Cleaning in the 21st Century
The Dark Ages?

Dr. Ina (L.E. Willemsen)
Consultant Infection Control
Amphia hospital
The Netherlands
March 15th 2017

Amphia hospital

- Large teaching hospital
- ± 45.000 admissions per day
- 3 hospital locations

- 235 people housekeeping employees, working across3 locations
- Department of infection control with 10 infection control practitioners



The importance of cleaning in a hospital

- Increase in life expectancy
- Increase in chronic diseases
- Increase in the complexity of care
- Increase in antimicrobial resistance

The importance of cleaning in a hospital

Evidence that contaminated surfaces contribute to the transmission of hospital pathogens and an overview of strategies to address contaminated surfaces in hospital settings

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Increased risk from the prior room occupant

«the room lotto»

Patient with a pathogen
(e.g. *C. difficile*, MRSA, VRE, *A.baumanii of P. auruginosa*)

Patient is discharged
Room is cleaned & disinfected

The next room occupant is at an increased risk of acquiring the pathogen

Increased risk from the prior room occupant

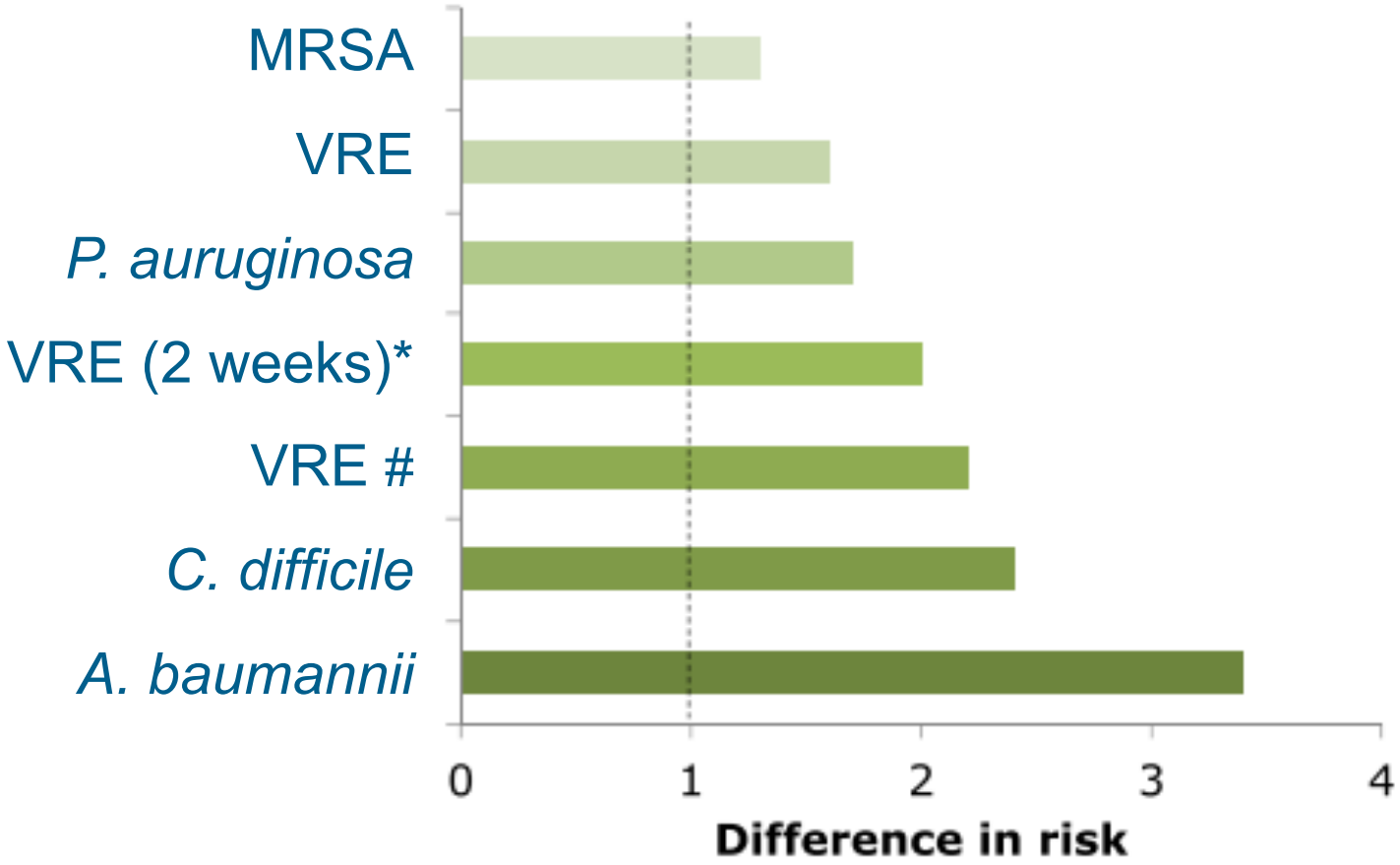
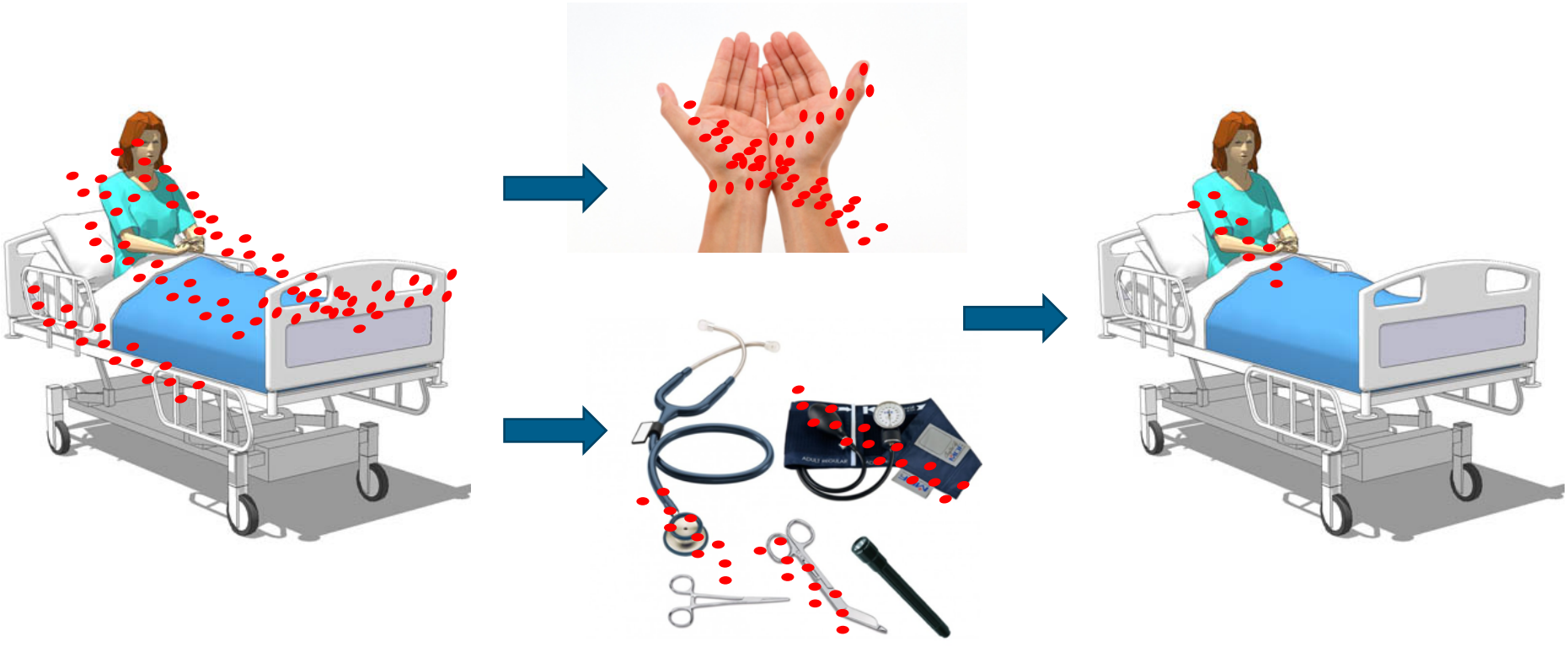


Figure: increased risk associated with the prior room occupant
* VRE in the two weeks prior to admission
# immediate prior room occupant was VRE positive

Otter et al. Am J Infect Control 2013;41(5 Suppl):S6-11

Routes of transmission – Hands & Instruments



Patient environment

Hands & Instruments

Next patient

The importance of cleaning in a hospital

Direct patient contact	Contact with environmental surfaces only
45% of 50 HCP acquired MRSA on their gloved hands	52% of 44 HCP acquired VRE on their hands or glove
50% of 30 HCP acquired *Clostridium difficile* on their gloved hand	40% of 50 HCP acquired MRSA on their gloved hands
	50% of 30 HCP acquired *C difficile* on their gloved hands
Compliance with hand hygiene: 80%	*Compliance with hand hygiene: 50%*

Otter et al. Evidence that contaminated surfaces contribute to the transmission of ……. AJIC May 2013

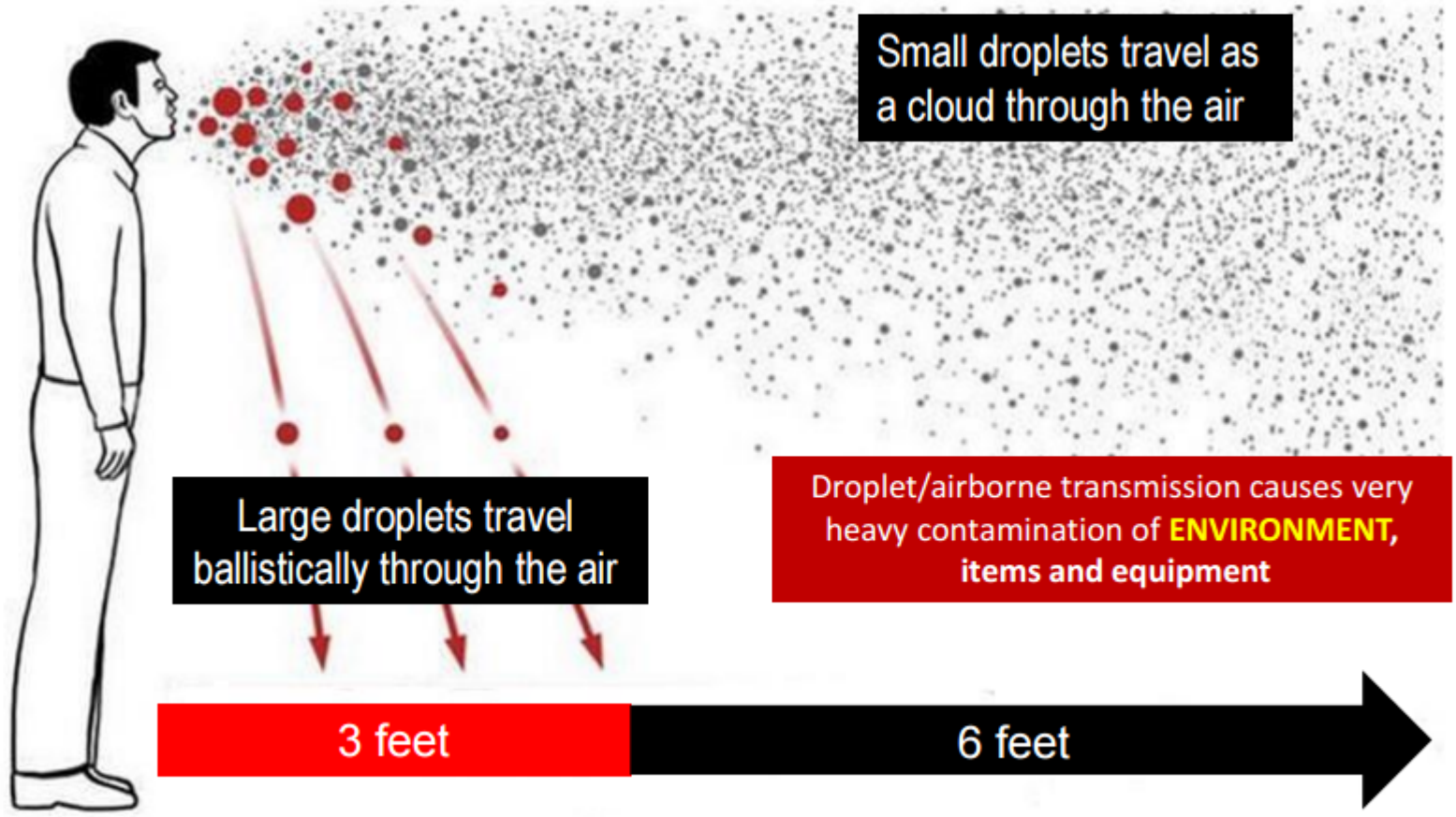
Routes of transmission – Hands & Instruments

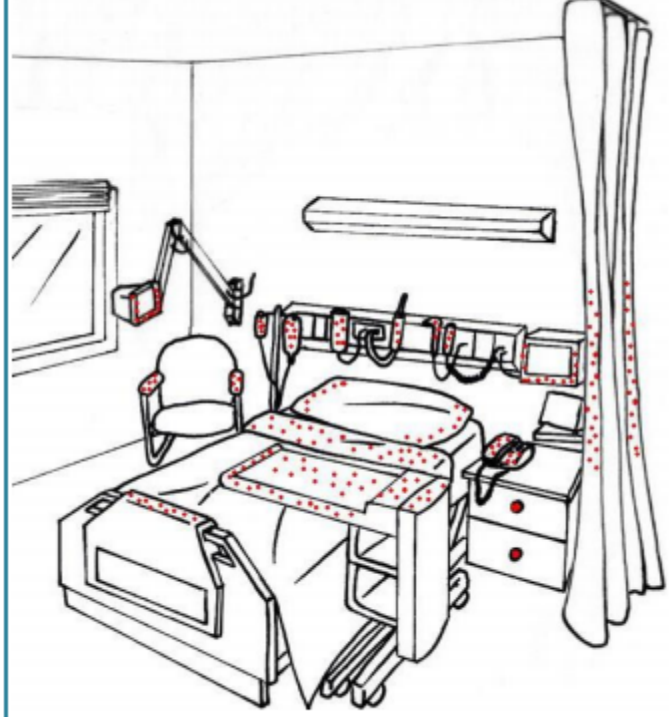
In the absence of clear cleaning policy for dect telephones and stethoscopes a study was performed to culture these items.

