Chlorhexidine

The solution to all our problems, or time bomb?

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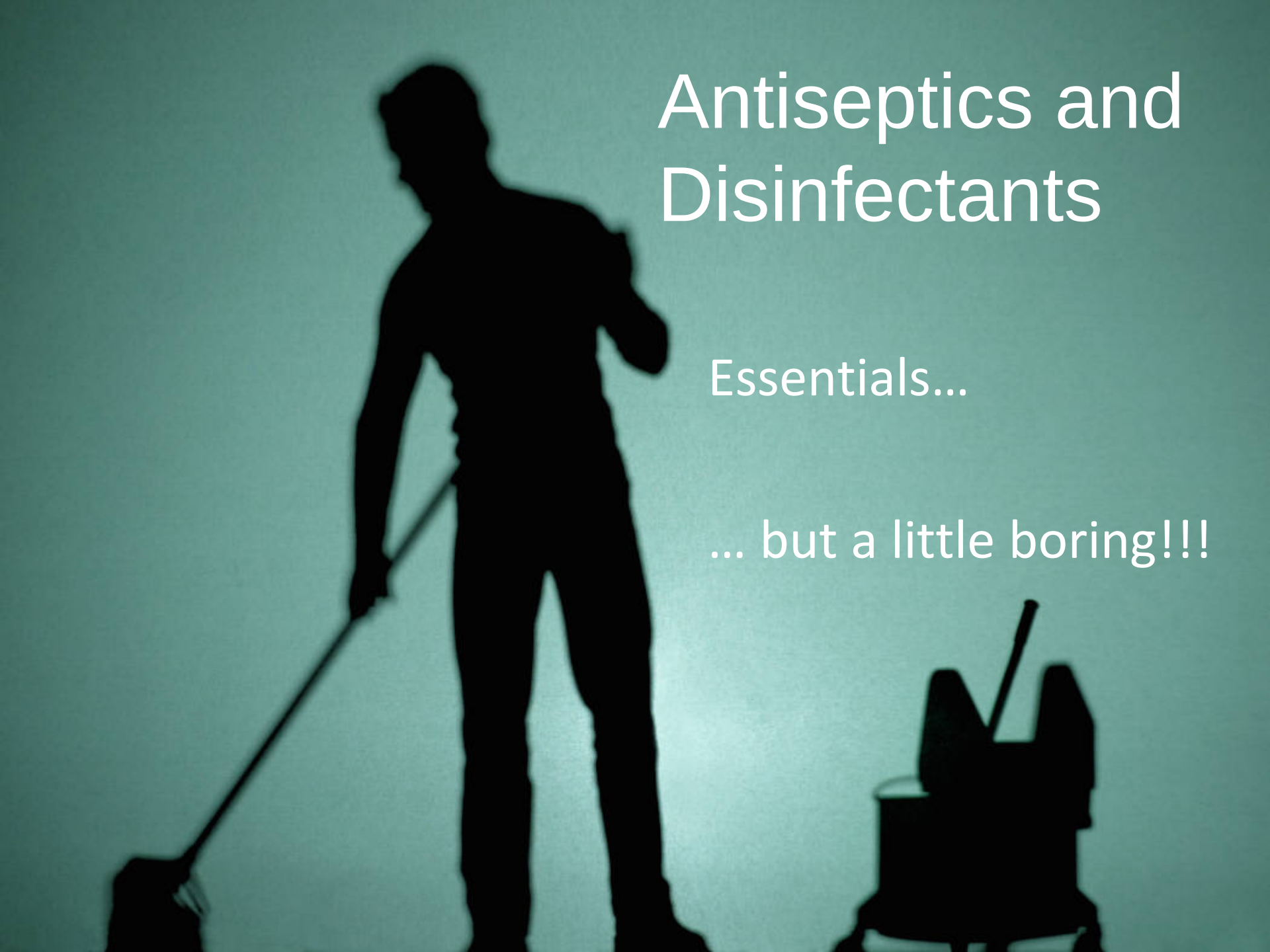

Antiseptics and Disinfectants

Essentials…

… but a little boring!!!

Can we spend 40 minutes focusing only on Chlorhexidine?

Antiseptic: definition

Chemical (germicide) that reduces the microbial load of the skin or mucous membranes

A "disinfectant" for living tissue

Joseph Lister (1827-1912)

•Surgeon in Edinburg

• Develops Surgical Antisepsis

- •Carbolic Acid Paste
- •Aerosolized Carbolic Acid

ON THE

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IN the course of an extended investigation into the nature of inflammation, and the healthy and morbid conditions of the blood in relation to it, I arrived several years ago at the conclusion that the essential cause of suppuration in wounds is decomposition, brought about by the influ-

skin for a very considerable distance, and this was inadmissible by the method described above, on account of the extensive sloughing of the surface of the cutis which it would involve. This difficulty has, however, been overcome by employing a paste composed of common whiting (carbonate of lime), mixed with a solution of one part of carbolic acid in four parts of boiled linseed oil, so as to form a firm putty. This application contains the acid in too dilute a form to excoriate the skin, which it may be made to cover to any extent that may be thought desirable, while its substance serves as a reservoir of the antiseptic material. So long as any discharge continues, the paste should be changed daily, and, in order to prevent the chance of mischief occurring during

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mischief and general febrile disturbance which follow severe injuries are due to the irritating and poisoning influence of decomposing blood or sloughs. For these evils are entirely avoided by the antiseptic treatment, so that limbs which otherwise would be unhesitatingly condemned to amputation may be retained, with confidence of the best results.

In conducting the treatment, the first object must be the destruction of any septic germs which may have been introduced into the wound, either at the moment of the accident or during the time which has since elapsed. This is done by introducing the acid of full strength into all accessible recesses of the wound by means of a piece of rag held in dressing forceps and dipped in the liquid.† This I did not venture to do in the earlier cases; but experience has shown that the compound which carbolic acid forms with the blood, and also any portions of tissue killed by its caustic action, including even parts of the bone, are disposed of by absorption and organisation, provided they are afterwards kept from decomposing. We are thus enabled to employ the antiseptic treatment efficiently at a period after the occurrence of the injury at which it would otherwise probably fail. Thus I have now under my care, in the Glasgow Infirmary, a boy who was admitted with compound fracture of the leg as late as eight hours and a half after the accident, in whom, nevertheless, all local and constitutional disturbance was avoided by means of carbolic acid, and the bones were soundly united five weeks after his admission.

The next object to be kept in view is to guard effectually against the spreading of decomposition into the wound along the stream of blood and serum which oozes out during the first few days after the accident, when the acid originally applied has been washed out or dissipated by absorption and evaporation. This part of the treatment has been greatly improved during the last few weeks. The method which I have hitherto published (see the *Lancet* for March 16th, 23rd, 30th, and April 27th of the present year) consisted in the application of a piece of lint dipped in the acid, overlapping the sound skin to some extent and covered with a tin cap, which was daily raised in order to touch the surface of the lint with the antiseptic. This method certainly succeeded well with wounds of moderate size; and indeed I may say that in all the many cases of this kind which have been so treated by myself or my house-surgeons, not a single failure has occurred. When, however, the wound is very large, the flow of blood and serum is so profuse, especially during the first twenty-four hours, that the antiseptic application cannot prevent the spread of decomposition into the interior unless it overlaps the sound

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More or less pus may appear after the lapse of the first week, and the larger the wound the more likely is this to happen. And here I would desire earnestly to enforce the necessity of persevering with the antiseptic application in spite of the appearance of suppuration, so long as other symptoms are favourable. The surgeon is extremely apt to suppose that any suppuration is an indication that the antiseptic treatment has failed, and that poulticing or water dressing should be resorted to. But such a course would in many cases sacrifice a limb or a life. I cannot, however, expect my professional brethren to follow my advice blindly in such a matter, and therefore I feel it necessary to place before them, as shortly as I can, some pathological principles intimately connected, not only with the point we are immediately considering, but with the whole subject of this paper.

If a perfectly healthy granulating sore be well washed and covered with a plate of clean metal, such as block tin, fitting its surface pretty accurately, and overlapping the surrounding skin an inch or so in every direction, and retained in position by adhesive plaster and a bandage, it will be found on removing it after twenty-four or forty-eight hours, that little or nothing that can be called pus is present, merely a little transparent fluid, while at the same time there is an entire absence of the unpleasant odour invariably perceived when water dressing is changed. Here the clean metallic surface presenting no recesses like those of porous lint for the septic germs to develope in, the fluid exuding from the surface of the granulations has flowed away undecomposed, and the result is absence of suppuration. This simple experiment illustrates the important fact, that granulations have no inherent tendency to form pus, but do so only when subjected to a preternatural stimulus. Further, it shows that the mere contact of a foreign body does not of itself stimulate granulations to suppurate; whereas the presence of decomposing organic matter does. These truths are even more strikingly exemplified by the fact which I have elsewhere recorded (*op. cit.*, March 23rd, 1867), that a piece of dead bone free from decomposition may not only fail to induce the granulations around it to suppurate, but may actually be absorbed by them; whereas a bit of dead bone soaked with putrid pus infallibly induces suppuration in its vicinity.

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To prevent the occurrence of suppuration with all its attendant risks was an object manifestly desirable, but till lately apparently unattainable, since it seemed hopeless to attempt to exclude the oxygen, which was universally regarded as the agent by which putrefaction was effected. But when it had been shown by the researches of Pasteur that the septic property of the atmosphere depended not on the oxygen, or any gaseous constituent, but on minute organisms suspended in it, which owed their energy to their vitality, it occurred to me that decomposition in the injured part might be avoided without excluding the air, by applying as a dressing some material capable of destroying the life of the floating particles. Upon this principle I have based a practice of which I will now attempt to give a short account.

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If the severest forms of contused and lacerated wounds heal thus kindly under the antiseptic treatment, it is obvious that its application to simple incised wounds must be merely a matter of detail. I have devoted a good deal of attention to this class, but I have not as yet pleased myself altogether with any of the methods I have employed. I am, however, prepared to go so far as to say that a solution of carbolic acid in twenty parts of water, while a mild and cleanly application, may be relied on for destroying any septic germs that may fall upon the wound during the performance of an operation; and also that, for preventing the subsequent introduction of others, the paste above described, applied as for compound fractures, gives excellent results. Thus I have had a case of strangulated inguinal hernia in which it was necessary to take away half-a-pound of thickened omentum, heal without any deep-seated suppuration or any tenderness of the sac or any fever; and amputations, including one immediately below the knee, have remained absolutely free from constitutional symptoms.

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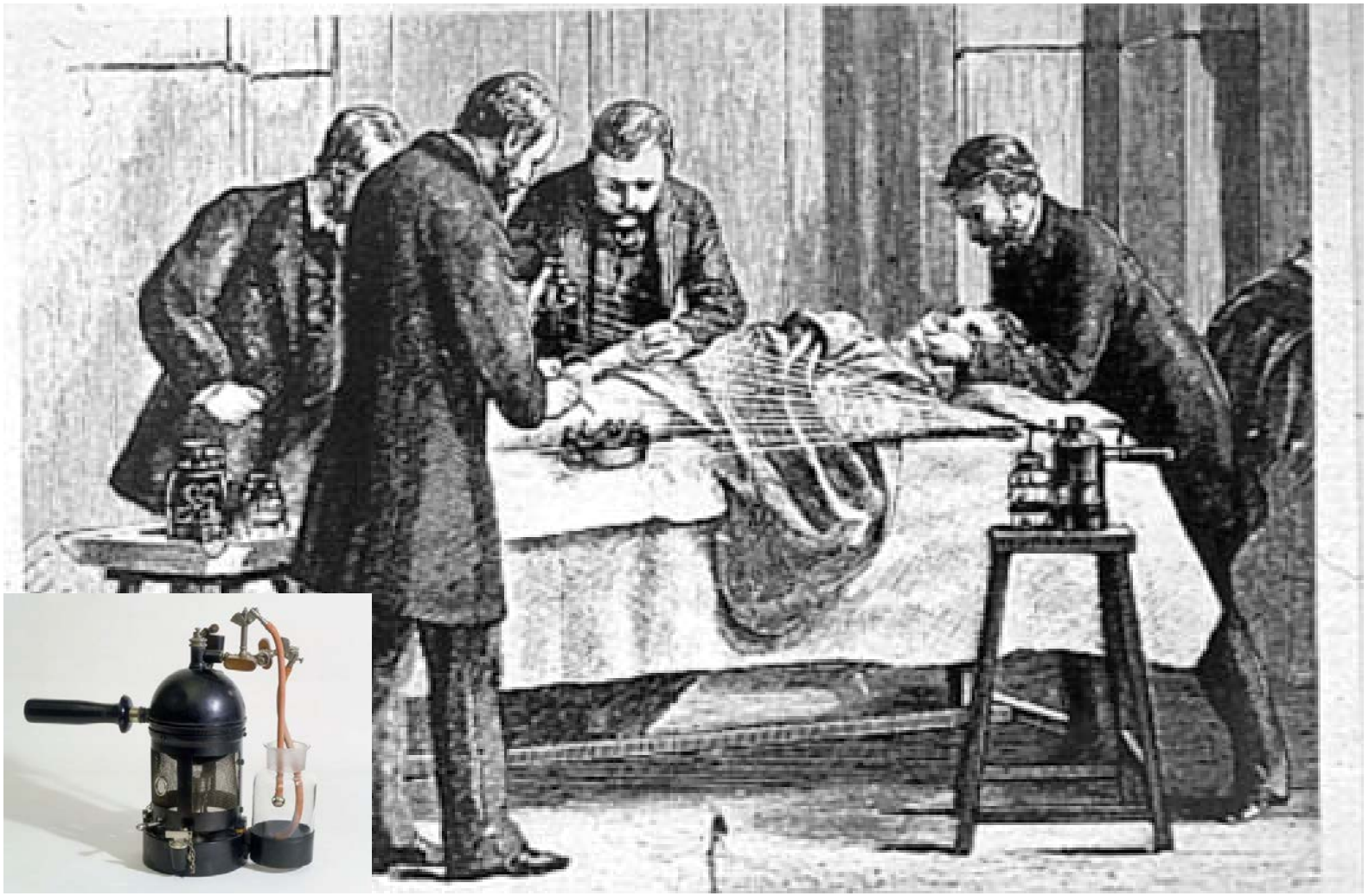


Antiseptic vs Antibiotic

	Antibiotic	Antiseptic
Mode of action	Unique Very specific (ex. ribosome, paroi, ADN gyrase)	Multiples Non specific (ex. Destruction membranes, non-specific reaction with proteins)
Safety for humans	High	Low
“resistance”	Mutation simple	Phenotypical adaptation (tolerance rather than resistance) (disapears if insult removed)

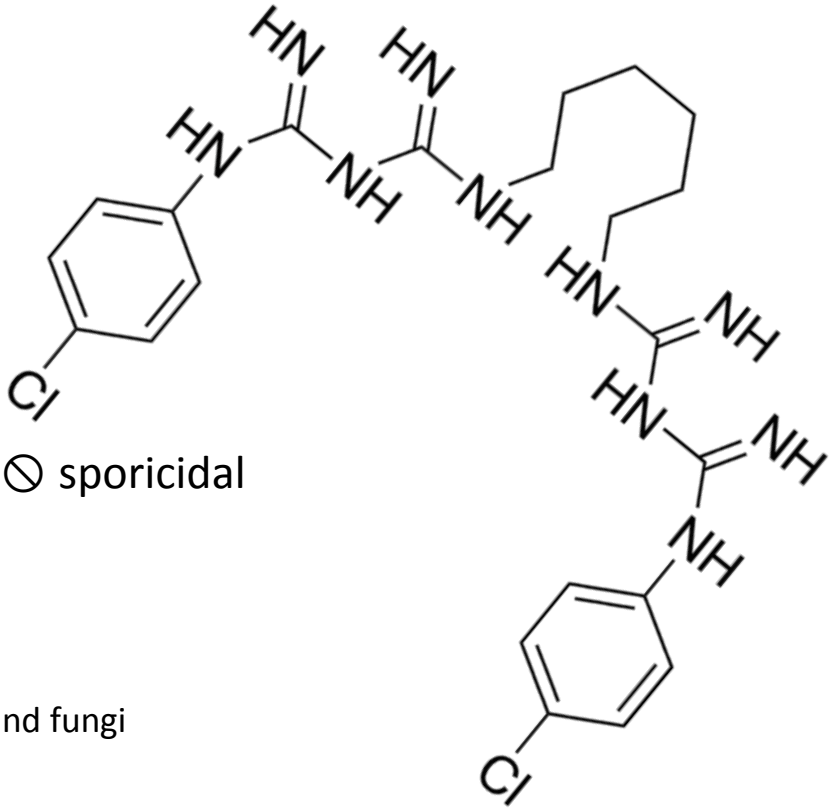
Antiseptiques

- Main classes antiseptics
  - Iodophors
  - Alcohols
  - Chlorhexidine

Chlorhexidine

- Biguanide
  - Ex. Metformine, proguanil
- Discovered 1954
  - ICI ltd (England) when developing anti-malaria tx
- 3 formes
  - Actetate (ex. Bactigras)
  - Gluconate (ex. Hibitane)
  - Digluconate (ex. Flamazine)
- Colorless, odorless

Chlorhexidine



- Bacteriostatic at low concentrations
- Bactericidal at higher [ ]
- Wide spectrum: Gram +/- virus, fungi but ⦸ sporicidal
- Mec Action
  - Not well understood, probably multiple
    - No receptor common to bacteria, viruses and fungi
  - Bacterial wall destruction?
    - Pores leading to depolarisation of bacteria
  - Precipitation in cytoplasm?
- Concentrations
  - 0.12% to 4%

Antifungal effect

Organism	No. samples	Ave. CMI (mg/L)
Filameuteux		
Aspergillus flavus	1	64
Aspergillus fumigatus	1	32
Aspergillus niger	1	16
Penicillium notatum	1	16
Rhizopus	1	8
Scopulariopsis spp.	1	8
Levures		
Candida albicans	2	9
Candida guillermondii	1	4
Candida parapsilosis	2	4
Candida pseudotropicalis	1	3
Cryptococcus neoformans	1	1
Saccharomyces cerevesiae	1	1
Candida glabrata	1	6
DErmatophytes		
Epidermophyton floccosum	1	4
Microsporum canis	2	4
Trychophyton equinum	1	4
Trichophyton mentagrophytes	1	3
Trichophyton tonsurans	1	3

Hibiscrub 2%: 20’000 mg/L

Virucidal effect

TABLE 15.6. *Virucidal activity of chlorhexidine gluconate*

Virus	Viral family	Activity	Concentration (%)	Reference
Respiratory syncytial virus	Paramyxovirus	+	0.25	Platt and Bucknall (1985)
Herpes hominis/simplex	Herpesvirus	+	0.02	Bailey and Longson (1972)
Polio virus type 2	Enterovirus	–	0.02	Bailey and Longson (1972)
Adenovirus type 2	Adenovirus	–	0.02	Bailey and Longson (1972)
Equine infectious anaemia virus	Retrovirus	+	2.0	Shen et al. (1977)
Variola virus (smallpox)	Poxvirus	+	2.0	Tanabe and Hotta (1976)
Herpes simplex type 1/type 2	Herpesvirus	+	0.02	Shinkai (1974)
Equine influenza virus	Orthomyxovirus	+	0.001	Eppley (1968)
Hog cholera virus	Togavirus	+	0.001	Eppley (1968)
Bovine viral diarrhoea	Togavirus	+	0.001	Eppley (1968)
Parainfluenza virus	Paramyxovirus	+	0.001	Eppley (1968)
Transmissible gastroenteritis virus	Coronavirus	+	0.001	Eppley (1968)
Rabies virus	Rhabdovirus	+	0.001	Eppley (1968)
Canine distemper virus	Paramyxovirus	+	0.01	Eppley (1968)
Infectious bronchitis virus	Coronavirus	+	0.01	Eppley (1968)
Newcastle virus	Paramyxovirus	+	0.01	Eppley (1968)
Pseudo rabies virus	Herpesvirus	+	0.01	Matishek (1978)
Cytomegalovirus	Herpesvirus	+	0.1	Faix (1986)
Coxsackie virus	Picornavirus	–	0.4	Narang and Codd (1983)
Echo virus	Picornavirus	–	0.4	Narang and Codd (1983)
Human Rota virus	Reovirus	–	1.5	Springthorpe et al. (1986)
Human Immunodeficiency Virus Type I	Retrovirus	+	0.2	Harbison and Hammer (1989)

+, Active in vitro at the concentration stated; –, not active in vitro at the concentration stated.

Availability

- Widely available
  - Mouth wash
  - Contact lenses cleaners
    - [ ] insufficient against Acanthamoeba?
  - Skin disinfectant
    - Hibiscrib; Hibiclens

Veterinary use

More Amazon.com Search Results for "chlorhexidine gluconate 4%"

TrizCHLOR 4 Wipes - Chlorhexidine 4% - 50 wipes
Buy new: ~~$12.99~~ $7.59
1 Used & new from $7.59

Topical Antimicrobial Testing and Evaluation
Buy new: $199.95
30 Used & new from $8.95
Prime

TrizCHLOR 4 Shampoo - 4% Chlorhexidine - 8 oz.
Buy new: ~~$17.99~~ $8.99
1 Used & new from $8.99
★★★★★ (3)

See all 21 results

See larger image and other views

Share your own customer images

HIBICLENS Chlorhexidine Gluconate Solution 4% - 8 Oz Bottle - Bottle

by Regent Medical

Be the first to review this item | Like (1)

List Price: ~~$15.10~~
Price: $7.50
You Save: $7.60 (50%)

Options: 8 Oz Bottle

In Stock.
Ships from and sold by ShopMedicalSupply.

