



Hand Hygiene and MDRO (Multidrug-resistant Organisms) - Science and Myth

PROF MARGARET IP
DEPT OF MICROBIOLOGY

MDROs and Hand Hygiene Guidelines

ANTIBIOTIC RESISTANCE THREATS
in the United States, 2013



U.S. Department of
Health and Human Services
Centers for Disease
Control and Prevention



World Health
Organization

Patient Safety

A World Alliance for Safer Health Care

Management of Multidrug-Resistant

Systems In Health Care Settings,

WHO Guidelines
on Hand Hygiene in Health Care

First Global Patient Safety Challenge
Clean Care is Safer Care

Rhinehart, RN MPH CIC; Marguerite Jackson, PhD; Linda
Healthcare Infection Control Practices Advisory Committee

Gratefully acknowledge Dr. Larry Strausbaugh for his many contributions
in preparation of this guideline.

The evolving threat of
antimicrobial resistance
Options for action



The Science of Hand Hygiene in Healthcare Settings

- Background
- Definition of MDROs
- Evidence for Hand Hygiene in prevention of MDROs
- Mechanism of Cross Transmission of Microbes
- Myths or Controversies?
- Challenges in Hand Hygiene Programmes
- Bundle Approach

Multidrug-resistant Organisms (MDROs)

MDR: Resistance to 3 or more of the following 8 classes

- Anti-pseudomonal cephalosporins (ceftazidime or cefepime)
- Carbapenems (ertapenem, imipenem or meropenem)
- Beta-lactam/ β -lactamase inhibitor combination (piperacillin/tazobactam)
- Fluoroquinolones (ciprofloxacin or levofloxacin)
- Aminoglycosides (amikacin, gentamicin or tobramycin)
- Aztreonam
- Polymyxin E
- Tigecycline

XDR: Susceptibility to 2 or less classes

PDR: Diminished susceptibility to all classes (no options for treatment)

MDROs

- Methicillin-resistant *Staphylococcus aureus* (MRSA)
- Vancomycin-resistant *Enterococcus* (VRE)
- Extended-spectrum β -lactamase producing organisms
- Multidrug-resistant *Acinetobacter* sp. (MDRA)
- Multidrug-resistant *Pseudomonas aeruginosa* (MRPA)
- Carbapenem-resistant Enterobacteriaceae (CRE)



Antibiotic-resistant Infections in US alone

NATIONAL SUMMARY DATA

Estimated minimum number of illnesses and deaths caused by antibiotic resistance*:

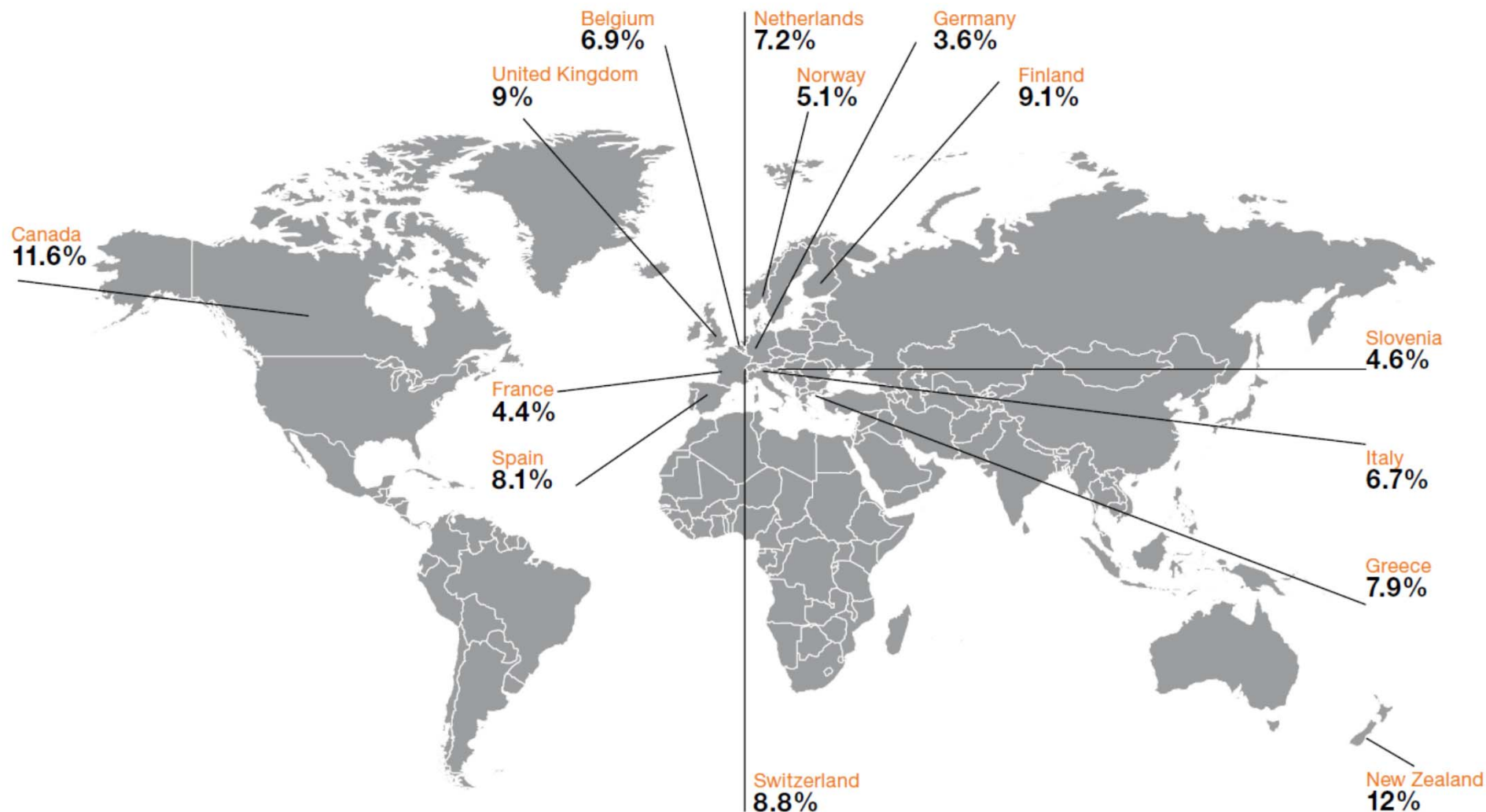
At least  **2,049,442** illnesses,
 **23,000** deaths

