

The hospital environment as a source of resistant Gram negatives

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Conflicts of interest

- No conflict to declare in relation to this presentation.

Overview

- Is it a problem?
- Is there a link?
- Cleaning approaches



“Dry dirt is comparatively safe dirt”

“Wet dirt becomes dangerous”

Florence Nightingale



A problem: survival of healthcare pathogens

MRSA	7 days to >7 months	4 cfu's
Acinetobacter	3 days to >5 months	250 cfu's
<i>E.coli</i>	12 months	10-10 ⁶ cfu's
<i>K.pneumoniae</i>	12 months	10 ² cfu's
<i>C.difficile</i>	>5 months	7 spores
VRE	5 days to >4 months	<10 ³ cfu's
Norovirus	8 hours to 7 days	<20 virions

Courtesy: Stephanie Dancer

Kramer, BMC Infect Dis, 2006; Wagenvoort, JHI 2000; Chiang, Crit Care Med 2009;

Wilcox M, 2010; Larson, Lancet 1978; Kjerulf et al, APMIS 1998

A Problem: survival of ESBL producers

- *Klebsiella* Vs *E. coli*

- Guet-Revillet et al (2012), AJIC 40:845-848.
 - 46 *Escherichia coli* and 48 *Klebsiella* infected/carrier patients were included
 - 4% of the 470 environmental samples performed yielded ESBL
 - *Klebsiella* spp was the most frequent species isolated in 15 rooms, (17%) Vs *E.coli* twice (*Citrobacter freundii* once)
 - hospital environmental contamination is more frequent in instances of fecal carriage or infection with ESBL-producing *Klebsiella* than ESBL-producing *E coli*.
- Gbaguidi-Haore et al (AJIC) 2013
 - Nineteen percent (4/21) of ESBL-*Klebsiella* and 3.7% (2/54) of ESBL-*E.coli* carriers environments were contaminated with the patient's EBLS *Enterobacteriaceae*

A problem: Detection rate of MR G+ve & GN-ve bacteria from environmental sites

Table I Isolation of multi-resistant pathogens from patients and their environment

Bacterial species	Number of patients	Number of positive samples/samples taken (%)	P-value
MRSA	50	165/648 (25.5)	
VRE	4	9/57 (15.5)	
Total	54	174/705 (24.7)	
<i>Pseudomonas aeruginosa</i>	40	16/555 (2.9)	
<i>Stenotrophomonas maltophilia</i>	35	23/435 (5.7)	
<i>Escherichia coli</i>	20	12/271 (4.4)	
<i>Enterobacter</i> spp.	13	18/158 (11.4)	
<i>Acinetobacter</i> spp.	12	11/151 (7.3)	
<i>Serratia</i> spp.	10	17/148 (4.7)	
<i>Klebsiella</i> spp.	3	2/54 (3.7)	

Table II Sampling of the hands of patients and hospital personnel

	Positive hands/hands sampled for Gram-positive bacteria	Positive hands/hands sampled for Gram-negative bacteria	P-value
Hands of patients	17/52 (32.7%)	8/126 (6.3%)	<0.0001
Hands of neighbour patients	0/7	0/46	
Hands of personnel	6/38 (15.8%)	7/102 (6.9%)	0.1145

Figure and Gram items. (pathoge

A link: Antibiotic resistance is associated with hospital ward

Table 1 Antibiotic resistance in environmental organisms from an intensive care unit (ICU), acute stroke unit (ASU) and medical day bed unit (MDBU) over a four-month period

	ICU	ASU	MDBU
Staphylococcal isolates (<i>N</i>)	89	91	96
No. of resistances (%)			
≤ 1	17	29	17
2-4	40	49	65
≥ 5	43	22	18
Coliform isolates (<i>N</i>)	3	15	8
No. of resistances			
≤ 4	0	80	72
≥ 5	100	20	28
Oxidase positive Gram-negative bacilli (<i>N</i>)	17	5	9
No. of resistances			
≤ 2	53	100	55
≥ 3	47	0	45
Antibiotic consumption (DDD/1000 patient-days)	3110.3	465.8	556.6

Antibiotic resistance is associated with hospital ward (staphylococci $P < 0.001$; coliforms $P = 0.04$; oxidase-positive Gram-negative bacilli $P = 0.06$). DDD, defined daily doses.