4 new from $7.50

$7.50 + $5.70 shipping
In Stock. Sold by ShopMedicalSupply
Quantity: 1
Add to Cart
or
Sign in to turn on 1-Click ordering.
Add to Wish List
Add to Shopping List

More Buying Choices

Mr. Medical — Add to Cart
$9.71 + $3.49 shipping

BP MEDICAL SUPPLIES — Add to Cart
$7.65 + $5.75 shipping

4 new from $7.50

Share

Product Features

Options: 8 Oz Bottle

Contra-indications

- Meninges
- Anatomic cavities
- Eyes and ears
  - At> 2% can cause permanent damage to eyes and ears
  - At 0.02%, safe and effective against keratitis Acanthamoeba (CDC)
- Topical application in babies <2 months

Chlorhexidine and pediatrics

- Topical chlorinexidine not recommended for children <2 months
  - Systemic absorption
- However
  - Animal model studies = Pregnancy risk category B
    - No effect on rabbit fetus despite dosing of up to 40mg/kg/jour
  - Not carcinogenic
    - Rat model ingestion of 38mg/kg/j CHG
  - Used +++ in developping countries without overt adverse effects
    - Topical application 4% CHG umbilical cord <24h birth decreases 75% omphalitis (n=4934) and ↓ trend in mortality

Mullany LC et al. Lancet 2006; 367(9514): 910-918

Residual effect

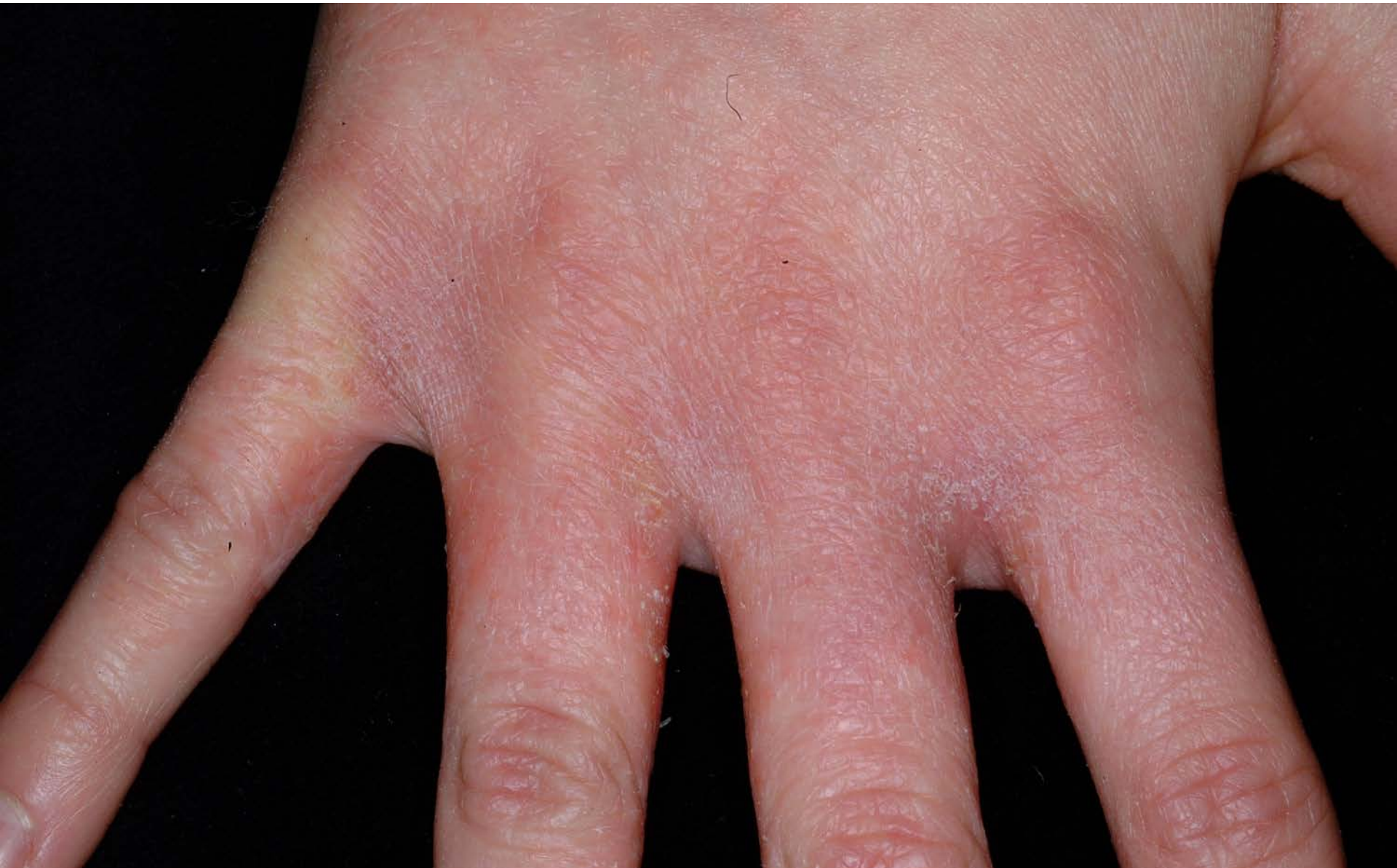
- In general, CHG is attributed a strong residual effect
  - Bacteriostatic effect following application of CHG
  - Protects against subsequent contamination
    - Eg. Presence of CHG on skin would protect even after CHG has dried off
  - Also debated
    - Some experts beleive R.E. is artificial and due to insufficient neutralization of product in lab studies 2^{aire} à neutralization (carry over of CHG in cultures)

Kampf G. Infect Control Hospit Epidemiol 2009; 30; 8

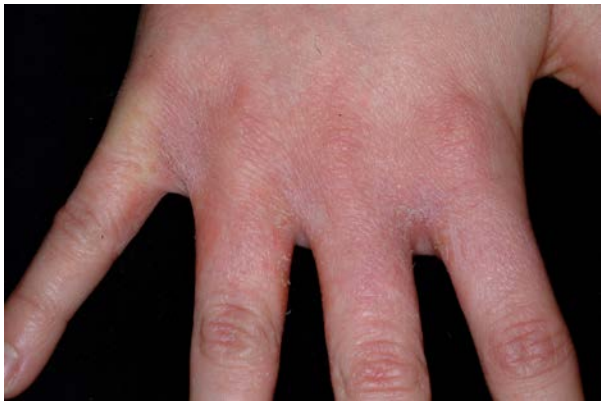
Adverse Effects

Rare, in general…

Dermatitis



Dermatitis



- Dermatitis
  - Relatively frequent
    - 4% >> 2%
  - Not only due to CHG
    - Other « ingredients » also implicated
      - Nicoletti G et al. J Hospit Infect 1990; 15: 323-337
  - Sometimes not any more frequent than regular soap
    - Larson E et al. Am J Infect Control 14:51-59

Allergy

- 0.5 to 5% of population have a reactive patch test to CHG
  - Worse if patch 1% rather than 0.5%
  - Worse if atopic patient
  - Sensitization is an issue (ad 50% of individuals)
    - Ex. patients exposed ++; mouth wash; cosmetics

Osmundsen PE Contact Dermatitis 1982; 8: 81-83
Liipo J Contact Dermatitis 2011; 64: 229-234

Allergy

- Anaphylaxis
  - 2 cases reported in literature

Krautheim AB et al. Contact Dermatitis 2004; 50(3): 113-6

Chlorhexidine – too much of a good thing?

CHG and Hand Hygiene

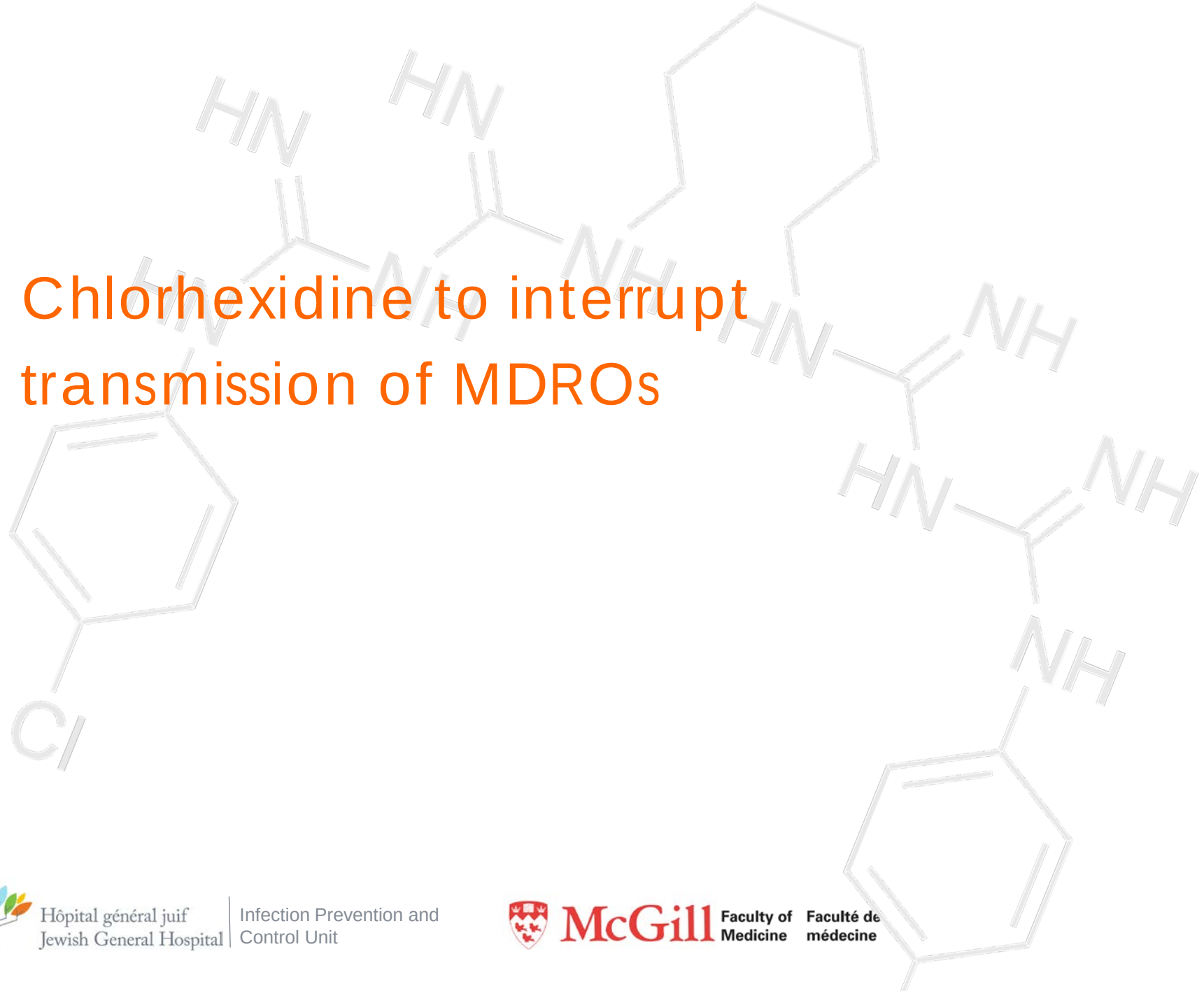
- CHG often included in HH products
  - Soaps
  - ABHRS
  - Surgical hand products
- Residual effect = popularity

CHG and Hand Hygiene

- Currently little evidence of **<u>clinical benefits</u>** of CHG for HH

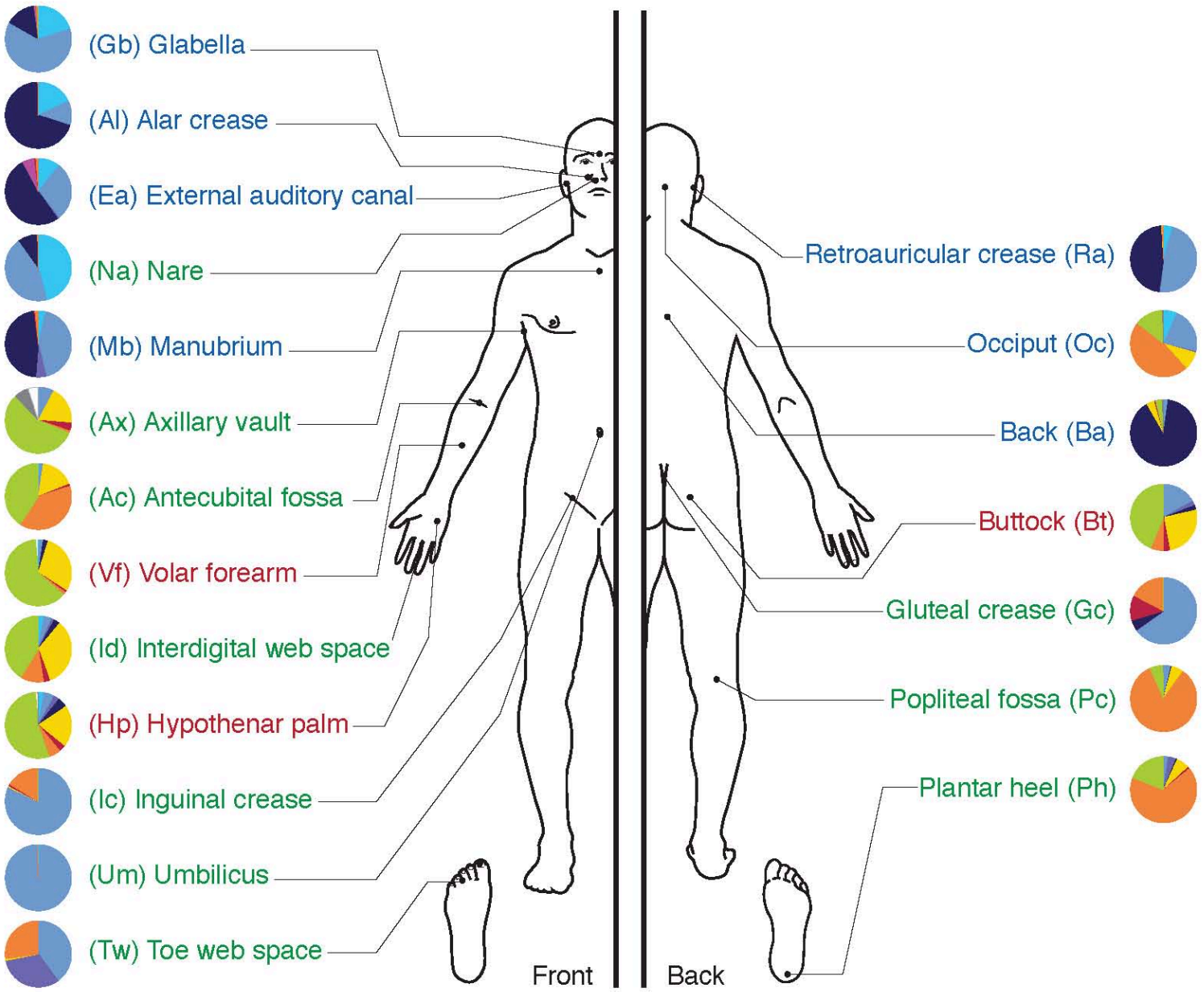
- WHO recommends NOT to use CHG in ABHRS given lack of evidence and risk of AE

Chlorhexidine to interrupt transmission of MDROs



Multiple ecosystems

>1000 different species



http://en.wikipedia.org/wiki/Skin_flora#/media/File:Skin_Microbiome20169-300.jpg

Community vs. Hospital Flora

Community vs. Hospital Flora

TABLE 1. Composition of microbial flora in 37 hospitalized patients and 30 healthy controls

Isolate[a]	Mean % of total flora isolated from:							
	Nose		Axilla		Perineum		Toe	
	Patient	Control	Patient	Control	Patient	Control	Patient	Control
CNS	65.8	37.3	53.1	66.5	38.8	14.2	56.3	38.4
SA	34.0	23.2	2.7	–[b]	2.8	10.0	5.4	13.3
LD	37.6	54.4	42.8	33.6	50.7	58.0	48.6	48.6
JK	11.6	–	41.2	–	27.7	1.7	21.5	23.6
LCD	32.9	32.8	3.5	19.9	23.7	26.4	21.5	23.6
GNB	27.0	17.7	26.0	23.3	26.1	7.7	65.2	0.001
Yeast	10.1	0.01	33.7	0.4	19.7	0.06	5.7	0.001
Other	0.03	–	33.3	6.6	–	0.0001	–	0.004

[a] Abbreviations: CNS, coagulase-negative staphylococci; JK, JK group coryneforms; SA, *S. aureus*; LCD, large-colony diphtheroids; LD, lipophilic diphtheroids; GNB, gram-negative bacilli.
[b] –, Not detected.

Hospitalized patients more likely to be colonized by GNB (including pseudo) and yeasts

Larson EL et al. J Clin Microbiol. 1986 Mar;23(3):604-8.

Community vs. Hospital Flora

TABLE 4. Number of coagulase-negative staphylococci resistant in patients and controls

Antimicrobial agent	% CNS[a] resistant in:	
	Patients	Controls
Penicillin	94.9	47.8[b]
Ampicillin	89.9	41.8[b]
Methicillin	44.3	2.9[b]
Erythromycin	74.7	19.4[b]
Clindamycin	68.4	0[b]
Gentamicin	60.8	0[b]
Tetracycline	25.3	19.4
Cephalothin	22.8	1.6[b]
Chloramphenicol	16.5	0
Vancomycin	0	0

[a] CNS, Coagulase-negative staphylococci.
[b] Flora of patients significantly more resistant than that of controls (chi-square, $P < 0.001$).

- Gram+ cocci more resistant against multiple antimicrobials

Larson EL et al. J Clin Microbiol. 1986 Mar;23(3):604-

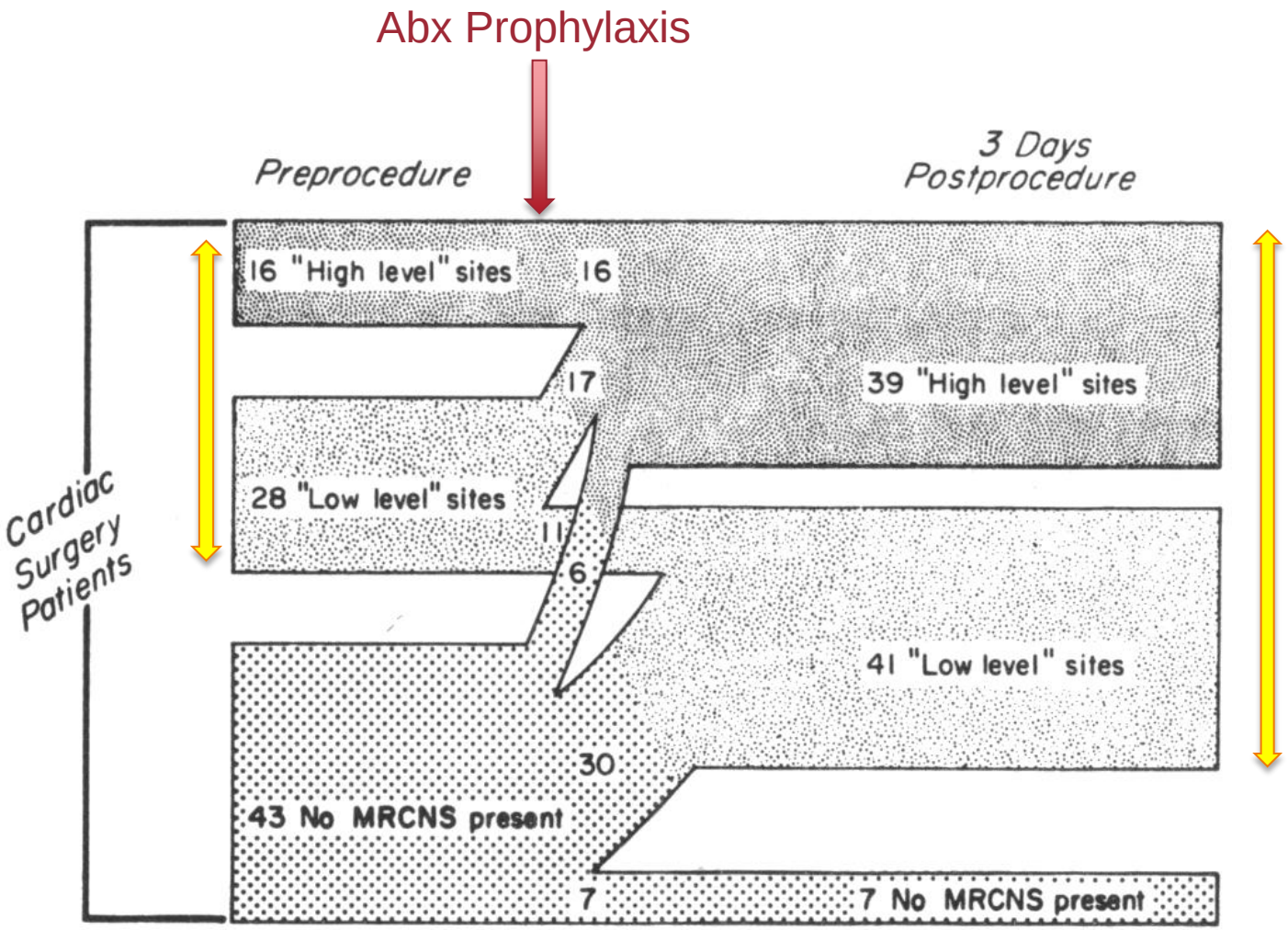


FIG. 2. Relationship of pre- to postprocedure recovery of MR coagulase-negative staphylococci (MRCNS) in 29 cardiac surgery and 10 coronary angioplasty patients. Samples from 117 sites (3 sites per patient; 39 patients) were cultured and designated as high level, low level, or no MR coagulase-negative staphylococci present based on the quantitative recovery of MR coagulase-negative staphylococci from the site. Numbers indicate numbers of sites.

Kernodle DS et al. AAC 1988

Bacterial Transmission

Microbial transmission – healthy skin

Dry skin to Dry Skin Transmission: effective…

Table I Recovery of bacteria from donor and recipient hands after standardised hand contact

	Total cfu		S. *aureus* on one or both hands	Gram-negative rods on one or both hands
	Mean	an		
Donor	1 614 105	00	9/18 (50%)	3/18 (16.7%)
Recipient	1264		0/18	0/18
Fraction transferred	0.08%	7%	0	0

cfu, colony-forming units.

3 log

Or not effective?

Wide variation in transmissibility

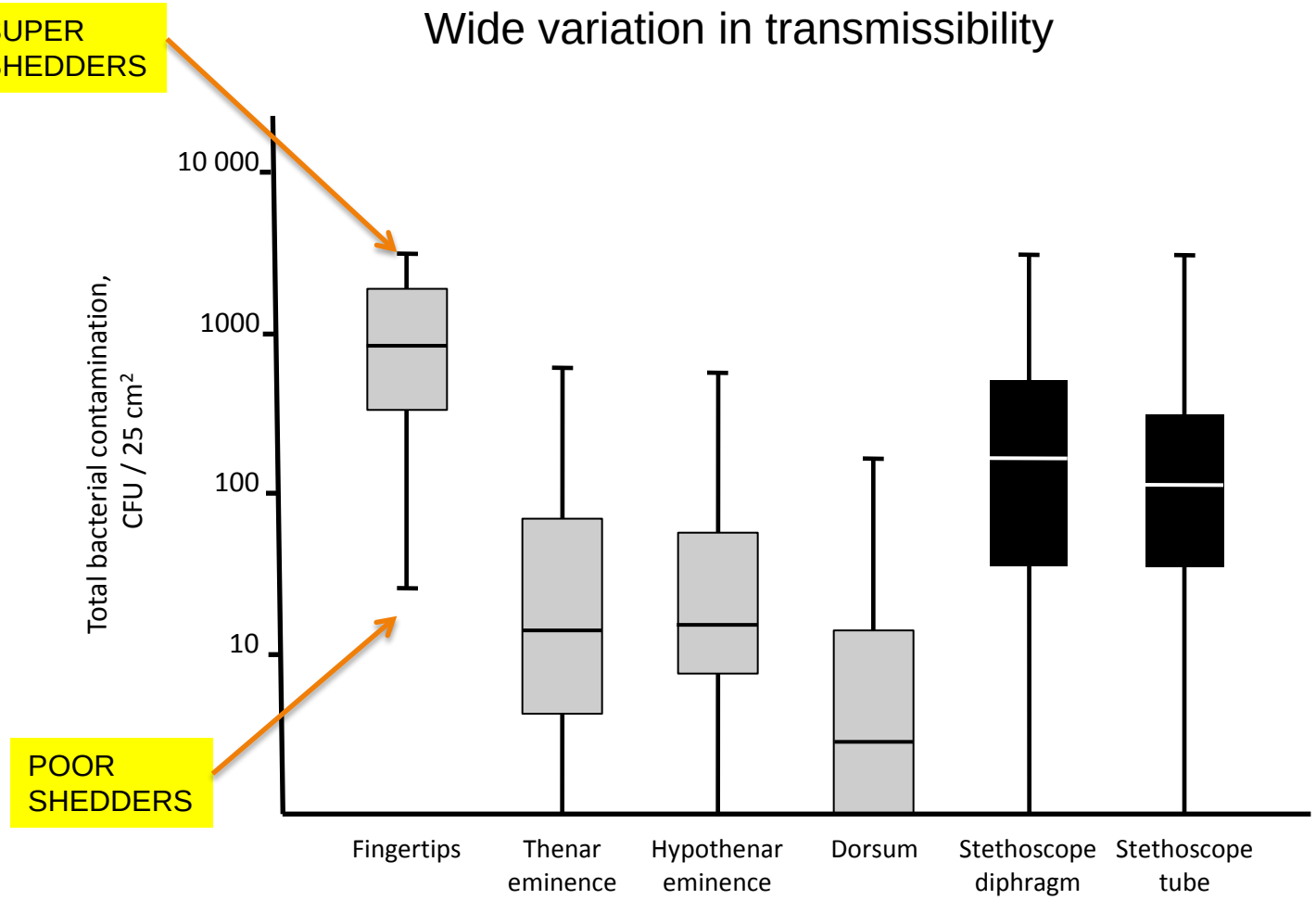
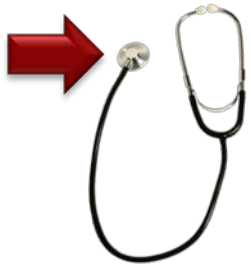


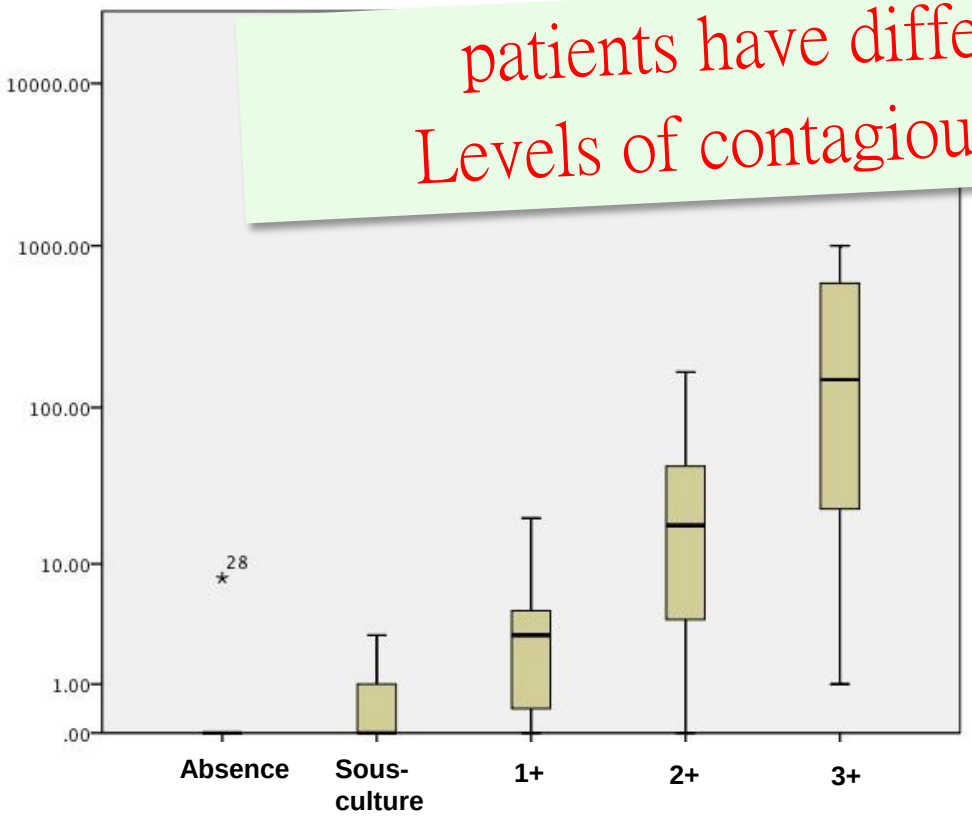
Figure 1. Total aerobic colony count recovered from physicians' gloved hands (grey boxes) and stethoscopes (black boxes) following a single physical examination.