**bacteria and fungus included in this report*

HH Apr14

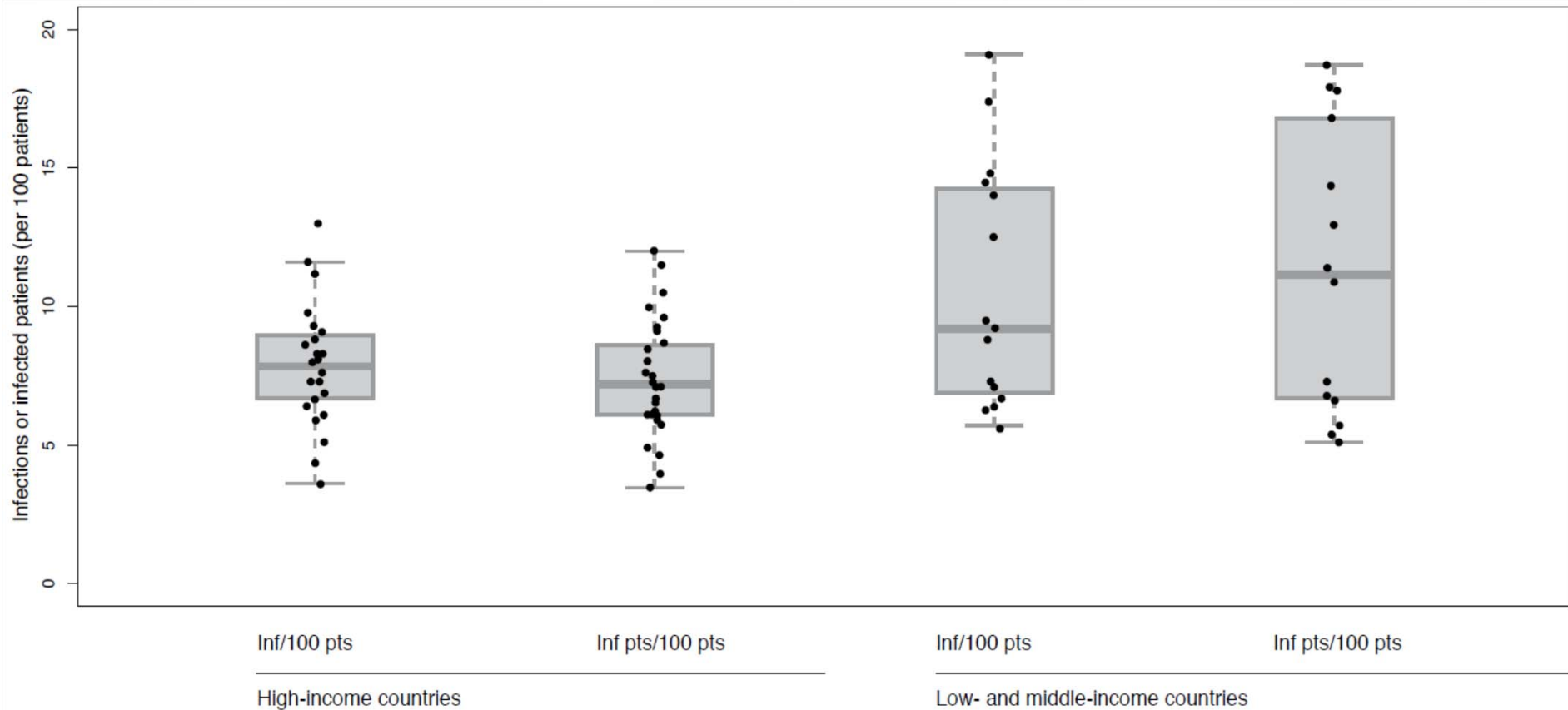
(CDC, Antibiotic Resistance Threats in US, 2013)

Prevalence of health care-associated infection in high-income countries, 1995-2010

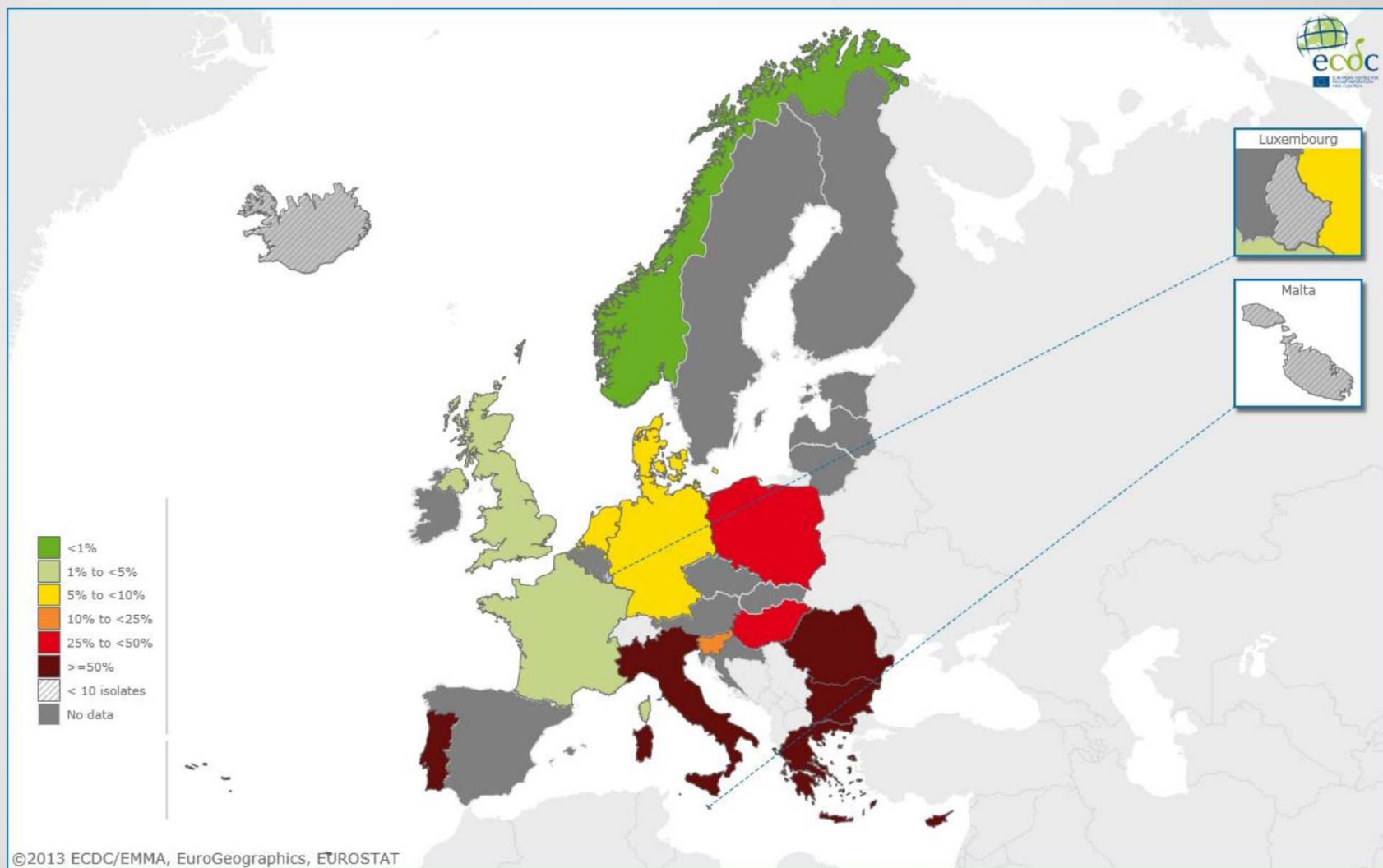


(WHO Burden of Health care-associated infection, 2011))

Health care-associated infection prevalence in high-income countries vs low- and middle-income countries, 1995-2010



Acinetobacter species: percentage of invasive isolates with resistance to carbapenems, EU 2012.