- Physicians and residents were asked to participate
- Items were sampled according to a standardized method
- Agar plate were cultured overnight at 35-37 gr C.

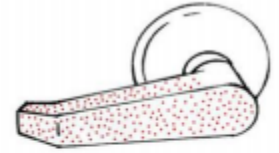
Day 0	
Dect phone	8% carried *S. aureus*
Stetoscope	12% carried *S. aureus*
Day 35	
Dect phone	5% carried *S. aureus*
Stethoscope	12% carried *S. aureus*

Routes of transmission – droplet / airborn





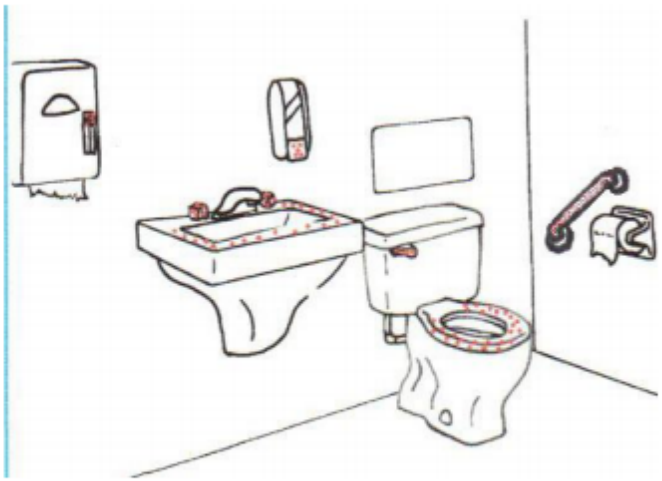
Patient Room



Door Handle

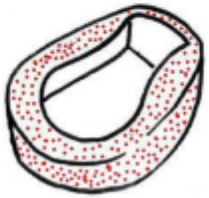
Call Bell

Light Switch



Patient Bathroom

Commode

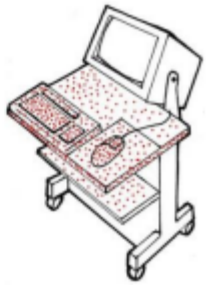


Bedpan

Examples of High-touch items and surfaces in the patient environment

Nursing Station

ECG Cart



Computer on Wheels

Hallway on Patient/Resident Floor

Wheelchair

Transport Items

Examples of High-touch items and surfaces outside the patient environment

Best Practices for Environmental Cleaning for Prevention and Control of Infections – PIDAC 2012

Surface survival

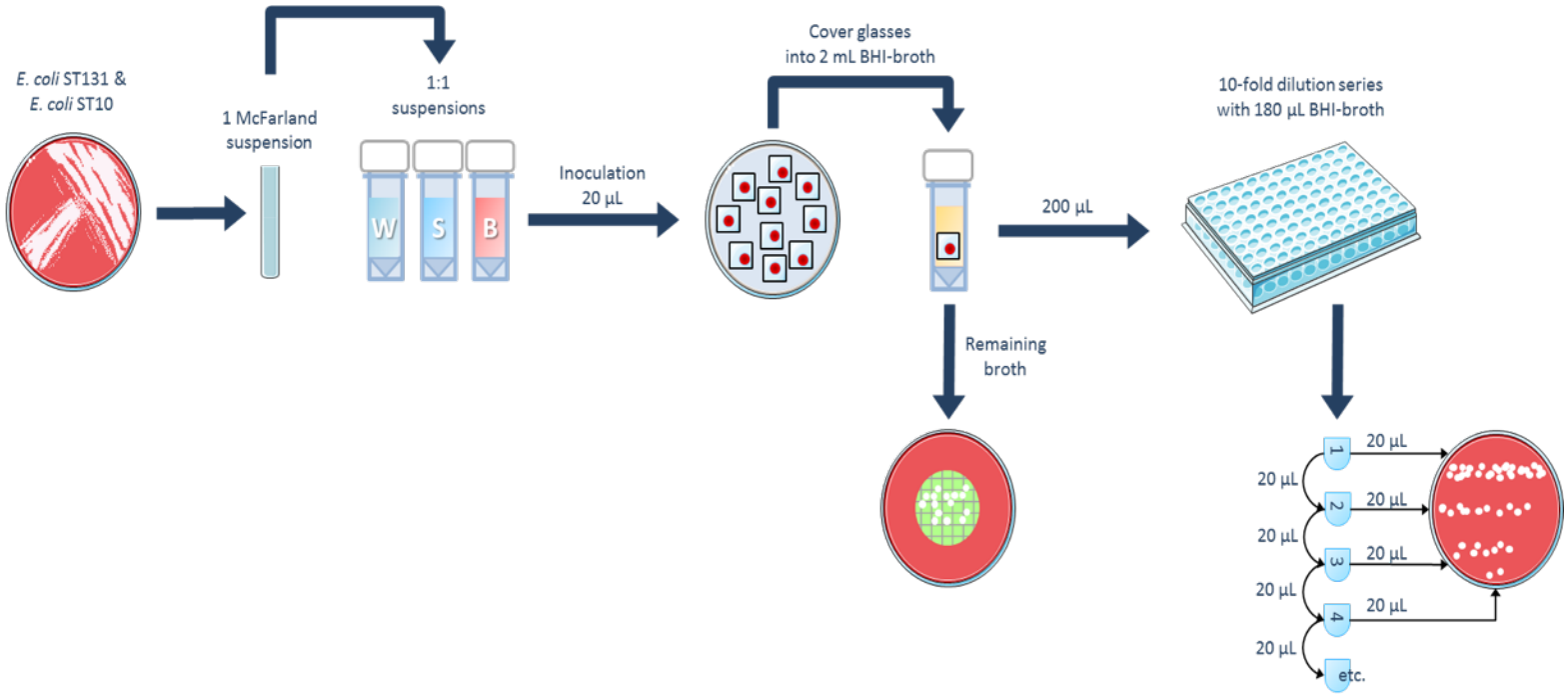
Organism	Survival time
Clostridium difficile (spore)	> 5 months
Acinetobacter spp	3 days to 11 months
Enterococcus spp (incl. VRE)	5 days to > 46 months
Pseudomonas aeruginosa	6 hours to 16 months
Klebsiella spp	2 hours to > 12 months
Staphylococcus aureus (incl. MRSA)	7 days to > 12 months
Norovirus	8 hours to > 2 weeks

NOTE. Adapted from Kramer et al. BMC Infect Dis 2006;6:130

Otter et al. Am J Infect Control 2013;41(5 Suppl):S6-11

Survival of ESBL producing *Escherichia coli*
in three different suspension fluids

How long can extended-spectrum β-lactamase (ESBL)-producing *E. coli* survive on dry inanimate surface in water, saline and sheep blood

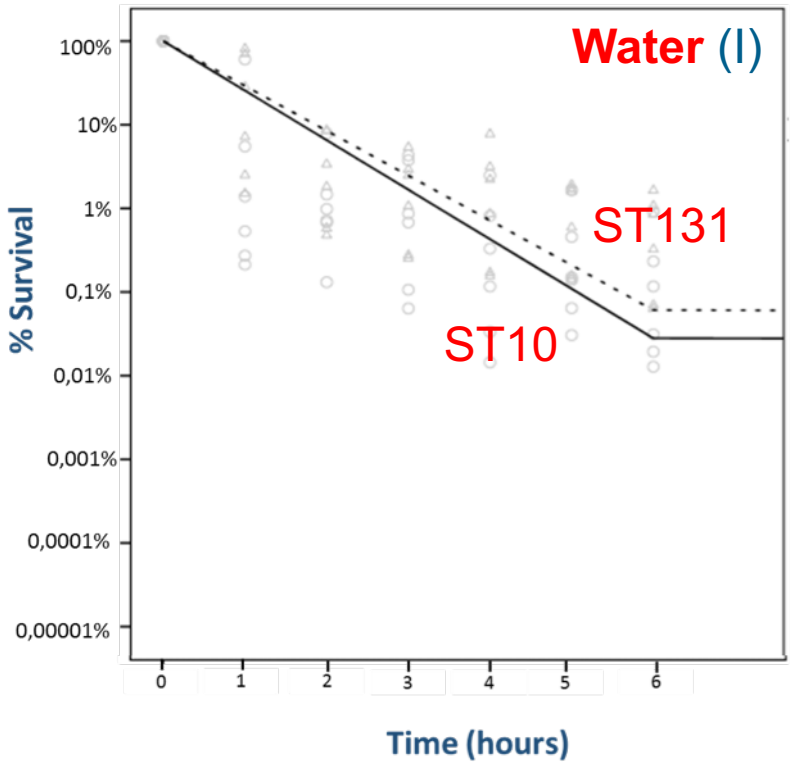


- *E. coli* ST131 and *E. coli* ST10
- Bacterial survival on the glasses was determined hourly during the first day, daily during following 6 days, and once weekly from day 7 up to 100 days.

V. Weterings et al. Submitted for publication

Survival of ESBL producing *Escherichia coli*
in three different suspension fluids

A biphasic survival curve for all materials was observed, whereby there was a rapid decrease in the number of viable bacteria in the first six hours, followed by a much slower decrease in the subsequent days.



Observed (circle ST10; triangle ST131) and predicted survival of ST10 (solid line) or ST131 (dotted line) in water, saline and sheep blood in the first 6h (I) and total study period (II).

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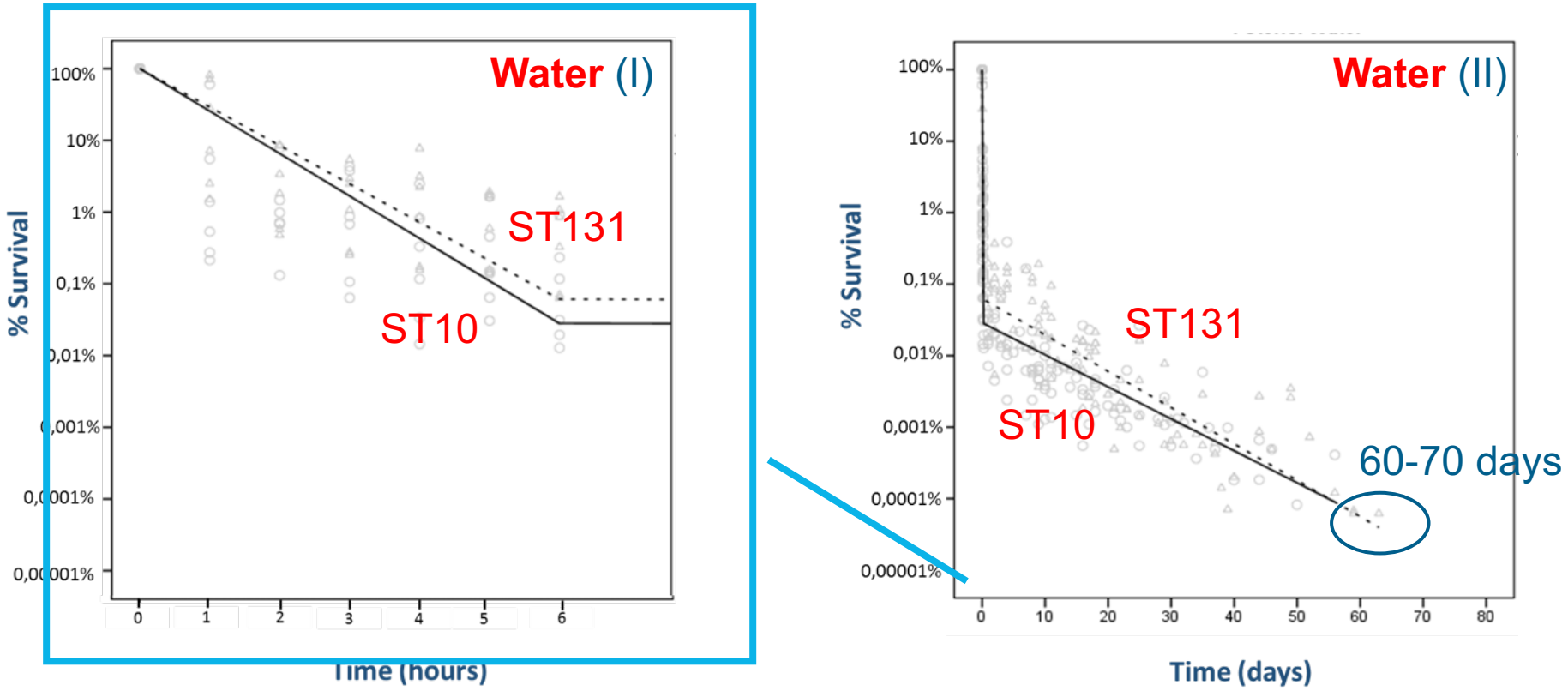