A link: Prior room occupancy has been shown to be a risk for acquisition of GNB

TABLE 2. Characteristics of patients with or without multidrug-resistant (MDR) *Pseudomonas aeruginosa* or *Acinetobacter baumannii* during intensive-care unit (ICU) stay

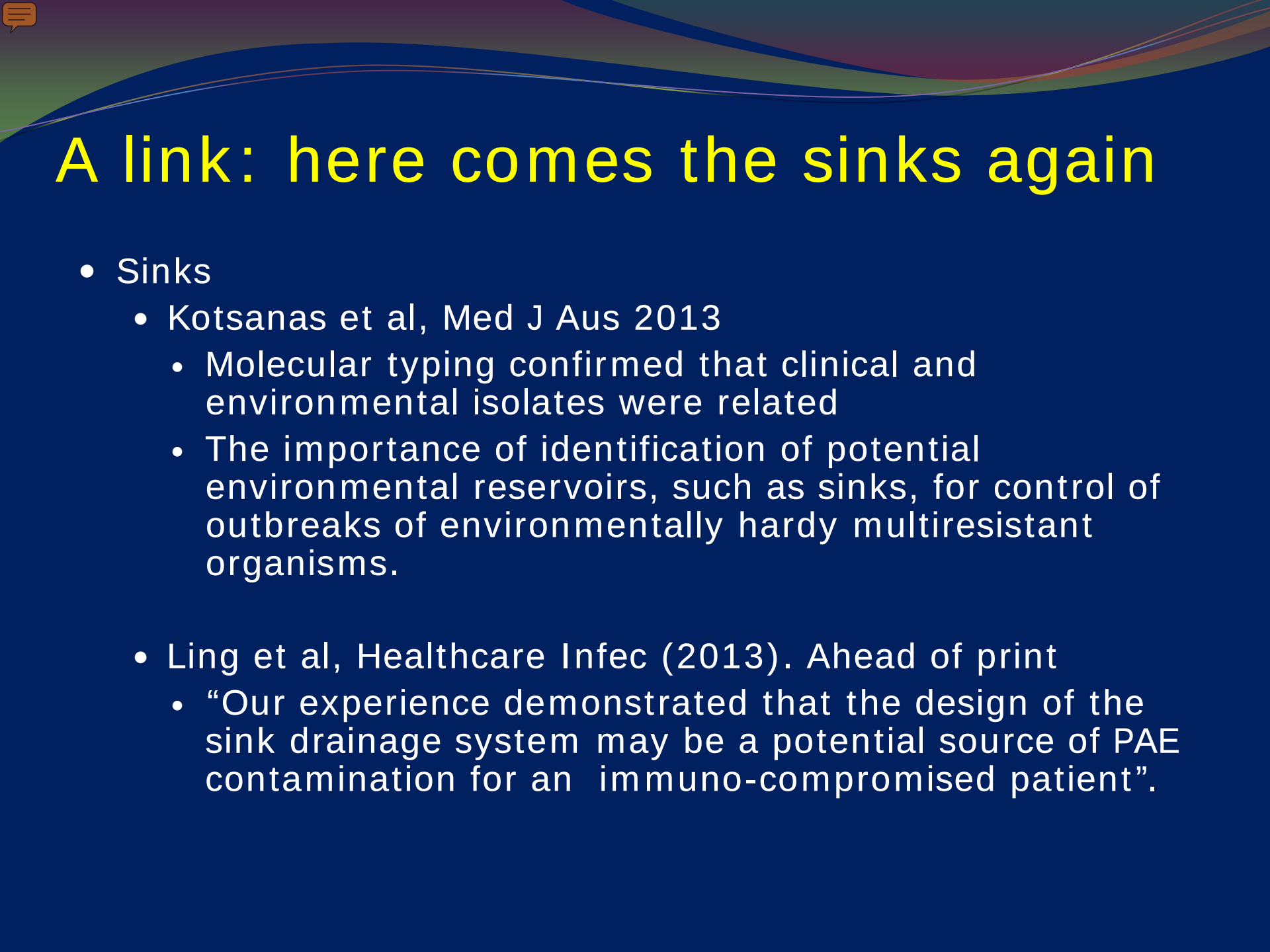
	ICU-acquired MDRPA		p value	OR (95% CI)	ICU-acquired <i>A. baumannii</i>		p value	OR (95% CI)
	Yes (n = 82)	No (n = 429)			Yes (n = 57)	No (n = 454)		
Prior room occupants with the same MDR GNB	21 (25)	64 (14)	0.023	1.9 (1.1–3.5)	16 (28)	36 (7)	<0.001	4.5 (2.3–8.9)

	ICU-acquired ESBL-producing GNB		p value	OR (95% CI)
	Yes (n = 50)	No (n = 461)		
Prior room occupants with ESBL-producing GNB	8 (16)	50 (10)	0.249	1.5 (0.6–3.5)