(<http://www.ecdc.europa.eu/en/eaad/Documents/EARS-Net-summary.pdf>)

The Importance of Hand Hygiene

KEY ELEMENT in

- Standard and Isolation Precautions
- 'Care Bundle Approach' to prevention of specific site infections
 - eg. Catheter-related bloodstream infections

Examples of Studies assessing Impact of Hand Hygiene Promotion on Healthcare associated Infections (HCAI)

YEAR	HOSPITAL SETTING	INTERVENTION	IMPACT ON HAND HYGIENE	IMPACT ON HCAI	REFERENCE
1989	Adult ICU	Education on hand washing, hand hygiene observation, performance feedback	Compliance increase from 14% to 73% (before patient contact) and from 28% to 81% (after patient contact)	Significant reduction ($P = 0.02$) in HCAI rates (from 33% to 12% and from 33% to 10%, respectively, after two intervention periods 4 years apart)	Conly et al, AJIC 1989
1990	Adult ICU	Hand-washing promotion	Compliance increase from 22% to 29.9%	No impact on HCAI rates	Simmonds et al, ICHE 1990
1994	NICU	Introduction of hand washing with triclosan 1% (w/v)	-	Elimination of MRSA, when combined with multiple other infection control measures. Significant reduction ($P < 0.02$) in nosocomial bacteraemia (from 2.6% to 1.1%) using triclosan compared with chlorhexidine for hand washing	Webster et al, J Paed Child Health 1994
2000	Hospital-wide	Alcohol-based hand rub introduction, hand hygiene observation, training, performance feedback, posters	Significant increase in compliance from 48% to 66%	Significant reduction ($P = 0.04$ and $P < 0.001$) in the annual overall HCAI prevalence (42%) and MRSA cross-transmission rates (87%). Active surveillance cultures and contact precautions implemented during same period. A follow-up study showed continuous increase in hand rub use, stable HCAI rates and cost savings.	Pittet et al, Lancet 2000
2004	Hospital-wide	Alcohol-based hand rub introduction, hand hygiene observation, posters, performance feedback, informal discussions	No significant increase in compliance before and after patient contact	Significant reduction ($P = 0.03$) in hospital-acquired MRSA cases (from 1.9% to 0.9%)	MacDonald et al, JHI 2004
2005	Hospital-wide	Alcohol-based hand rub introduction, hand hygiene observation, training, posters	Compliance increase from 62% to 81%	Significant reduction ($P = 0.01$) in hospital-associated rotavirus infections	Zerr et al, Ped Infect Dis J 2005
2005	Adult ICUs	Hand-washing observation, training, guideline dissemination, posters, performance feedback	Compliance increase from 23.1% to 64.5%	Significant reduction ($P < 0.001$) in HCAI rates (from 47.5 to 27.9 per 1000 patient-days)	Rosenthal et al, AJIC 2005
2005	Hospital-wide	Alcohol-based hand rub introduction, hand hygiene observation, training, posters, promotional gadgets	Compliance increase from 21% to 42%	Significant reduction (57%, $P = .01$) in MRSA bacteraemia	Johnson et al, Med J Aust 2005
2008	ICU	Prospective, controlled, cross-over trial in two units with education, posters and alcohol based hand rub introduction	Compliance increase from 38-37% to 68-69%	No impact on device-associated infection and infections due to multidrug-resistant pathogens	Rupp et al, ICHE 2008
2008	NICU	Alcohol-based hand rub introduction, training, posters	-	Significant reduction ($P = 0.009$) in HCAI incidence (4.1 vs 1.2 per 1000 patient-days)	Capretti et al, AJIC 2008

Effectiveness of a hospital-wide programme to improve compliance with hand hygiene

1. First multimodal intervention conducted 1995-2000 at Univ of Geneva Hospitals
2. >20,000 opportunities for hand hygiene observed.
3. Sustained improvement in compliance with hand hygiene
 - Use of alcohol-based handrub increased from 3.5 to 15.4L / 1000 patient-days, $p<0.001$)
4. Decrease of 50% health care-associated infections and MRSA transmission.
 - Hospital-acquired infection decreased from 16.9% to 9.9% ($p=0.04$)
 - MRSA transmission rates from 2.16 to 0.93 episodes / 10,000 patient days, $p<0.001$)

(Pittet et al, Lancet 2000;356:1307-12)

Multimodal hand hygiene improvement strategy

- System change:
 - alcohol-based handrub at the point of care; access to water supply, soap and towels;
- Training and education;
- Evaluation and feedback;
- Reminders in the workplace; and
- Institutional safety climate.

Effectiveness of a hospital-wide programme to improve compliance with hand hygiene

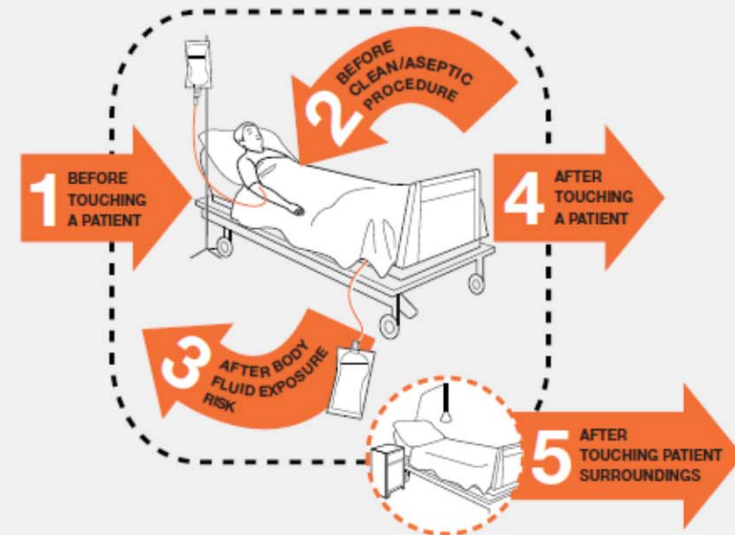
- This intervention model was adopted for use by WHO Global Patient Safety Challenge in 2005 as a basis for global promotion of hand hygiene.
- 8-year study of programme estimated total costs associated with health care – associated infections (n=37,887) to be SFr 132.6M.
- Hand hygiene promotion program cost-effective, with costs generated by 260 nosocomial infections (<1% of reduction in infections) equaled budget of hand hygiene campaign.

(Pittet et al, Lancet 2000;356:1307-12;
Pittet et al, ICHE 2004;25:264-6)

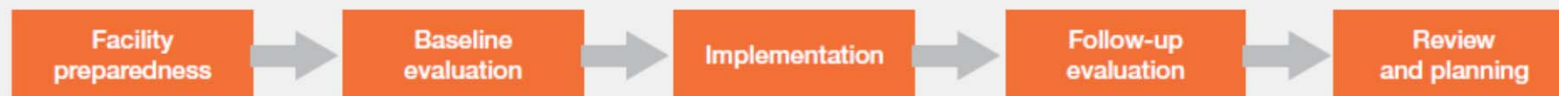
WHO multimodal strategy for improving hand hygiene



+



+



Cost Effectiveness of a hospital-wide hand hygiene programme

- Use of an alcohol-based handrub, education and staff performance feedback, reduced incidence of MRSA infections and expenditures for teicoplanin in hospitals in England. For every £1 spent on ABHR, £9-20 were saved on teicoplanin expenditure.
- An economic analysis of the 'cleanyourhands' promotional campaign in England and Wales concluded that the programme would be cost beneficial if hospital infection rates were decreased by as little as 0.1%.

