

Preventing hospital-acquired infection

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Health-care associated infection (HAI)

Definitions^{1,2}

HAI: infection occurring in a patient during the process of care in a hospital or other health-care facility. Frequent infections: urinary tract infection, surgical-site infection, bloodstream infection, hospital-acquired pneumonia, ventilator-associated pneumonia

Cumulative incidence: No. of new infective episodes or new patients acquiring infection per 100 patients followed up for a defined time period (e.g. duration of hospital stay)

Infection incidence density: No. of infection episodes per 1000 patient-days or device-days

Africa: systematic review: 2004-2009²

- 19 articles included, 2 met study definition of high-quality
- Hospital-wide prevalence of HAI: 2.5% - 14.8% (Algeria, Burkino Faso, Senegal, Tanzania)
- Surgical wards cumulative incidence: 5.7% - 45.8% (Ethiopia, Nigeria)
- Surgical site infection cumulative incidence: 2.5% - 30.9%
- Causative organism: Gram negative bacilli in surgical site infection and VAP

¹Allegranzi B, et al. Lancet 2011;377:228-41

²Nejad SB, et al. Bull World Health organ 2011;89:757-765

HAI in developing countries

Systematic review and meta-analysis¹

- 220 studies included, including 14 from Africa & 40 paediatric studies
- 118 (54%) studies were low-quality

Overall results

- Pooled prevalence of HAI (high-quality): 15.5 per 100 patients [CI: 12.6 – 18.9]
- European CDC: 7.1 per 100 patients; USA: 4.5 per 100 patients (2002)^{2,3}

Paediatric studies

- Cumulative incidence of HAIs on paediatric wards or children's hospitals was 0.9-17.7 and 2.7-26.7 per 100 patents respectively
- Infection incidence densities of HAIs in paediatric ICUs and neonatal units was 1.6-46.1 and 15.2-62.0 per 1000 patient days respectively

¹Allegranzi B, et al. Lancet 2011;377:228-41

²ECDC: Annual report on communicable diseases in Europe

³Klebens RM, et al. Public Health Rep 2007;122:160-66

Determinants of HAI in developing countries

- Inadequate environmental hygienic conditions
- Poor infrastructure
- Insufficient equipment
- Understaffing
- Overcrowding
- Little knowledge & application of basic infection-control measures, including hand hygiene practice
- Prolonged and inappropriate use of invasive devices
- Prolonged and inappropriate use of antibiotics
- Lack of local and national policies
- Reuse of equipment (including needles & gloves)
- Lack of real-time surveillance

Combined hand hygiene audits Oct & Nov 2012

| Area | No. People who washed hands | No. People who used D-Germ or Alcogel | No. Missed opportunities | Total number observed | Percent missed opportunities | Percent who practiced hand hygiene |
|---------------|-----------------------------|---------------------------------------|--------------------------|-----------------------|------------------------------|------------------------------------|
| B1 | 6 | 0 | 55 | 61 | 90.2% | 9.8% |
| C1 ICU | 23 | 9 | 57 | 89 | 64.0% | 36.0% |
| C2 | 42 | 1 | 34 | 77 | 44.2% | 55.8% |
| D1 | 12 | 9 | 44 | 65 | 67.7% | 32.3% |
| E1 | 0 | 1 | 41 | 41 | 97.6% | 2.4% |
| S11 | 3 | 7 | 96 | 106 | 90.6% | 9.4% |
| All | 86 | 27 | 326 | 439 | 74.3% | 25.7% |