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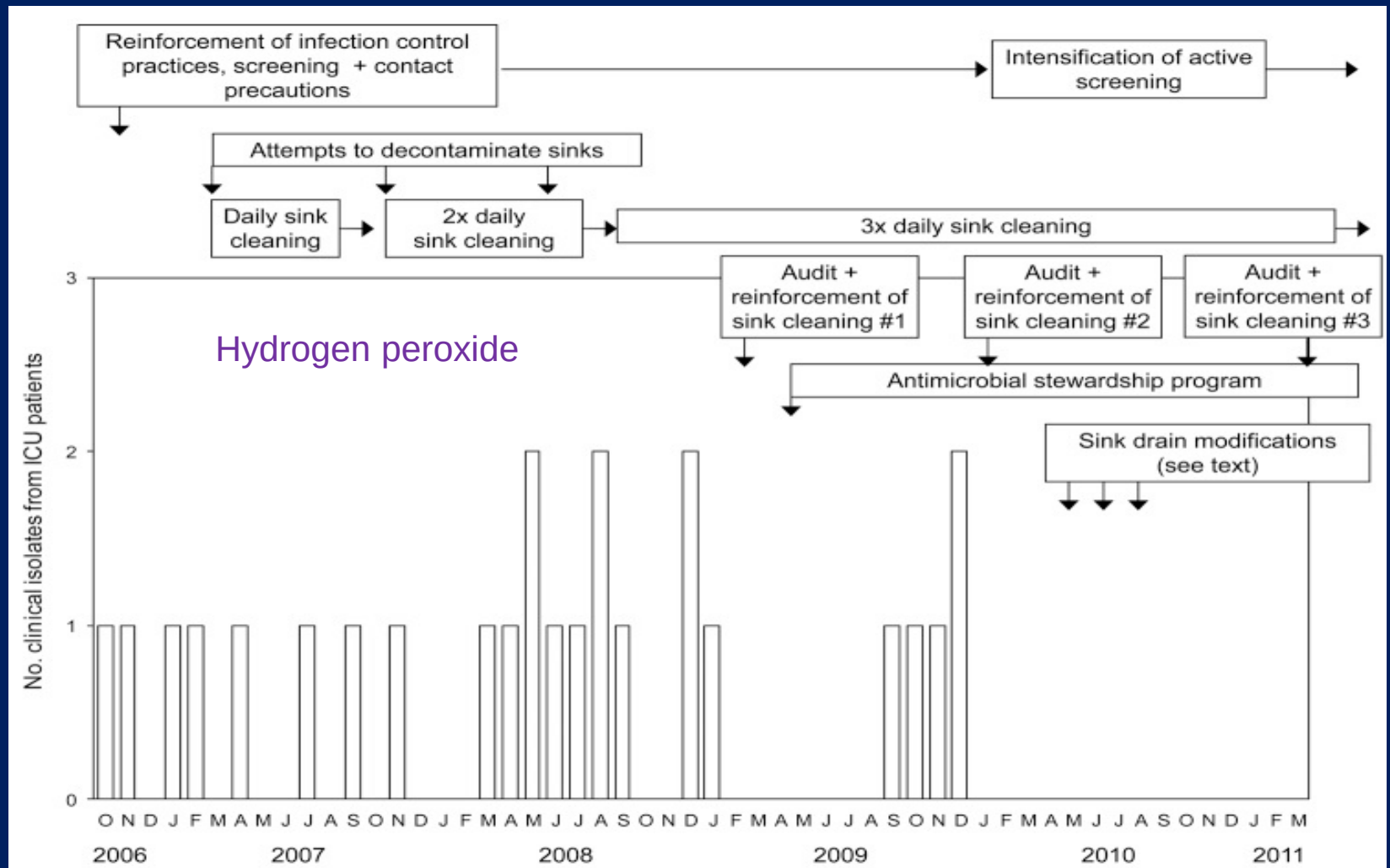




A link: here comes the sinks again

- Sinks
 - Kotsanas et al, Med J Aus 2013
 - Molecular typing confirmed that clinical and environmental isolates were related
 - The importance of identification of potential environmental reservoirs, such as sinks, for control of outbreaks of environmentally hardy multiresistant organisms.
 - Ling et al, Healthcare Infec (2013). Ahead of print
 - “Our experience demonstrated that the design of the sink drainage system may be a potential source of PAE contamination for an immuno-compromised patient”.

A link: MDR *Klebsiella* in sinks used for handwashing



Hydrogen peroxide

Complex Relationship – Environment and hands are important



The role of hands, the environment and transmission

“Pathogenic organisms can be frequently detected on hands of acute care patients”

Table 1

Prevalence of bacteria detected on patients' hands

Organism	Patients with specific organisms (n)	Patient samples (n)
MRSA	14	100
VRE	9	100
<i>Acinetobacter</i>	11	100
<i>C difficile</i>	14	100
Gram negative	34	100
One pathogen	39	100
At least 2 pathogens	8	100

Something to watch: Gram negatives – Aerosol? Seasonal?

“Assessment of the levels of airborne bacteria, Gram-negative bacteria and Fungi in hospital lobbies”

Table 5. The levels of log-transformed bacteria, gram-negative bacteria, and fungi among the categories of occupational and environmental variables.