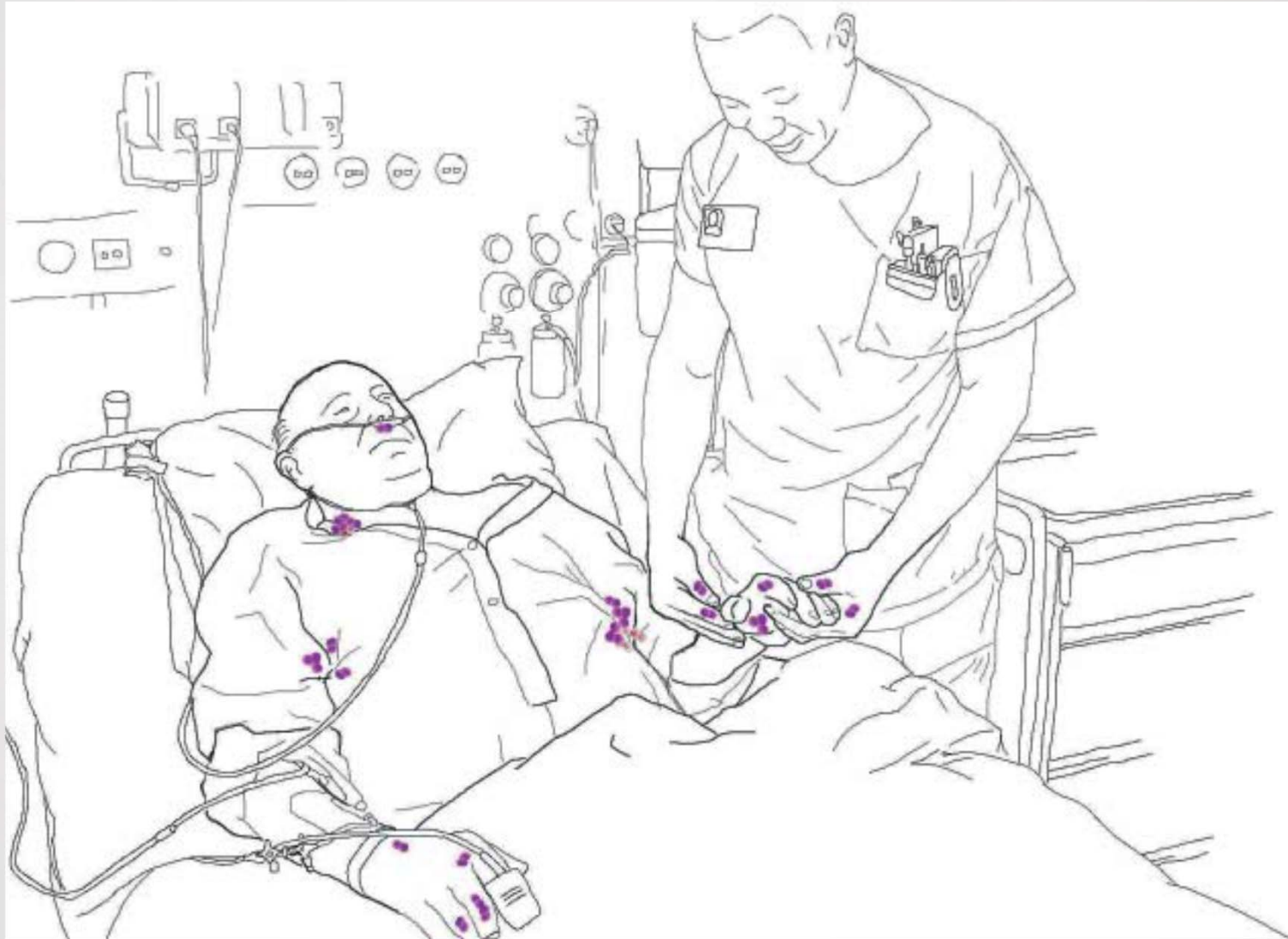
(MacDonald et al. JHI 2004, 56:56-63; Nat Patient Safety Agency 2004
(www.npsa.nhs.uk/cleanyourhands/resource-area/evidence-base/?EntryID34=58433)

Cross-Transmission of Microbes

1. Microbes on patient's skin or shed onto inanimate objects
2. Transfer of microbes to hands of HCWs
3. Survival of microbes on hands
4. Incorrect / inadequate hand cleansing
5. Contaminated hands / inanimate object come into direct contact with patient

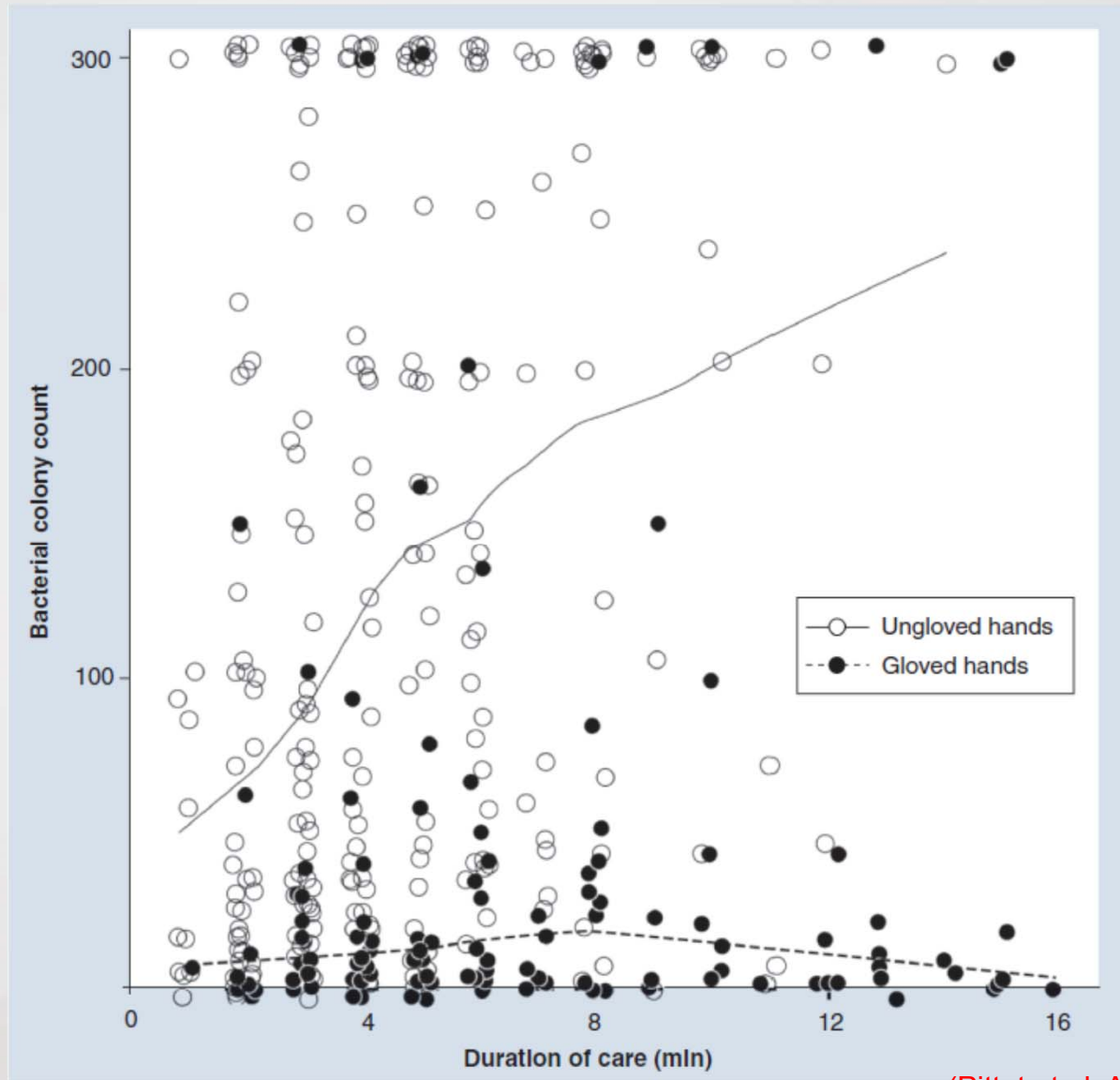
(Pittet et al, Lancet Infect Dis 2006;6:641-52)