Hospital-acquired (nosocomial) infections

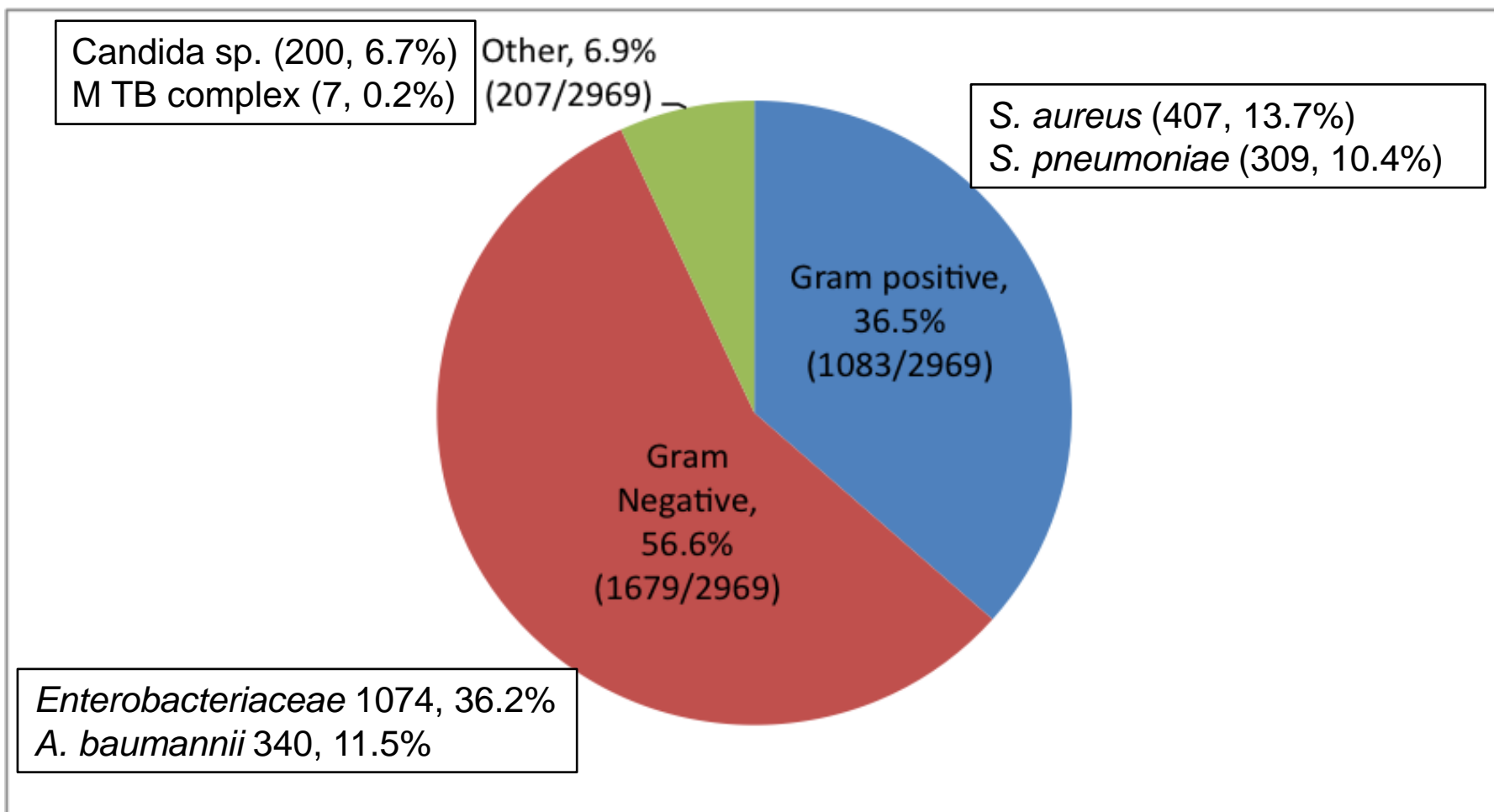
- Nosocomial infections (hospital-acquired infections): infections acquired during hospital care which are not present or incubating at admission. Infections occurring more than 48 hours after admission are usually considered nosocomial. Definitions to identify nosocomial infections have been developed for specific infection sites [e.g. CDC]
- Bloodstream infection: at least one of the following criteria:

| | |
|---------------|---|
| LCBI 1 | Patient has a recognized pathogen cultured from one or more blood cultures AND organism cultured from blood is not related to an infection at another site. |
| LCBI 2 | Patient has at least one of the following signs or symptoms: fever ($>38^{\circ}\text{C}$), chills*, or hypotension* AND positive laboratory results are not related to an infection at another site AND common commensal (i.e., diphtheroids [<i>Corynebacterium</i> spp. not <i>C. diphtheriae</i>], <i>Bacillus</i> spp. [not <i>B. anthracis</i>], <i>Propionibacterium</i> spp., coagulase-negative staphylococci [including <i>S. epidermidis</i>], viridans group streptococci, <i>Aerococcus</i> spp., and <i>Micrococcus</i> spp.) is cultured from two or more blood cultures drawn on separate occasions. Criterion elements must occur within a timeframe that does not exceed a gap of 1 calendar day. *With no other recognized cause |
| LCBI 3 | Patient ≤ 1 year of age has at least one of the following signs or symptoms: fever ($>38^{\circ}\text{C}$ core) hypothermia ($<36^{\circ}\text{C}$ core), apnea*, or bradycardia* AND positive laboratory results are not related to an infection at another site AND common skin commensal (i.e., diphtheroids [<i>Corynebacterium</i> spp. not <i>C. diphtheriae</i>], <i>Bacillus</i> spp. [not <i>B. anthracis</i>], <i>Propionibacterium</i> spp., coagulase-negative staphylococci [including <i>S. epidermidis</i>], viridans group streptococci, <i>Aerococcus</i> spp., <i>Micrococcus</i> spp.) is cultured from two or more blood cultures drawn on separate occasions. Criterion elements must occur within a timeframe that does not exceed a gap of 1 calendar day. *With no other recognized cause |