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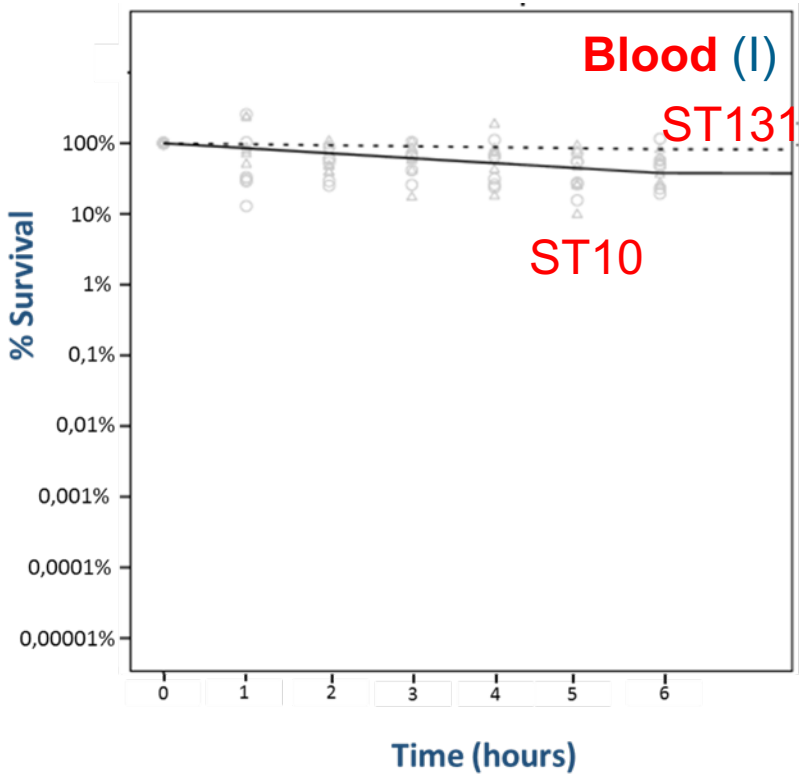

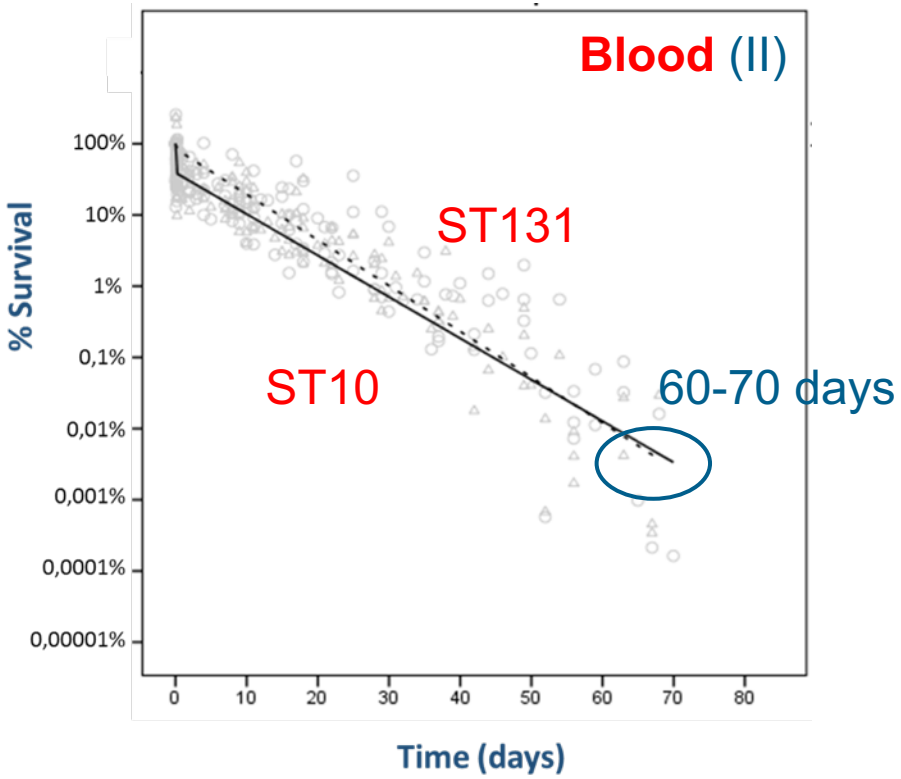

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Survival of ESBL producing *Escherichia coli*
in three different suspension fluids

This study shows that ESBL-producing *E. coli* ST10 and ST131 can survive on dry inanimate surfaces for long periods of time, even up to **71** days.

In the first 6h of the experiment:

- **Increased survival of ST131** as compared to ST10.
- The proportion surviving per hour was substantially higher in **sheep blood** than in the other media.

After the first 6h of the experiment

- No difference between suspension fluids and ST-type.

V. Weterings et al. Under submission

«OK, you made your point....»
cleaning is important!

Cleaning techniques

Boyce *Antimicrobial Resistance and Infection Control* (2016) 5:10
DOI 10.1186/s13756-016-0111-x

Antimicrobial Resistance and Infection Control

REVIEW Open Access

Modern technologies for improving cleaning and disinfection of environmental surfaces in hospitals

John M. Boyce

- Personnel-related issues
- Issues related to disinfection protocols and practices
- Monitoring housekeeping practices
- New liquid disinfectants
- Self-disinfecting surfaces
- No-touch room decontamination methods (e.g. hydrogen peroxide; ultraviolet)

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Modern technologies for improving cleaning and disinfection of environmental surfaces in hospitals

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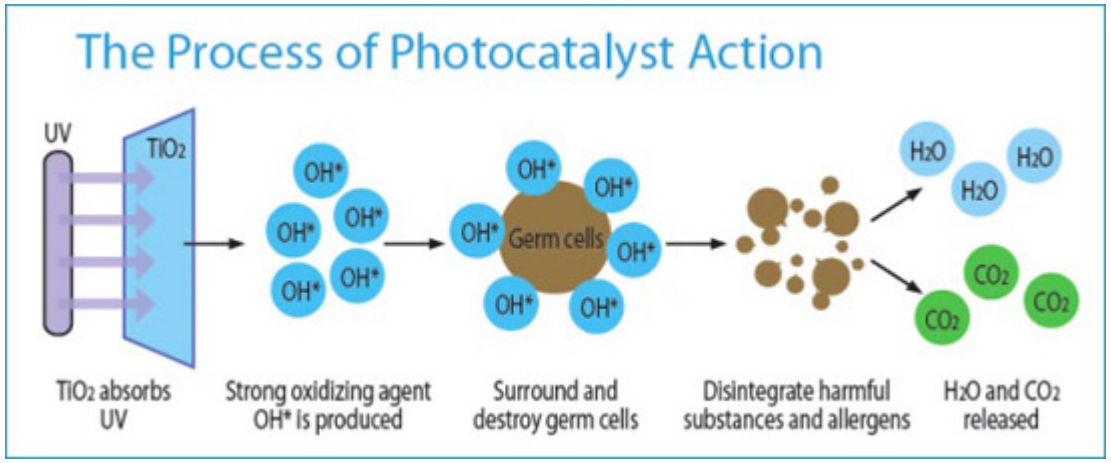
- Personnel-related issues
- Issues related to disinfection protocols and practices
- Monitoring housekeeping practices
- New liquid disinfectants
- Self-disinfecting surfaces (e.g. coatings)
- No-touch room decontamination methods - Xenex

Self disinfecting surfaces - coatings



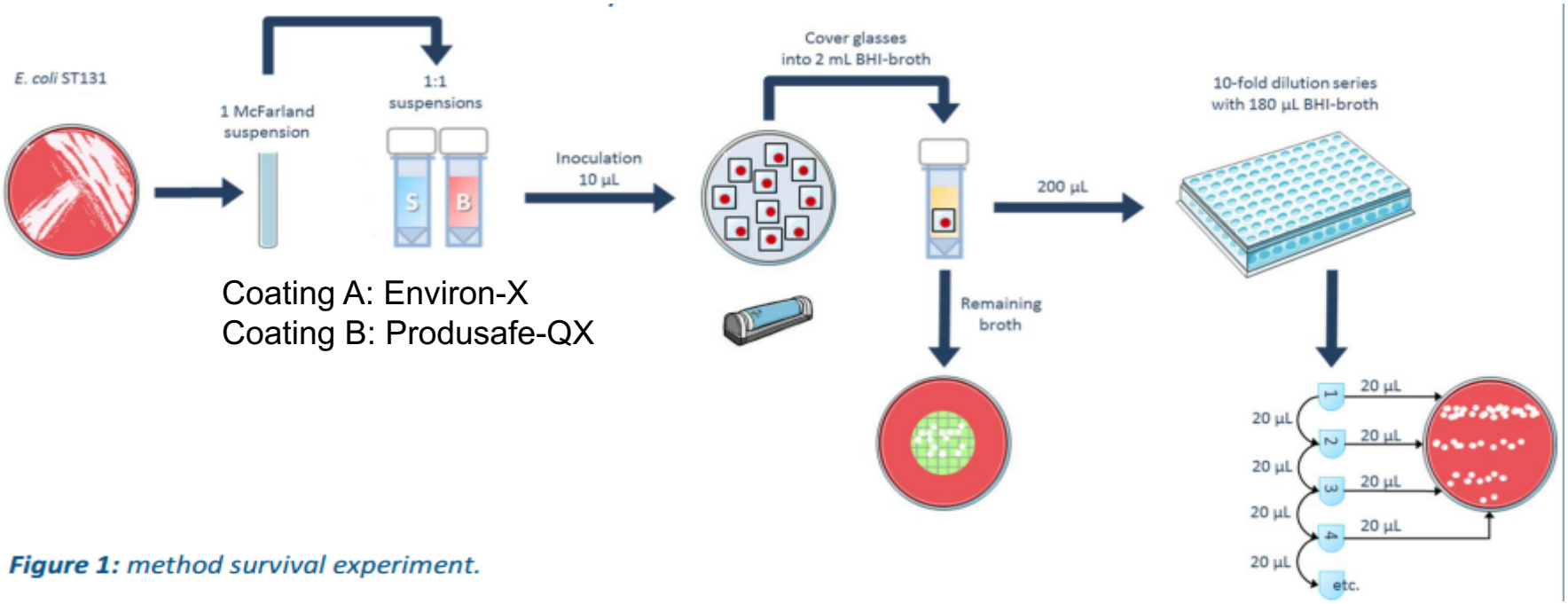
Titanium dioxide (TiO_2) + UV light → Reactive Oxigen Species (·OH)

↓

ROS damages the bacterial cell wall and membrane

We tested the influence of two TiO_2-based coating on the survival of Escherichia coli ST131 in the environment?

Self disinfecting surfaces - coatings



Coating A: Environ-X
Coating B: Produsafe-QX

***Figure 1:** method survival experiment.*

J.Stohr et al. Posterpresentation at ECCMID 2016

Self disinfecting surfaces - coatings

Coating A	reduction	Max effect
E.coli in sterile saline	1.55 log reduction	7 hour
E.coli in sheep blood	no reduction	-

Coating B	reduction	Max effect
E.coli in sterile saline	3.15 log reduction	5 hour
E.coli in sheep blood	no reduction	-

J.Stohr et al. Posterpresentation at ECCMID 2016

Self disinfecting surfaces - coatings

This study shows that TiO_2-based coatings reduce bacterial survival in sterile saline in an in vitro setting.

Questions remain with respect to the efficacy of TiO2 based coatings in clinical settings, as

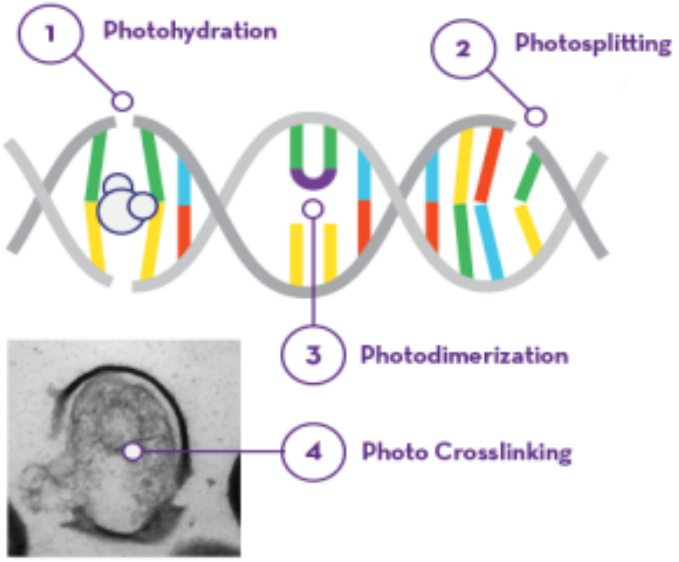
- the antibacterial effect was absent in the presence of blood;
- the presence of UV-light is a prerequisite for the antibacterial effect;
- data on the long-term persistence of the antibacterial effect of TiO2 coatings are lacking

* Environ-X and Produsafe QX supplied the coated cover glasses, but didn't participate in the study design, the interpretation of results, or the decision to publish the data.

Pulsed Xenon Ultravilote light

The Xenex Pulsed Xenon lamps produce a flash of full spectrum germicidal light that irreversibly damages micro-organisms.