Results are presented on a logarithmic scale. The top and bottom of the box plots represent the interquartile ranges and the horizontal lines represent the median values. The error bars extend to the maximum and minimum values.

MRSA Patient contagiousness



patients have different
Levels of contagiousness!



Croissance MRSA **inguinal**

Predictors of HCWs' hands and stethoscope contamination

Variable	Total	Predictors of heavy stethoscope diaphragm contamination				
		No heavy growth N= 42	Heavy growth N=14	OR	95% CI	*P* value
BMI, median (IQR)	24.6 (21.7-28.9)	23.9	28.9	1.20	1.04-1.40	0.01
Humidity of patient's skin						
Dry (%)	12 (21.4%)	12 (28.6%)	0 (0%)	n/a[a]	n/a[a]	0.02[b]
Slightly humid (%)	32 (57.1%)	24 (57.1%)	8 (57.1%)	n/a[a]	n/a[a]	1.00
Very humid (%)	12 (21.4%)	6 (14.3%)	6 (42.9%)	n/a[a]	n/a[a]	0.02[c]
Median CFU count on patient's skin per 25cm^2 (IQR)	1037 (255-3000)	629 (107-3000)	3000 (3000-3000)	1.001	1.001-1.002	0.002

Tschopp C et al. Infect Control Hosp Epidemiol. 2016 Jun;37(6):673-9.

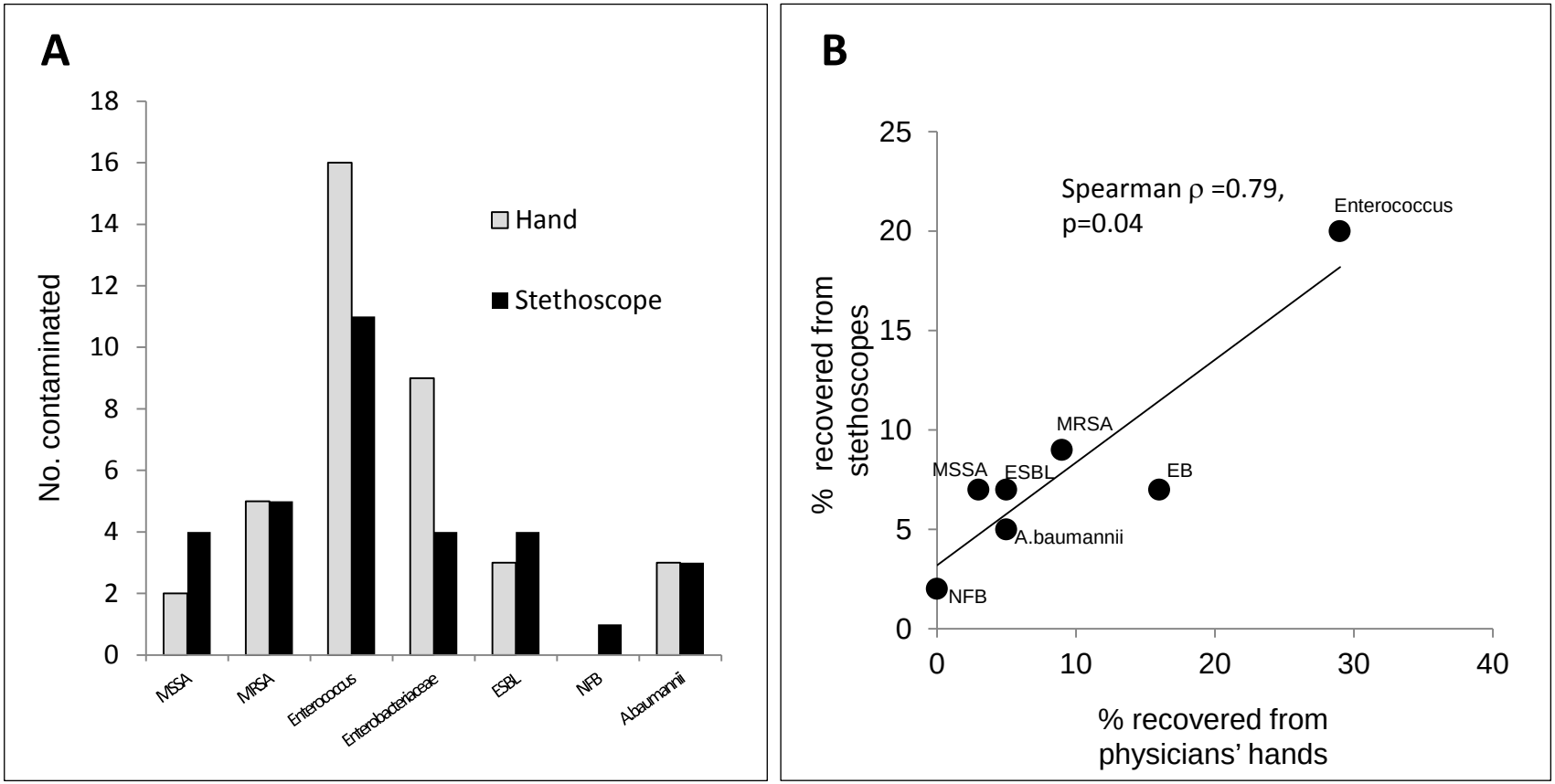
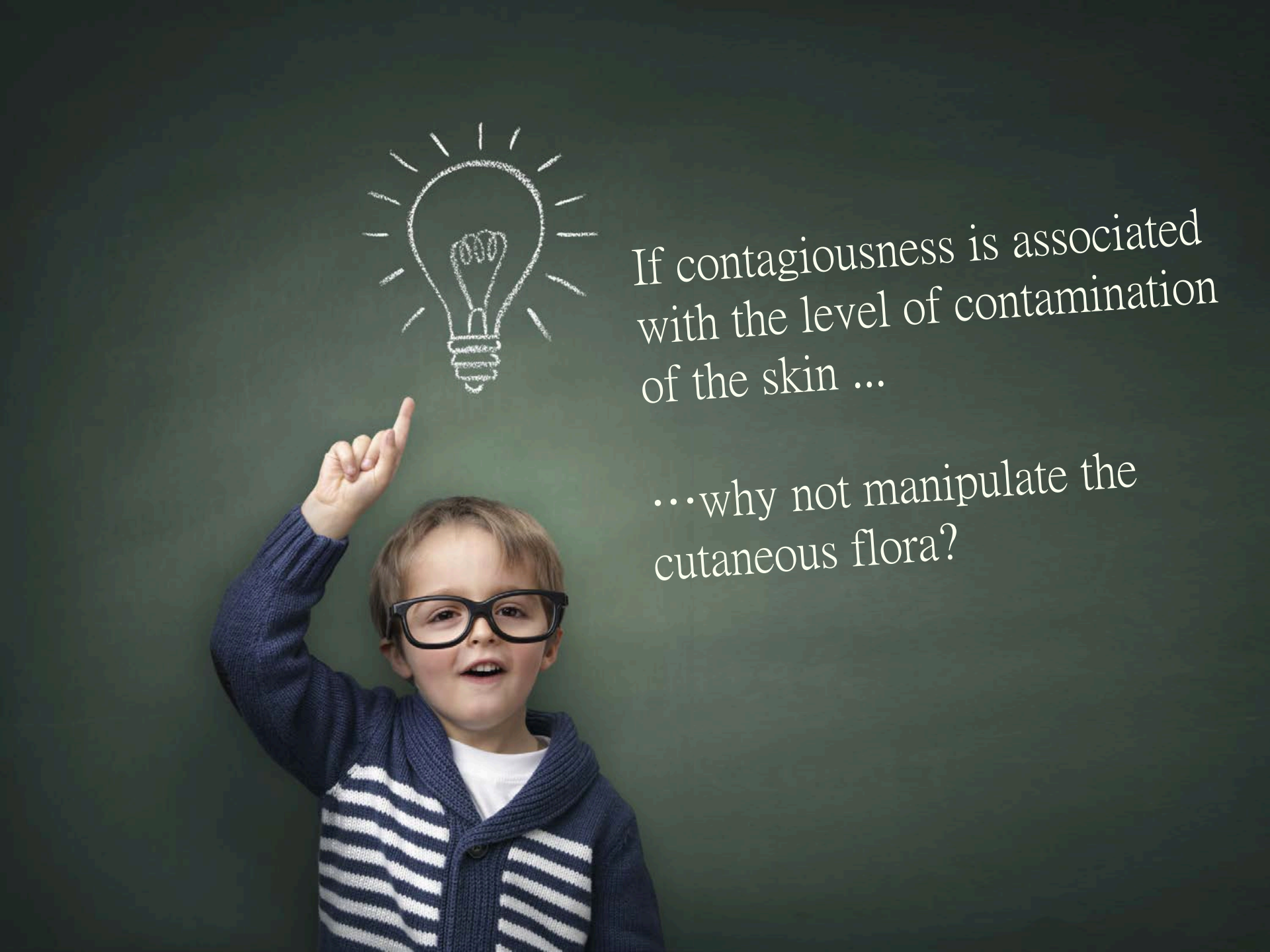


Figure 2. Panel A. Bar chart showing the frequency of recovery of various microorganisms from stethoscopes and physicians' hands following 56 standardized physical examinations. **Panel B.** Scatterplot showing the relation between frequency of recovery of various microorganisms from stethoscopes and physicians' hands.

Abbreviation: MSSA, methicillin-sensitive *Staphylococcus aureus*; MRSA, methicillin-resistant *Staphylococcus aureus*; EB, Enterobacteriaceae; ESBL, extended-spectrum beta-lactamase-producing *Enterobacteriaceae*; NFB, nonfermenting gram-negative bacilli.

Tschopp C et al. Infect Control Hosp Epidemiol. 2016 Jun;37(6):673-9.


If contagiousness is associated with the level of contamination of the skin ...
…why not manipulate the cutaneous flora?

Decreasing contagiousness

ORIGINAL INVESTIGATION

Chlorhexidine Gluconate to Cleanse Patients in a Medical Intensive Care Unit

The Effectiveness of Source Control to Reduce the Bioburden of Vancomycin-Resistant Enterococci

Michael O. Vernon, DrPH; Mary K. Hayden, MD; William E. Trick, MD; Robert A. Hayes, BSc; Donald W. Blom, RN; Robert A. Weinstein, MD; for the Chicago Antimicrobial Resistance Project (CARP)

- 21 bed ICU
- Sequential study
  - Soap + water x 6 months, then
  - CHG wipes 2% without rincing x 6 months, then
  - Wipes <u>without</u> CHG x 6 months

CHG 2% wipes vs. Soap+water

Compared with soap and water, CHG wipes:

- ↓ Skin contam,
- ↓ Environmental Contam.
- ↓ Contam HCWs' hands
- ↓ Acquisition ERV

Compared with soap and water, non-CHG wipes:

- ⊘ ↓ Contam. skin,
- ↑ Contam. environment(?!)
- ⊘ ↓ Contam HCWs' hands
- ⊘ ↓ Acquisition ERV

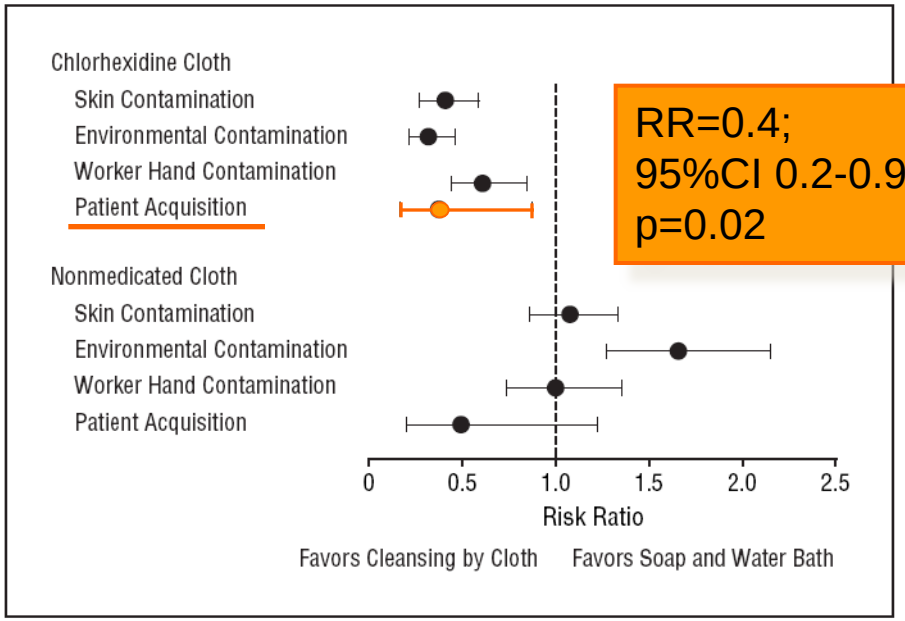


Figure 2. Risk ratios for skin contamination and environmental or health care worker contamination by or patient acquisition of vancomycin-resistant enterococci (VRE). Comparison of soap and water baths to cleansing with either chlorhexidine or nonmedicated cloths. Summary risk ratios are displayed for the frequency of VRE contamination of patients' skin (inguinal and antecubital), environmental surfaces (bed rail, overbed table, or pull sheet), and workers' hands (culture specimens taken after exiting the room of a patient with VRE colonization or a common room in the medical intensive care unit). The point estimate and upper and lower bounds of the 95% confidence intervals are displayed.

Vernon MO et al. Arch Intern Med 2006

CHG 2% skin vs soap + water

- ↓ contamination environment

Table 3. Percentage of Environmental Surface Culture Specimens That Were Positive for Vancomycin-Resistant Enterococci During the 3 Study Periods*

Site Where Culture Specimen Was Obtained	Study Period		
	Soap and Water (n = 311)	Chlorhexidine (n = 307)†	Nonmedicated Cloth (n = 140)‡
Table	10 (3)	4 (1)	13 (9)
Bed rail	33 (11)	13 (4)	23 (16)
Pull sheet	63 (20)	17 (6)	43 (31)

*Each environmental culture acquired is included in the analysis. Data are presented as number (percentage). The same number of cultures were obtained for each environmental surface.

†$P<.001$ by Mantel-Haenszel summary χ^2 test; stratified by environmental surface; comparison with the soap and water period.

‡$P = .02$ by Mantel-Haenszel summary χ^2 test; stratified by environmental surface; comparison with the soap and water period.

Vernon MO et al. Arch Intern Med 2006

The effect of daily bathing with chlorhexidine on the acquisition of methicillin-resistant *Staphylococcus aureus*, vancomycin-resistant *Enterococcus*, and healthcare-associated bloodstream infections: Results of a quasi-experimental multicenter trial*

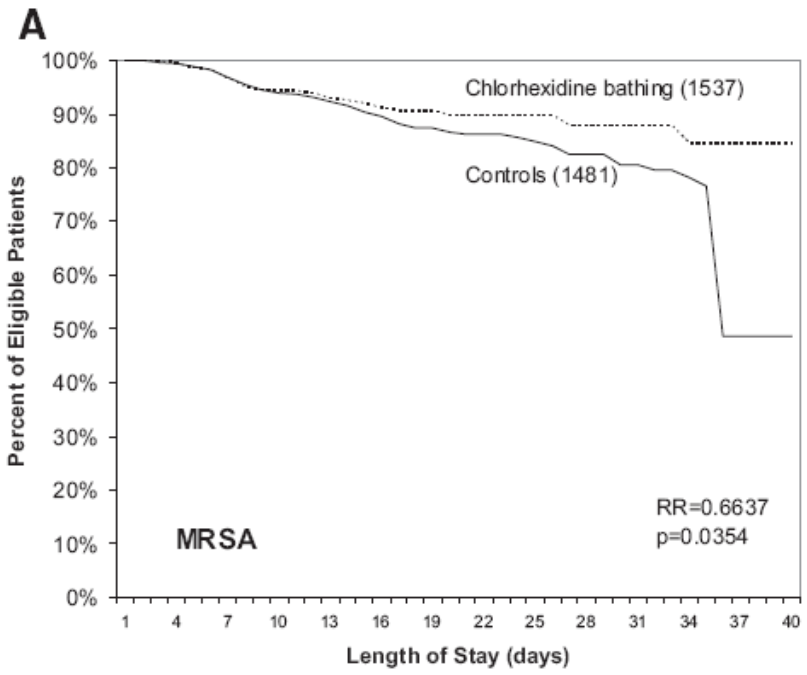
Michael W. Climo, MD; Kent A. Sepkowitz, MD; Gianna Zuccotti, MD, MPH; Victoria J. Fraser, MD; David K. Warren, MD; Trish M. Perl, MD, MSc; Kathleen Speck; John A. Jernigan, MD; Jaime R. Robles, PhD; Edward S. Wong, MD

- Multicenter study (6 ICU)
- Before-and-after study
- Interventions:
  - Soap + water baths
    or
  - Daily CHG bath (bottle CHG 4% in water)

Climo MW et al. Crit Care Med 2009; 37:1858

CHG baths, MRSA and VRE

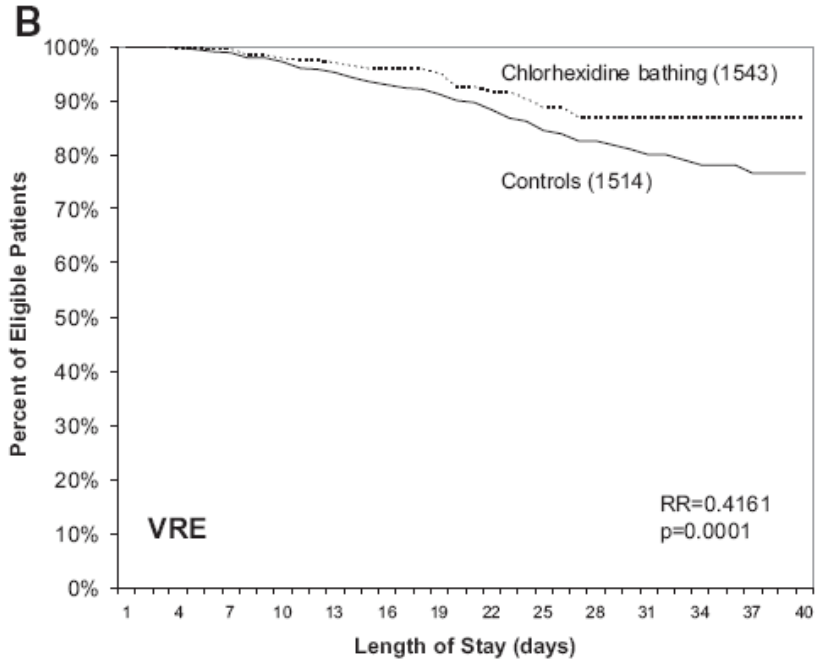
- ↓ 32% acquisition MRSA
- 5.04 vs. 3.44 cases/1000 patient-days; p=0.046
- Effect mainly when stay >14-21d



Climo MW et al. Crit Care Med 2009; 37:1858

CHG baths, MRSA and VRE

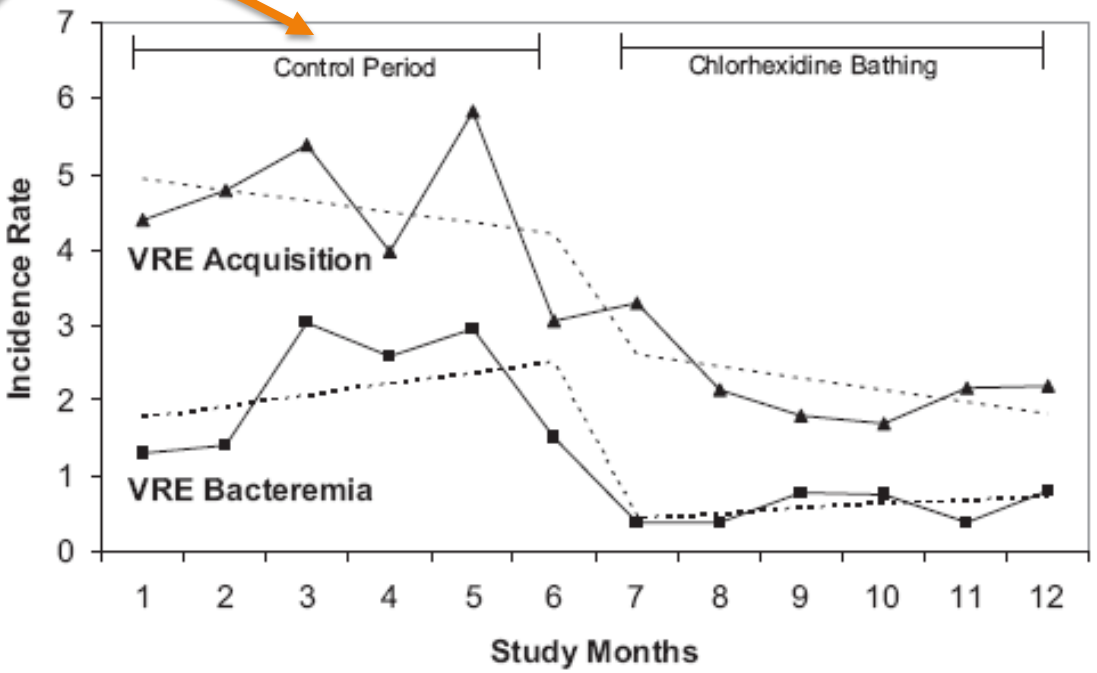
- ↓ 50% acquisition ERV
- 4.35 vs. 2.19 cases/1000 patient-days; p=0.008



Climo MW et al. Crit Care Med 2009; 37:1858

CHG baths, MRSA and VRE

i.e. bed bath soap and water!



- Diminution VRE BSI 73%
  - 2.13 vs 0.59/1000 PD; p=0.0006
  - Protects VRE+ patients against VRE BSI
    - RR, 0.30; p=0.035

Climo MW et al. Crit Care Med 2009; 37:1858

i.e. bed bath soap and water!