WHO: <http://www.who.int/csr/resources/publications/drugresist/en/whocdscsreph200212.pdf>

CDC: http://www.cdc.gov/nhsn/PDFs/pscManual/17pscNosInfDef_current.pdf

Bloodstream infection at RCWMCH



Bloodstream infection at RCWMCH

***Staphylococcus aureus* (2007-2011)¹**

- Total of 365 bacteraemic events i.e. 3.28 events/1000 hospital admissions/yr
- Of 357 events, **118 (33%) were nosocomial**, 56 (16%) healthcare-associated, 183 (51%) community-acquired
- Resistance pattern: MSSA, 270 (74%), MRSA, 95 (26%); MRSA caused 72% and 21% of nosocomial and healthcare-associated infections
- Overall case-fatality rate 8.8% (32 deaths attributed to *S. aureus* infection), with MRSA being the only significant risk factor for mortality

***Klebsiella pneumoniae* (2007-2011)²**

- Total of 410 bacteraemic events documented
- **353 (86%) events were nosocomial**, 27 (7%) other healthcare-associated & 27 (7%) community-acquired
- Resistance: 338 (82%) ESBL-producers, 72 (18%) non-ESBL-producers
- Case fatality rate 22.7% (93 deaths)

¹Naidoo R, et al. PLoS One 2013;8(10):e78396

²Buys H, et al. (analysis in process)

Nosocomial infection in the ICU

MDR *Acinetobacter baumannii* (2010)¹

- 194 patients (46.9% tracheal aspirates, 47.4% BAL, 5.2% Blood culture, 0.5% NPA)
- Median (IQR) time to isolation after admission to PICU: 3 (1-7) days

Ventilator-associated pneumonia (Jan 2004 – Sep 2005)²

- 55/244 (23.5%) patients experienced VAP
- In contrast the reported VAP rate ranged from 3-10%

Viral respiratory tract infection (Apr – Dec 2009)³

- 974 patients admitted of whom 195 (20%) had 1/more positive viral isolates
- 175 had complete clinical notes: 28 (16%) admitted to hospital for >7 days before ICU admission & in 95 (54.3%) virus was isolated >48 hours after admission (designated presumed HAIs)

¹Reddy D, et al. SCAH Annual Research Day 2012

²Morrow BM, et al. J Paediatr Child Health 2009;45:104-111

³Ghani ASA, et al. Pediatr Crit Care Med 2012;13:e275-e281

Recent outbreaks

Carbapenem-resistant *Pseudomonas aeruginosa*

- Systemic infection in 2 children in D2 Jun/Jul 2011, molecular typing showed isolates were related to similar isolate identified in a child with bacteraemia in Oct 2010, in C1 ICU

Carbapenem-resistant *Pseudomonas aeruginosa*

- Site of burns lesions, 5 children; ward C2, Oct - Nov 2011: isolates had variable antimicrobial susceptibility profiles but molecular fingerprinting showed that the isolates were all closely related

Respiratory syncytial virus

- Lower respiratory tract infection caused by a single RSV genotype, 18-20 children: E1 & C1 (ICU): Mar - Apr 2012

Carbapenem-resistant *Klebsiella pneumoniae*

- Resistant to ertapenem, intermediately sensitive to imipenem & meropenem, sensitive to colistin: peritoneal fluid from a patient in C1 (ICU) with intra-abdominal sepsis/multiple liver abscesses, Nov 2012
- Resistance mechanism not identified

Recent outbreaks (2)

Vancomycin-resistant *enterococcus faecium* (Feb-Mar 2013)