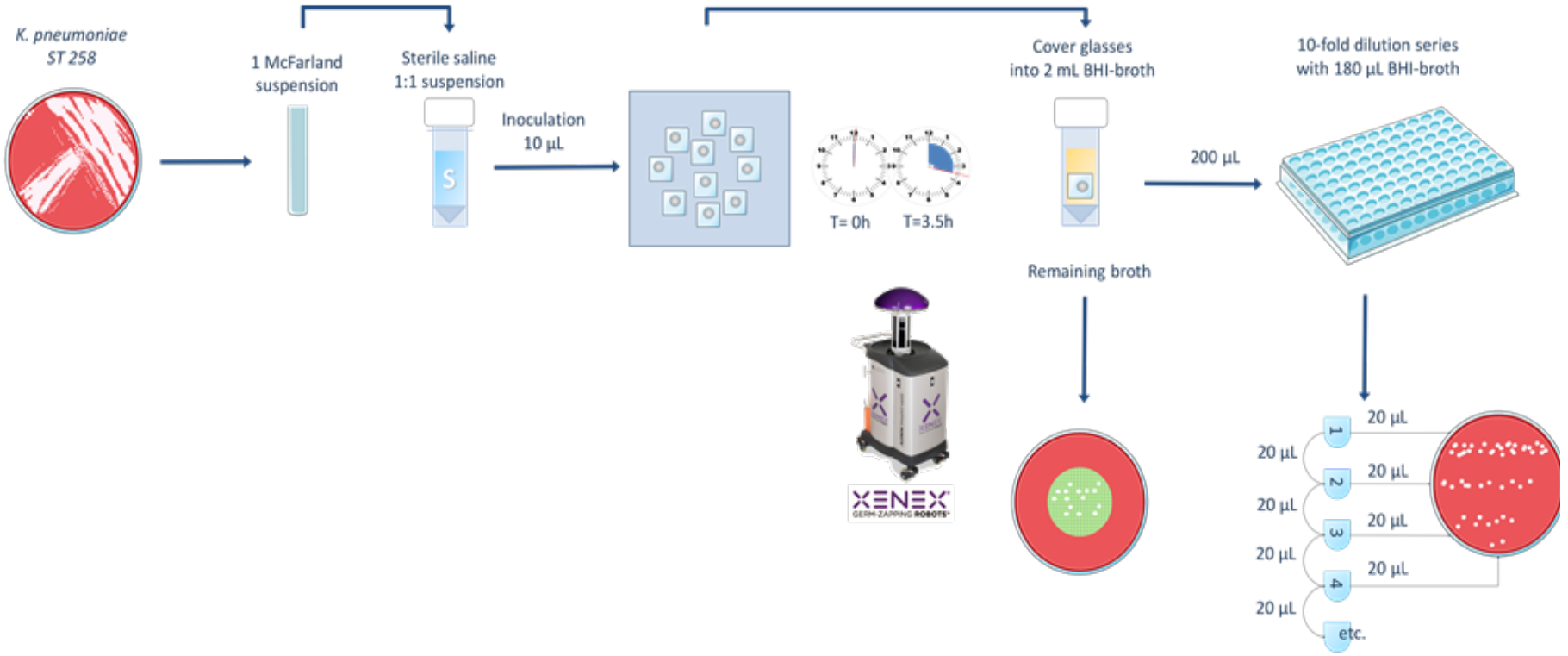
1. Photohydration (pulling water molecules into the DNA that prevents transcription)
2. Photosplitting (breaking the backbone of the DNA)
3. Photodimerization (improper fusing of DNA bases)
4. Photo crosslinking (cell wall damage and cell lysis)



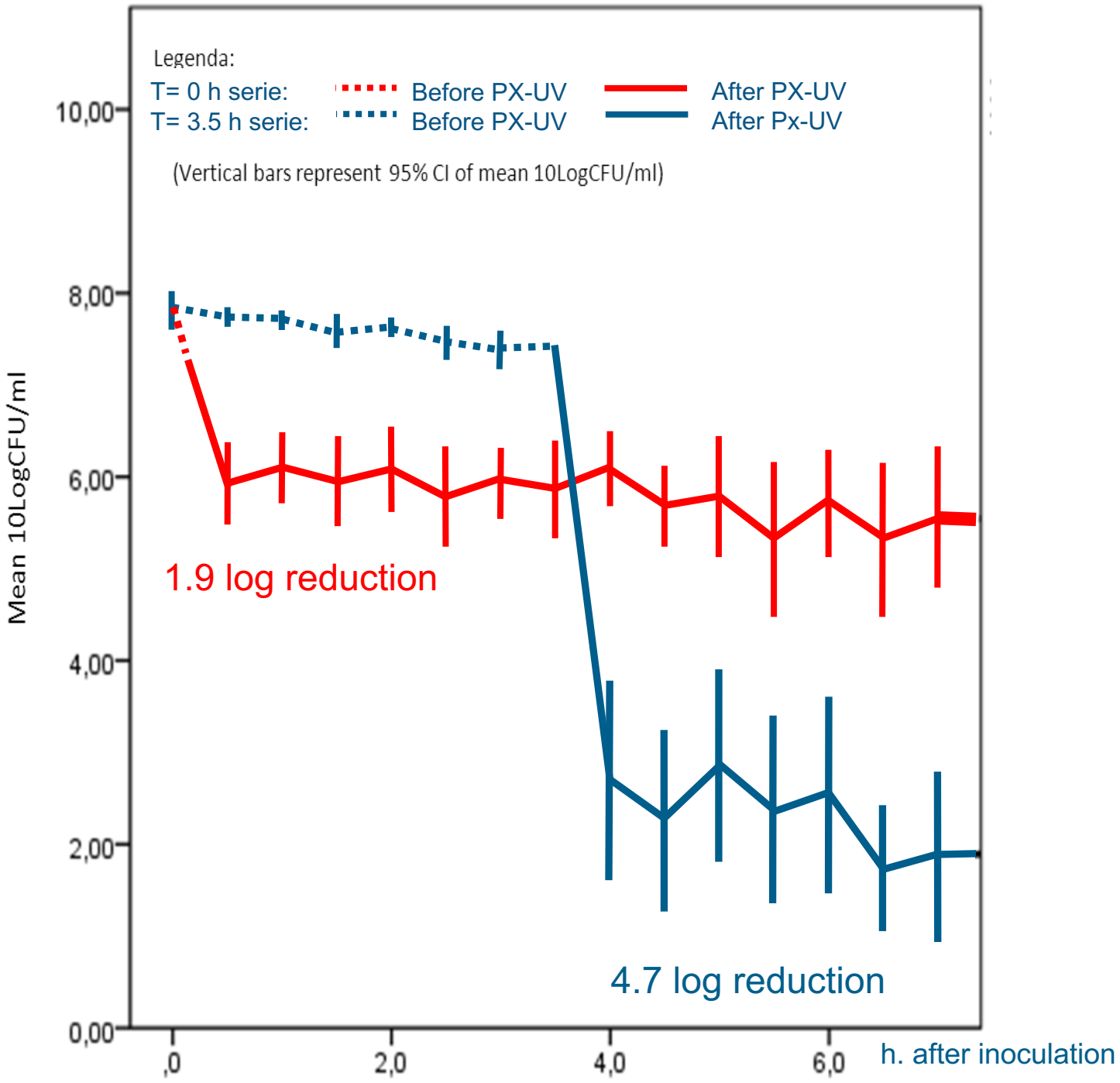
Easy in use
No need to seal room vents or doors
No penetration through glass or plastic

Pulsed Xenon Ultravilote light

What is the influence of PX-UV, after variable time-intervals, on the survival time of *K. pneumoniae* Sequence Type (ST) 258, a pandemic strain.



I. Willemsen et al. Oral presentation at ECCMID 2016


Legenda:
T= 0 h serie:
Before PX-UV
After PX-UV
T= 3.5 h serie:
Before PX-UV
After Px-UV
(Vertical bars represent 95% CI of mean 10LogCFU/ml)
Mean 10LogCFU/ml
10,00
8,00
6,00
4,00
2,00
0,00
1.9 log reduction
4.7 log reduction
,0
2,0
4,0
6,0
h. after inoculation

Pulsed Xenon Ultravilote light

This study shows that PX-UV effectively reduces bacterial counts in the environment.
However, the effect was much stronger after 3.5 hours.
This is probably due to the evaporation of water, exposing the bacteria to the direct effect of UV-light.

The PX-UV is a promising technique to control environmental contamination with highly-resistant microorganisms. This should be studied in a clinical setting.

* REV Desinfectie Robots supplied the Xenex Germ-Zapping Robot, but didn't participate in the study design, the interpretation of results, or the decision to publish the data.

Laboratory versus clinical setting

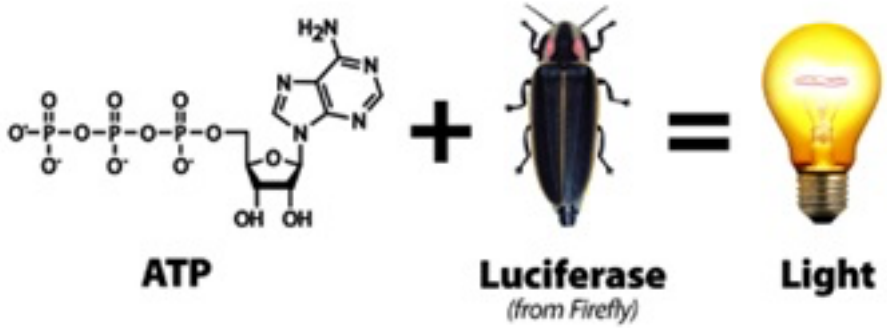
Wat is clean?

Measuring environmental contamination

Method	Advantages	Disadvantages
Visual inspection	Simple	Does not provide reliable assessment of cleanliness
Fluorescent marker system	Inexpensive Minimal equipment needed	Must mark surfaces before cleaning, and check them after cleaning
Aerobic colony counts	Relatively simple Detects presence of pathogens	More expensive Results not available after 48 hrs
ATP bioluminescence assay systems	Provides quantitative measure of cleanliness Quick results	More expensive Requires special equipment

Measuring environmental contamination

ATP (Adenosine Tri-Phosphate) = Organic matter (debris, food, bacteria)
The presence of ATP is indicative for insufficient cleaning



The more light (= RLU), the more contamination

Advantage:

- Standardized
- Objective
- Quantitative
- Real time feedback
- Useful for education purposes and feedback

Griffith CL et al. J Hosp Infect 2000;45:19; Boyce JM et al. Infect Control Hosp Epidemiol 2009;30:678; Boyce JM et al. Infect Control Hosp Epidemiol 2010;31:99

Interpretation ATP measurement

CLEAN	CONTAMINATED
< 1500 RLU	>250

Inmediately after cleaning

CLEAN	CONTAMINATED
< 1500 RLU	>1500

During the day

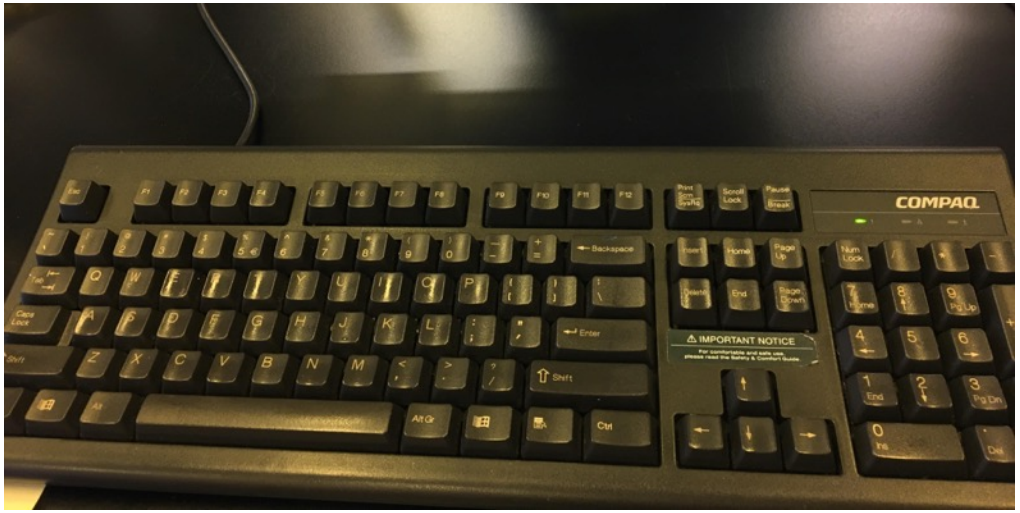
CLEAN	INTERMEDIATE	CONTAMINATED
< 1500 RLU	1500 – 3000 RLU	> 3000 RLU

* *Sherlock et al. Is it really clean? J. Hosp. Infect. 2009;72:140-146*

* *Boyce JM et al. Infect. Control. Hosp. Epidemiol. 2009;30:678084*

Interpretation ATP measurement

CLEAN	GREY ZONE	CONTAMINATED
< 1500 RLU	1500 – 3000 RLU	>3000 RLU



Computer keyboard
in our laboratory

2.603 RLU

Interpretation ATP measurement

CLEAN	GREY ZONE	CONTAMINATED
< 1500 RLU	1500 – 3000 RLU	> 3000 RLU

Computer keyboard in our laboratory **after cleaning**

639 RLU

Interpretation ATP measurement

CLEAN	GREY ZONE	CONTAMINATED
< 1500 RLU	1500 – 3000 RLU	> 3000 RLU

Table in the canteen, with food rest!