Independent variables	No of sample	Bacteria, CFU/m ³			GNB, CFU/m ³			Fungi, CFU/m ³			
		Mean	SD	ANOVA model p	Mean	SD	ANOVA model p	Mean	SD	ANOVA model p	
Sampling time											
Service hours (08:00–18:00)	44	9.3 × 10 ²	5.7 × 10 ²	P ≤ 0.0001	1.5 × 10	1.3 × 10	P = 0.0422	5.6 × 10	3.3 × 10	p < 0.0001	
After service hours (18:00–24:00)	32	4.4 × 10 ²	3.0 × 10 ²		2.0 × 10	2.2 × 10		1.1 × 10 ²	6.4 × 10		
Season											
Summer	25	9.7 × 10 ²	6.2 × 10 ²	p = 0.0001	2.2 × 10	2.4 × 10	p = 0.0005	7.8 × 10	5.4 × 10	p = 0.0206	
Fall	37	7.5 × 10 ²	4.3 × 10 ²		1.8 × 10	1.3 × 10		8.6 × 10	5.6 × 10		
Winter	14	2.3 × 10 ²	1.1 × 10 ²		0.4 × 10	0.3 × 10		5.3 × 10	4.7 × 10		
Scale of hospital (number of beds)											
<1,000	52	6.3 × 10 ²	4.4 × 10 ²	p = 0.0192	1.3 × 10	1.7 × 10	p = 0.0016	7.3 × 10	5.6 × 10	p = 0.1365	
≥1,000	24	9.3 × 10 ²	6.4 × 10 ²		2.4 × 10	1.6 × 10		8.7 × 10	5.1 × 10		
Lobby age (years)											
<10	24	9.3 × 10 ²	6.4 × 10 ²	p = 0.0001	2.4 × 10	1.6 × 10	p = 0.0059	8.7 × 10	5.1 × 10	p = 0.0788	
10–19	27	4.1 × 10 ²	3.2 × 10 ²		1.0 × 10	1.2 × 10		6.3 × 10	5.1 × 10		
≥20	25	8.7 × 10 ²	4.4 × 10 ²		1.7 × 10	2.2 × 10		8.4 × 10	6.0 × 10		