- 4 children in G1, with VRE expressing the Van A gene [3 x bacteraemia, 1 x G.I.T. colonisation]
- 1 child in the ICU, post-mortem tissue cultured VRE expressing Van B gene

Carbapenem-resistant *Enterobacteriaceae* May 2013

- **WARD D2**
- **Index case, age 5 mo** (pus swab): *E. coli* plus *Klebsiella oxytoca* both possessing a New Delhi Metallo- β -lactamase (NDM) gene
- Subsequent rectal swab: gastrointestinal colonisation by two different strains of *E coli* both carrying the NDM gene
- **Colonised contacts (number screened=22):**
- Patient 2 (D2), age 39 days: *Klebsiella oxytoca* carrying the NDM gene
- Patient 3(D2), age 33 days: *Klebsiella pneumoniae* sp. carrying the NDM gene
- Patient 4 (D2), age 7 years: *E. Coli* carrying the NDM gene
- Patient 5 (MMH), age 19 days: *E. coli* carrying the NDM gene; rectal swab in D2 at 9 days of life No CRE or *Ps.* isolated
- **SCREENING OF CONTACTS: B1, G1, E1 & C1 ICU (n=31)**
- Patient 6 (B1, age 18 mo): *Klebsiella pneumoniae* sp carrying a GES-type β -lactamase gene
- Patient 7: (G1, age 18 mo): *E. coli*, positive Hodge test suggesting presence of carbapenemase activity, NDM gene not isolated

Vancomycin-resistant *enterococcus faecium* (Sep-Nov 2013)

- Index case, 3 yr old ex Uitenhage: admitted 28 August 2013 with Burkitt lymphoma, developed neutropaenic fever with typhilitis in G1, VRE cultured 18 Sep 2013, died in C1 ICU 21Sep 2013
- 27 contacts screened, 7 colonised contacts, of whom 1 progressed to bacteraemia in Nov 2013

Airborne precautions

- Dissemination of airborne droplet nuclei ($\leq 5 \mu\text{m}$) evaporated droplets containing microorganisms
- Traditionally organisms causing: Pulmonary TB (drug-susceptible & -resistant isolates), Measles, Varicella infection (chickenpox, shingles)
- Breathing/coughing/sneezing/talking generate infective particles between 0.05 & $500 \mu\text{m}$, implying that particles do not exclusively disperse by airborne or droplet transmission¹
- Infection control measures:
 - Single room containment
 - Specialised ventilation: 6-12 air changes/hour with air directed to the outside or re-circulated through a high-efficiency particulate air (HEPA) filter, opening windows
 - Respiratory protective devices e.g. N95 mask

Droplet precautions

- Transmission of diseases by expelled particles that settle quickly to the ground, usually within 1m of the site of generation ($>5\text{ }\mu\text{m}$)
- Single room if possible. If not available, spatial separation of ≥ 1 metre between the bed of the infected child and the beds of other children
- Staff and visitors should wear a surgical mask when in the vicinity of the patient. A surgical mask should be worn by the patient whenever leaving the area if possible.
- If the child is suspected of having SARS or viral haemorrhagic fever, isolate and use an N95 respirator in the vicinity of the patient

All acute respiratory infections, including
RSV, adeno,
influenza, Severe
Acute Respiratory
Syndrome (SARS)
Diphtheria
(pharyngeal)
Mumps
*Mycoplasma
pneumonia*
Neisseria meningitides
Pertussis
Plague (pneumonic)
Rubella
Group A streptococcal
pharyngitis or Scarlet
fever
Viral hemorrhagic
fevers