Microbes Present and Transfer to Hands of HCW



(Pittet et al, Lancet Infect Dis 2006;6:641-52)

Relationship between duration of patient care and bacterial contamination



(Pittet et al, Arch Intern Med 1999)

Survival of MDROs on Hands

- *E.coli* and *Klebsiella spp* showed a 50% survival after 6 min and 2 min
- Vancomycin-resistant *Enterococcus faecalis* and *E. faecium* survived >60 min on gloved and ungloved fingertips
- *Pseudomonas aeruginosa* and *Burkholderia cepacia* survived over 30 min in saline, and 180 min in sputum
- *Acinetobacter spp* usually survives longer periods on skin than other gram negative bacteria
- Artificial nails and jewellery increased risk of carriage of Enterobacteriaceae and other gram negative bacteria

(Fryklund et al, JHI1995;
Noskin et al, ICHE 1995;
Doring et al, Pulm 1996;
Fagermes et al, J Adv Nurs 2011;
McNeil et al, CID 2001)

Contamination of HCWs' hands before Hand Hygiene

Study variable	Mean CFU, log ¹⁰ ± SD	Variance	P value
Wearing gloves during care provision			
Yes (n = 64)	1.54 ± 0.54	0.29	.012
No (n = 70)	1.75 ± 0.41	0.17	
Sex			
Female (n = 85)	1.63 ± 0.50	0.25	.58
Male (n = 49)	1.68 ± 0.47	0.22	
Occupation			
Nurse (n = 65)	1.62 ± 0.48	0.23	.753
Physicians (n = 49)	1.67 ± 0.47	0.23	
Other HCWs (n = 20)	1.69 ± 0.55	0.30	
Clinical departments			
Intensive care unit (n = 52)	1.58 ± 0.53	0.29	.317
Surgical ward (n = 10)	1.80 ± 0.28	0.28	
Pediatric ward (n = 5)	1.84 ± 0.33	0.33	
Others (n = 47)	1.70 ± 0.44	0.44	
Patient contact activities			
Contact with body fluid, secretions, waste (n = 41)	1.44 ± 0.59	0.35	.050
Contact with surfaces in patient surroundings (n = 31)	1.67 ± 0.42	0.42	
Contact with patient intact skin (n = 53)	1.73 ± 0.39	0.39	
Contact with environmental surfaces outside the patient area (n = 4)	1.99 ± 0.34	0.34	
No contact (n = 5)	2.10 ± 0.11	0.01	

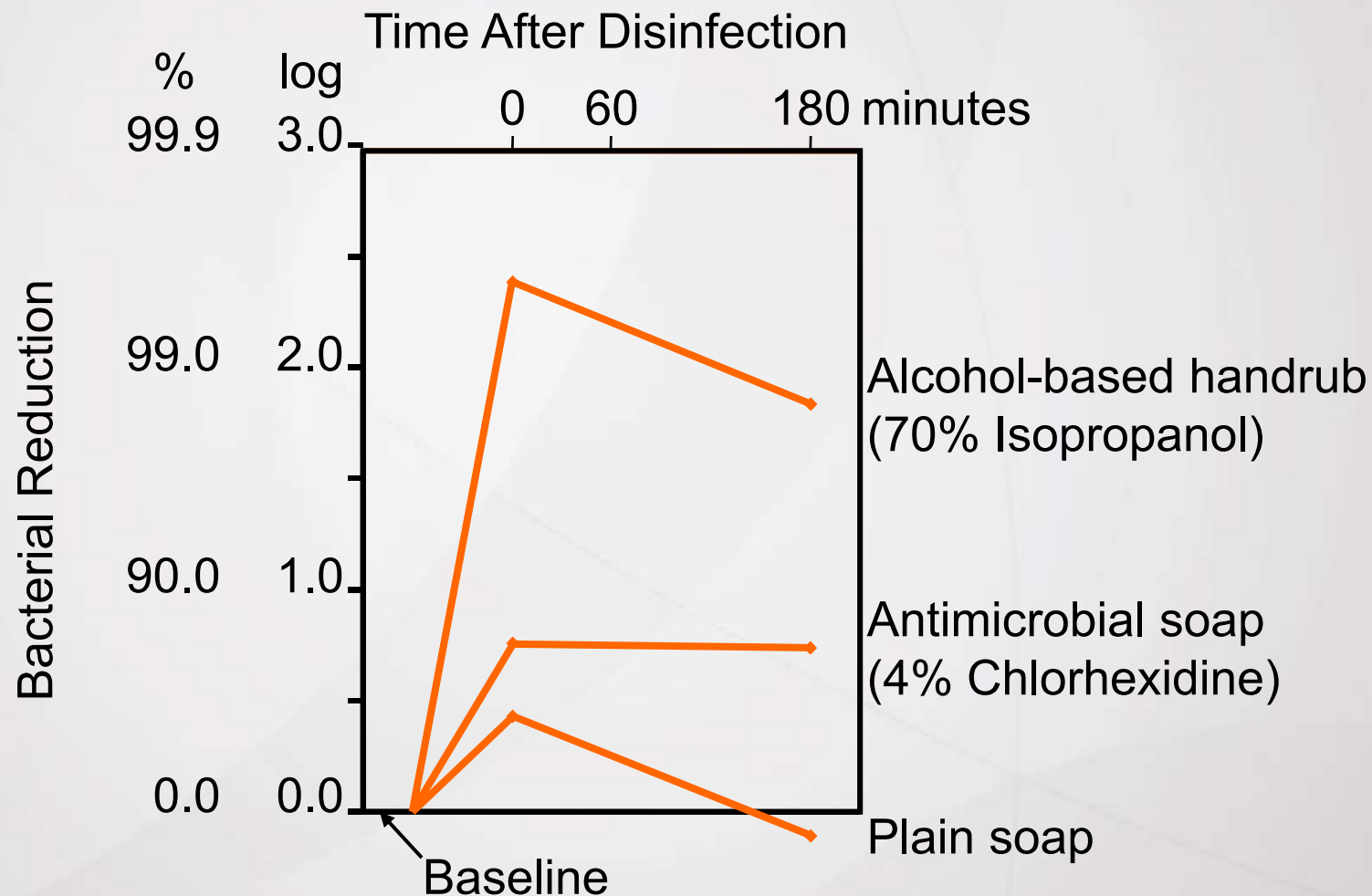
(Salmon et al, AJIC 2014; 42:178-81)

Antibacterial Efficacy of Different Hand Hygiene Methods

Solution	Mean CFU* log ¹⁰ ± SD (variance)		
	Before	After	CFU reduction
Plain soap solution, unfiltered water (n = 24)	1.81 ± 0.31 (0.097)	1.71 ± 0.51 (0.261)	0.12 ± 0.56 (0.318); <i>P</i> = .422
Plain soap solution, filtered water (n = 43)	1.54 ± 0.52 (0.266)	0.74 ± 0.51 (0.264)	0.80 ± 0.43 (0.18); <i>P</i> < .0001
<i>P</i> value, mean CFU difference in filtered and unfiltered water		<.001	
CHG 4%, unfiltered water (n = 6)	1.56 ± 0.29 (0.083)	1.00 ± 0.88 (0.771)	0.58 ± 0.84 (0.712); <i>P</i> = .173
CHG 4%, filtered water (n = 29)	1.75 ± 0.47 (0.224)	0.45 ± 0.41 (0.169)	1.30 ± 0.55 (0.301); <i>P</i> < .0001
ABHR (n = 32)	1.60 ± 0.55 (0.308)	0.20 ± 0.36 (0.132)	1.40 ± 0.60 (0.365); <i>P</i> < .0001

*Mean CFU log¹⁰ of aggregated microorganisms.