9,194 RLU

Interpretation ATP measurement

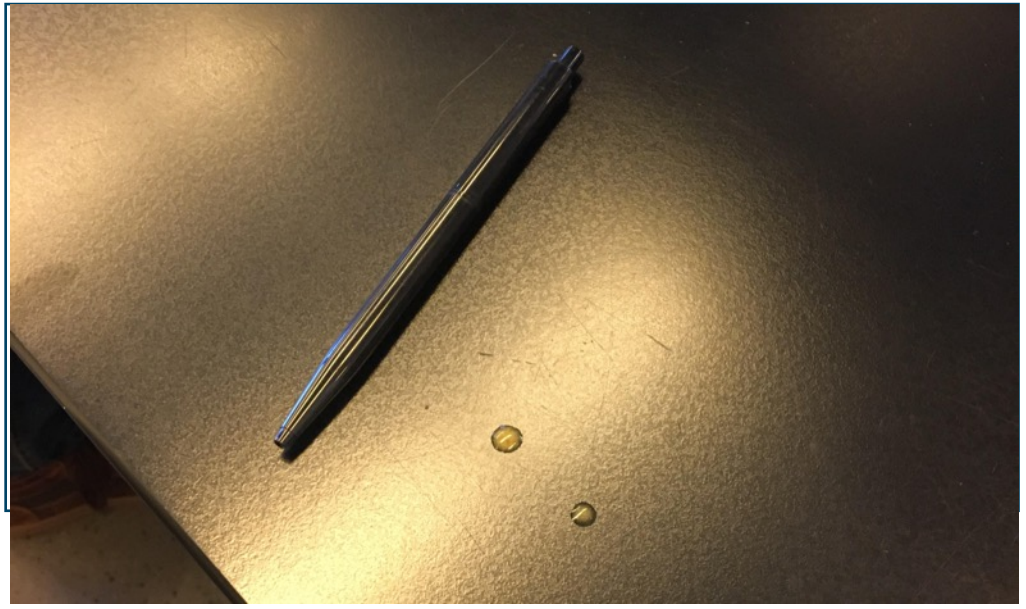
CLEAN	GREY ZONE	CONTAMINATED
< 1500 RLU	1500 – 3000 RLU	> 3000 RLU

Table in the canteen, with food rest, **after cleaning**

329 RLU

Interpretation ATP measurement

CLEAN	GREY ZONE	CONTAMINATED
< 1500 RLU	1500 – 3000 RLU	> 3000 RLU



Body fluid !!
one small droplet

97,074 RLU

Measuring environmental contamination

Which items should be tested?

1. Frequently touched by patients

2. Frequently touched by healthcare workers

3. Medical devices
   - Glucose meter
   - Thermometer

4. Sanitary items
   - Toilet seat
   - Potty chair

RESULTS Amphia hospital (example ward A)

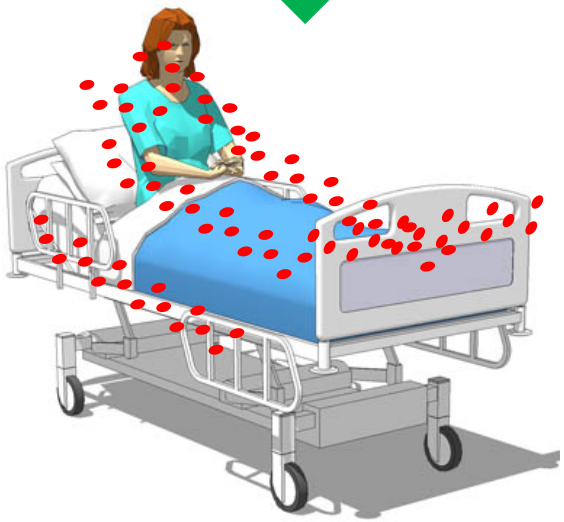
locatie	ward A (I)	ward A (II)	ward A (III)
bed rail	1858	1841	2158
bed rail	5683	1759	776
overbed table (surface top)	2816	638	435
washstand	397	134	109
shower chair	1068	3097	179
support bar in the toilet room	1870	569	828
toilet seat (upper-side)	12131	3579	6339
door handle nursing office	3195	1138	962
patient alarm bell	3443	11411	1535
i.v. pole (most frequently touched part)	3954	1069	1271
keyboard PC in the nursing office	6370	3611	2400
ward telephone (inside nursing office)	2536	4766	822
control panel bedpan washer	400	198	99
bedside commode (bedpan-chair)	968	757	4193
cabinet for medical supply & bandages (hand grip	1652	1876	357
blood pressure cuff	1148	1187	578
ear thermometer	1701	1390	553
blood glucose meter	1541	881	844
work surface of the bench for drug preparation	833	55	193
keyboard Computeer On Wheels (COW)	8209	983	1814

RESULTS nursing home (example NH A)

RESULTS nursing home (example NH A and B)

bed rail	3.373	1566		926	233
overbed table	9.689	3044		1.119	80
toilet seat	938	3981		1.407	233
bedside commode	3.196	3535		1239	1299
washstand	36.560	261		1329	1040
support bar toilet	38.846	8164		1198	2096
table livingroom	3.446	282		1608	233
doorknob livingroom	6.552	7091		7113	1237
keyboard computer	706	3492		1.030	521
telephone	1.703	4804		2975	1476
medicine supply	1.181	2061		439	287
cabinet for medical supplies & ban	215	3607		5451	55
ear thermometre	895	3142		296	672
glood glucose meter	2.393	3391		190	302
patient lift handle	221.269	22.132		1149	9590

RISK IN HEALTHCARE



Bundle approach

"a collection of things, tied or wrapped up together"

Infection RIsk Scan = IRIS

Measurement of both patient and ward-related variables.

Standardised
Objective
Bundle approach

Outcome or process values are compared to **reference data** (breakpoints) and classified in risk categories: **high**, **intermediate**, **low** risk (traffic light colors)

Results are visualised in a risk profile and an improvement plot

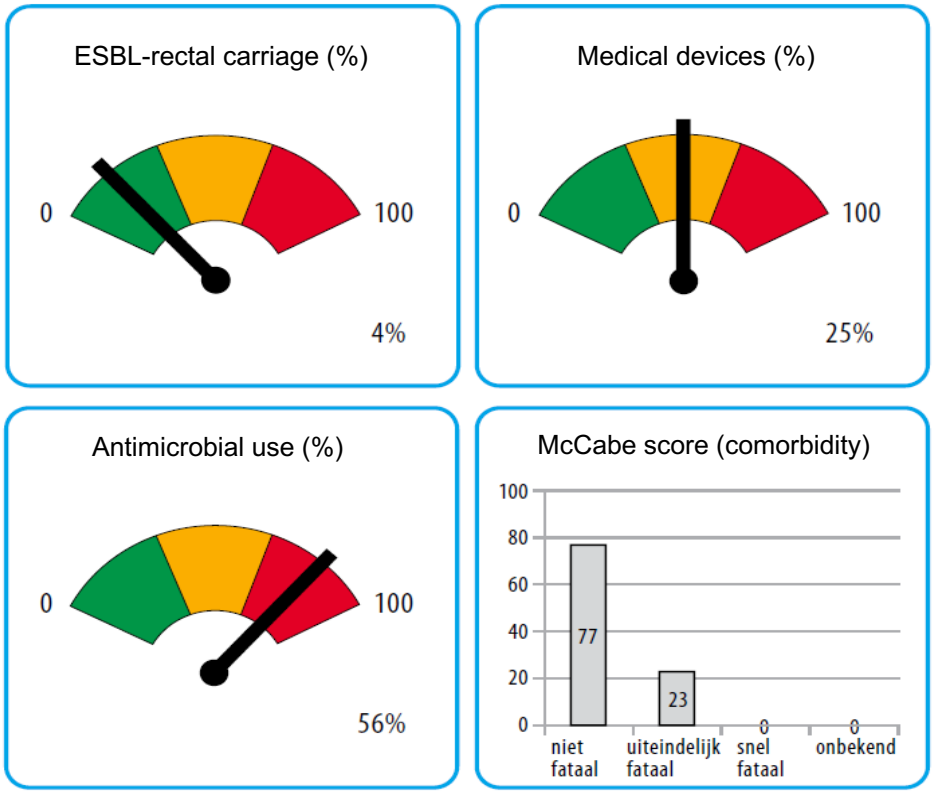
Infection RIsk Scan = IRIS

RISK PROFILE
Patient-related risks

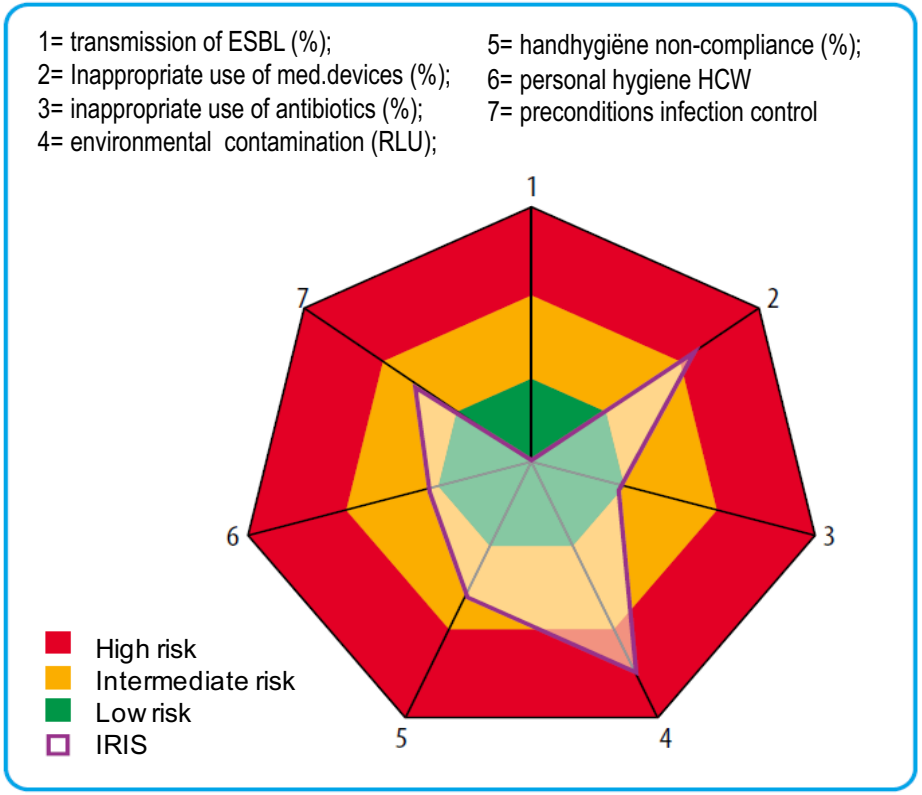
IMPROVEMENT PLOT
Variables that can be influenced by HCWs

Infection RIsk Scan = IRIS

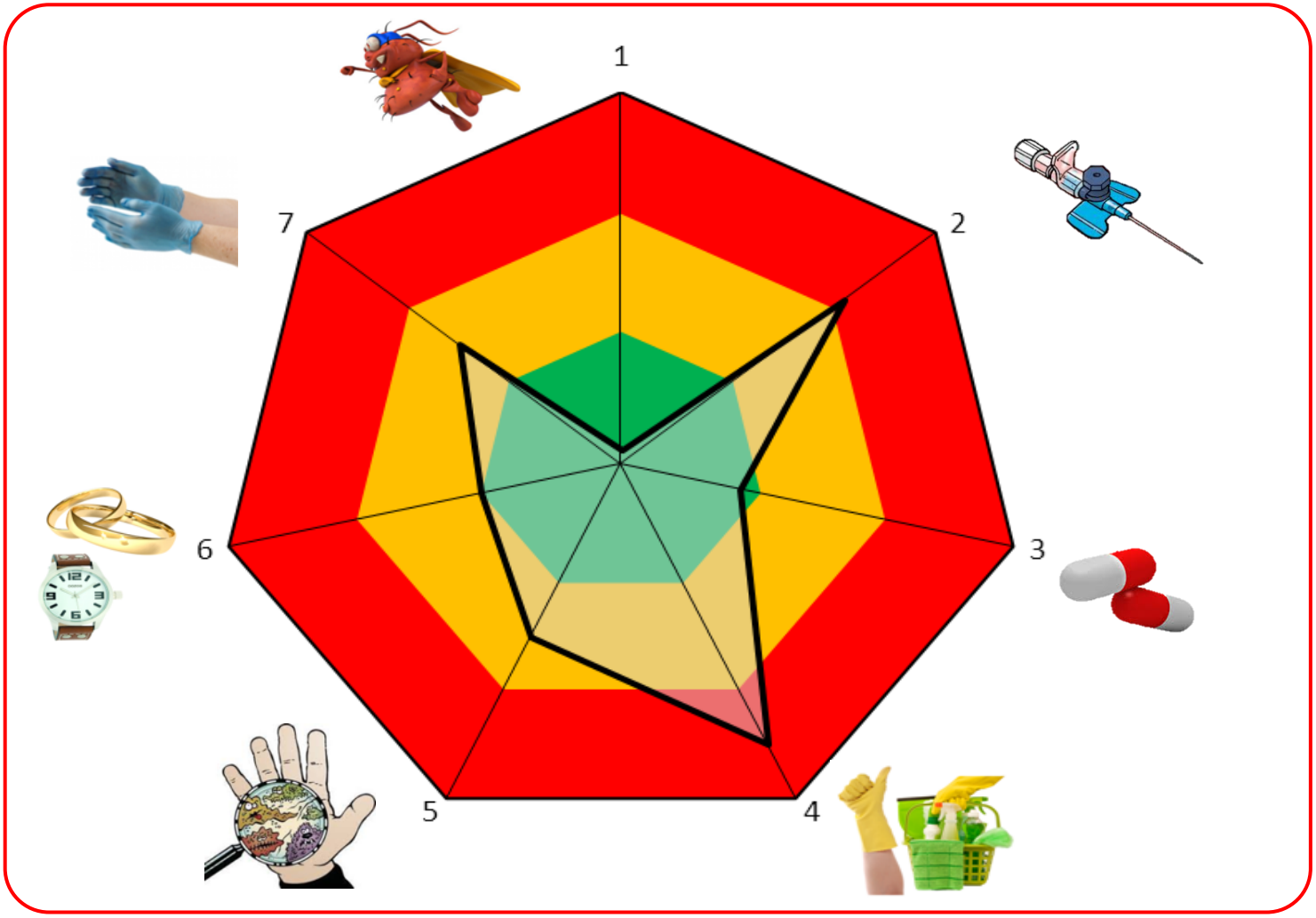
RISK PROFILE



IMPROVEMENT PLOT



Infection RIsk Scan = IRIS



1= transmission of ESBL (%);

