Preventing hospital-acquired infection

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## Health-care associated infection (HAI)

### Definitions

**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: 2004-2009

- 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

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**HAI in developing countries**

<table>
<thead>
<tr>
<th>Systematic review and meta-analysis¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>▪ 220 studies included, including 14 from Africa &amp; 40 paediatric studies</td>
</tr>
<tr>
<td>▪ 118 (54%) studies were low-quality</td>
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<table>
<thead>
<tr>
<th>Overall results</th>
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<tbody>
<tr>
<td>▪ Pooled prevalence of HAI (high-quality): 15.5 per 100 patients [CI: 12.6 – 18.9]</td>
</tr>
<tr>
<td>▪ European CDC: 7.1 per 100 patients; USA: 4.5 per 100 patients (2002)²,³</td>
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<table>
<thead>
<tr>
<th>Paediatric studies</th>
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<tr>
<td>▪ 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</td>
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<tr>
<td>▪ 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</td>
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</tbody>
</table>

²ECDC: Annual report on communicable diseases in Europe
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

Rosenthal VD, Lancet 2011;377:187-188
## Combined hand hygiene audits Oct & Nov 2012

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

Charmain Rinquist & Naseeba Kader
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:

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

CDC: http://www.cdc.gov/nhsn/PDFs/pscManual/17pscNosInfDef_current.pdf
Bloodstream infection at RCWMCH

Candida sp. (200, 6.7%)
M TB complex (7, 0.2%)

S. aureus (407, 13.7%)
S. pneumoniae (309, 10.4%)

Enterobacteriaceae 1074, 36.2%
A. baumannii 340, 11.5%

**Bloodstream infection at RCWMCH**

**Staphylococcus aureus (2007-2011)**
- 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. aureaus infection), with MRSA being the only significant risk factor for mortality

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

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2. Buys H, et al. (analysis in process)
## Nosocomial infection in the ICU

### MDR *Acinetobacter baumanii* (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)

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\(^1\) Reddy D, et al. SCAH Annual Research Day 2012  
# Recent outbreaks

<table>
<thead>
<tr>
<th>Carbapenem-resistant <em>Pseudomonas aeruginosa</em></th>
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<tbody>
<tr>
<td>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</td>
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<tr>
<th>Carbapenem-resistant <em>Pseudomonas aeruginosa</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>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</td>
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<table>
<thead>
<tr>
<th>Respiratory syncitial virus</th>
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<table>
<thead>
<tr>
<th>Carbapenem-resistant <em>Klebsiella pneumoniae</em></th>
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<tbody>
<tr>
<td>Resistant to ertapenem, intermediately sensitive to imipenem &amp; meropenem, sensitive to colistin: peritoneal fluid from a patient in C1 (ICU) with intra-abdominal sepsis/multiple liver abscesses, Nov 2012</td>
</tr>
<tr>
<td>Resistance mechanism not identified</td>
</tr>
</tbody>
</table>
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 *Enterobactericeae* May 2013

- **WARDD2**
  - **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 (≤5 μm) 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 & 500μm, 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 μm)

• 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
Evaluates in Costa Rica, Italy, Mali, Pakistan & Saudi Arabia
Compliance increased from 51.0% to 67.2%

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.
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 colonization\(^2\)
- Isolates belonging to complex-17 particularly responsible for global spread & hospital outbreaks\(^3\)
- Faecal carriage = major reservoir: 1 hospitalized patient with infection caused by VRE from 2-10 faecal carriers\(^2\)
- Resistant genes (e.g. VanA, VanB, etc.) may be transmitted to other organisms especially anaerobes and staphylococcus\(^4\)

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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 dis 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 intestine\(^1\)
  - Importation of resistant \textit{enterobacteriaceae} from livestock; international travel, inter-hospital transfer\(^2,3\)
  - Intestinal colonisation of ESBL-producing \textit{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 (\textit{K. pneumoniae}) colonisation\(^5\):

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\(^2\)Seiffert SN, et al. Drug Resistance Updates 2013 9in press0
\(^3\)Van der Bij AK, et al. J Antimicrob Chemother 2012;67:2090-10
\(^4\)Löhr IH, et al. J Antimicrob Chemother online from 3 January 2013
\(^5\)Ben-David D, et al. ICHE 2011;32:845-53
Control of CRE

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 Israel:
- 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

2% chlorhexidine decolonisation

Multi-centre, cluster-randomised, nonblinded crossover trial\(^1\)
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 trial\(^2\)
MRSA screening & isolation (Gr 1) vs targeted decolonisation (Gr 2) versus universal decolonisation, no screening (Gr 3) in ICUs
Declonisation 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 bloodstream 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\(^1,3\)

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