Ability of Hand Hygiene Agents to reduce bacteria on hands



Transmission Dynamics of Microbes to Patient

Influenced by:

1. Type of organisms
2. Inoculum size
3. Source and destination surfaces
4. Moisture

eg. *Staph*, *Pseudomonas*, *Serratia* > *E.coli*

Other factors facilitating patient colonization:

1. Host factors eg. disruption of mechanical barrier / host defence
2. Presence of medical devices
3. Exposure to antimicrobials
4. Other co-morbidities

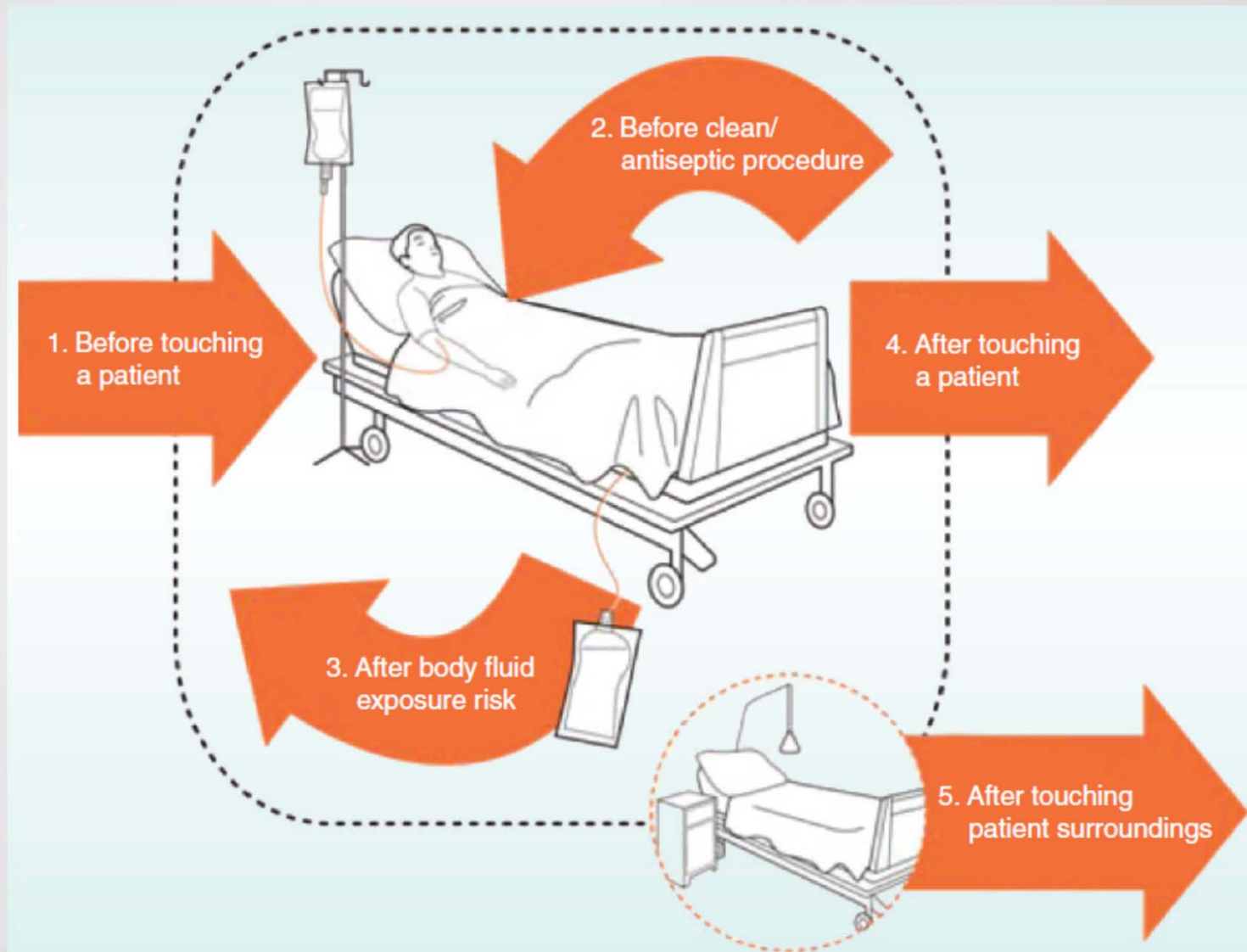
Environmental contamination may present source for re-contamination of hands eg. VRE.

(Stewardson et al, Future Microb 2011;6:855-76)

Myths or Controversies

- Perception by HCWs that their hands are 'clean' and hand hygiene is intended to protect the HCWs
- Use of alcohol-based hand rub (ABHR)
 - Systemic absorption of alcohol
 - Insignificant or undetectable level in series of studies
 - Irritant or cause dermatitis to skin
 - 4 of 2750 HCWs had to avoid ABHR in large study
 - Fire Hazard
 - none of 798 US hospitals reported fire association in 1430 hospital-years of ABHR use
 - Increased rates of *Clostridium difficile* infection
 - Lack of association on increased rates

Five Moments for Hand Hygiene



Factors associated with Hand Hygiene Compliance

Category	Variable	Compliance	OR (95% CI)
Indication for hand hygiene	Moment I	31% (879/2868)	1.00
	Moment II	34% (128/376)	1.18 (0.90–1.53)
	Moment III	61% (251/410)	5.07 (3.94–6.50)**
	Moment IV	56% (1927/3419)	3.81 (3.40–4.30)**
	Mixed	37% (107/291)	1.50 (1.10–2.03)*
Isolation status	Patient isolated	44% (296/673)	1.02 (0.79–1.32)
	No isolation	45% (2996/6691)	1.00
Profession	Nurse	46% (2258/4914)	1.00
	Physician	44% (485/1108)	0.89 (0.76–1.05)
	Other	41% (549/1342)	0.77 (0.66–0.90)**
Glove use	Gloves used	47% (111/2386)	1.08 (0.96–1.22)
	No gloves	44% (2181/4978)	1.00
Ward type	Medical	45% (1331/2946)	1.00
	Surgical	45% (792/1749)	1.09 (0.73–1.61)
	Intensive care	48% (820/1724)	1.26 (0.83–1.91)
	Other/ outpatient	37% (349/945)	0.72 (0.46–1.10)
Activity index ^a	Quartile (range)		
	Q1 (3–11)	49% (344/702)	1.00
	Q2 (12–18)	44% (805/1828)	0.78 (0.63–0.98)
	Q3 (19–27)	45% (889/1971)	0.84 (0.66–1.06)
	Q4 (>27)	44% (1254/2863)	0.76 (0.60–0.95)
Total		45% (3292/7364)	

OR, odds ratio; CI, confidence interval.

* $P < 0.05$, ** $P < 0.005$.

^a Number of hand-hygiene opportunities per hour.