Contact precautions

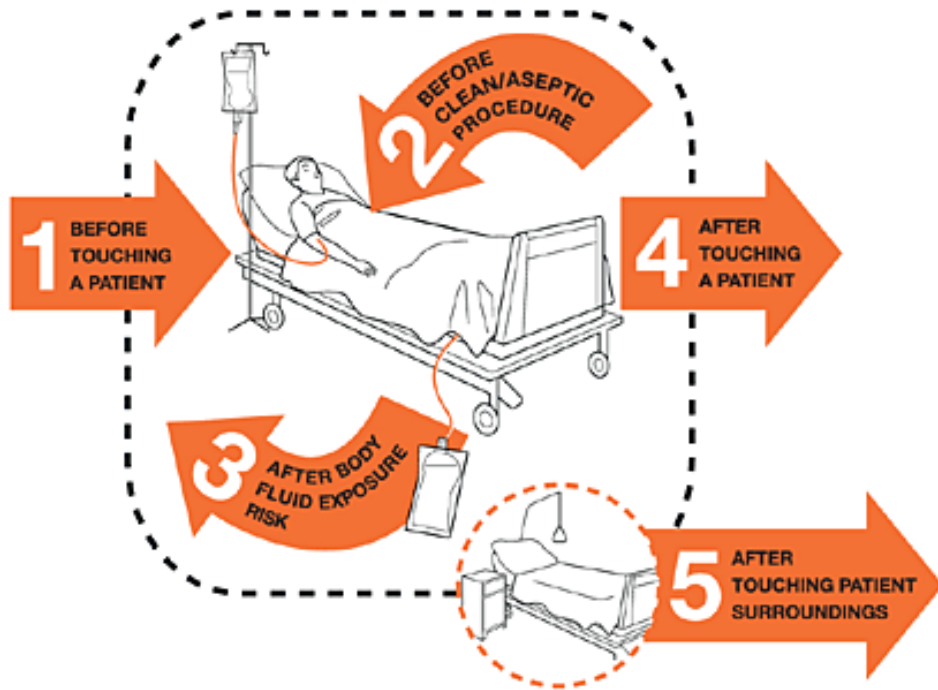
- The most common route of transmission in health care settings
- Direct body surface-to-body surface physical transfer of microorganisms from a person with infection or colonized to a susceptible host
- Where possible, provide the patient with a single cubicle e.g. pan-resistant bacterial infections, viral haemorrhagic fevers
- Gloves (clean, non-sterile) should be used at all times
- Hand hygiene should be performed after glove removal
- Gowns and aprons should be used during direct contact with patients

Infections caused by multi-drug or pan-drug resistant bacteria
All acute respiratory infections
Clostridium difficile
Diphtheria (cutaneous)
Enteroviruses
E coli 0157
Hepatitis A
Pediculosis (lice)
Rotavirus
Salmonella species
Scabies
Shigella species
Staphylococcus aureus
Viral hemorrhagic fevers

Hand hygiene

WHO: My 5 Moments for Hand Hygiene

- defines the key moments when health-care workers should perform hand hygiene.
- evidence-based, field-tested, user-centred approach



WHO's strategy for improving hand hygiene

Evaluated in Costa Rica, Italy, Mali, Pakistan & Saudi Arabia

Compliance increased from 51.0% to 67.2%

WHO: <http://www.who.int/gpsc/en/>

Allegretti B, et al. Lancet Infect Dis 2013;13:843-51



Isolation cubicles at RCWMCH

- Priority should be given to children with PTB, MDR-TB, XDR-TB, Measles, Varicella infection, Adenovirus pneumonia, children with Methicillin Resistant *Staphylococcus Aureus* (MRSA) infection or Extended Spectrum Beta-Lactamase (ESBL)-producing *Klebsiella pneumoniae* infection, Pan-resistant bacterial infection and Viral hemorrhagic fevers



VRE Colonisation

Vancomycin-resistant *Enterococcus faecium*

- Emerged about 25 years ago; has been reported in SA; avoparcin in food animals contributed substantially to the selection of VRE^{1,2}
- Adapted to hospital environments: increased adhesion and biofilm formation → persistent colonization²
- Isolates belonging to complex-17 particularly responsible for global spread & hospital outbreaks³
- Faecal carriage = major reservoir: 1 hospitalized patient with infection caused by VRE from 2-10 faecal carriers²
- Resistant genes (e.g. VanA, VanB, etc.) may be transmitted to other organisms especially anaerobes and staphylococci⁴