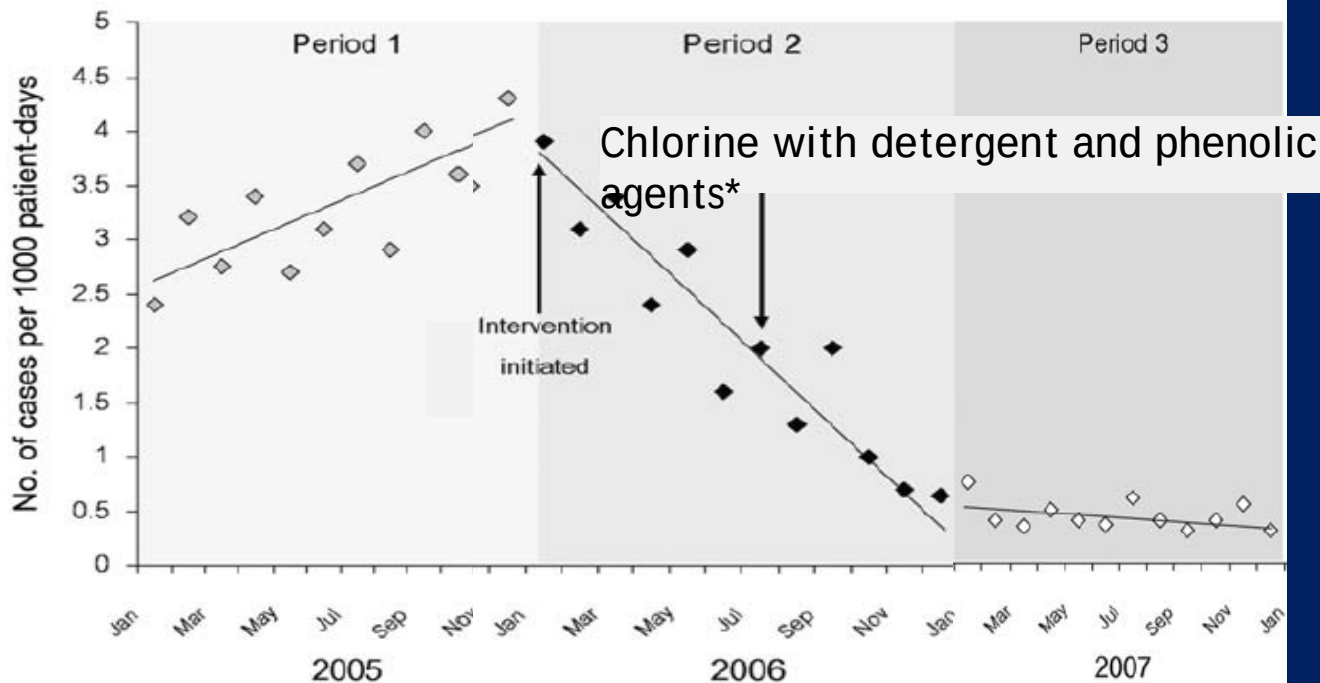
Cleaning approaches: how and what

Solution/approach: a focus on MRGN

- Detergent
- Sodium hypochlorite
- Steam
- Hydrogen peroxide
- Copper

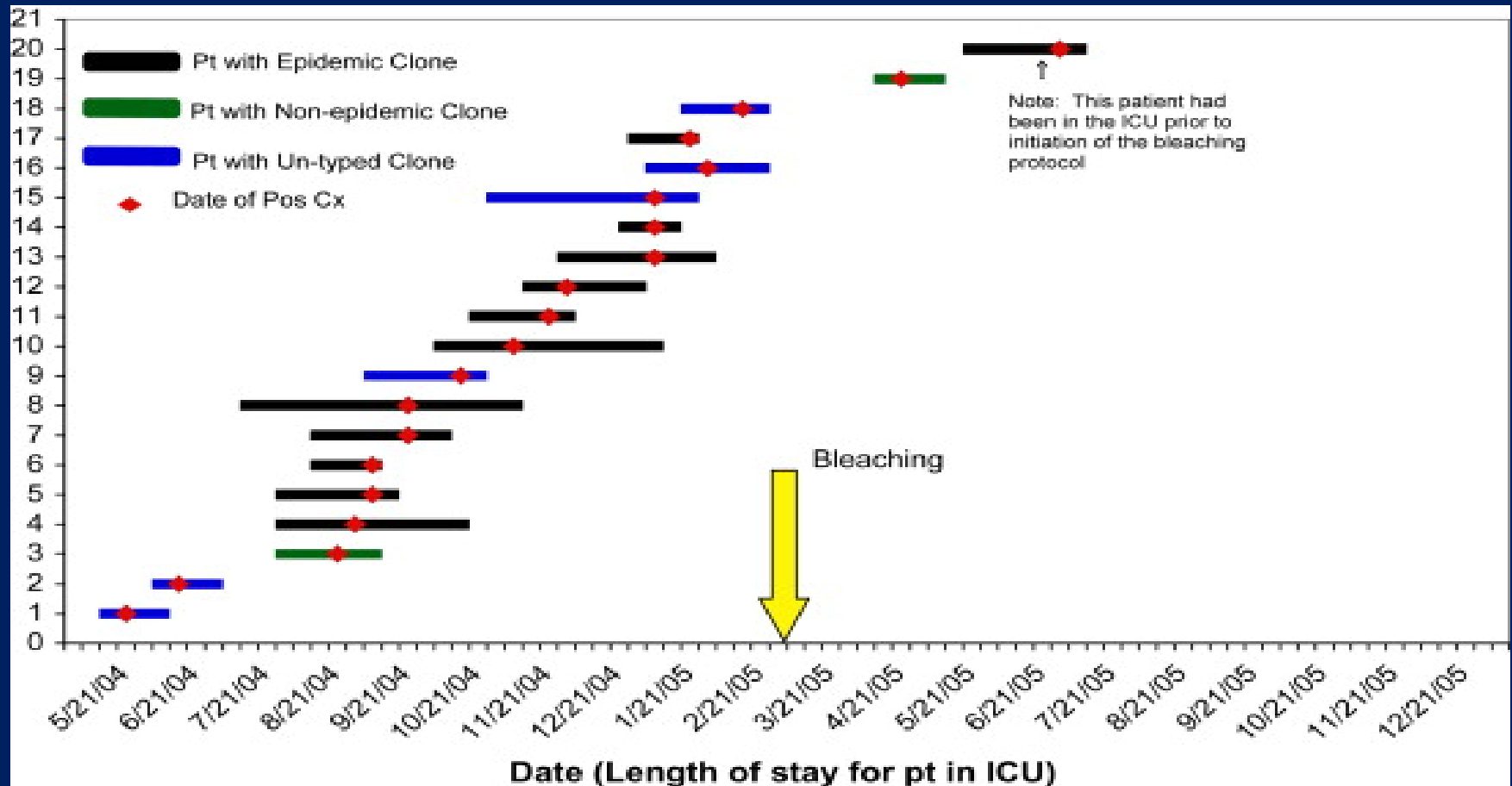
Cleaning approaches: Sodium hypochlorite

Figure 1. Rates of pandrug-resistant *Acinetobacter baumannii* infection and colonization in 3 intensive care units