(Levovic et al, JHI 2013;83:276-283)

Challenges in Hand Hygiene Programmes

- Compliance
- Efficacy of hand hygiene products
- Novel methods of hand hygiene
- Hand hygiene techniques and transmission
- Monitoring hand hygiene compliance and feedback

Comparative Efficacy of ABHRs



Comparative efficacy of ABHRs evaluated according to ASTM E1174

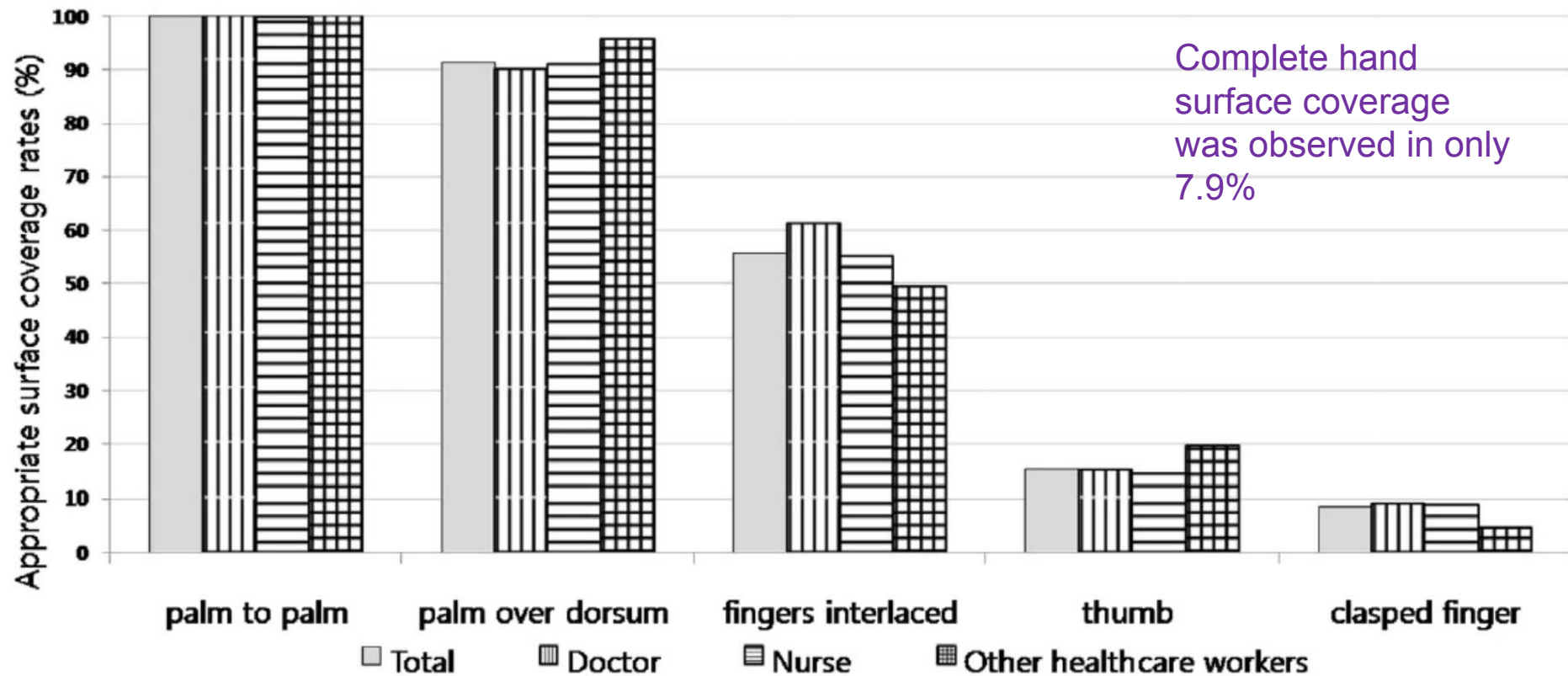
Test product code	Study No.*	Test product description	Application 1 log ₁₀ reduction (95% CI)	Application 10 log ₁₀ reduction (95% CI)
A	1	70% Vol/vol ethanol gel	3.58 (3.34-3.82)	3.50 (3.26-3.74)
	2		3.35 (3.14-3.56)	4.09 (3.78-4.40)
B	1	70% Vol/vol ethanol foam	3.55 (3.32-3.74)	4.00 (3.26-4.24)
	2		3.48 (3.34-3.61)	4.41 (4.14-4.69)
D	1	90% Vol/vol ethanol gel	3.12 (2.89-3.35)	1.80 (1.57-2.63)
E	1	80% Vol/vol ethanol rinse	3.07 (2.84-3.29)	2.39 (2.17-2.61)
F	1	75% Vol/vol isopropanol rinse	3.12 (2.88-3.36)	2.03 (1.80-2.27)
G	2	62% Vol/vol ethanol gel	2.99 (2.77-3.21)	1.97 (1.75-2.19)
H	2	70% Vol/vol ethanol foam	2.83 (2.61-3.05)	1.94 (1.72-2.16)
I	2	68% Vol/vol ethanol gel	2.48 (2.26-2.70)	1.31 (1.09-1.53)
J	2	62% Vol/vol ethanol foam	2.86 (2.64-3.08)	2.71 (2.49-2.93)
K	2	70% Vol/vol ethanol gel	2.88 (2.66-3.10)	2.47 (2.25-2.69)
L	2	60% Vol/vol ethanol foam	3.26 (3.04-3.48)	2.54 (2.32-2.76)

CI, Confidence interval.

*Data are from 2 separate studies.

(Edmonds et al, AJIC 2012)