2= Inappropriate use of med.devices (%)

3= inappropriate use of antibiotics (%);

4= environmental contamination (RLU);

5= handhygiëne non-compliance (%);

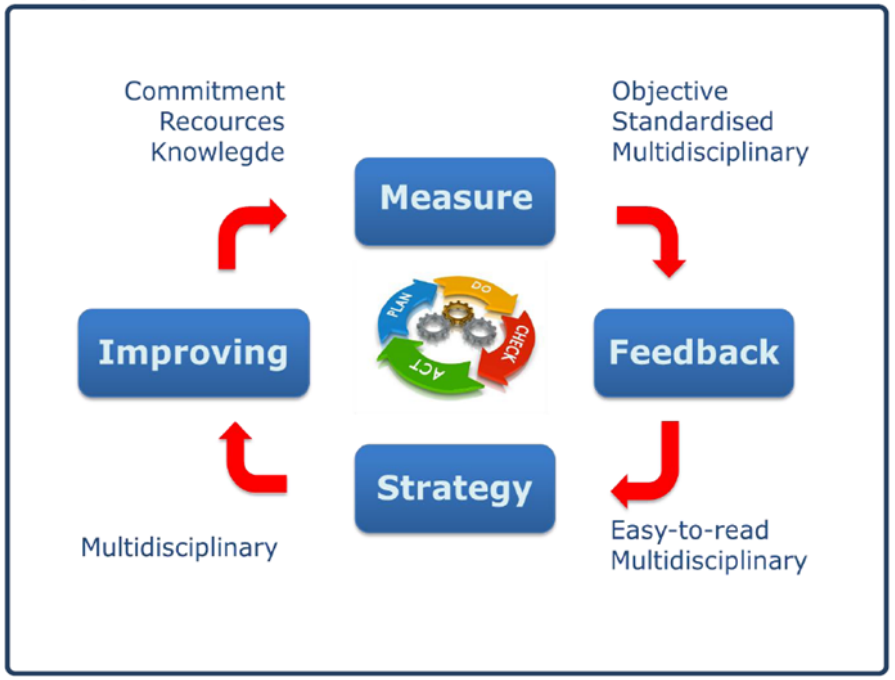
6= personal hygiene HCW

7= preconditions infection control

Infection RIsk Scan = IRIS

To provide **relevant** and **easy to understand** information, showing an overall view of the current infection control practice.

Based on the results a **targeted quality improvement program is implemented**.



IRIS – Amphia hospital

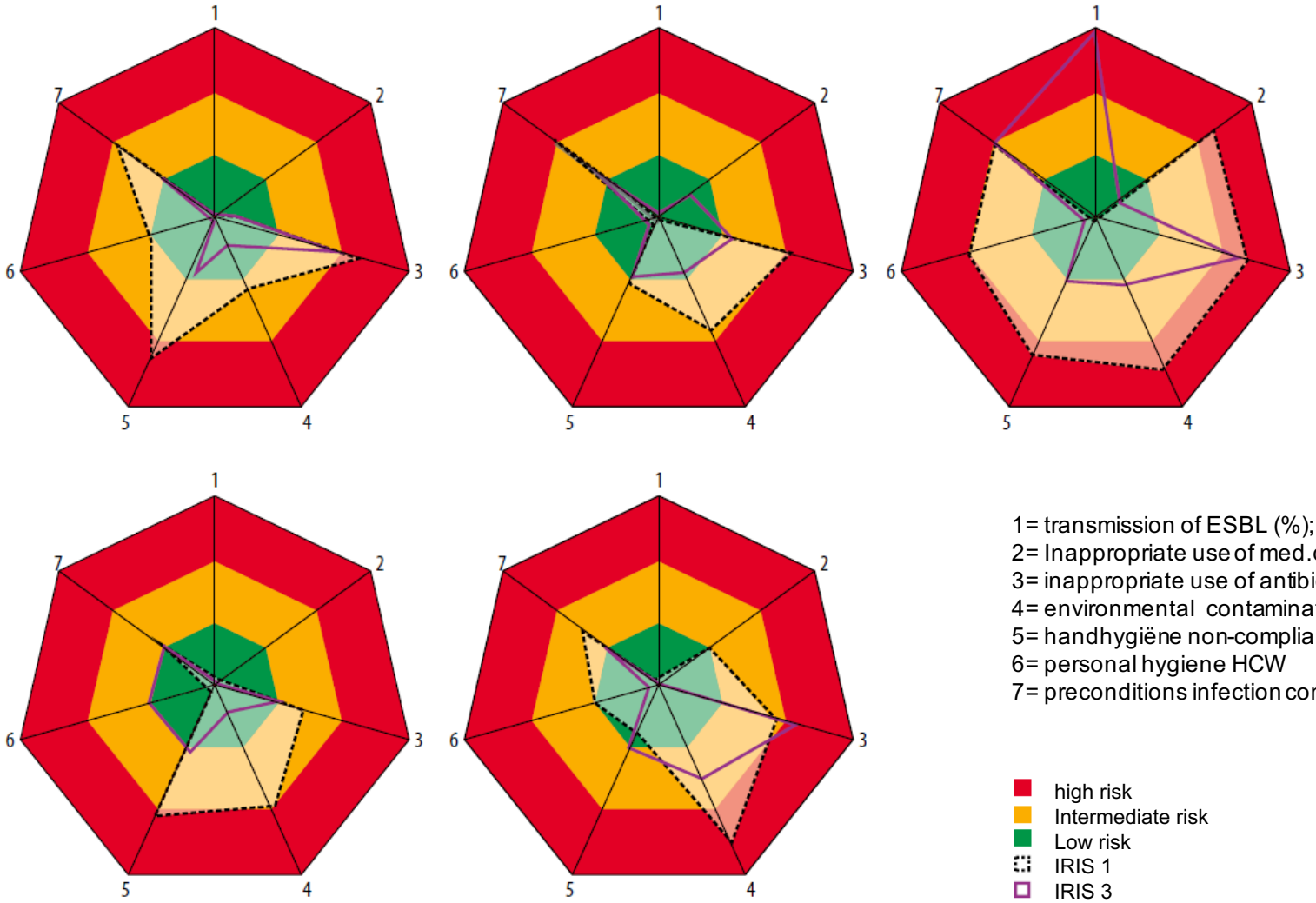


Figure: improvement plots from 5 hospital wards of different medical specialties. IRIS was performed tree times with an interval of 6-8 months

** Willemsen & Kluytmans. De Infectierisicoscan in de praktijk, Verbetering van infectiepreventie en antibiotica gebruik door transparantie. NTvG. 2016*

Environmental contamination

High level of contamination of:

- Keyboard Computer on wheels (COW)
- Potty-chairs
- “ orphan“ objects

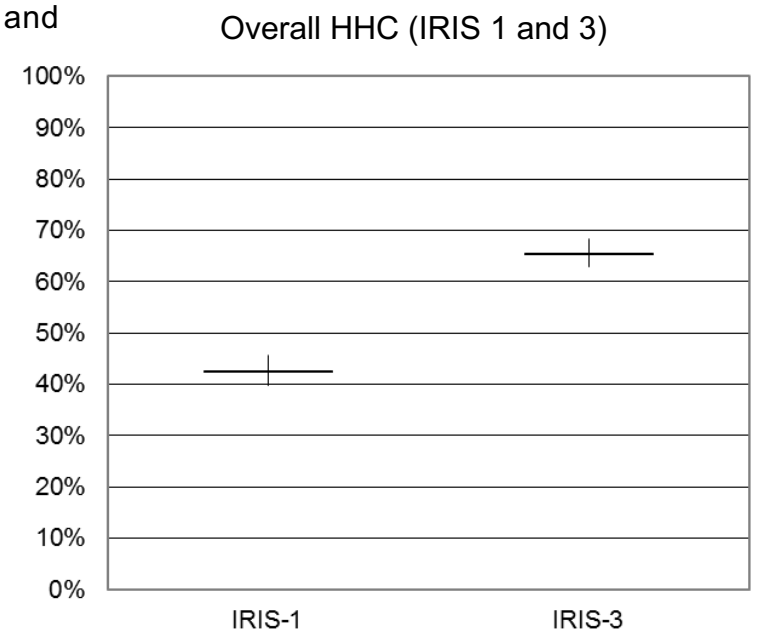
- Better agreements on responsibilities
- Dedicated cleaning staff
- Monitoring cleaning practices
- Monitoring cleaning performed by nursing staf

→ Significant reduction in ATP level ($p<0.0001$)

HANDHYGIENE

- Education program Hand hygiene (performed by nurses)
- Hand disinfectants at the bed-side
- Peer review feedback
- Increase in compliance from 43% to 66%
  (over 1000 observations per IRIS, p<0.000)

and



Infection RIsk Scan – Nursing Homes

- Residential setting
- More interaction between residents
- Lower awareness about hygiene among residents
- Difficult instruction opportunities among residents

Infection RIsk Scan – Nursing Homes (NH)

Setting: 9 Nursing Homes within one organisation
Inclusion: 774 residents (range 14-189 per NH)

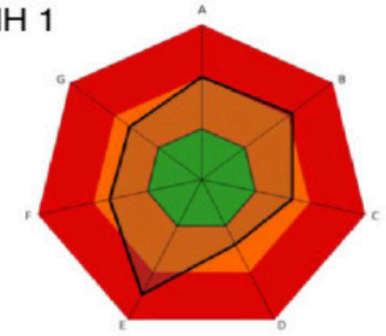
No significant difference in population between the 9 NHs.

An IRIS scan was performed. Results were expressed in an IRIS-plot for each NH

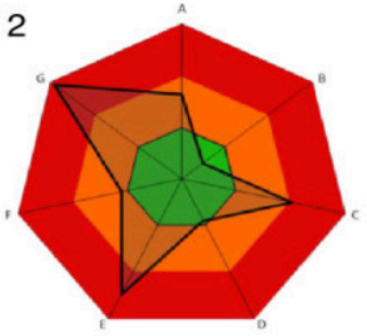
** Willemsen et al. Measuring the qualitt of infection control in Dutch nursing homes using the IRIS. Antimicrob Resist and Inf Control. 2014*

Infection RIsk Scan – Nursing Homes (NH)

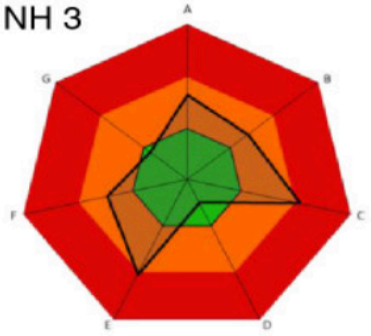
NH 1



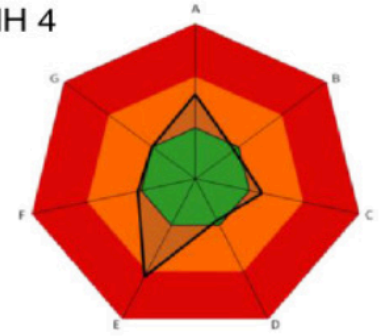
NH 2



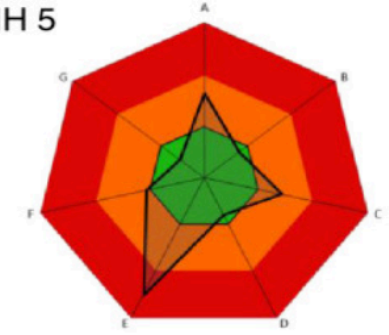
NH 3



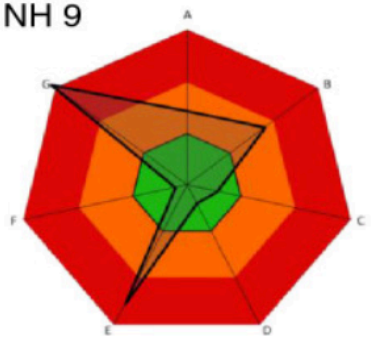
NH 4



NH 5



NH 9



A= local guidelines not available;
B=shortcomings in constraints;
C=healthcare associated infections;
D=use of medical devices;
E=environmental contamination;
F=antimicrobial use;
G=ESBL carriage

All axis are scaled from 0 up to 100% of the total population of tested subjects/objects