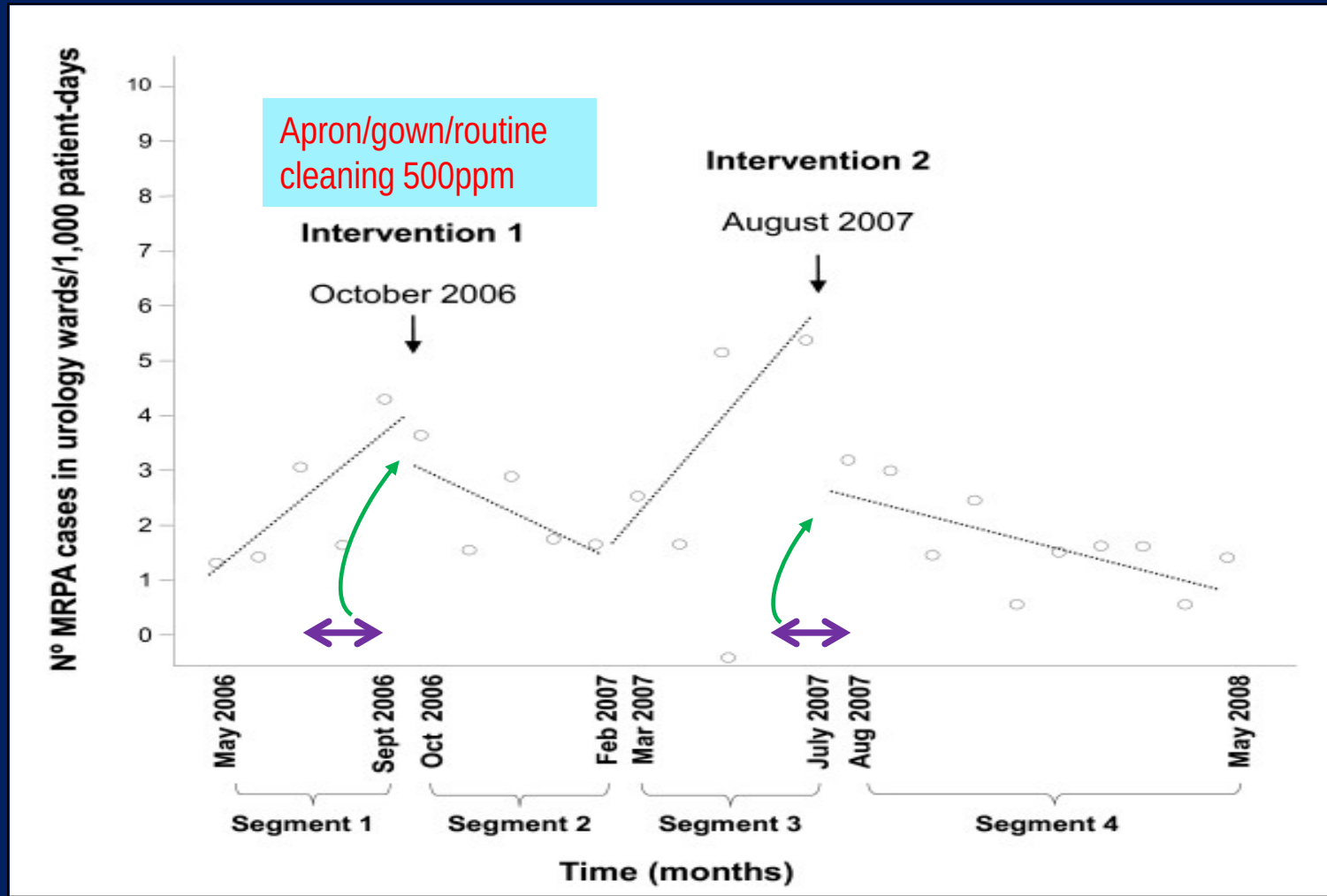
*Phenolic agents used for surfaces
body fluid and or blood