Table 3. Time series analysis of the results of introduction of daily chlorhexidine bathing on the incidence of MRSA and VRE colonization and bacteremia

Outcome Measure	Incidence Rate as Modeled at End of Intervention in the Absence of Chlorhexidine Bathing[a]	Observed Incidence Rate at End of Intervention[b]	Change in Incidence Rate Attributable to Introduction of Chlorhexidine Bathing (% Change)[c]
MRSA incidence	2.59	1.93	−0.66 (25%)
MRSA bacteremia	<0.1	<0.1	0 (0)
VRE incidence	3.34	1.83	−1.51 (45%)
VRE bacteremia	3.38	0.74	−2.64 (78%)

MRSA, methicillin-resistant *Staphylococcus aureus*; VRE, vancomycin-resistant *Enterococcus*.

[a]Incidence rate (cases per 1000 patient days) as modeled in time series analysis at the end of the intervention period based on level and secular trends observed during the baseline period in the absence of chlorhexidine bathing. This represents the expected value that would be observed had chlorhexidine bathing not been introduced; [b]modeled incidence rate (cases per 1000 patient days) observed at the end of the intervention period; [c]difference between the time series' modeled value in the absence of chlorhexidine bathing and the observed model value at the end of the intervention period with the percentage change in parenthesis.

Climo MW et al. Crit Care Med 2009; 37:1858

Bain CHG, SARM et VRE

- ↓ colonisation in most centers
  - More pronounced if pre-intervetion rates are higher

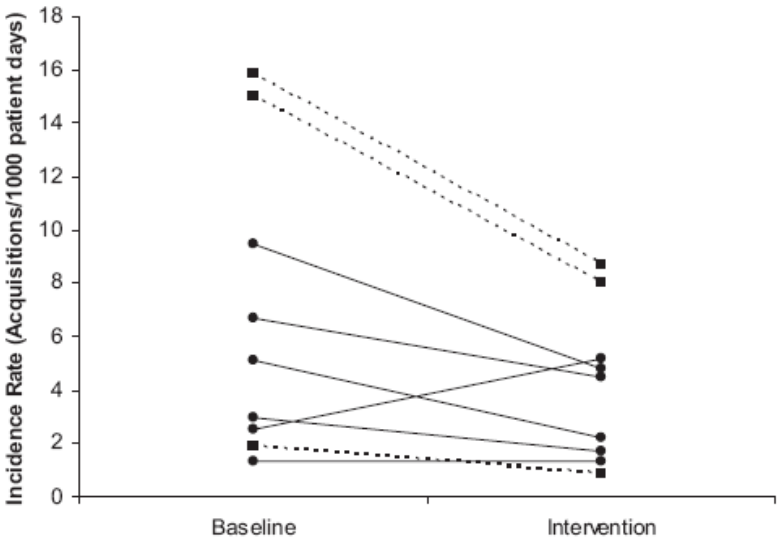


Figure 3. Reduction in the incidence of vancomycin-resistant *Enterococcus* (VRE) and methicillin-resistant *Staphylococcus aureus* (MRSA) colonization associated with chlorhexidine bathing for all study units. The mean incidence rate of VRE (■) and MRSA (●) for each study unit is shown during the baseline period in comparison with the intervention period. The introduction of chlorhexidine bathing for all patients admitted to the intensive care units (ICUs) during the intervention was associated with a reduction in the mean incidence rate of MRSA in five of six ICUs. The mean incidence rate of VRE was decreased in all three ICUs following the introduction of chlorhexidine bathing.

Climo MW et al. Crit Care Med 2009; 37:1858

NB Principal investigator switched to CHG wipes 2% pre-impregnated for subsequent study:

N Engl J Med. 2013 Feb 7;368(6):533-42

PSSSST! Home recipe=
CHG 4%, 4oz. In half basin warm water

The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

Effect of Daily Chlorhexidine Bathing on Hospital-Acquired Infection

Michael W. Climo, M.D., Deborah S. Yokoe, M.D., M.P.H., David K. Warren, M.D., Trish M. Perl, M.D., Maureen Bolon, M.D., Loreen A. Herwaldt, M.D., Robert A. Weinstein, M.D., Kent A. Sepkowitz, M.D., John A. Jernigan, M.D., Kakotan Sanogo, M.S., and Edward S. Wong, M.D.

ABSTRACT

BACKGROUND

Results of previous single-center, observational studies suggest that daily bathing of patients with chlorhexidine may prevent hospital-acquired bloodstream infections and the acquisition of multidrug-resistant organisms (MDROs).

METHODS

We conducted a multicenter, cluster-randomized, nonblinded crossover trial to evaluate the effect of daily bathing with chlorhexidine-impregnated washcloths on the acquisition of MDROs and the incidence of hospital-acquired bloodstream infections. Nine intensive care and bone marrow transplantation units in six hospitals were randomly assigned to bathe patients either with no-rinse 2% chlorhexidine–impregnated washcloths or with nonantimicrobial washcloths for a 6-month period, exchanged for the alternate product during the subsequent 6 months. The incidence rates of acquisition of MDROs and the rates of hospital-acquired bloodstream infections were compared between the two periods by means of Poisson regression analysis.

RESULTS

A total of 7727 patients were enrolled during the study. The overall rate of MDRO acquisition was 5.10 cases per 1000 patient-days with chlorhexidine bathing versus 6.60 cases per 1000 patient-days with nonantimicrobial washcloths (P=0.03), the equivalent of a 23% lower rate with chlorhexidine bathing. The overall rate of hospital-acquired bloodstream infections was 4.78 cases per 1000 patient-days with chlorhexidine bathing versus 6.60 cases per 1000 patient-days with nonantimicrobial washcloths (P=0.007), a 28% lower rate with chlorhexidine-impregnated washcloths. No serious skin reactions were noted during either study period.

CONCLUSIONS

Daily bathing with chlorhexidine-impregnated washcloths significantly reduced the risks of acquisition of MDROs and development of hospital-acquired bloodstream infections. (Funded by the Centers for Disease Control and Prevention and Sage Products; ClinicalTrials.gov number, NCT00502476.)

From the Hunter Holmes McGuire Veterans Affairs Medical Center (M.W.C., E.S.W.) and the Virginia Commonwealth University Medical Center (M.W.C., K.S., E.S.W.), Richmond; Brigham and Women's Hospital and Harvard Medical School, Boston (D.S.Y.); Washington University School of Medicine, St. Louis (D.K.W.); Johns Hopkins University, Baltimore (T.M.P.); Northwestern University (M.B.) and Cook County Health and Hospitals System (R.A.W.), Chicago; Iowa University Hospital, Iowa City (L.A.H.); Memorial Sloan-Kettering Cancer Center, New York (K.A.S.); and the Prevention Epicenters Program, Centers for Disease Control and Prevention, Atlanta (J.A.J.). Address reprint requests to Dr. Climo at the McGuire Veterans Affairs Medical Center, 1201 Broad Rock Blvd., Section 111-C, Richmond, VA 23249, or at michael.climo@va.gov.

N Engl J Med 2013;368:533-42.
DOI: 10.1056/NEJMoa1113849

- Multicenter cluster-randomized nonblinded crossover
- 9 USI et centres de GMO; 7727 patients

- 2 arms:
  - Washcloth CHG 2% vs. nonantimicrobial die

- Acquisition MRSA or VRE

  - 5.1 vs. 6.6/ 1000pd (↓ 23%; p=0.03)

  - BSI 4.78 vs. 6.60/1000pd (↓ 28%; p=0.007)

The NEW ENGLAND JOURNAL of MEDICINE

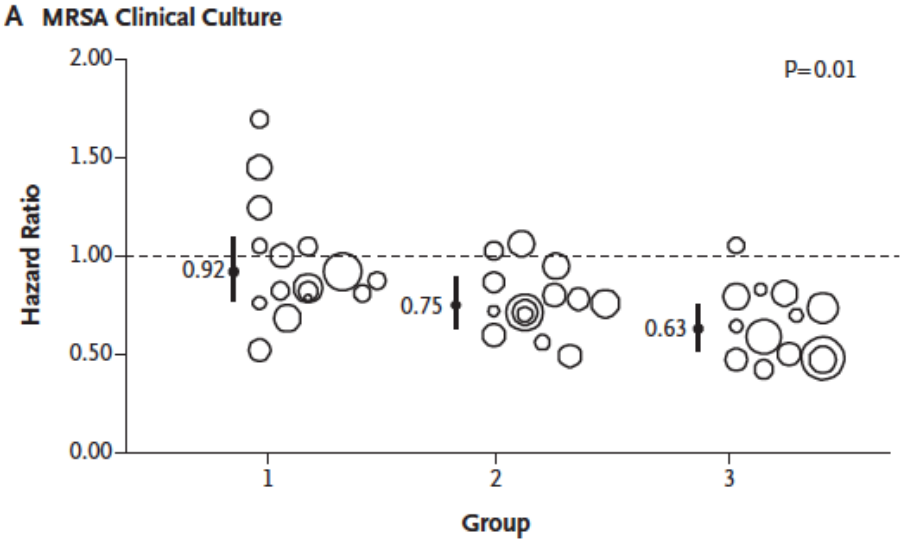
ESTABLISHED IN 1812 JUNE 13, 2013 VOL. 368 NO. 24

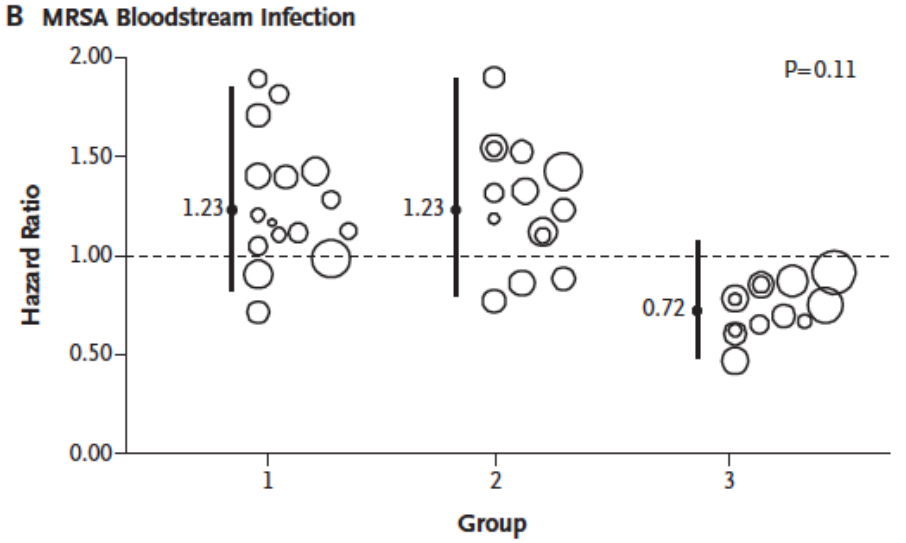
Targeted versus Universal Decolonization to Prevent ICU Infection

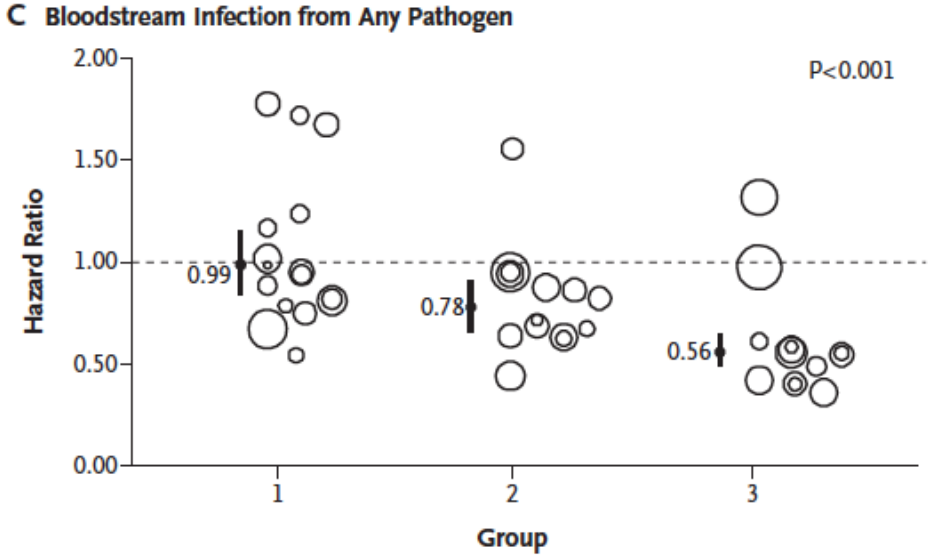
Susan S. Huang, M.D., M.P.H., Edward Septimus, M.D., Ken Kleinman, Sc.D., Julia Moody, M.S., Jason Hickok, M.B.A., R.N., Taliser R. Avery, M.S., Julie Lankiewicz, M.P.H., Adrijana Gombosev, B.S., Leah Terpstra, B.A., Fallon Hartford, M.S., Mary K. Hayden, M.D., John A. Jernigan, M.D., Robert A. Weinstein, M.D., Victoria J. Fraser, M.D., Katherine Haffenreffer, B.S., Eric Cui, B.S., Rebecca E. Kaganov, B.A., Karen Lolans, B.S., Jonathan B. Perlin, M.D., Ph.D., and Richard Platt, M.D., for the CDC Prevention Epicenters Program and the AHRQ DECIDE Network and Healthcare-Associated Infections Program*

- Cluster-randomized trial, 43 CH, 72 ICUs
- 3 strategies compared
  1. MRSA screening and isolation
  2. MRSA screening and isolation and decolonisation
  3. No screening; decolonize everyone
- Decolonisation: mupirocin intra-nasal + 2% CHG wipes pre-impregnated

Huang SS N Engl J Med. 2013 Jun 13;368(24):2255-65.







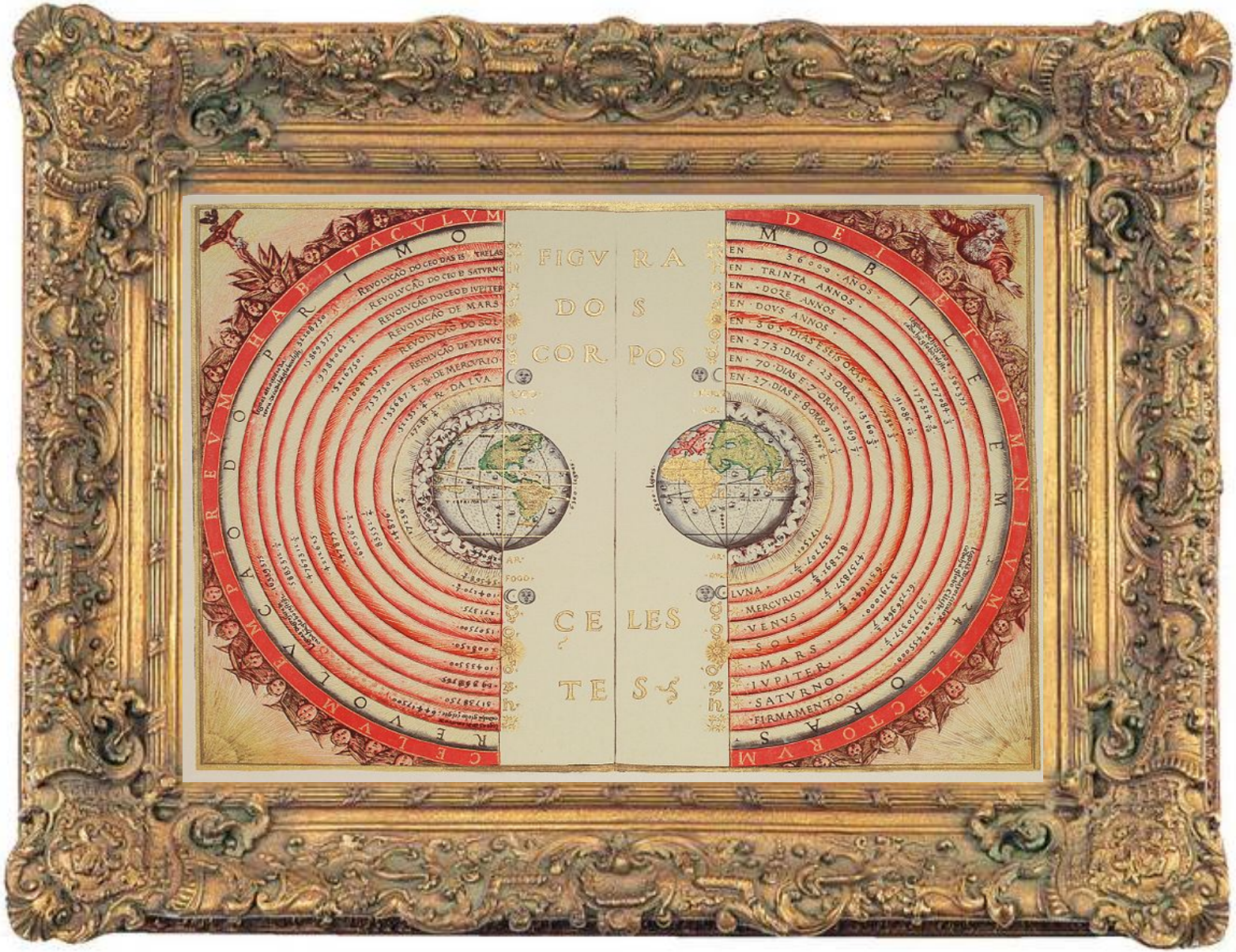
- NNT = 99
- Adverse effects rare

Figure 2. Effect of Trial Interventions on Outcomes.

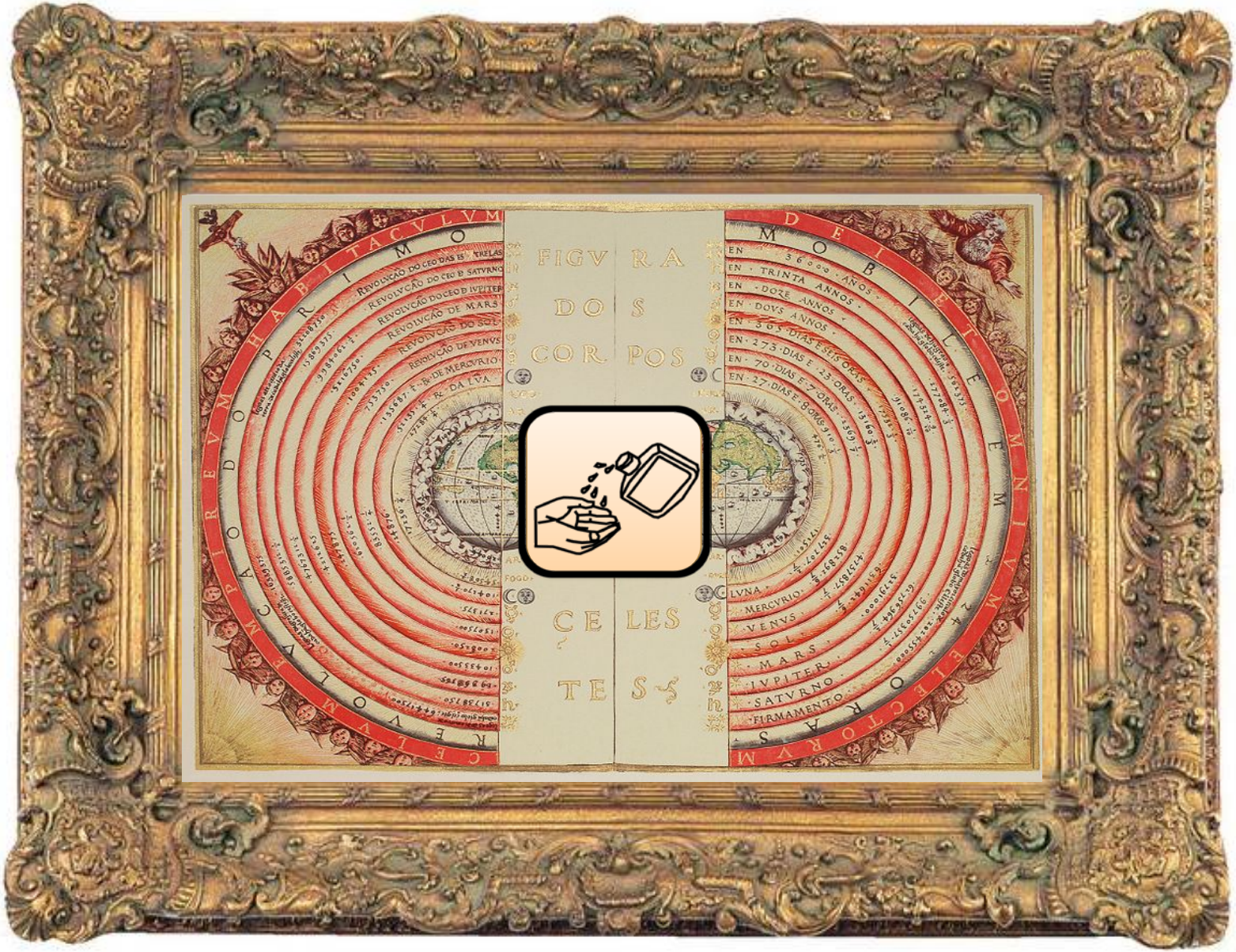
Shown are group-specific hazard ratios and 95% confidence intervals (indicated by vertical lines) for outcomes attributable to the intensive care unit. Results are based on unadjusted proportional-hazards models that accounted for clustering within hospitals. Analyses were based on the as-assigned status of hospitals. Panel A shows hazard ratios for clinical cultures that were positive for methicillin-resistant *Staphylococcus aureus* (MRSA) infection, Panel B hazard ratios for MRSA bloodstream infection, and Panel C hazard ratios for bloodstream infection from any pathogen. Bubble plots of hazard ratios (predicted random effects or exponentiated frailties) from individual hospitals relative to their group effects are shown. The size of the bubble indicates the relative number of patients contributing data to the trial.

Huang SS N Engl J Med. 2013 Jun 13;368(24):2255-65.