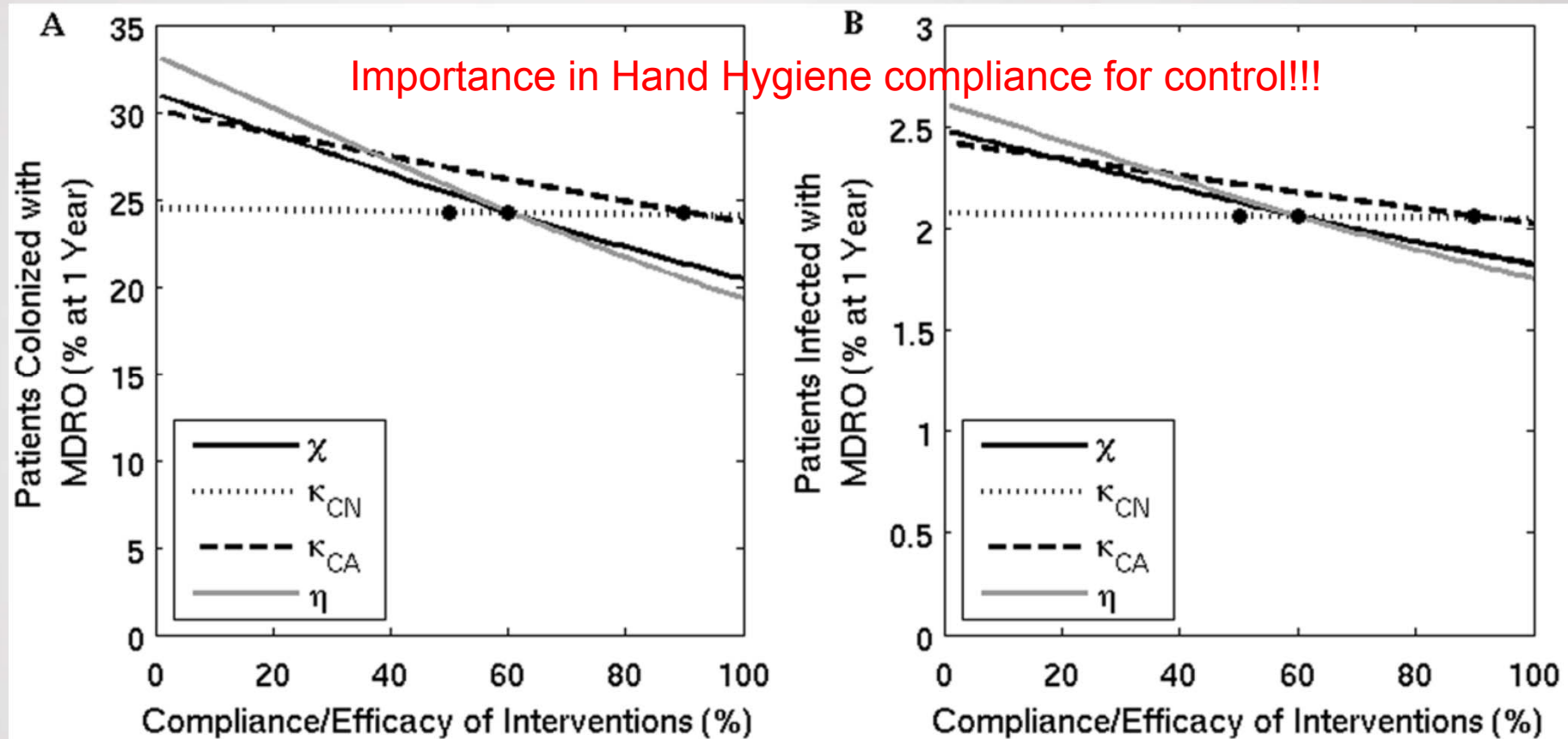
Hand Surface Coverage Rates



Challenges in Hand Hygiene

- Identify relative risk of transmission for the type of patient care activities
- Establish the relative efficacy of hand hygiene vs infection control components for different MDROs and as individual measure to contain antimicrobial resistance

Model of MDRO and Efficacy of Infection Control Interventions

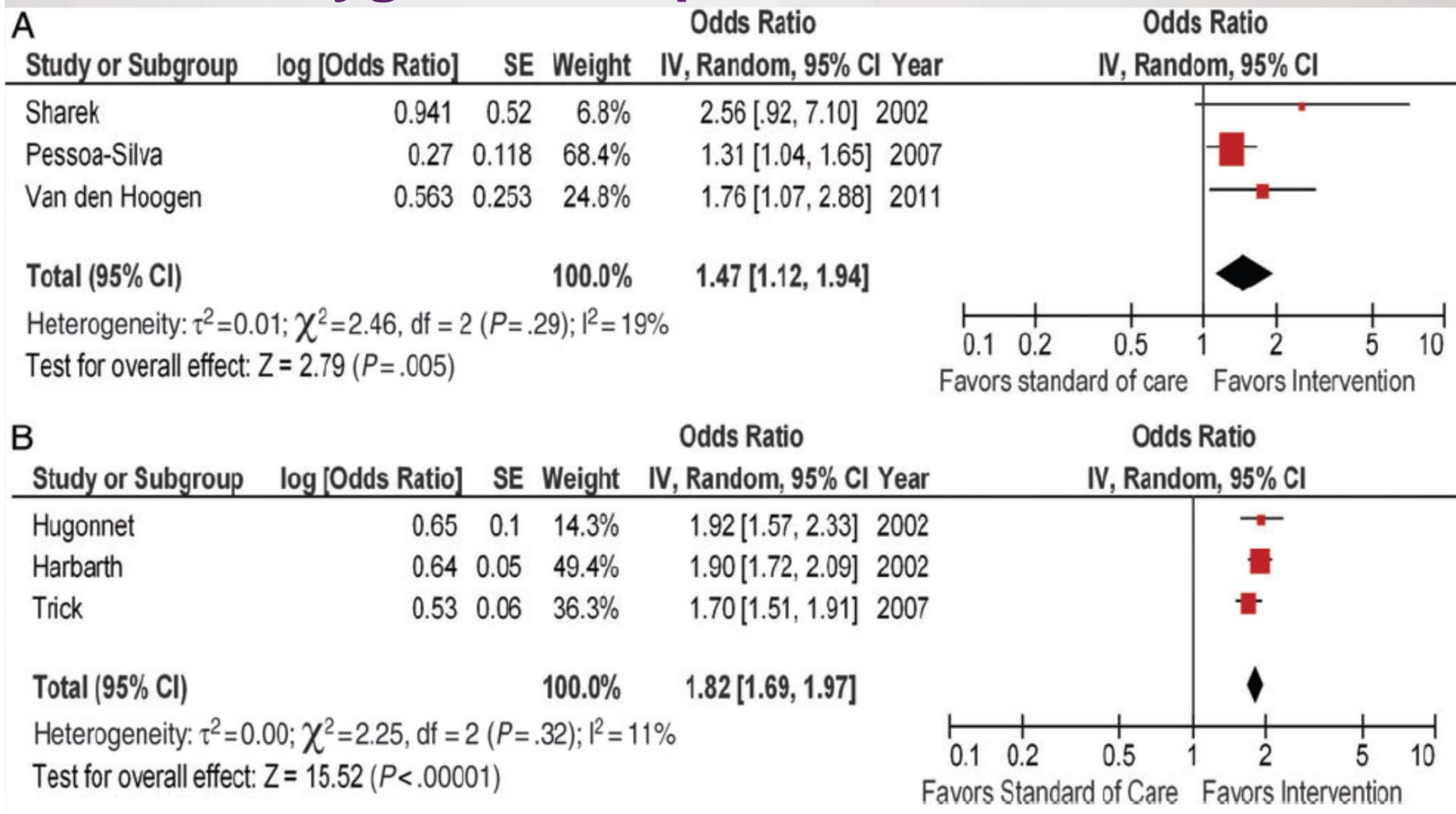


The percent of patients colonized (A) and infected (B) with an MDRO at one year when the compliance or efficacy of four interventions are varied. Solid black line (χ) - contact precautions, dotted line (κ_{CN}) - screening of colonized patients not on antimicrobials, dashed line (κ_{CA}) - screening of colonized patients receiving antimicrobials, and grey line (η) - compliance with hand hygiene measures. The dots mark the baseline values.

doi:10.1371/journal.pone.0030170.g002

(D'Agata et al, PLOS One 2012:7:e30170)

Bundles of Interventions and Hand Hygiene Compliance



A, Association between bundle that included education, feedback, and reminders and improved hand hygiene compliance in neonatal intensive care units. B, Association between bundle that included education, feedback, reminders, access to alcohol-based hand rub, and improved hand hygiene compliance. Abbreviations: CI, confidence interval; IV, inverse variance weighting; SE, standard error.

(Schweizer et al, CID 2014)

Bundles of Interventions and Hand Hygiene Compliance

Improved hand hygiene compliance with Bundle

A : - education,
 - feedback,
 - reminders.

B : - education,
 - feedback,
 - reminders,
 - access to alcohol-based hand rub.

Summary

- Hand hygiene is an effective, simple and cost-effective means for reducing transmission and infections
- Evidence supports the use of multiple modes hand hygiene programmes to reduce healthcare-associated infections
- Challenges in maximizing hand hygiene implementation and sustaining compliance
- Continual educational programme, with extension of hand hygiene promotions into populations outside the healthcare setting and in the community

Infection Prevention



**Thank you
for
Listening!**

Lend Healthcare A Hand
By Washing Yours™