- high
- intermediate
- low
- risicoscan

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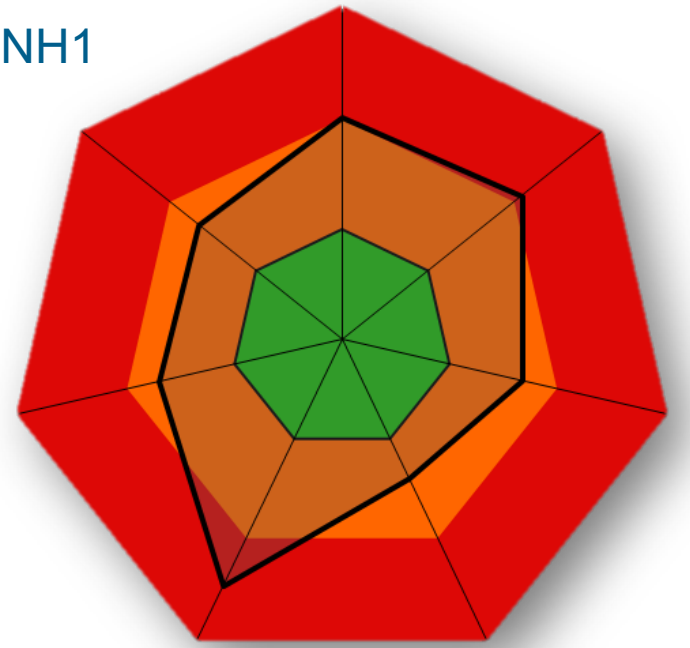
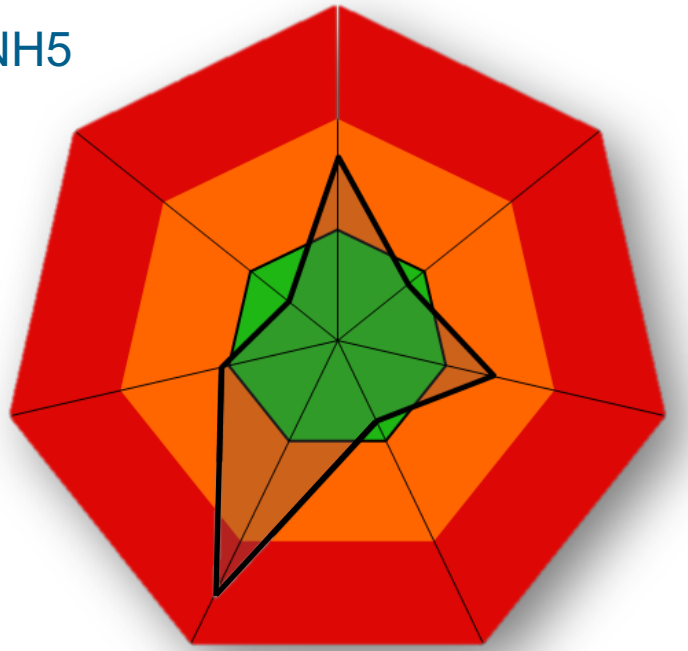
Infection RIsk Scan – Nursing Homes (NH)

NH1



NH5



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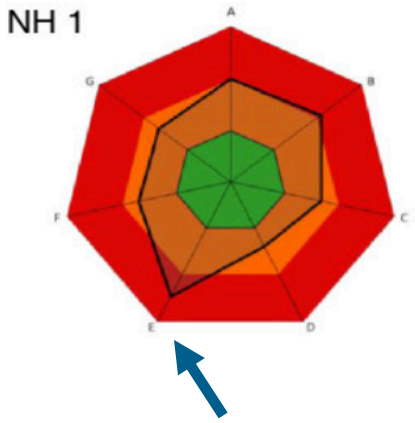

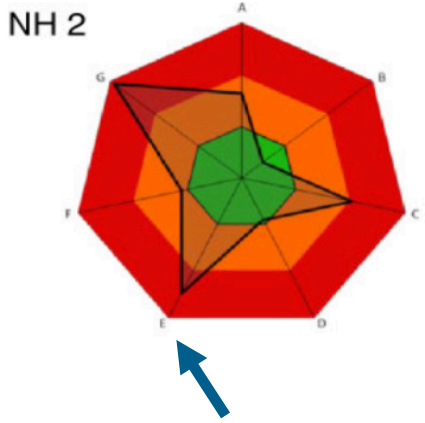

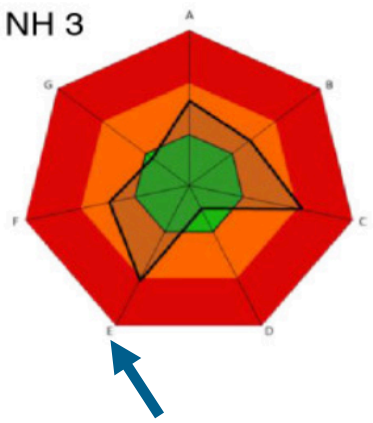

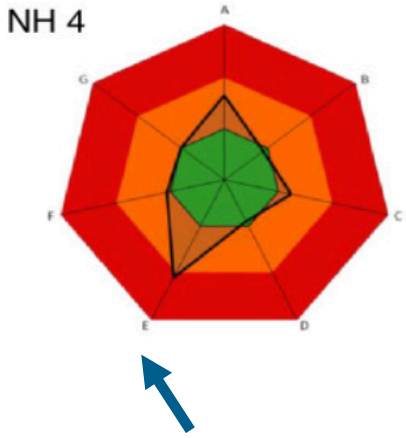

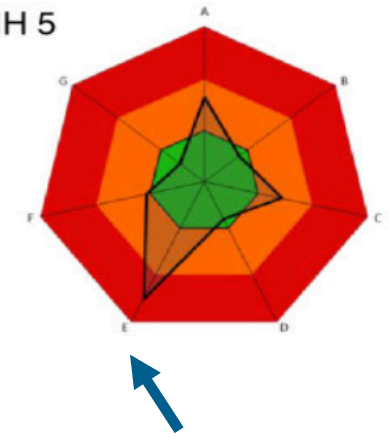

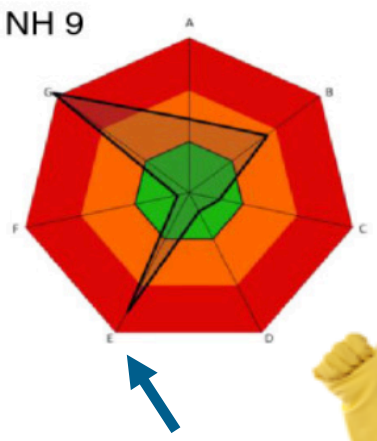

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Infection RIsk Scan – Nursing Homes (NH)

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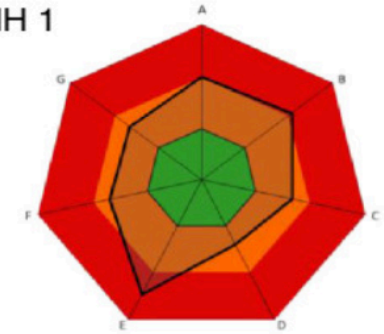

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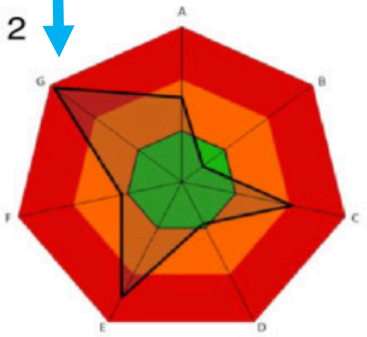
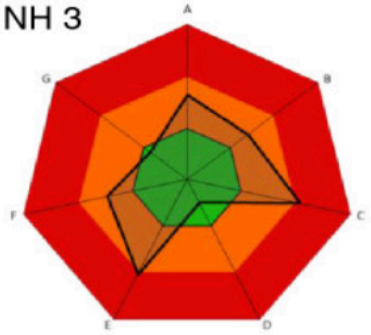


NH 3



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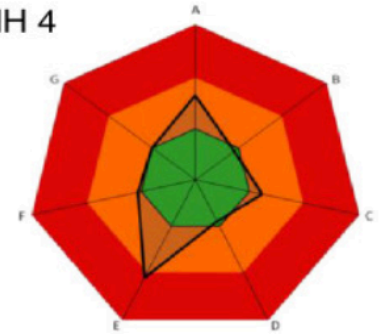
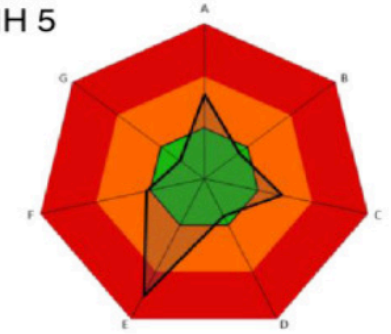
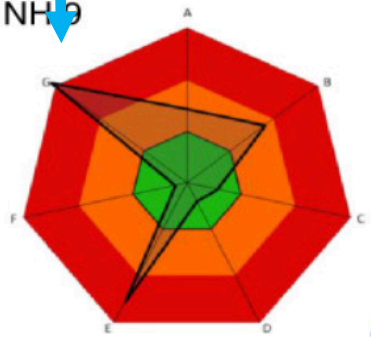


NH 5



NH 9



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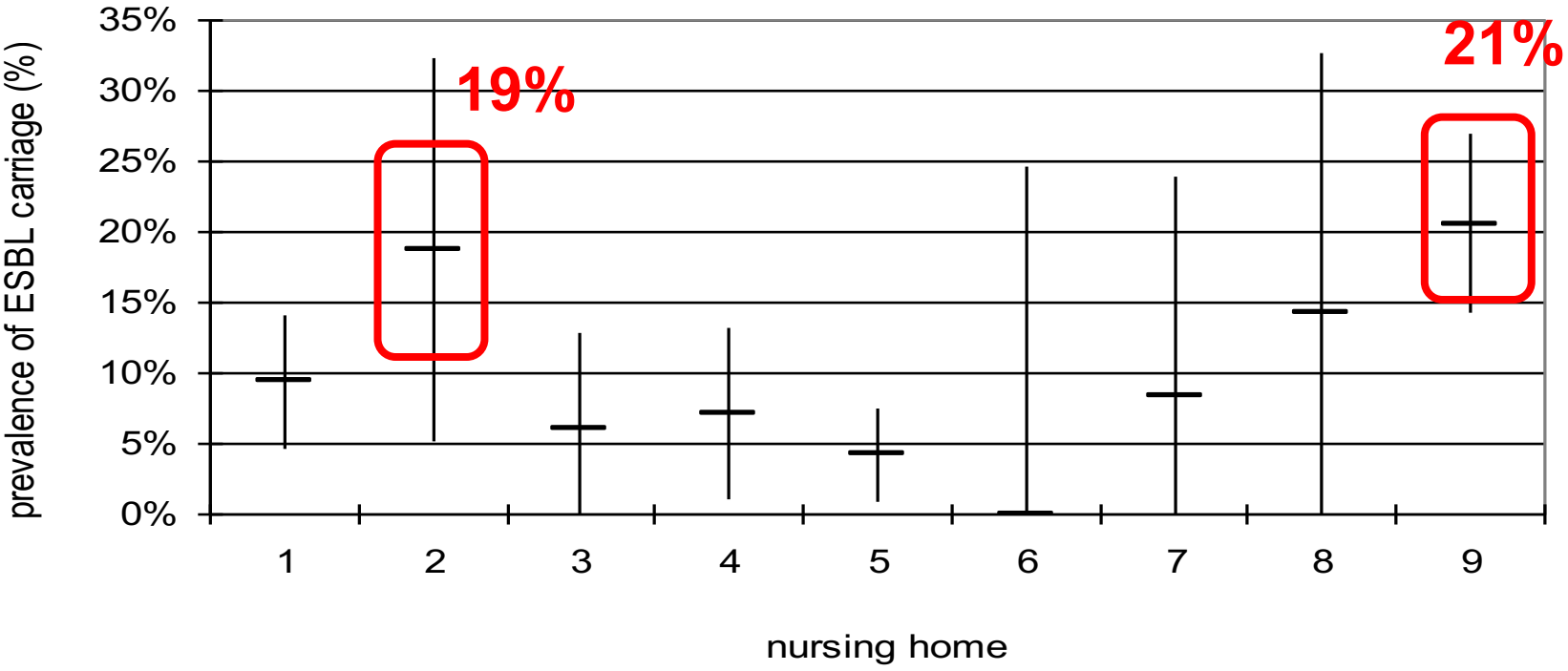
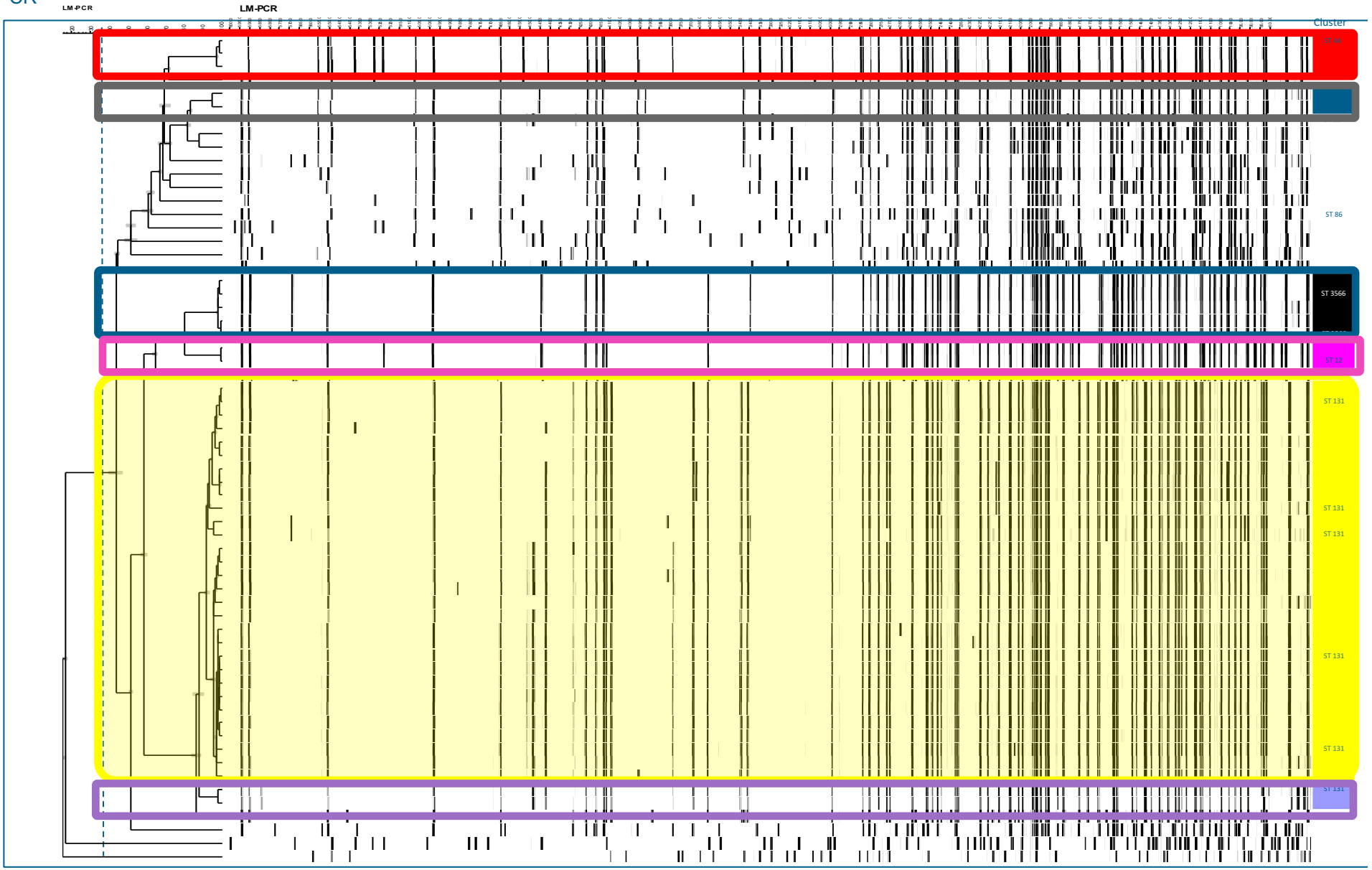
Antimicrobial resistance in the NH