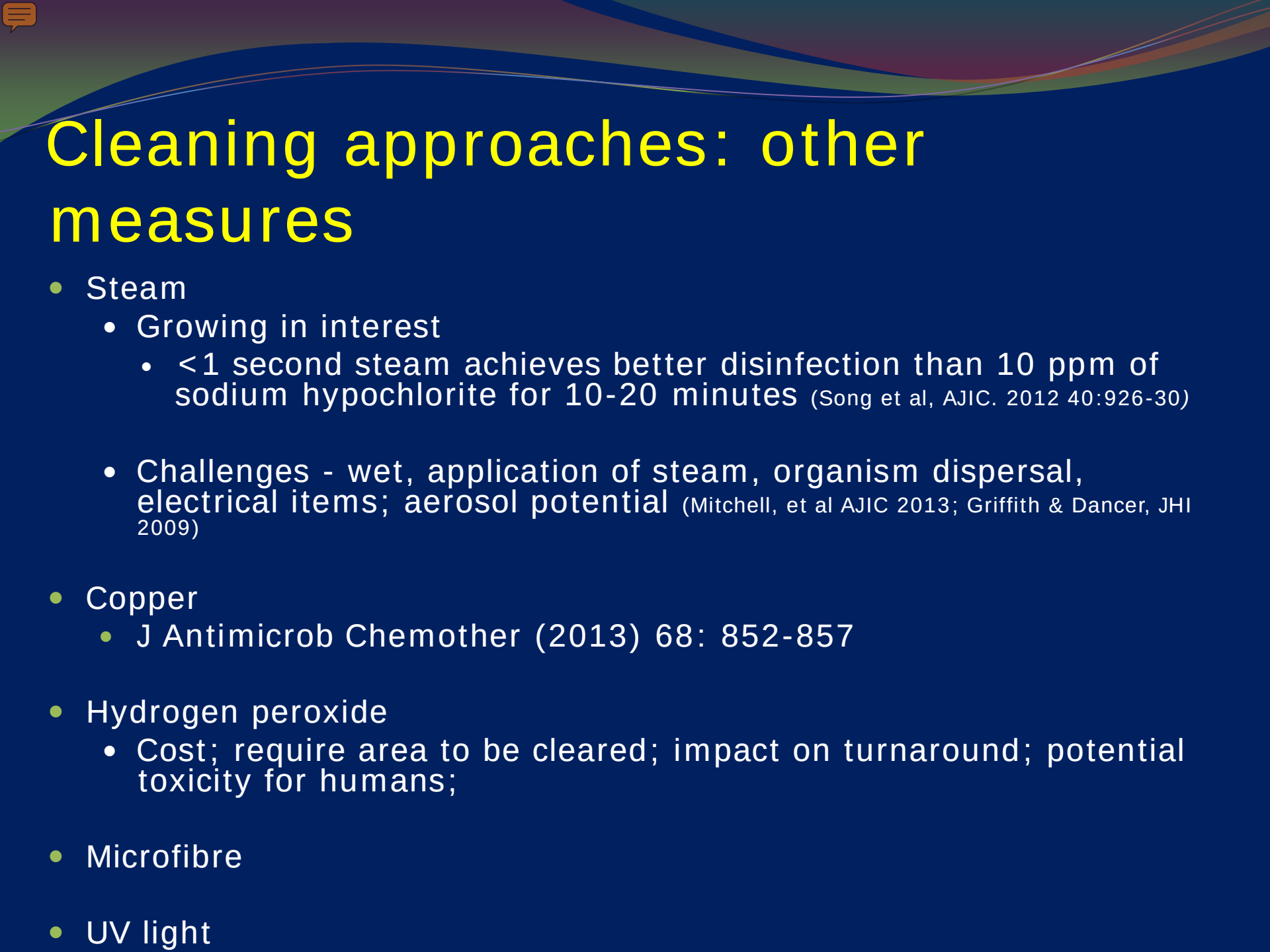
Cleaning approaches: Management of MDR *Acinetobacter baumannii* outbreak



Timeline of *A. baumannii* outbreak in the ICU during the period when the epidemic clone was present.