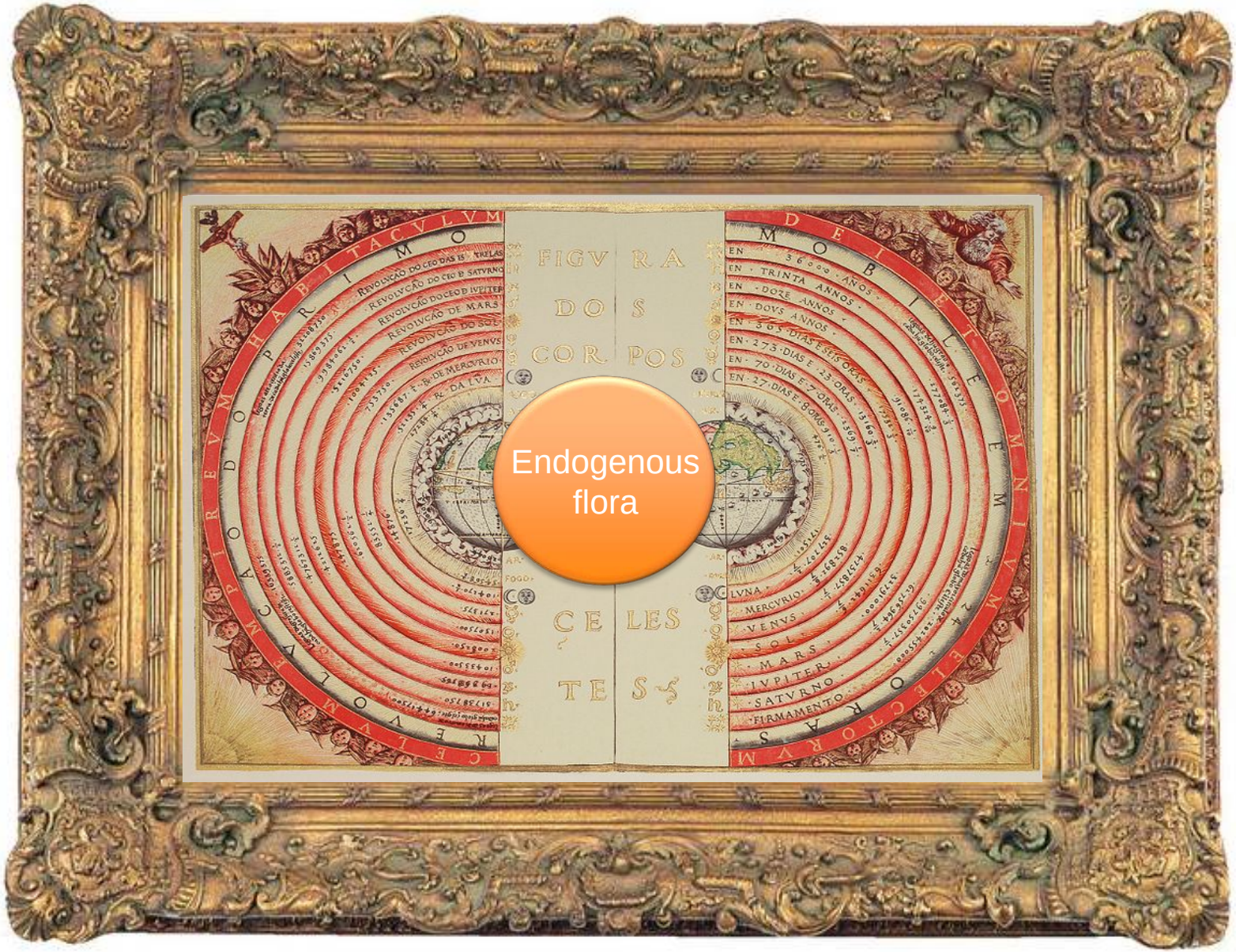
Chlorhexidine and HAI



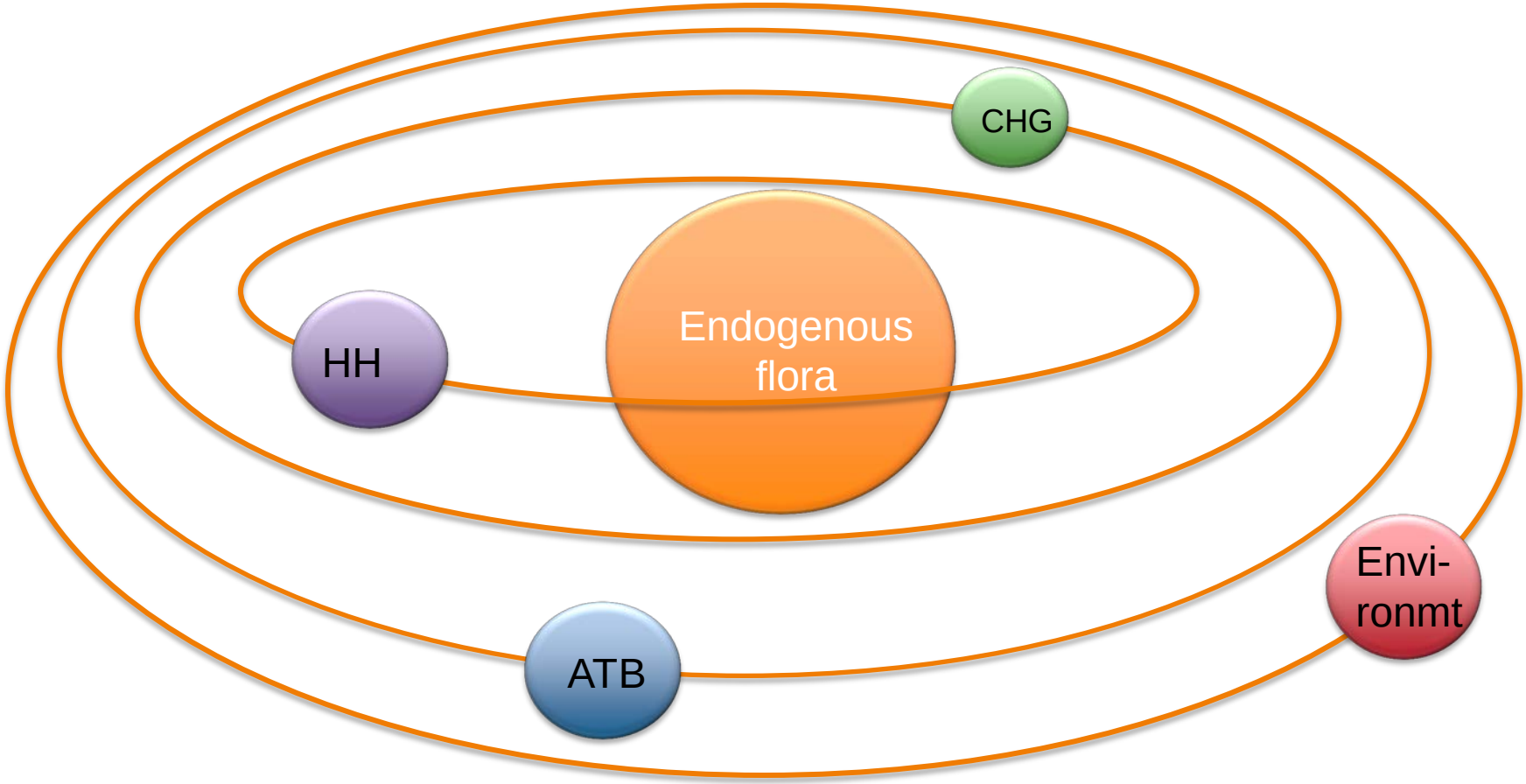
Bartolomeu Velho, 1568 Bibliothèque Nationale, Paris



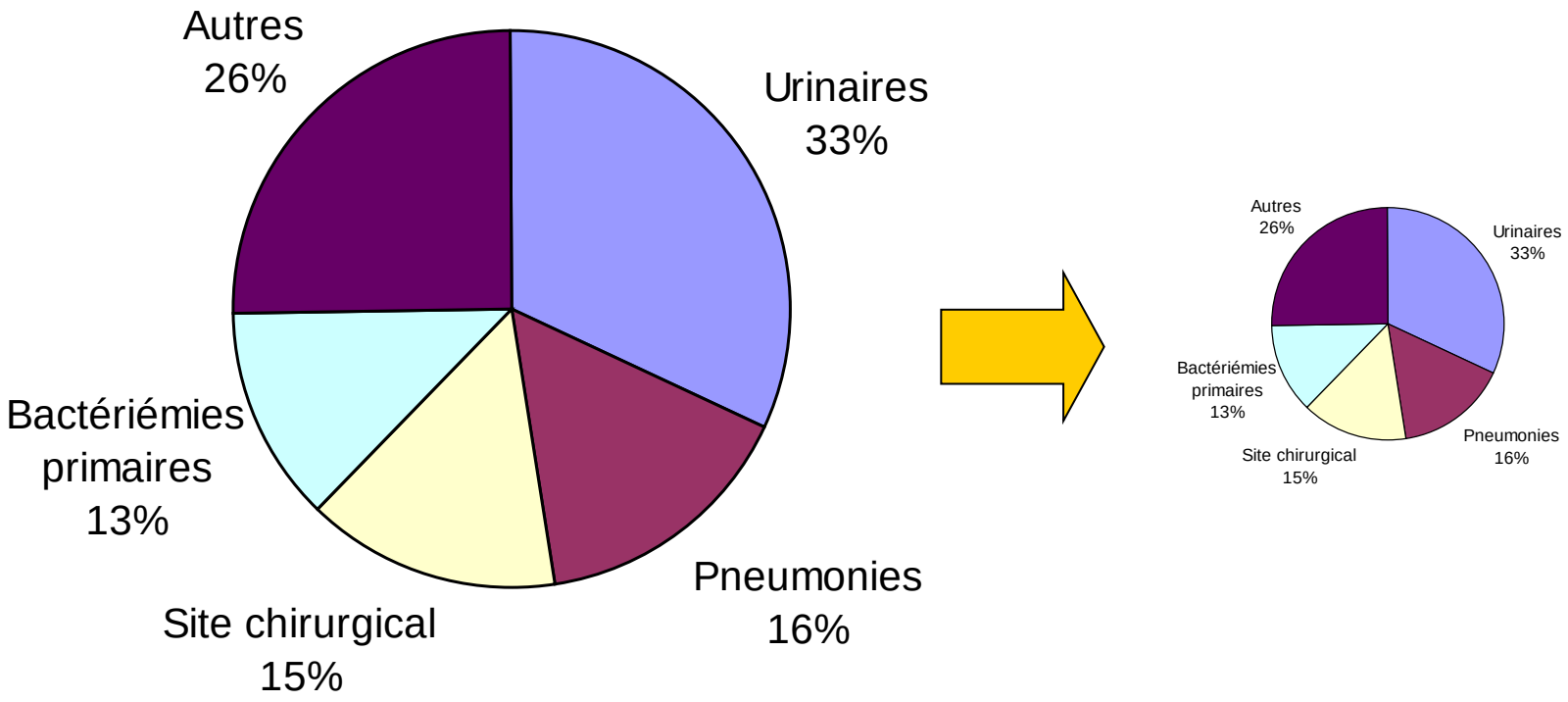
Bartolomeu Velho, 1568 Bibliothèque Nationale, Paris



Bartolomeu Velho, 1568 Bibliothèque Nationale, Paris


CHG
Endogenous flora
HH
Envi-ronmt
ATB

Main HAIs

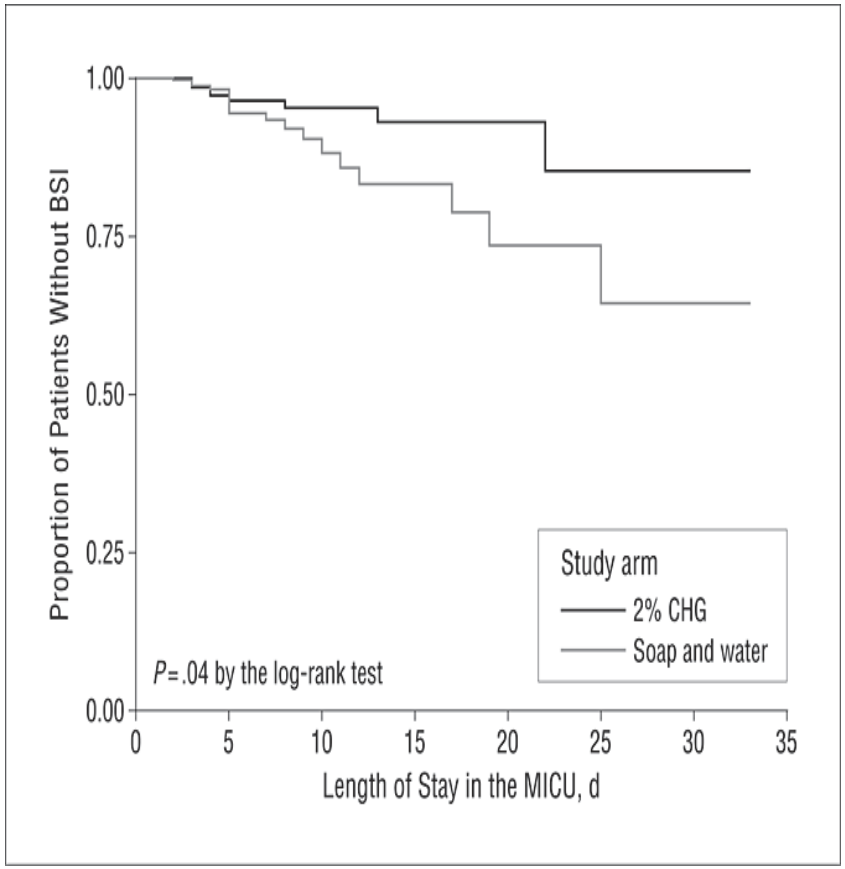


Our mission: to introduce measures to prevent nosocomial infections

CHG and CLABSI

CHG and CLABSI

- Crossover study; 52 weeks, 2 ICUs of same center
- Chlorhexidine 2% (CHG) wipes vs. soap+water
- Primary BSI
  - CHG: 4.1 infections/1000 PD
  - Soap: 10.4 infections/1000 PD
  - Difference incidence
    - 6.3 infections/1000pd (95% CI 1.2-11.0)



Bleasdale SC et al. Arch Intern Med. 2007;167:2073.

CHG-impregnated sponges

- Theory: Decolonization of the catheter insertion site would reduce the risk of extra-luminal colonization and catheter infections

- Keep in mind
  - Insertion site not visible
  - No effect on endoluminal colonization

CHG-impregnated sponges

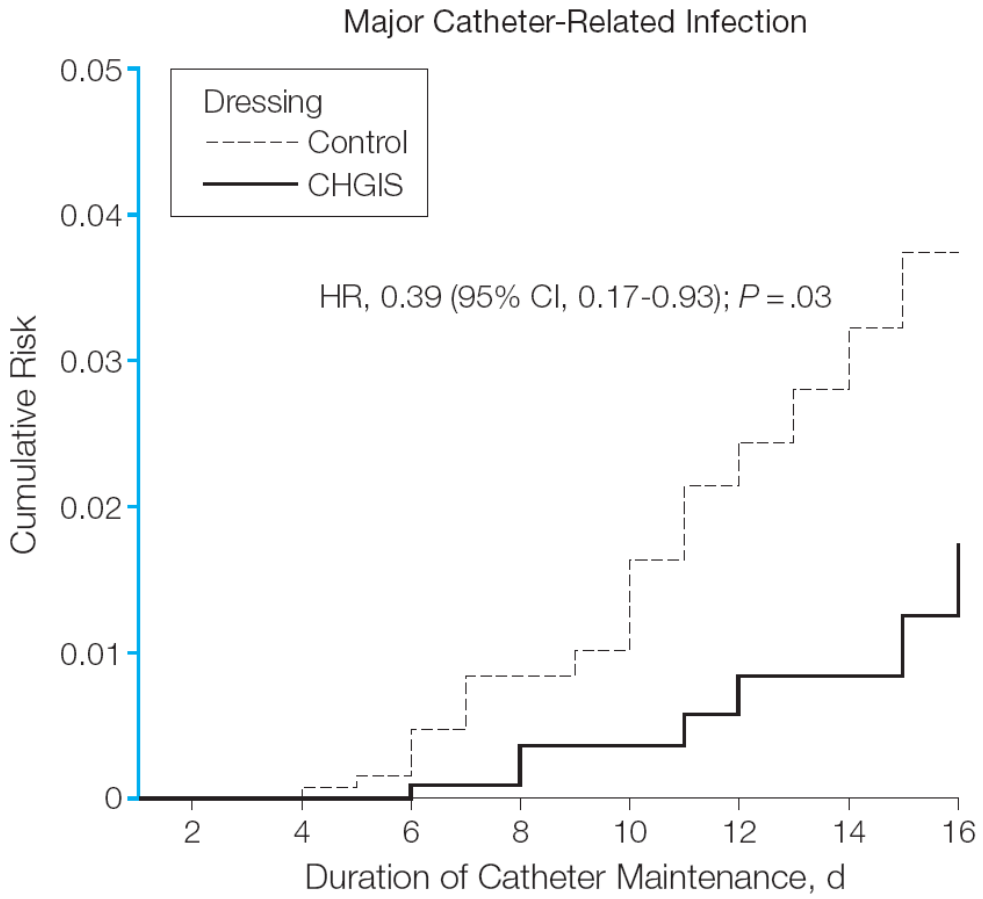
- RCT Compare Biopatch vs. standard dressing
- Types of catheters:
  - Arterial
  - CVC (non-impregnated ATB)
- Outcomes:
  - CR-BSI
    - ≥ 1 positive peripheral blood culture, a quantitative catheter tip culture growing the same organism or differential time to positivity of blood cultures ≥ 2 hours, and no other source
  - Catheter-related clinical sepsis without bloodstream infection
    - Fever, positive cath tip, pus at line site, and no other source

Timsit JF et al. JAMA. 2009;301:1231-41.

CHG-impregnated sponges

- 1636 catheters
- Ave. duration insertion: 6d
- Major infection rates (CR-BSI or KT sepsis)
  - Sponge-CHG: 0.6 infections/1000 JKT
  - Standard dressing: 1.4 infections/1000 JKT
  - Hazard ratio 0.39 (95% CI 0.16-0.93)

    NNT: 117
- 8 episodes contact dermatitis in intervention arm (5.3/1000 catheters)



Timsit JF et al. JAMA. 2009;301:1231-41.

Chlorhexidine and SSI

Chlorhexidine-Alcohol versus Povidone-Iodine for Surgical-Site Antisepsis

Rabih O. Darouiche, M.D., Matthew J. Wall, Jr., M.D., Kamal M.F. Itani, M.D., Mary F. Otterson, M.D., Alexandra L. Webb, M.D., Matthew M. Carrick, M.D., Harold J. Miller, M.D., Samir S. Awad, M.D., Cynthia T. Crosby, B.S., Michael C. Mosier, Ph.D., Atef AlSharif, M.D., and David H. Berger, M.D.

N Engl J Med
Volume 362(1):18-26
January 7, 2010

Methods

- Multicenter RCT
- Goal: evaluate efficacy of CHG-EtOH 2% compared with Povidone Iodine to prevent SSI
- Outcome
  - SSI < 30d post-ops

Darouiche RO et al. N Engl J Med. 2010; 362:18-26

Methods

- Population
  - 849 patients; randomization 1:1
  - Clean-contaminated Surgeries (colo-rectal, GI, thoracic, Gyne, Uro)
  - 2 comparable groups (demographics, patho…)s_

Darouiche RO et al. N Engl J Med. 2010; 362:18-26

SSI Incidence

Table 2. Proportion of Patients with Surgical-Site Infection, According to Type of Infection (Intention-to-Treat Population).

Type of Infection	Chlorhexidine–Alcohol (N=409)	Povidone–Iodine (N=440)	Relative Risk (95% CI)*	P Value†	
	no. (%)				
Any surgical-site infection	39 (9.5)	71 (16.1)	0.59 (0.41–0.85)	0.004	**-41%**
Superficial incisional infection	17 (4.2)	38 (8.6)	0.48 (0.28–0.84)	0.008	**-52%**
Deep incisional infection	4 (1.0)	13 (3.0)	0.33 (0.11–1.01)	0.05	**-67%**
Organ-space infection	18 (4.4)	20 (4.5)	0.97 (0.52–1.80)	>0.99	
Sepsis from surgical-site infection	11 (2.7)	19 (4.3)	0.62 (0.30–1.29)	0.26	

* Relative risks are for chlorhexidine–alcohol as compared with povidone–iodine. The 95% confidence intervals were calculated with the use of asymptotic standard-error estimates.

† P values are based on Fisher's exact test.

Darouiche RO et al. N Engl J Med. 2010; 362:18-26

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Deep incisional infection			3 (0.11–1.01)	0.05
Organ-space infection			0.97 (0.52–1.80)	>0.99
Sepsis from surgical-site infection		19 (4.3)	0.62 (0.30–1.29)	0.26

-41%

-52%

-67%

NNTT = 17

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Darouiche RO et al. N Engl J Med. 2010; 362:18-26

Adverse Events

Table 4. Clinical Adverse Events (Intention-to-Treat Population).

Clinical Adverse Event	Chlorhexidine–Alcohol (N=409)	Povidone–Iodine (N=440)	Absolute Difference*	P Value†
	no. (%)		*percentage points (95% CI)*	
Adverse events in ≥5% of patients in either group	228 (55.7)	256 (58.2)	−2.4 (−9.1 to 4.2)	0.49
Drug-related adverse events‡	3 (0.7)	3 (0.7)	0.1 (−1.1 to 1.2)	>0.99
Serious adverse events in >1% of patients in either group	72 (17.6)	70 (15.9)	1.7 (−3.3 to 6.7)	0.52
Serious drug-related adverse events	0	0	—	—
Death	4 (1.0)	3 (0.7)	0.3 (−0.9 to 1.5)	0.72

* The absolute difference is shown as the rate in the chlorhexidine–alcohol group minus the rate in the povidone–iodine group.
† P values were calculated with the use of Fisher's exact test.
‡ Drug-related adverse events included pruritus, erythema, or both around the surgical wound and are reported even though the rate was not 5% or higher in either group.

Darouiche RO et al. N Engl J Med. 2010; 362:18-26

Prevention of Nosocomial Infection in Cardiac Surgery by Decontamination of the Nasopharynx and Oropharynx With Chlorhexidine Gluconate

A Randomized Controlled Trial

- Rational: Decolonization to prevent SSI
- Design: Double-blind placebo-controlled RCT
- Single center, 2 yeats
  - 991 patients
  - SDD if intubated >48h
- Intervention:
  - Mouth wash and nasal application CHG 0.12%

JAMA, November 22/29, 2006—Vol 296, No. 20 (Reprinted)

CHG nasopharynx and SSI

- Intervention
  - 0.12% CHG
    - 10mL mounth wash QID
    - Intra-nasal gel QID
  - Start on admission (i.e. prior to surgery)
    - Average, 1.9 day prior to surgery
  - End: upon removal of NG tube

Segers P et al. JAMA 2006; 296 (20)

Nasopharyx/ Oral CHG decontamination

Table 2. Primary Outcomes

	No. (%) of Patients		
	Chlorhexidine Gluconate (n = 485)	Placebo (n = 469)	*P* Value*
No. of nosocomial infections (cumulative)	116	164	.002
Lower respiratory tract infection	45 (9.3)	74 (15.8)	.002
Urinary tract infection	14 (2.9)	21 (4.8)	.09
Bacteremia	9 (1.9)	17 (3.6)	.001
Primary	4 (0.8)	4 (0.9)	.96
Endocarditis	1 (0.2)	2 (0.9)	.54
No. of surgical site infections (cumulative)	48	52	.61
Deep	9 (1.9)	24 (5.1)	.002
Sternal	25 (5.2)	29 (6.4)	.49
Deep and sternal	5 (1.0)	14 (3.0)	.001
Donor site	20 (4.1)	22 (4.7)	.67
Other	3 (0.6)	2 (0.9)	.97

*One-tailed.

Segers P et al. JAMA 2006; 296 (20)

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Segers P et al. JAMA 2006; 296 (20)

Nasopharyx/ Oral CHG decontamination

Table 3. Secondary Outcomes

	No. (%) of Patients		
	Chlorhexidine Gluconate (n = 485)	Placebo (n = 469)	*P* Value*
Nonprophylactic antimicrobial agents	66 (13.6)	101 (21.5)	.02
Duration of hospital stay, mean (SD), d			
Preoperative	1.6 (1.2)	1.9 (1.9)	.22
Intensive care	1.2 (1.1)	1.3 (1.3)	.30
Total	9.5 (7.0)	10.3 (9.5)	.04
Nosocomial infection (intensive care stay)	1.4 (1.4)	2.6 (5.3)	.05
Nosocomial infection (total stay)	13.2 (10.8)	16.8 (16.1)	.05
Surgical site infection (total stay)	14.4 (13.8)	22.1 (21.0)	.03
Readmission	19 (3.9)	23 (4.9)	.46
Death	8 (1.7)	6 (1.3)	.64
Preoperative duration of trial medication, mean (SD), d	1.9 (1.2)	1.9 (1.2)	.48
Trial medication adverse effects	1 (0.2)	0	.32

*Two-tailed.