¹McCarthy KM, et al. J Hosp Infect 2000;44:294-300

²Cattoir V, et al. J Antimicrob Chemother 2013;68:731-42

³Willems RJL, et al. Emerging Infect Dis 2005;11:821-28

⁴Orth H, et al. S Afr J Epidemiol Infect 2011;107:107-8

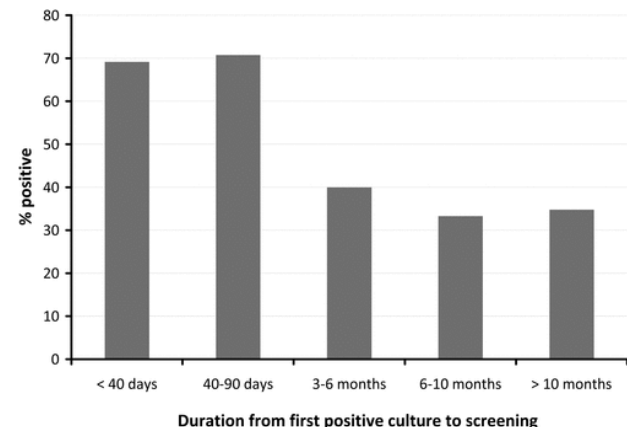
Measures to reduce VRE spread

(systematic review and meta-analysis)

- 549 abstracts retrieved and screened
- 9 studies included in meta-analysis
 - Hand hygiene was associated with a 47% decrease in VRE acquisition rate
 - Contact precautions did not significantly reduce VRE acquisition, RR 1.08, CI: 0.63 – 1.83
 - Due to low number of studies meta-analysis was not applied to surveillance screening, environmental cleaning & antibiotic formulary interventions,
 - No studies were available on the effectiveness of isolation & cohorting of patients and staff

Enterobacteriaceae Colonisation

- Ubiquitous in nature – survives in diverse environments; colonises intestine¹
- Importation of resistant *enterobacteriaceae* from livestock; international travel, inter-hospital transfer^{2,3}
- Intestinal colonisation of ESBL-producing *Klebsiella pneumoniae* in infants (n=51): median carriage time after discharge: 12.5 (IQR: 9.5 – 17.5) months, carriage up to 2 years; antibiotics during hospitalisation associated with prolonged carriage;⁴
- CRE (*K. pneumoniae*) colonisation⁵:



¹Holden N, et al. FEMS Microbiol Rev 2009;33:689-03

²Seiffert SN, et al. Drug Resistance Updates 2013 9in press0

³Van der Bij AK, et al. J Antimicrob Chemother 2012;67:2090-10

⁴Löhr IH, et al. J Antimicrob Chemother online from 3 January 2013

⁵Ben-David D, et al. ICHE 2011;32:845-53

Control of CRE¹

Core measures for all facilities

- Hand hygiene
- Contact precautions
- Patient and staff cohorting
- Minimise use of invasive devices
- Promote antimicrobial stewardship
- Screening

Supplemental measures for facilities with CRE transmission

- Active surveillance testing
- Chlorhexidine bathing

Case study: Country-wide containment achieved using a bundle of measures in Israel²:

- Measures: (1) mandatory reporting, (2) mandatory isolation of hospitalized carriers, (3) strict adherence to contact precautions, (4) dedicated nursing staff on all shifts, (5) re-isolation of known carriers upon readmission, (6) creation of task team to collect data from hospitals and intervene where necessary to contain the outbreak
- Incidence of CRE reduced from 55.5 to 11.7 cases/100,000 patient-days

¹CDC. 2012 CRE toolkit; <http://www.cdc.gov/hai/pdfs/cre/CRE-guidance-508.pdf>

²Schwaber MJ, et al. Clin Infect Dis 2011;52:848-855

2% chlorhexidine decolonisation

Multi-centre, cluster-randomised, nonblinded crossover trial¹

Daily bathing with chlorhexidine-impregnated washcloths in ICUs BMT units:
-23% reduction in multidrug-resistant organisms (MDRO) acquisition, $p=0.03$
-28% reduced rate of hospital-acquired bloodstream infection, $p=0.007$

Cluster-randomised trial²

MRSA screening & isolation (Gr 1) vs targeted decolonisation (Gr 2) versus universal decolonisation, no screening (Gr 3) in ICUs

Decolonisation 2% intranasal mupirocin and chlorhexidine-impregnated washcloths

- Universal colonisation was superior for lowering the rate of MRSA clinical isolates (0.92 vs 0.75 vs 0.63 isolates per 1000 days) and blood stream infection from any pathogen (0.99 vs 0.78 vs 0.56 infections per 1000 days)

Effectiveness in reducing acquisition of Gram-positive organisms; data on the effectiveness of chlorhexidine on Gram-negatives is still limited^{1,3}

¹Climo MW, et al. N Engl J Med 2013;368:533-42

²Huang SS, et al. N Engl J Med 368:2255-65

³Munoz-Price LS, et al. Curr Opin Infect Dis 2013;26:378-87