Cleaning approaches: outbreak



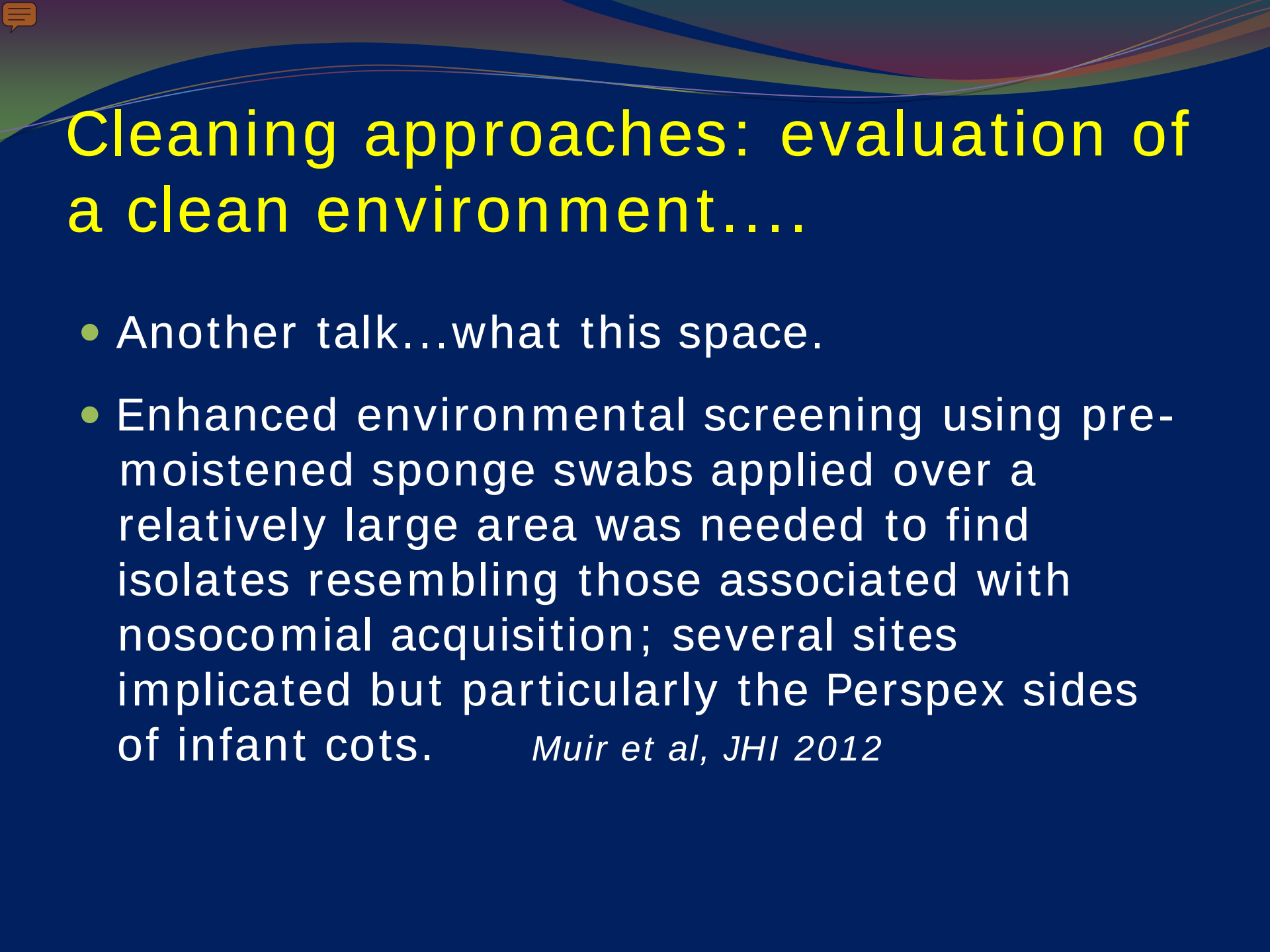


Cleaning approaches: other measures

- Steam
 - Growing in interest
 - <1 second steam achieves better disinfection than 10 ppm of sodium hypochlorite for 10-20 minutes (Song et al, AJIC. 2012 40:926-30)
 - Challenges - wet, application of steam, organism dispersal, electrical items; aerosol potential (Mitchell, et al AJIC 2013; Griffith & Dancer, JHI 2009)
- Copper
 - J Antimicrob Chemother (2013) 68: 852-857
- Hydrogen peroxide
 - Cost; require area to be cleared; impact on turnaround; potential toxicity for humans;
- Microfibre
- UV light

So we have cracked it!

- What about biofilm?
 - Song et al, AJIC (2012) 40:926-30
 - Use of steam
 - Vickery et al, Healthcare Infection (2013) 18:61-66
 - *“Any implanted medical device may become infected with a bacterial biofilm. The organisms most commonly isolated from biofilm-infected biomedical devices are Staphylococcus aureus and coagulase-negative staphylococci followed by Streptococcaceae and Gram-negative bacilli”*



Cleaning approaches: evaluation of a clean environment....

- Another talk...what this space.
- Enhanced environmental screening using pre-moistened sponge swabs applied over a relatively large area was needed to find isolates resembling those associated with nosocomial acquisition; several sites implicated but particularly the Perspex sides of infant cots. *Muir et al, JHI 2012*

Questions to be answered..

- Evaluate the influence of ESBL *E.coli* density in the stool on environmental contamination
 - Assess role and implication of biofilm formation
 - Evaluate the role of environmental contamination in cross transmission of *Klebsiella*.
 - Studies examining disinfectants and effect on transmission
-
- In the future
 - Reconsider role of 'wet' cleaning
 - Risk assess – hot, humid, seasonal patterns

Conclusion

Is it a problem? - Yes

Is there a link? - Yes and growing evidence

Cleaning approaches – Hmm

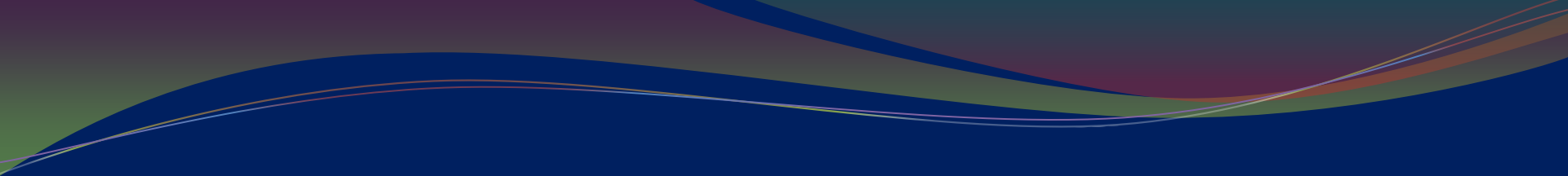
- Focus has been on Gram positives and specific organisms
- Maybe basic cleaning strategies for Gram negative organisms are more important than previously thought.

Maybe we should look at other species for advice?



“10% Gram-negative bacilli isolated from the body surfaces of German cockroaches demonstrated ESBL production”

Czajka E *et al*, *Przegl Epidemiol* 2003;57:655-62

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Thank you