Segers P et al. JAMA 2006; 296 (20)

Nasopharyx/ Oral CHG decontamination

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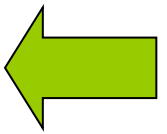
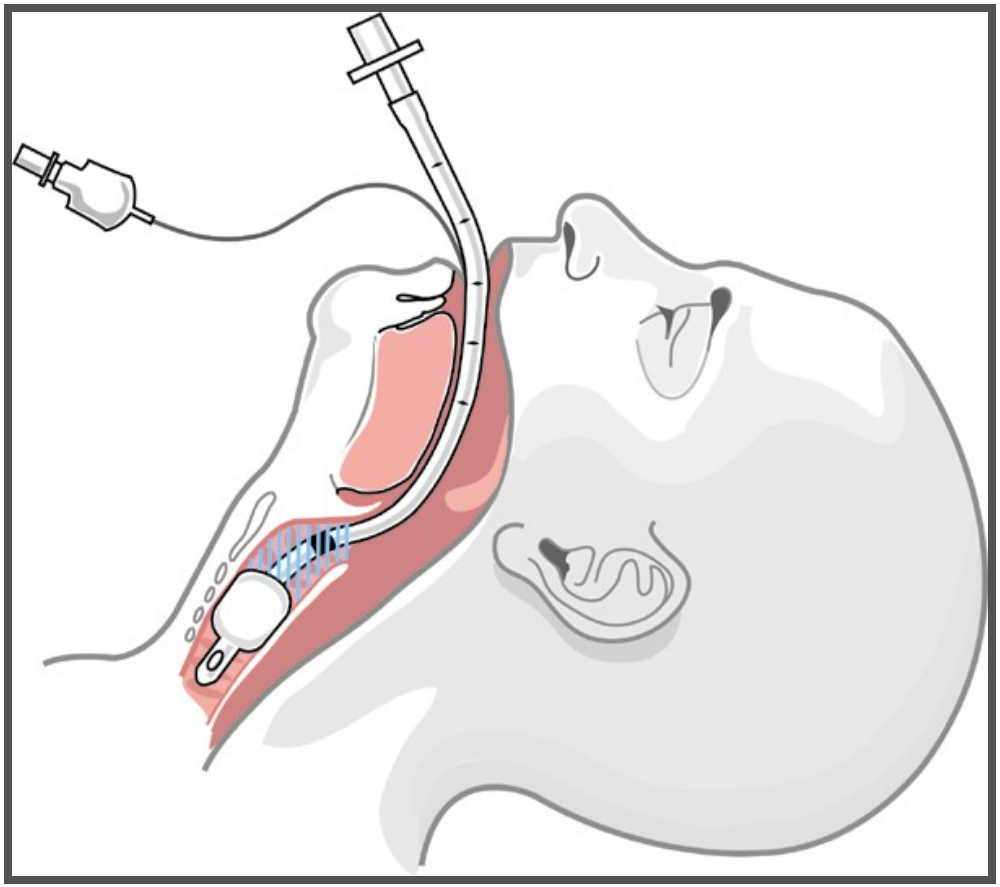


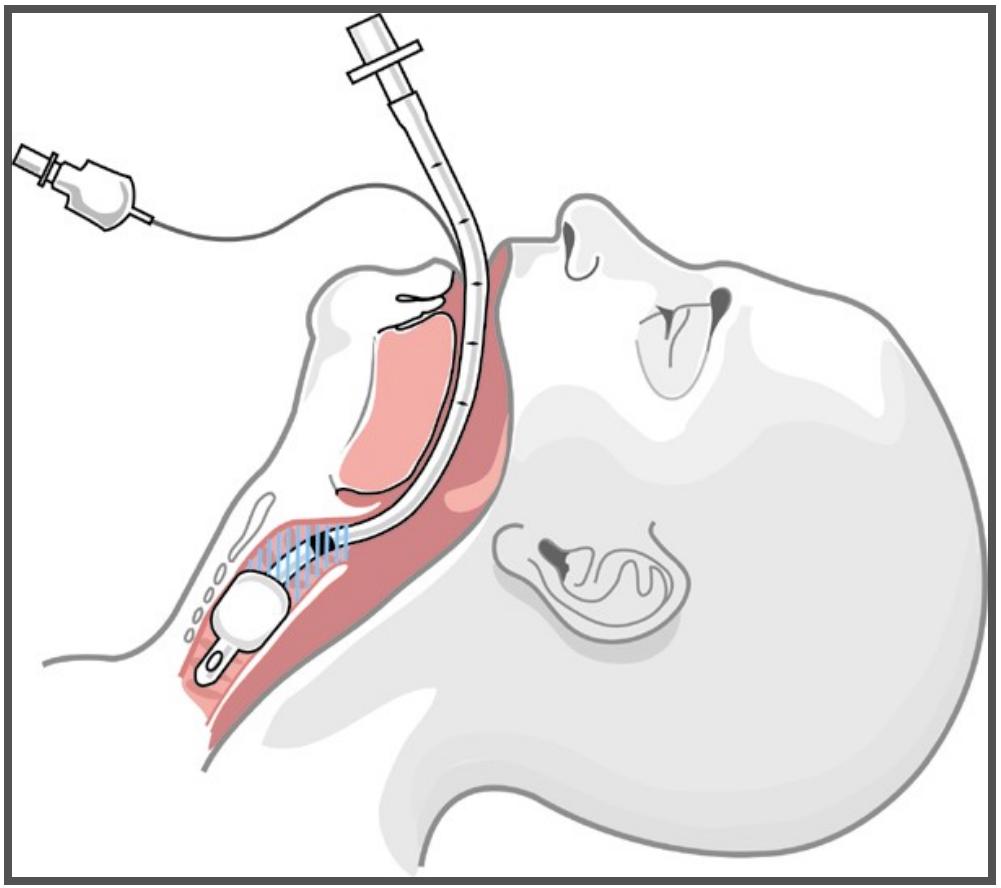
Segers P et al. JAMA 2006; 296 (20)

Chlorhexidine and pneumonia

Physiopathology of VAP?



Physiopathology of VAP?



"Aspiration of oropharyngeal pathogens or leakage of bacteria around the endotracheal tube cuff is the primary route of bacterial entry into the trachea."

American Thoracic Society [ATS]/Infectious Diseases Society of America [IDSA] Guidelines for Management of Adults with VAP. 2005. Am J Respir Crit Care Med. 171: 388-416.

Studies CHG-VAP

2 metanalyses shown benefit of CHG mouthwash to prevent VAP

Chan, E. Y., Ruest, A., Meade, M. O., and Cook, D. J. Oral decontamination for prevention of pneumonia in mechanically ventilated adults: systematic review and meta-analysis. BMJ 2007;334(7599):889-900.

Pineda, L. A., Saliba, R. G., and El Solh, A. A. Effect of oral decontamination with chlorhexidine on the incidence of nosocomial pneumonia: a meta-analysis. Crit Care 2006. 10;1;R35-R41.[1]

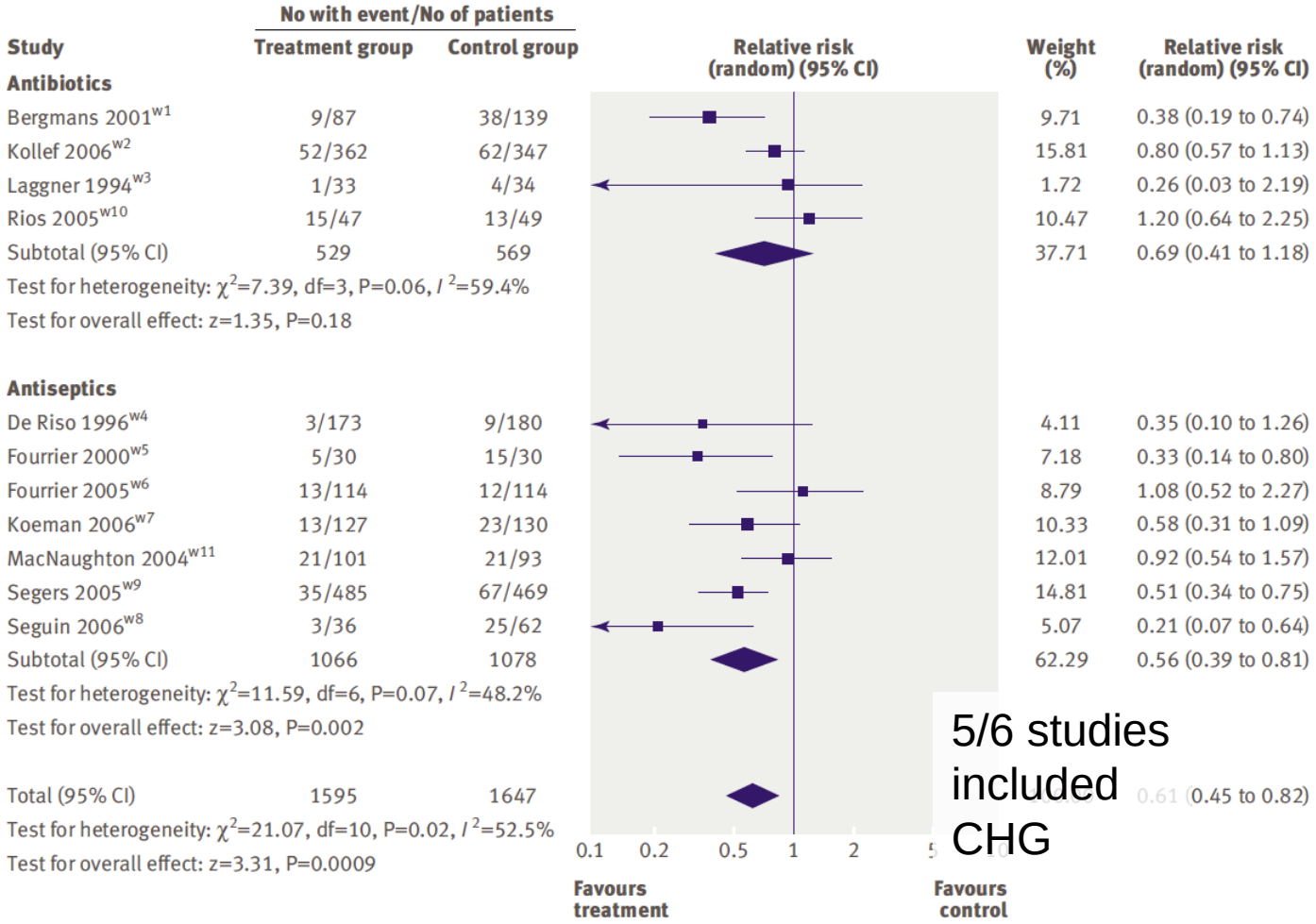
[1] 4% vs 7%; OR 0.42; 95% CI, 0.16-1.06; p=0.07

Metanalysis

- Objective: evaluate the impact of oral decontamination of VAP incidence
- 11 studies included
- Results
  - No impact of oral antibiotic decontamination
  - Decrease VAP with antiseptic decontamination D
    - RR, 0.61; 95% CI, 0.45-0.82

Chan EY et al. BMJ, March 26, 2007

Metanalysis



Study	No with event/No of patients: Treatment group	Control group	Weight (%)	Relative risk (random) (95% CI)
Antibiotics				
Bergmans 2001[w1]	9/87	38/139	9.71	0.38 (0.19 to 0.74)
Kollef 2006[w2]	52/362	62/347	15.81	0.80 (0.57 to 1.13)
Laggner 1994[w3]	1/33	4/34	1.72	0.26 (0.03 to 2.19)
Rios 2005[w10]	15/47	13/49	10.47	1.20 (0.64 to 2.25)
Subtotal (95% CI)	529	569	37.71	0.69 (0.41 to 1.18)
Test for heterogeneity: χ^2=7.39, df=3, P=0.06, I^2=59.4%				
Test for overall effect: z=1.35, P=0.18				
Antiseptics				
De Riso 1996[w4]	3/173	9/180	4.11	0.35 (0.10 to 1.26)
Fourrier 2000[w5]	5/30	15/30	7.18	0.33 (0.14 to 0.80)
Fourrier 2005[w6]	13/114	12/114	8.79	1.08 (0.52 to 2.27)
Koeman 2006[w7]	13/127	23/130	10.33	0.58 (0.31 to 1.09)
MacNaughton 2004[w11]	21/101	21/93	12.01	0.92 (0.54 to 1.57)
Segers 2005[w9]	35/485	67/469	14.81	0.51 (0.34 to 0.75)
Seguin 2006[w8]	3/36	25/62	5.07	0.21 (0.07 to 0.64)
Subtotal (95% CI)	1066	1078	62.29	0.56 (0.39 to 0.81)
Test for heterogeneity: χ^2=11.59, df=6, P=0.07, I^2=48.2%				
Test for overall effect: z=3.08, P=0.002				
Total (95% CI)	1595	1647		0.61 (0.45 to 0.82)
Test for heterogeneity: χ^2=21.07, df=10, P=0.02, I^2=52.5%				
Test for overall effect: z=3.31, P=0.0009				

5/6 studies included CHG

Chan EY et al. BMJ, March 26, 2007

Chlorhexidine bathing outside of ICU

- Most studies done in ICU and BMT

  Vernon MO et al. Arch Intern Med 2006
  Climo MW et al. Crit Care Med 2009; 37:1858
  Climo MW et al. N Engl J Med. 2013 Feb 7;368(6):533-42.
  Huang SS N Engl J Med. 2013 Jun 13;368(24):2255-65.
  Noto MJ et al. JAMA. 2015 Jan 27;313(4):369-78. (-)
  Chen W et al. J Thorac Dis. 2013 Aug;5(4):518-24. **meta-analyse**; 11/12 studies in ICU
  Derde LP et al. Lancet Infect Dis. 2014;14(1):31-39.

- Few data on impact of CHG in non-ICU

  Kassakian Sz et al. Infect Control Hosp Epidemiol. 2011Mar;32(3):238-43.
  Medical ward single center
  No impact on VRE infections (p=0.2)
  Lower rate of infection – higher cost per averted infection?

American Journal of Infection Control ■■ (2016) ■■-■■

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journal homepage: www.ajicjournal.org

Major Article

Reduction in hospital-associated methicillin-resistant *Staphylococcus aureus* and vancomycin-resistant *Enterococcus* with daily chlorhexidine gluconate bathing for medical inpatients

Christopher F. Lowe MD [a,b,c,*], Elisa Lloyd-Smith PhD [a], Baljinder Sidhu RN [a], Gordon Ritchie PhD [b,c], Azra Sharma MSc [a], Willson Jang BSc [b], Anna Wong MLT [b], Jennifer Bilawka BMLSc [b], Danielle Richards RN [a], Thomas Kind RN [a], David Puddicombe MSc [a], Sylvie Champagne MD [b,c], Victor Leung MD [a,b,c,d], Marc G. Romney MD [a,b,c]

[a] *Infection Prevention and Control, Providence Health Care, Vancouver, BC, Canada*
[b] *Division of Medical Microbiology, Providence Health Care, Vancouver, BC, Canada*
[c] *Department of Pathology and Laboratory Medicine, University of British Columbia, Vancouver, BC, Canada*
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Hôpital général juif Jewish General Hospital | Infection Prevention and Control Unit

McGill Faculty of Medicine Faculté de médecine

American Journal of Infection Control ■■ (2016) ■■-■■

Contents lists available at ScienceDirect

American Journal of Infection Control

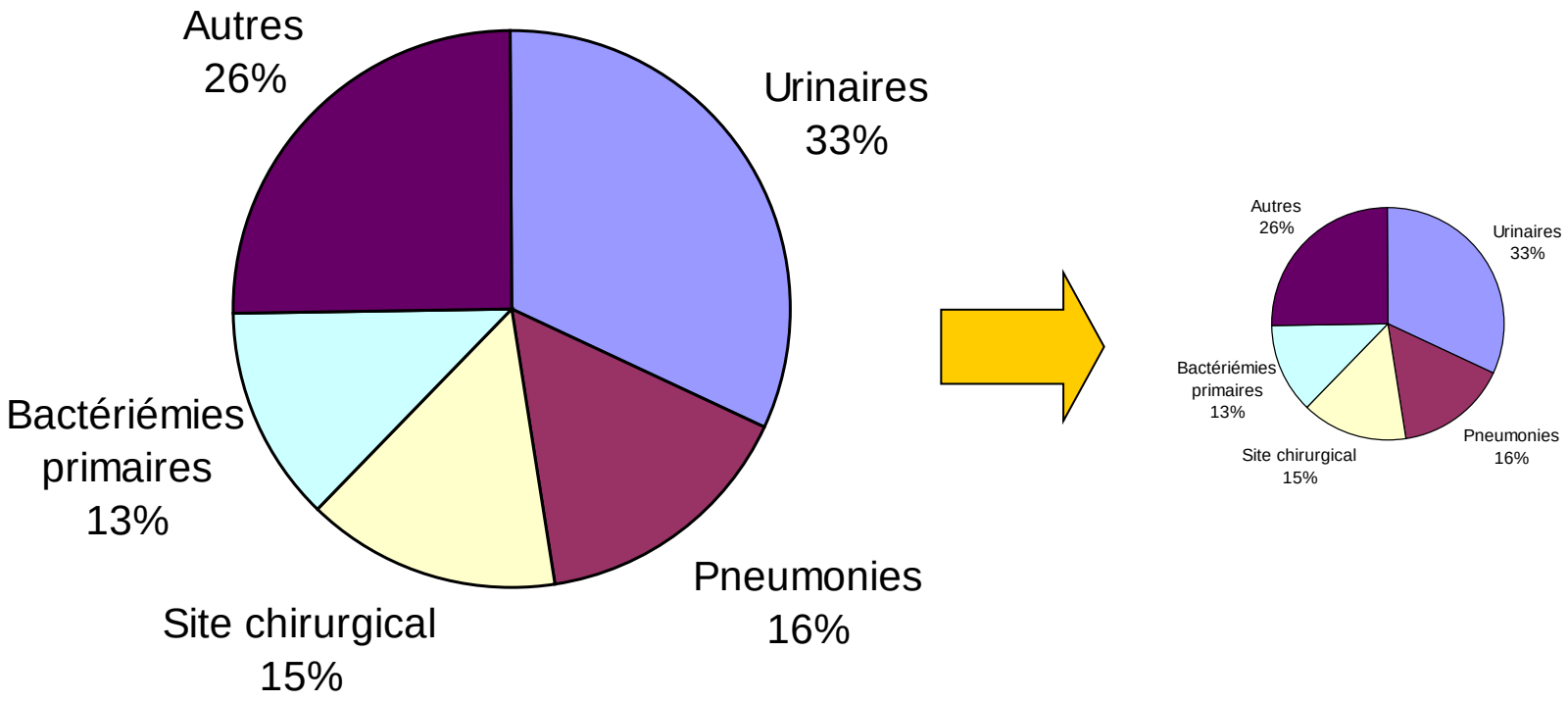
journal homepage: www.ajicjournal.org

Major Article

Reduction in hospital-associated methicillin-resistant *Staphylococcus aureus* and vancomycin-resistant *Enterococcus* with daily chlorhexidine gluconate bathing for medical inpatients

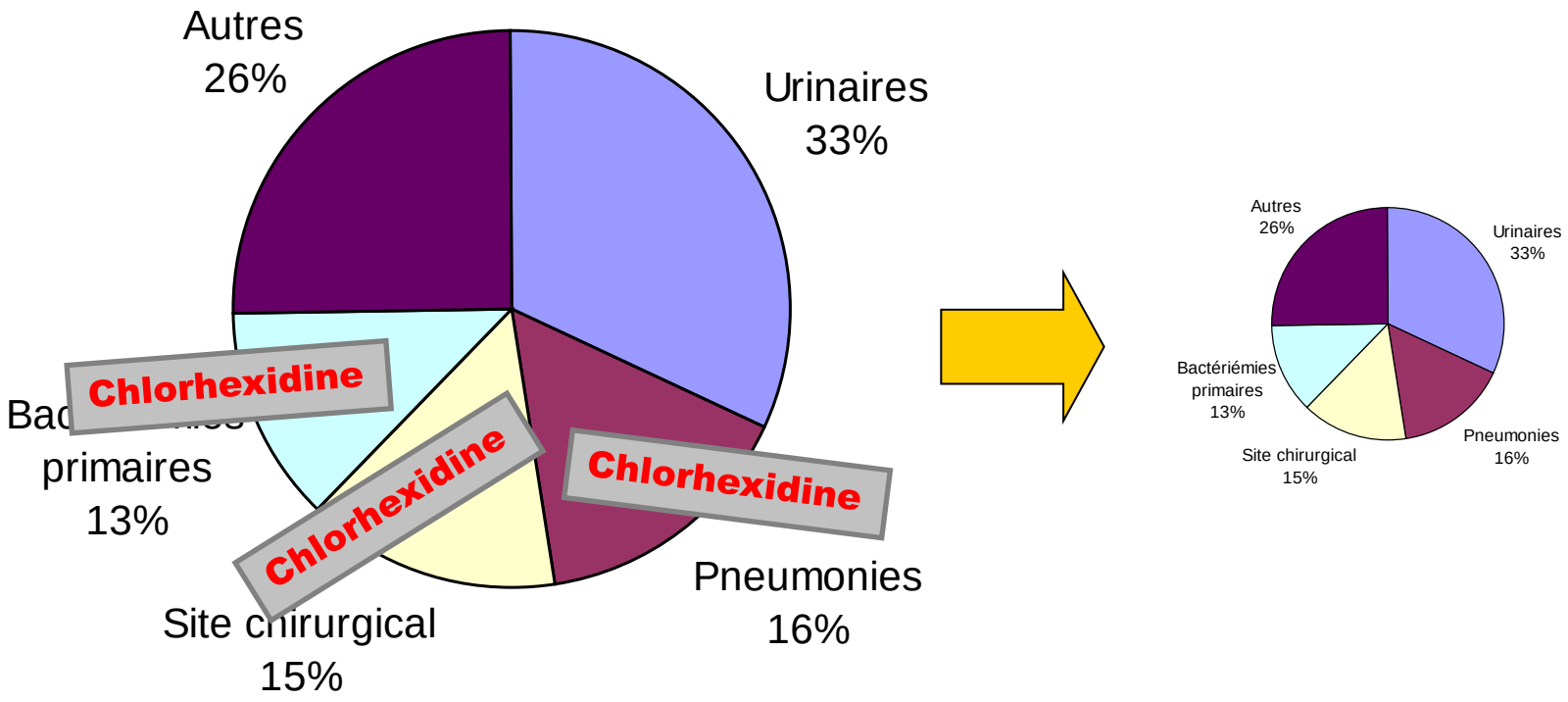
- Crossover study 4 medical wards, 7 months
- Soap and water vs. CHG wipes
- Results
  - Compliance CHG wipes = 58%
  - Decrease in MRSA acquisition by 55%
  - Decrease in VRE acquisition by 36%

Main HAIs



Our mission: to introduce measures to prevent nosocomial infections

Main HAIs



Our mission: to introduce measures to prevent nosocomial infections

- I want to do research in infection control...

- If a positive result you want, *the Chlorhexidine* you must use

Diagnosis, Prevention, and Treatment of Catheter-Associated Urinary Tract Infection in Adults: 2009 International Clinical Practice Guidelines from the Infectious Diseases Society of America

Thomas M. Hooton,[1] Suzanne F. Bradley,[2] Diana D. Cardenas,[2] Richard Colgan,[4] Suzanne E. Geerlings,[7] James C. Rice,[5,*] Sanjay Saint,[3] Anthony J. Schaeffer,[6] Paul A. Tambayh,[8] Peter Tenke,[9] and Lindsay E. Nicolle[10,11]

Departments of [1]Medicine and [2]Rehabilitation Medicine, University of Miami, Miami, Florida; [3]Department of Internal Medicine, Ann Arbor Veterans Affairs Medical Center and the University of Michigan, Ann Arbor, Michigan; [4]Department of Family and Community Medicine, University of Maryland, Baltimore; [5]Department of Medicine, University of Texas, Galveston; [6]Department of Urology, Northwestern University, Chicago, Illinois; [7]Department of Infectious Diseases, Tropical Medicine, and AIDS, University of Amsterdam, Amsterdam, The Netherlands; [8]Department of Medicine, National University of Singapore, Singapore; [9]Department of Urology, Jahn Ference Del-Pesti Korhaz, Budapest, Hungary; and Departments of [10]Internal Medicine and [11]Medical Microbiology, University of Manitoba, Winnipeg, Canada

Guidelines for the diagnosis, prevention, and management of persons with catheter-associated urinary tract infection (CA-UTI), both symptomatic and asymptomatic, were prepared by an Expert Panel of the Infectious Diseases Society of America. The evidence-based guidelines encompass diagnostic criteria, strategies to reduce the risk of CA-UTIs, strategies that have not been found to reduce the incidence of urinary infections, and management strategies for patients with catheter-associated asymptomatic bacteriuria or symptomatic urinary tract infection. These guidelines are intended for use by physicians in all medical specialties who perform direct patient care, with an emphasis on the care of patients in hospitals and long-term care facilities.

