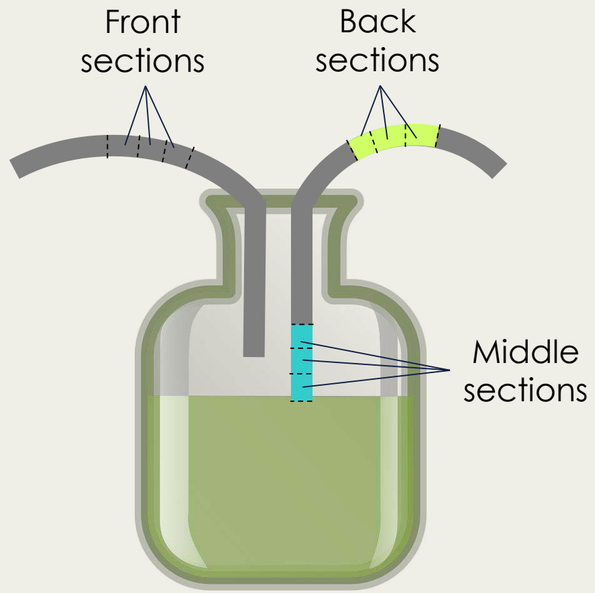




Previous research (Ledwoch et al. 2020)

- Drain biofilm recovered after 4 days following 3 x 15 minute doses of disinfectant treatment
- In many cases, drain biofilm regrows in 1 day
- Red = front section, blue = middle section, green = back section





The trap is a perfect environment for microbial growth

Biofilms in the trap are difficult to eradicate and control

The drain biofilm recovers quickly even if treatment is somewhat effective

So what next...

COMBAT

Complex Biofilms and AMR Transmission

Sinks and healthcare

- Sinks and drains are responsible for pathogen transmission during outbreaks

- Most outbreaks can be controlled with a series of measures:
  - Sink replacement
  - Room design modifications
  - Splash barriers
  - Frequent use of the correct disinfectant products

- Impossible to completely eradicate sink contamination

- Implementation and training on how to prevent outbreak reoccurrence

DSB and drain concluding remarks

Contribution to hospital acquired infections

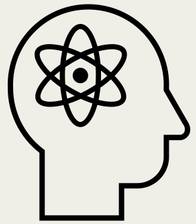
Difficult to eradicate and control

Patients and staff at risk

Composed of multidrug resistant pathogens

Require improved disinfectant procedures and products

What is happening in Pharmaceutical Microbiology at Cardiff University?



- Development of a raman detection device for DSB
- Investigations into the link between HCAI and DSB in UK hospitals
- Composition and effect of antimicrobials from drain biofilms around the world
- Antibiotic usage and therapy
- Photodisinfection of sanitary towels for third world countries
- Development of wipe products and formulation testing

Thank you!

Any questions?

Special thanks to Prof. J-Y Maillard, Dr K Ledwoch, GAMA Healthcare, COMBAT team and all of lab 1.50

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