643 out of 774 residents were screened → 70/643 (10.9%) ESBL carriage

ef:121207eco.Breda
M-PCR

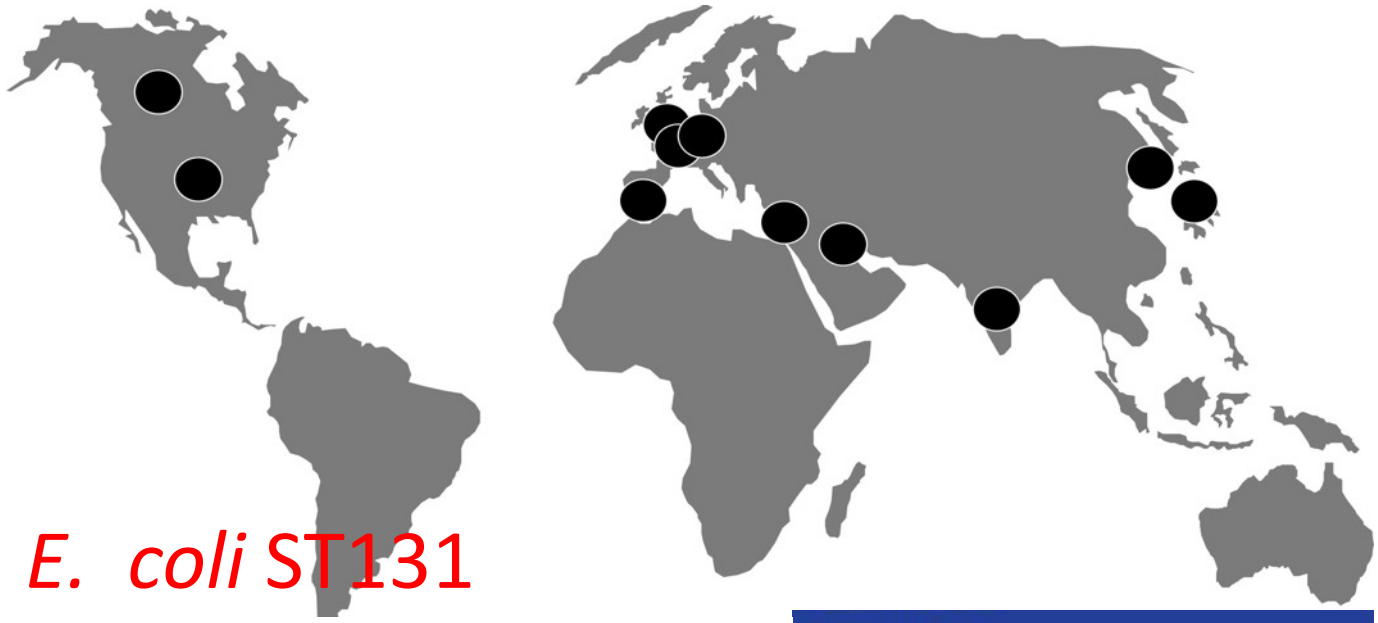
E. coli / Breda



Outbreak strain – *E. coli* ST131

E. coli ST131 is a “highly transmissable” and virulent outbreak strain.

- Long term carriage
- “Super clone”
- Virulent
- Resistent



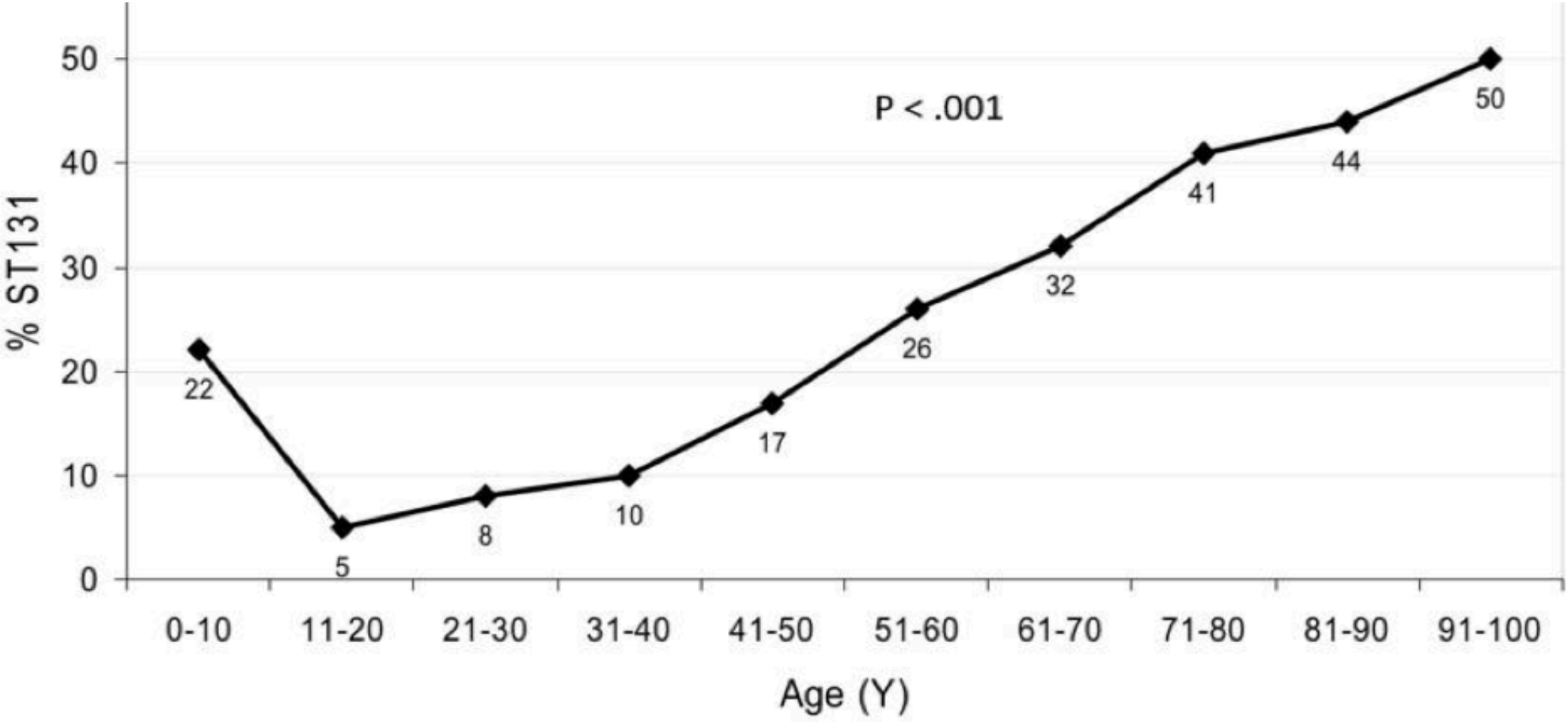
E. coli ST131

Livermore D M J. Antimicrob. Chemother. 2009;64:i29-i36

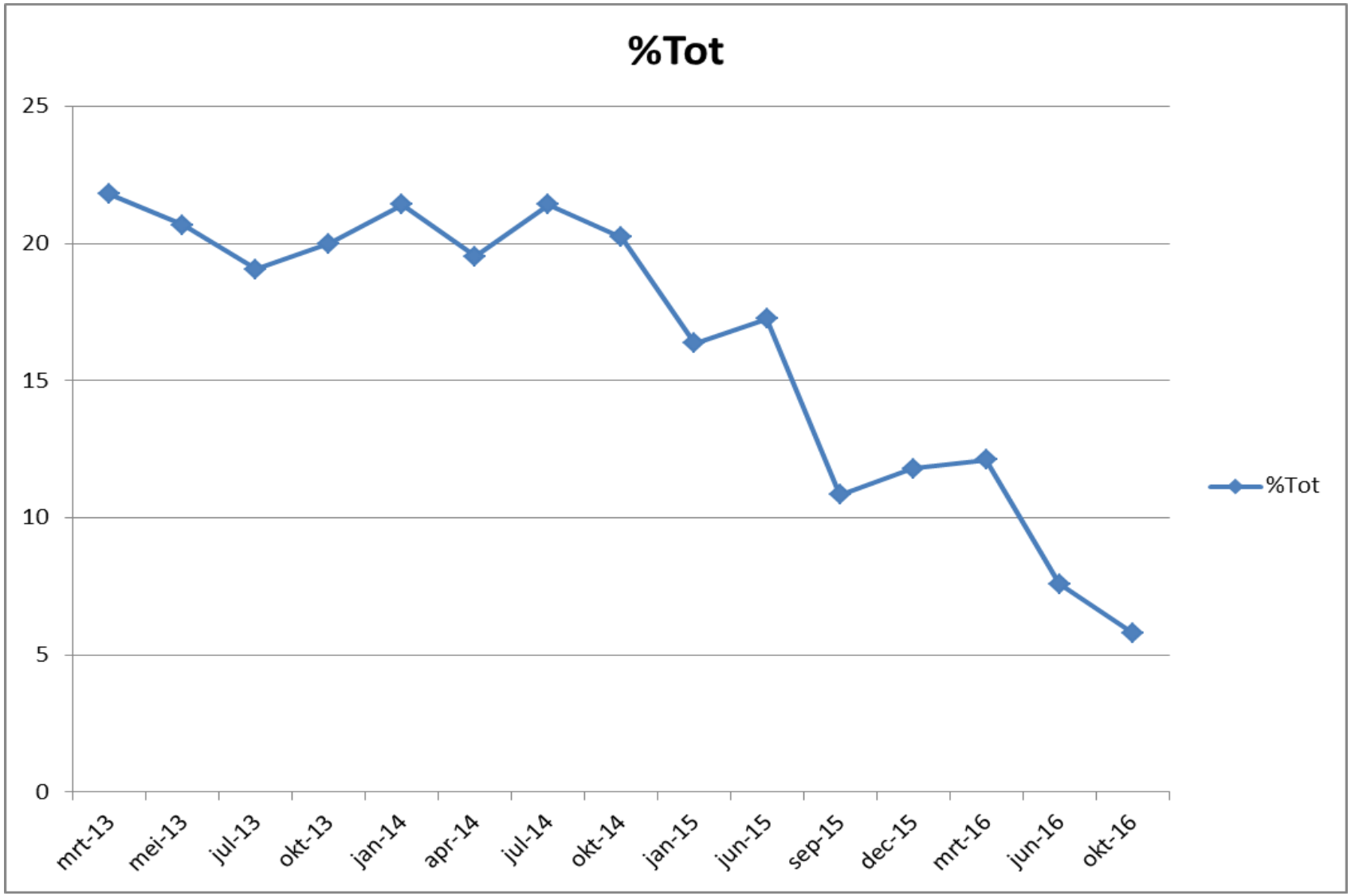
Journal of Antimicrobial Chemotherapy

Escherichia coli Sequence Type 131 Is a Dominant, Antimicrobial-Resistant Clonal Group Associated with Healthcare and Elderly Hosts

Ritu Banerjee, MD, PhD;[1] Brian Johnston, BS;[2] Christine Lohse, MS;[3] Stephen B. Porter, BS;[2] Connie Clabots, BS;[2] James R. Johnson, MD[2]



Current situation in this NH



Cleaning in the 21th century


IT DOESN'T HURT TO BE OPTIMISTIC. YOU CAN ALWAYS CRY LATER.
LUCIMAR SANTOS DE LIMA
PICTUREQUOTES.com

i-4-1-health project (Netherland – Belgium)

Goal: to obtain insight in the presence and transmission of antimicrobial resistance in

- Hospitals
- Nursing homes
- Schools and kindergardens
- Veterinary farms

by using the IRIS method

The ultimate goal is to control and reduce resistance in the border area.

I-4-1 HEALTH

Interreg
EUROPESE UNIE
Vlaanderen-Nederland
Europees Fonds voor Regionale Ontwikkeling

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Amphia ziekenhuis
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- Joep Stohr
- Jolande Nelson

Thebe
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- Sandrien Verhoef

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- Leonard Mermel

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- Martine Verelst
- Veroniek Saegemans