EXECUTIVE SUMMARY

Catheter-associated (CA) bacteriuria is the most common health care–associated infection worldwide and is a result of the widespread use of urinary catheterization, much of which is inappropriate, in hospitals and long-term care facilities (LTCFs). Considerable personnel time and other costs are expended by health care institutions to reduce the rate of CA infections, especially those that occur in patients with symptoms or signs referable to the urinary tract (CA urinary tract infection [CA-UTI]). In these guidelines, we provide background information on the epidemiology and pathogenesis of CA infections and evidence-based recommendations for their diagnosis, prevention and management. Unfortunately, the catheter literature generally reports on CA asymptomatic bacteriuria (CA-ASB) or CA bacteriuria (used when no distinction is made between CA-ASB and CA-UTI; such cases are predominantly CA-ASB), rather than on CA-UTI. As a result, most recommendations in these guidelines refer to CA-bacteriuria, because this is the only or predominant out-

Received 23 November 2009; accepted 24 November 2009; electronically published 4 February 2010.

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Reprints or correspondence: Dr Thomas M. Hooton, 1120 NW 14th St, Ste 1144, Clinical Research Bldg, University of Miami Miller School of Medicine, Miami, FL 33136 (thooton@med.miami.edu).

Clinical Infectious Diseases 2010; 50:625–663

1058-4838/2010/5005-0001$15.00
DOI: 10.1086/650482

These guidelines were developed by the Infectious Diseases Society of America in collaboration with the American Geriatrics Society, American Society of Nephrology, American Spinal Injury Association, American Urological Association, Association of Medical Microbiology and Infectious Diseases–Canada, European Association of Urology , European Society of Clinical Microbiology and Infectious Diseases, Society for Healthcare Epidemiology of America, Society of Hospital Medicine, and the Western Pacific Society of Chemotherapy.

It is important to realize that guidelines cannot always account for individual variation among patients. They are not intended to supplant physician judgment with respect to particular patients or special clinical situations. The IDSA considers adherence to these guidelines to be voluntary, with the ultimate determination regarding their application to be made by the physician in the light of each patient's individual circumstances.

CHG and Urinary Tract Infections

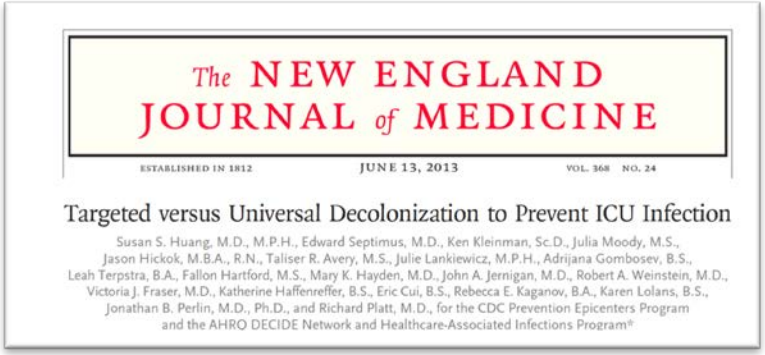
Numerous Studies Have Failed to Detect any Benefit

- Noto MJ, Domenico HJ, Byrne DW, et al. Chlorhexidine bathing and healthcare-associated infections. A randomized clinical trial. JAMA 2015; 313: 369–78.
- Rupp ME, Cavalieri RJ, Lyden E, et al. Eff ect of hospital-wide chlorhexidine patient bathing on healthcare-associated infections. Infect Control Hosp Epidemiol 2012; 33: 1094–100.
- Evans HL, Dellit TH, Chan J, Nathans AB, Maier RV, Cuschieri J. Effect of chlorhexidine whole-body bathing on hospital-acquired infections among trauma patients. Arch Surg 2010; 145: 240–46.
- Bleasdale SC, Trick WE, Gonzalez IM, Lyles RD, Hayden MK, Weinstein RA. Effectiveness of chlorhexidine bathing to reduce catheter-associated bloodstream infections in medical intensive care unit patients. Arch Intern Med 2007; 167: 2073–79.
- Popovich KJ, Hota B, Hayes R, Weinstein RA, Hayden MK. Eff ectiveness of routine cleansing with chlorhexidine gluconate for infection prevention in the medical intensive care unit. Infect Control Hosp Epidemiol 2009; 30: 959–63.

Effect of body surface decolonisation on bacteriuria and candiduria in intensive care units: an analysis of a cluster-randomised trial

Susan S Huang, Edward Septimus, Mary K Hayden, Ken Kleinman, Jessica Sturtevant, Taliser R Avery, Julia Moody, Jason Hickok, Julie Lankiewicz, Adrijana Gombosev, Rebecca E Kaganov, Katherine Haffenreffer, John A Jernigan, Jonathan B Perlin, Richard Platt, Robert A Weinstein, for the Agency for Healthcare Research and Quality (AHRQ) DEcIDE Network and Healthcare-Associated Infections Program, and the CDC Prevention Epicenters Program

- Secondary analysis of Cluster RCT



The NEW ENGLAND JOURNAL of MEDICINE

ESTABLISHED IN 1812 JUNE 13, 2013 VOL. 368 NO. 24

Targeted versus Universal Decolonization to Prevent ICU Infection

Susan S. Huang, M.D., M.P.H., Edward Septimus, M.D., Ken Kleinman, Sc.D., Julia Moody, M.S., Jason Hickok, M.B.A., R.N., Taliser R. Avery, M.S., Julie Lankiewicz, M.P.H., Adrijana Gombosev, B.S., Leah Terpstra, B.A., Fallon Hartford, M.S., Mary K. Hayden, M.D., John A. Jernigan, M.D., Robert A. Weinstein, M.D., Victoria J. Fraser, M.D., Katherine Haffenreffer, B.S., Eric Cui, B.S., Rebecca E. Kaganov, B.A., Karen Lolans, B.S., Jonathan B. Perlin, M.D., Ph.D., and Richard Platt, M.D., for the CDC Prevention Epicenters Program and the AHRQ DECIDE Network and Healthcare-Associated Infections Program*

- CHG decolonization including perineum and 6 inches of urinary catheters

Huang SS et al. Lancet Infect Dis 2016; 16: 70–79

Effect of body surface decolonisation on bacteriuria and candiduria in intensive care units: an analysis of a cluster-randomised trial

Susan S Huang, Edward Septimus, Mary K Hayden, Ken Kleinman, Jessica Sturtevant, Taliser R Avery, Julia Moody, Jason Hickok, Julie Lankiewicz, Adrijana Gombosev, Rebecca E Kaganov, Katherine Haffenreffer, John A Jernigan, Jonathan B Perlin, Richard Platt, Robert A Weinstein, for the Agency for Healthcare Research and Quality (AHRQ) DEcIDE Network and Healthcare-Associated Infections Program, and the CDC Prevention Epicenters Program

- Results
  - NO impact on high-level bacteriruria (>50,000 CFU/mL of a recognized pathogen)
- Slight decrease in candiduria in men and in bacteriruria due to a uropathogen of any CFU/mL (p=0.05)
  - Uncertain significance (colonization more probable)
  - NB. No clinical assessment of CAUTI made (difficult to document symptoms in ICU patients)

Huang SS et al. Lancet Infect Dis 2016; 16: 70–79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INFECTION CONTROL AND HOSPITAL EPIDEMIOLOGY OCTOBER 2014, VOL. 35, NO. S3

ORIGINAL ARTICLE

Cost Savings of Universal Decolonization to Prevent Intensive Care Unit Infection: Implications of the REDUCE MRSA Trial

Susan S. Huang, MD, MPH;[1] Edward Septimus, MD;[2] Taliser R. Avery, MPH;[3] Grace M. Lee, MD, MPH;[3] Jason Hickok, MBA, RN;[4] Robert A. Weinstein, MD;[5] Julia Moody, MS;[4] Mary K. Hayden, MD;[6] Jonathan B. Perlin, MD, PhD;[4] Richard Platt, MD, MS;[3] G. Thomas Ray, MBA[7]

Cost-benefit analysis in the ICU

Strategy	No. of BSI	Total Cost per admission	Difference in cost per admission	Difference cost per 1000 adm (including costs of BSI)
Screening and isolation	20	19,400.00$	ref	ref
Screening and targeted decolonization	15	19,330.00$	4.00$	-71,000.00$
Universal decolonization	11	19,230.00$	-17.00$	-171,000.00$

Huang SS et al. Infect Control Hosp Epidemiol 2014;35(S3):S23-S31

- OK…
  - Considerable evidence suggests that CHG is effective in reducing patient contagiousness
  - Why is it not used more frequently?

Conflicting Data

1

Research

Original Investigation | CARING FOR THE CRITICALLY ILL PATIENT

Chlorhexidine Bathing and Health Care–Associated Infections
A Randomized Clinical Trial

Michael J. Noto, MD, PhD; Henry J. Domenico, MS; Daniel W. Byrne, MS; Tom Talbot, MD, MPH; Todd W. Rice, MD, MSc; Gordon R. Bernard, MD; Arthur P. Wheeler, MD

- 5 USI USA (Tennessee)
- Cluster randomized crossover (n=9340)
- Durée: 12 mois
- 2% CHG wipes ou non-medicated wipes

Noto MJ et al. JAMA. 2015 Jan 27;313(4):369-78.

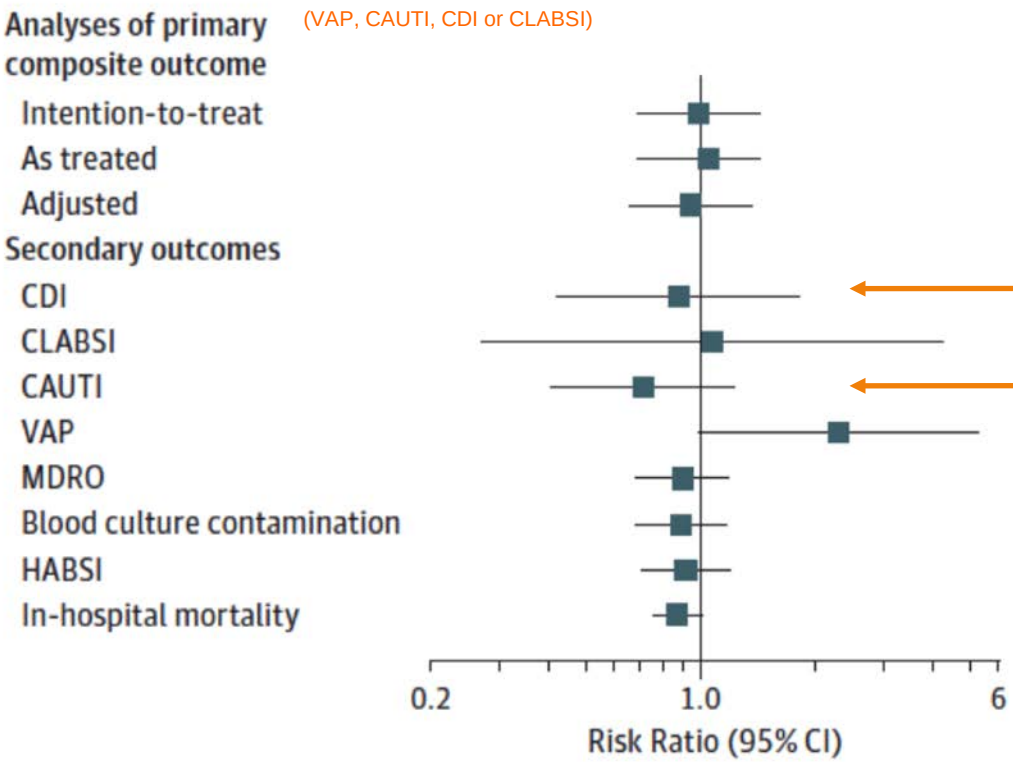
Research

Original Investigation

Chlorhexid … Infections
A Randomi…

Michael J. Noto, MD, PhD; …
Todd W. Rice, MD, MSc; Go…

Figure 2. Effect of Chlorhexidine Bathing on Primary and Secondary Outcomes



Effect CHG = ?

Effect CHG = ?

The chlorhexidine effect on intention-to-treat, as-treated, and adjusted ana… line… tra… pne… Inte… …ts of the primary outcomes, are shown. HA-BSI indicates health care–associated bloodstream infection; MDRO, multidrug-resistant organisms. For crude data, see Table 2.

No monitoring of compliance with measure
No Active Monitoring of MDRO Transmission
Low incidence of HAI

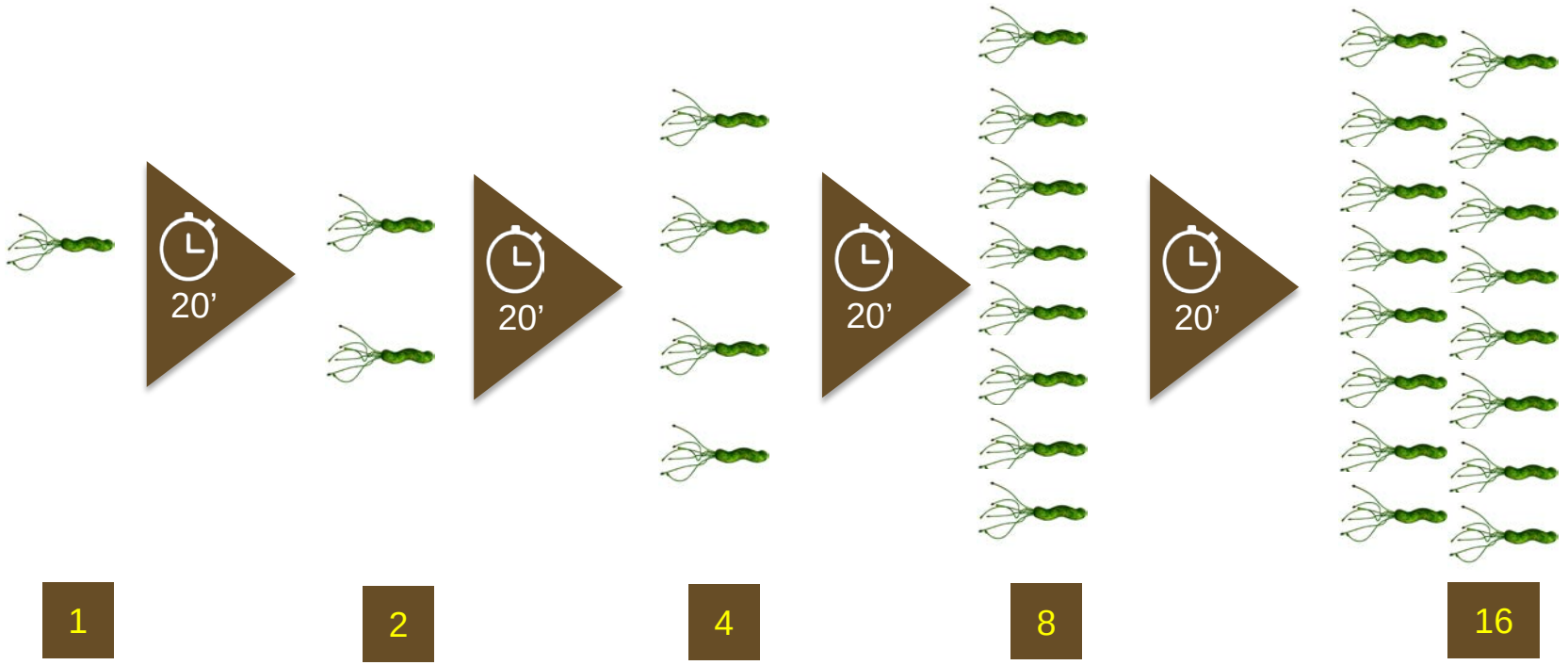
Jan 27;313(4):369-78.

Hôpital général Jewish General

2

MICROBES

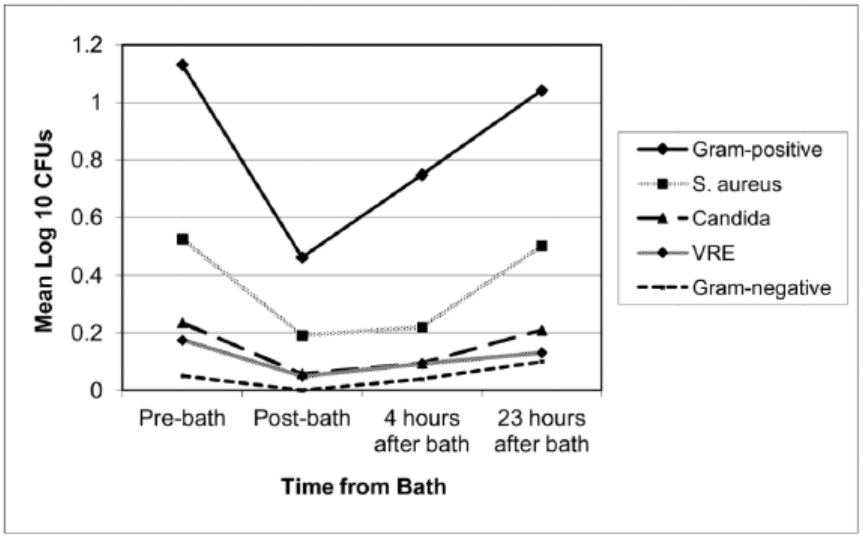
Generation time



1 log = 10 times more

A bacteria only needs to multiply 3-4 times to become 10x more numerous

Limiting factor = competition for nutrients…



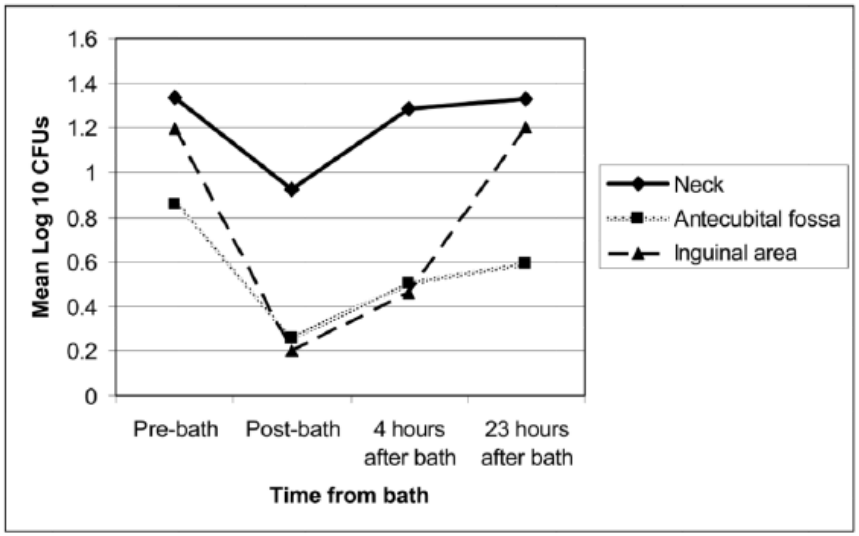
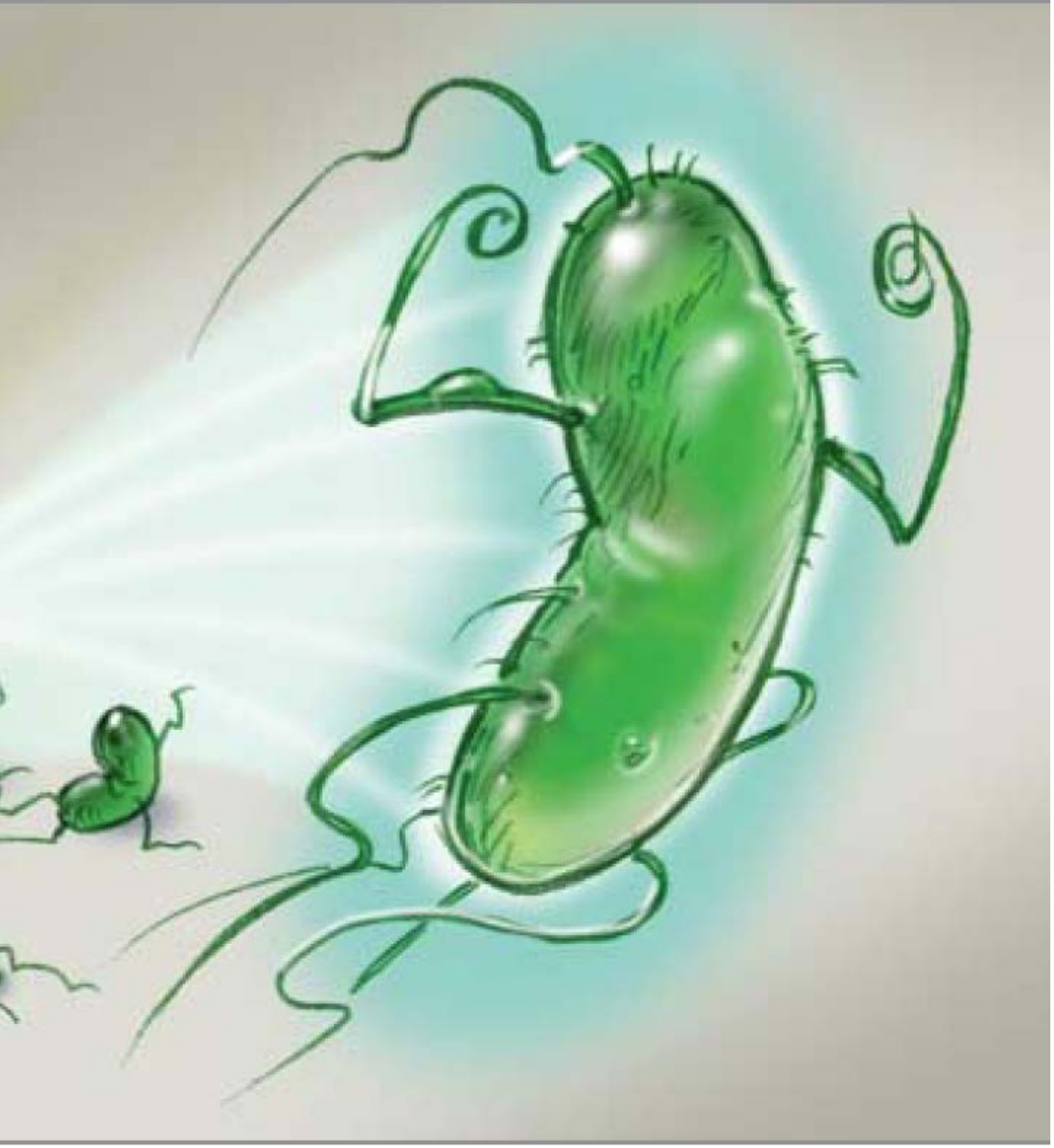


Figure 2.
The relationship of mean $\log_{10}$ colony counts and time from CHG bath. All patients tested had received at least one CHG bath approximately 24 hours before the pre-bath time.
Figure 2a (top): Relationship displayed by category of microbe isolated. Gram-positive organisms included coagulase-negative staphylococci, *Staphylococcus aureus*, *Streptococcus spp.*, *Aerococcus sp.*, *Micrococcus sp.*, and *Enterococcus spp.* Gram-negative organisms included *Proteus mirabilis*, *Pseudomonas aeruginosa*, and *Acinetobacter baumannii.*
Figure 2b (bottom): Relationship for gram-positive organisms displayed by body site.
ABBREVIATION: CFUs, colony counts. VRE, vancomycin-resistant enterococcus. CHG, chlorhexidine digluconate.

Popovich KJ et al. Infect Control Hosp Epidemiol. 2012 Sep;33(9):889-96.



3

RESISTANCE?

Resistance vs adaptation

- Resistance to chlorhexidine
  - Genetically determined
  - Intrinsic

- Adaptation phenotypical
  - Not genetically determined
  - Not transferable
  - Disappear with removal of selective pressure

Resistance to CHG

- Definition
  - Not as straightforward as with ATB
    - **ATB: R = capacity to grow at [ ] that is reached by the ATB at site of infection**
  - Definition for CHG
    - **CHG R: Increase of MIC above wild-type levels**
    - MIC> 50mg/l = resistance to CHG?
      - Based on P.aeruginosa

Resistance to CHG

– It would be more appropriate to speak of an "increase in MIC" rather than "low-level resistance".

Clinical relevance=?

Meyer B, Cookson B. J Hospit Infect 2010; 76:200-5

Mechanism of resistance

- Exact mechanisms Misunderstood
  - Considering multiple mechanisms of action, probably multiple resistance mechanisms
    - Efflux pumps (qacA/B, smr) most commonly described
- Tolerance easier to develop when exposed to low concentrations
  - Ex. contact lenses cleaner (0.001%)

Resistance genes

- Genes qacA/B et smr
  - Efflux pumps (multidrug)
  - Geographic variation
    - qacA/B
      - 10-20% MRSA UK
      - 30-40% MRSA Asia
      - 80% MRSA Brasil
    - Smr
      - 3% des SARM Asie
      - 31% des SARM Inde
  - Impact on CHG
    - ↑ 2-4x BMC

Prevalence in Canada

- Toronto
  - 334 MRSA strains ICU 2005-2009
    - 2% qacA/B +
    - 7% smr +
    - No significant impact on MIC or MBC

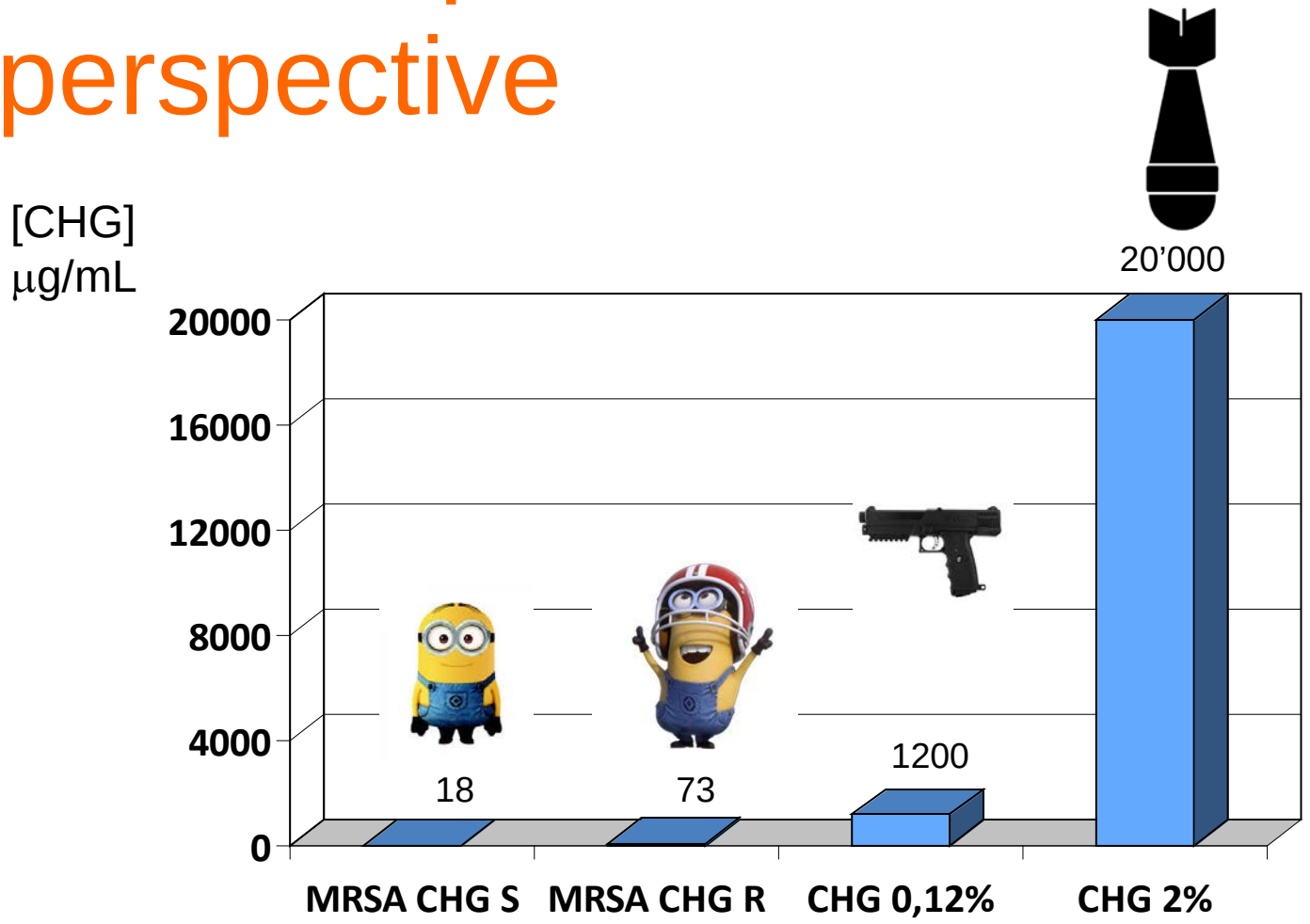
Longtin J. et al. Antimicrob Agents Chemother 2011 Mar 14

Clinical impact

- In UK, qacA/B + strains had higher MBC than wild strains
  - 73 µg/mL vs. 18 µg/mL; p=0.04

Smith, K. 2008. J Antimicrob Chemother 2010 61:78-84.

Let’s keep numbers in perspective



HOWEVER…

Could our love for CHG induce a new set of problems?

Science of the Total Environment 616–617 (2018) 172–178

Contents lists available at ScienceDirect

Science of the Total Environment

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

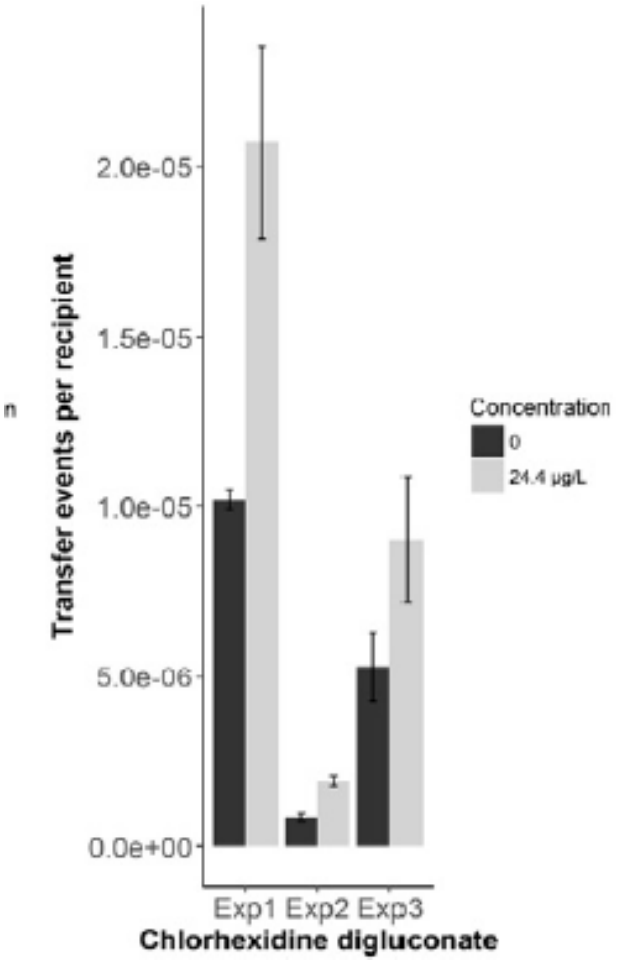
Antibiotics and common antibacterial biocides stimulate horizontal transfer of resistance at low concentrations

Jutkina J., Marathe N.P., Flach C.-F., Larsson D.G.J. *

[a] Centre for Antibiotic Resistance Research (CARe) at University of Gothenburg, Sweden
[b] Department of Infectious Diseases, Institute of Biomedicine, The Sahlgrenska Academy at University of Gothenburg, Sweden

- Exposure of E. coli to sub-MIC (200x below MIC) concentrations of CHG can stimulate horizontal transfer of antibiotic-resistance genes

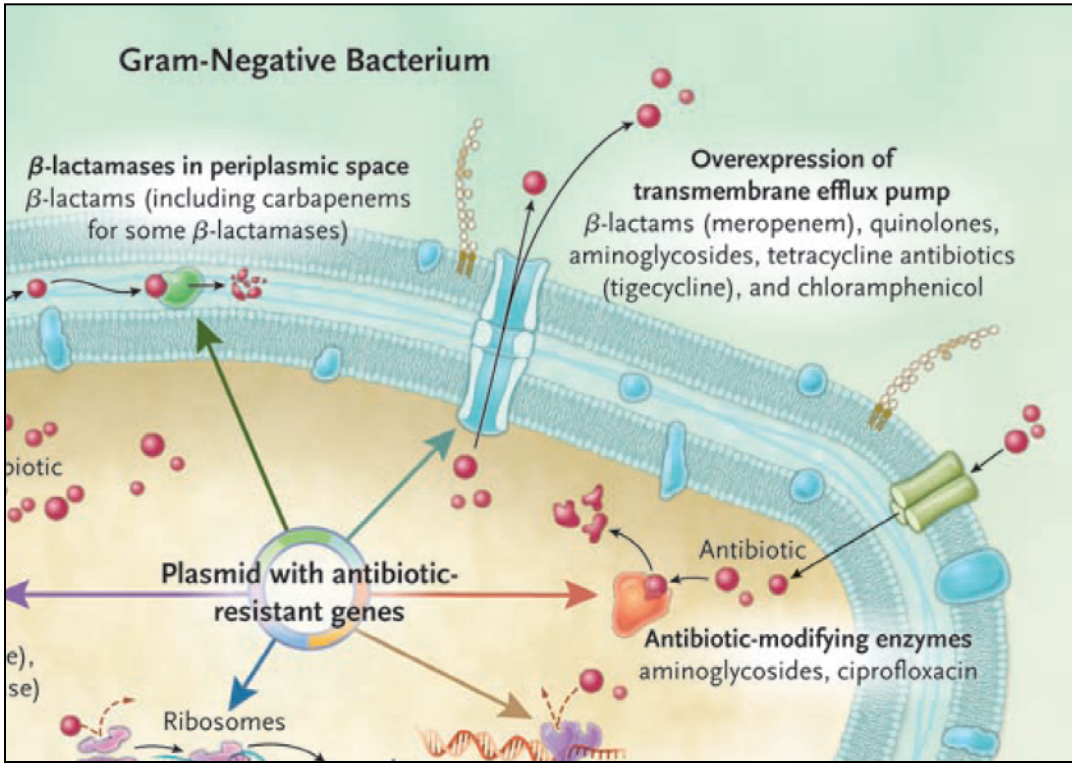
CHG Facilitating Resistance Gene Propagation?



Jutkina J et al. Sci Total Environ. 2018 Mar;616-617:172-178.

Cross-resistance CHG and ATB

- Greatest “fear” of unintended consequence
  - Resistance mechanisms to CHG could be used to develop resistance to other antibiotics
    - Ex. Efflux pumps



N ENGL J MED 362;19 NEJM.ORG MAY 13, 2010

Cross-resistance CHG-ATB?

S.aureus and MRSA exposed x 5 minutes to low [CHG] (2.5 to 40mg/ml) **causes ↑ MIC ATB**

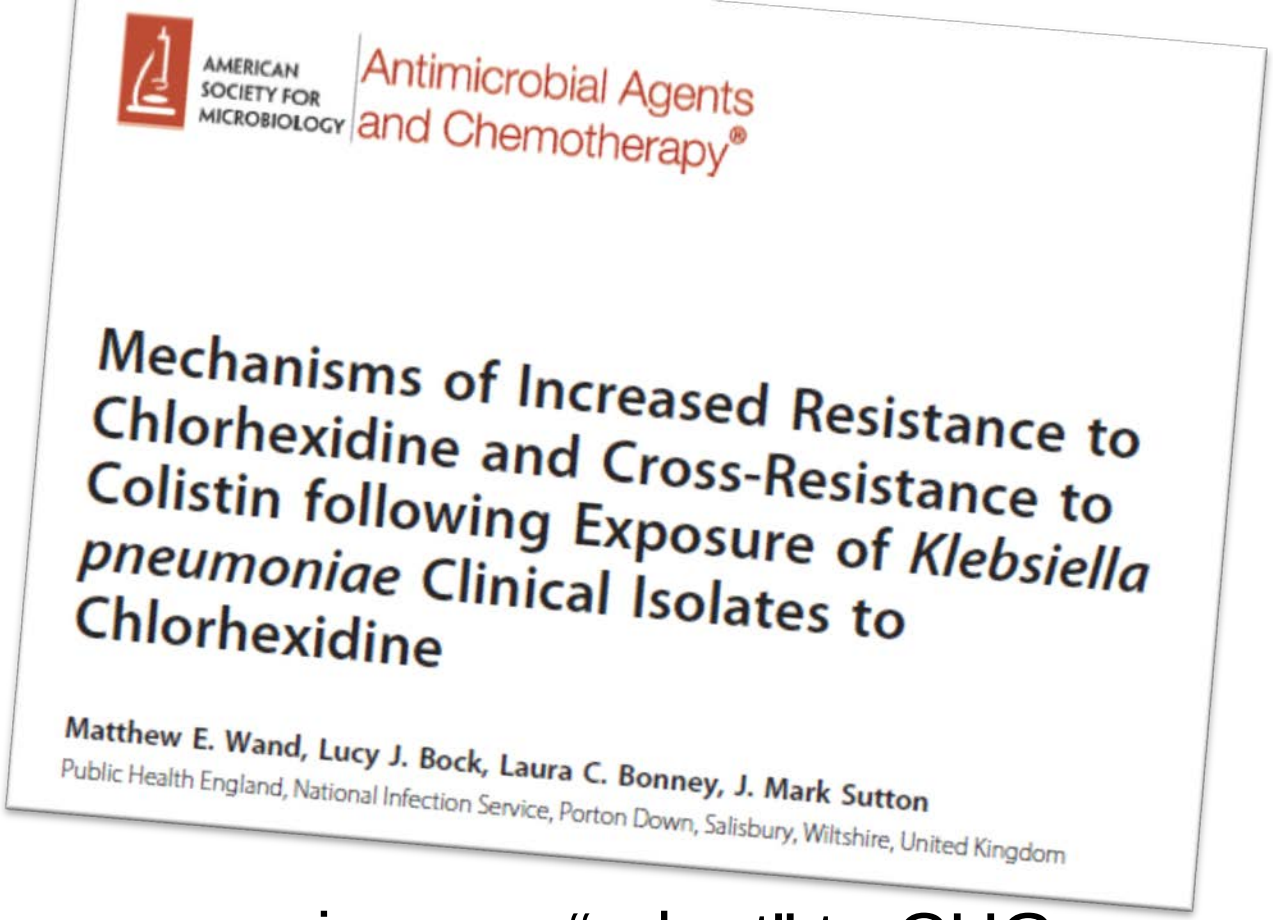
Table 4. Post-chlorhexidine-exposure MICs (mg/L) for EMRSA-16 and the susceptible control *S. aureus* NCTC 6571 after various biocide drying times

	Hours of drying	AMP	CTX	VAN	GEN	CIP	CEF	TET	OXA
EMRSA 16	control (no exposure)	>128	8	1	0.5	1	8	2	4
	2	>128	8	1	0.5	2	8	2	8
	24	>128	8	1	0.5	2	4	2	4
48 H CHG EXPOSURE →	48	>128	16	128	2	2	64	2	128
NCTC 6571 (susceptible *S. aureus*)	control (no exposure)	0.06	1	1	0.25	0.25	4	0.5	0.12
	2	0.06	1	1	0.5	0.25	1	0.25	0.12
	24	0.002	1	0.002	0.25	0.002	0.002	0.002	0.002
48 H CHG EXPOSURE →	48	128	32	>128	2	2	64	1	128

AMP, ampicillin; CTX, cefotaxime; VAN, vancomycin; GEN, gentamicin; CEF, cefuroxime; TET, tetracycline; OXA, oxacillin; CIP, ciprofloxacin.

Vali L et al. J Antimicrob Chemother 2008; 61: 524-32

Unlcear if effect would persist after removal of CHG



- K. pneumoniae can “adapt” to CHG
- Study of the phenotypic consequences of adaptation mechanism on various ATB

Wand ME et al. Antimicrob Agents Chemother. 2016 Dec 27;61(1). pii: e01162-16.

Antimicrobial Agents and Chemotherapy

WT: Wild Type
CA: CHG adapted

Impact de l'adaptation à la CHG sur la Colistine (CST)

Mechanisms of Increased Resistance to Chlorhexidine and Cross-Resistance to Colistin following Exposure of *Klebsiella pneumoniae* Clinical Isolates to Chlorhexidine

Matthew E. Wand, Lucy J. Bock, Laura C. Bonney, J. Mark Sutton
Public Health England, National Infection Service, Porton Down, Salisbury, Wiltshire, United Kingdom

TABLE 1 MIC values of various antibiotics and disinfectants for chlorhexidine-adapted strains

Strain	MIC (mg/liter)[a]										
	CHD	CHD + CCCP	BCI	Oct	HDPCM	EtOH (%)	CST	CST + CCCP	AZM	FEP	TEC
M109 WT	8	0.5–1	16	4	4–8	3.125	2	2	8–16	0.06–0.125	>64
M109 CA	32–64[b]	0.5–1	8–16	2–4	4–8	6.25	2–4	0.5–1	8–16	0.06–0.125	>64
NCTC 13439 WT	8–16	2–4	16	2–4	16	6.25	4	2	32	>64	>64
NCTC 13439 CA	256[b]	1–2	16	2–4	8–16	6.25	>64[b]	1	32	>64	>64
M3 WT	8–16	1–2	8–16	2–4	8	6.25	2–4	2	16–32	>64	>64
M3 CA	32–64[b]	0.5–2	8–16	2–4	8–16	3.125	>64[b]	1–2	8–16	>64	>64
NCTC 13443 WT	8–16	1–2	8–16	4	8–16	3.125	2	2	64	>64	>64
NCTC 13443 CA	256–512[b]	1–2	8–16	2	8–16	3.125	>64[b]	2	16–32	>64	>64
NCTC 13368 WT	32	2–4	32	4–8	32–64	6.25	2–4	2–4	64	64	>64
NCTC 13368 CA	256[b]	1–2	16	4–8	16	6.25	>64[b]	2–4	64	64	>64
MGH 78578 WT	8–16	1–2	8–16	4	8–16	6.25	2–4	2–4	32	>64	>64
MGH 78578 CA	256–512[b]	0.5–2	8–16	4	8	3.125	>64[b]	1–2	32–64	0.5[b]	>64

[a]The disinfectants used were chlorhexidine digluconate (CHD), benzalkonium chloride (BCI), octenidine dihydrochloride (Oct), hexadecylpyridinium chloride monohydrate (HDPCM), and ethanol (EtOH). The antibiotics used were CST, AZM, FEP, and TEC. All the MICs are shown as ranges of the results of at least three independent experiments. "+ CCCP" indicates the addition of the efflux pump inhibitor carbonyl cyanide 3-chlorophenylhydrazone. Additional antibiotics are shown in Table S2 in the supplemental material.
[b]There was a ≥4-fold increase or decrease in the MIC for chlorhexidine-adapted strains (CA) relative to nonadapted strains (WT).

- **5 of 6 strains that adapted to CHG became R to Colistin**

- BUT: Did not induce Resistance to Aztreonam, Cefepime (FEP) and Teicoplanin (TEC)

Wand ME et al. Antimicrob Agents Chemother. 2016 Dec 27;61(1). pii: e01162-16.

Antimicrobial Agents and Chemotherapy®

Mechanisms of Increased Resistance to Chlorhexidine and Cross-Resistance to Colistin following Exposure of *Klebsiella pneumoniae* Clinical Isolates to Chlorhexidine

Matthew E. Wand, Lucy J. Bock, Laura C. Bonney, J. Mark Sutton
Public Health England, National Infection Service, Porton Down, Salisbury, Wiltshire, United Kingdom

- Whole genome sequencing identified **multiple** mutations
- Main mutation seems to be a mutation in a repressor gene (smvR) that leads to upregulation of smvA (encodes an efflux pump)
  - Genes present in Klebsiella, Pseudomonas and Acinetobacter, but not in E.coli

TABLE 2 Chromosomal genetic changes after exposure to chlorhexidine

Strain and gene name	Type of change	Change[b]	MGH 78578 equivalent based on NCBI reference sequence NC_009648.1	Function
M109				
wcaJ	SNP	Q399STOP		CPS biosynthesis glycosyltransferase
yfiN	SNP	A173V	KPN_RS15690	Diguanylate cyclase
smvR	Deletion	400-bp Del	KPN_RS10110	TetR family transcriptional regulator
NCTC 13439[a]				
mipA	SNP	Q98STOP	KPN_RS06390	MltA-interacting protein
rarA	SNP	W37R	KPN_RS15910	AraC family transcriptional regulator
smvR	Deletion	Complete Del	KPN_RS10110	TetR family transcriptional regulator
narU	Deletion	Complete Del	KPN_RS10115	Nitrite extrusion protein 2
narZ	Deletion	Complete Del	KPN_RS10120	Nitrate reductase A subunit alpha
narH	Deletion	Complete Del	KPN_RS10125	Nitrate reductase A subunit beta
narJ	Deletion	First 130 aa Del	KPN_RS10130	Nitrate reductase molybdenum cofactor assembly chaperone
M3				
phoP	SNP	E82K	KPN_RS06075	PhoP family transcriptional regulator
ackA	SNP	S274F	KPN_RS14420	Acetate kinase
smvR	Deletion of 5 bp after nucleotide 22	Truncation of 72 aa (normally 191 aa)	KPN_RS10110	TetR family transcriptional regulator
—[c]	Deletion (G) after nucleotide 445	Truncation of 174 aa (normally 184 aa)	KPN_RS17785	Isopentenyl-diphosphate delta-isomerase
NCTC 13443[a]				
sufD	SNP (synonymous)		KPN_RS11525	Fe-S cluster assembly protein
phoQ	SNP	A20P	KPN_RS06070	Two-component sensor protein
lptD	SNP	Y625N	KPN_RS00270	LPS assembly outer membrane complex protein
smvR	SNP	W125STOP	KPN_RS10110	TetR family transcriptional regulator
—	Insertion (T) after nudeotide 375	Truncation of 125 aa (normally 235 aa)	KPN_RS14015	Membrane protein; putative permease
NCTC 13368				
acoK	SNP	E253A		LuxR family transcriptional regulator

(Continued on next page)

Wand ME et al. Antimicrob Agents Chemother. 2016 Dec 27;61(1). pii: e01162-16.

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Mechanisms of Increased Resistance to Chlorhexidine and Cross-Resistance to Colistin following Exposure of *Klebsiella pneumoniae* Clinical Isolates to Chlorhexidine

Matthew E. Wand, Lucy J. Bock, Laura C. Bonney, J. Mark Sutton
Public Health England, National Infection Service, Porton Down, Salisbury, Wiltshire, United Kingdom

- Fitness:
  - CHG-adapted strains were less fit
  - Lower capacity to infect the wax moth (Galleria mellonella)
  - Lower growth rate
  - Some CHG adapted strains got rid of plasmids… One strain even reverted to sensitivity to meropenem!

Wand ME et al. Antimicrob Agents Chemother. 2016 Dec 27;61(1). pii: e01162-16.

DAPTO and CHG cross-resistance

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MECHANISMS OF RESISTANCE

Reduced Chlorhexidine and Daptomycin Susceptibility in Vancomycin-Resistant *Enterococcus faecium* after Serial Chlorhexidine Exposure

Pooja Bhardwaj,[a] Amrita Hans,[a] Kinnari Rulkar,[a] Ziqiang Guan,[b] Kelli L. Palmer[a]

- Exposure of VRE to small doses of CHG leads to 4-fold increase in CHG MIC and also to a decrease in Daptomycin susceptility (MIC from 2 ug/ml [wild type] to 4-6 ug/ml)
- Multiple Dapto resistance mechanisms implicated (complex)

Bhadwaj P et al. Antimicrob Agents Chemother. 2017 Dec 21;62(1).

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journal homepage: www.elsevierhealth.com/journals/jhin

Review

Acquired resistance to chlorhexidine – is it time to establish an 'antiseptic stewardship' initiative?

G. Kampf [a, b, *]

[a] Knieler und Team GmbH, Infection Control Science, Hamburg, Germany
[b] Ernst-Moritz-Arndt Universität, Institut für Hygiene und Umweltmedizin, Greifswald, Germany

Still, some experts and worried…

J Hosp Infect. 2016 Nov;94(3):213-227.