Brief introduction of prevention and control of healthcare-associated infections in China

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2018-3-18
The slides presented here are just a personal views and does not represent any organizations or institutions

No conflicts of interest
Outlines

- Laws, regulations and guidelines for HAI prevention and control
- Brief review of major indicators of HAI
- Transmission Model of MDR in ICU
- Africa CDC
At the end of November of 2017 in China:
- **Population (Mainland):** 1.4 billion
- **Hospitals:** 30,000 (public 12181 and private 18113)
- **Primary health care institutions:** 938,000
- **Professional public health institutions:** 22,000
  - CDC in different levels: 3481
  - Health Supervision Center: 3132

From Jan. to Nov. 2017 in China
- **Visit for diagnosis and treatment in hospitals:** 3.07 billion
- **Discharged patients:** 213 million
Laws, Regulations and Guidelines

Law

Regulations
- Regulation on Hospital Infection Management (2006)
- Regulation on Medical Waste Management (2003)
- Regulation on Disinfection Management (2002)
Laws, Regulations and Guidelines

Technical guidelines

- Guideline for Prevention and Control of Surgical Site Infection (GJB 7480—2012)
- Guideline for Diagnosis of Nosocomial Infection (2001)
- Guidelines for Clinical Application of Antimicrobial drugs (2016)
- Guideline for Endoscope Cleaning and Disinfection (2016)
- Guideline for Dental Equipment Disinfection in Healthcare Settings (2016)
- Specification of Nosocomial Outbreak Reporting and Disposal Management (2016)
- Standard for construction of Hospital Clean Operation Department (2016)
Technical guidelines

- Central Sterile Supply Department (CSSD): WS 310—2009
  - Part I: management standard
  - Part II: standard for operating procedure of cleaning, disinfection and sterilization
  - Part III: surveillance standard for cleaning, disinfection and sterilization
- Guideline for isolation in hospitals (WS/T 311—2009)
- Guideline for nosocomial infection surveillance (WS/T 312—2009)
- Guideline for hand hygiene of healthcare workers in healthcare settings (WS/T 313—2009)
Technical guidelines

- Guideline of Hospital Air Purification management (WS/T368—2012)
- Guidelines for washing and disinfection technique of medical textiles in healthcare facilities (2016)
- Guidelines for prevention and control of healthcare associated infection in intensive care unit (2016)
Chinese Healthcare-Associated Infection Surveillance Network

National Center for HAI Surveillance:
located in XiangYa Hospital in Hunan province
Cross sectional survey every two years

Constituent ratio (%)

Year 2010
269 Hospitals:
169,888 patients:
7196 HAI
Prevalence rate of HAI 4.29%;

Prevalence of nosocomial infection in different hospitals

<table>
<thead>
<tr>
<th>Hospital type (no. of beds)</th>
<th>No. of hospitals</th>
<th>No. of patients included</th>
<th>Prevalence rate(%)</th>
<th>The percentile</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>P10</td>
</tr>
<tr>
<td>&lt;300</td>
<td>79</td>
<td>11562</td>
<td><strong>2.28</strong></td>
<td>0.00</td>
</tr>
<tr>
<td>300-599</td>
<td>76</td>
<td>27655</td>
<td><strong>3.08</strong></td>
<td>0.64</td>
</tr>
<tr>
<td>600-899</td>
<td>42</td>
<td>30795</td>
<td><strong>4.36</strong></td>
<td>2.64</td>
</tr>
<tr>
<td>≥900</td>
<td>72</td>
<td>97728</td>
<td><strong>4.44</strong></td>
<td>2.27</td>
</tr>
</tbody>
</table>

1766 Hospitals; 1008,584 patients, 26972 HAI
Prevalence rate of HAI 2.6%;
Percentage of antibiotic Use: 35.1%

Percentage of all HAI: Low respiratory tract infection 47.5%
Urinary tract infection 11.5%
SSI 10.4%
Prevalence rate of Class I SSI: 1.01%
Percentage of antibiotic Prophylaxis for Class I SSI: 27.9%
Bacterial examination rate for treatment usage of antibiotic: 45.9%

In hospitals with >900 beds:
Prevalence rate of HAI 3.4%;
Percentage of antibiotic Use: 32.3%
Bacterial examination rate: 56.1%

Web-based Surveillance Network

71 hospitals, 7 different districts, automatic data flow

The data flow chart of web-based surveillance

1. Data generation
2. Data push
3. Data transfer
4. Data transfer
5. Data input

Hospital Information System

Internet network

Internet or other web system

Information center server

Web-based hospital infection surveillance system

Hospital network

Wards A
Wards B
Wards C
Geographic location of hospitals

- 52 hospitals including 47 tertiary care hospitals and 5 secondary care hospitals
- 37 cities of 22 provinces
- 0.6% of all the secondary and tertiary care hospitals (n=8984) in 2015 in China

Main Results in our Survey

- 53,939 patients
- Prevalence of HAI was 3.7%.
- Most common types were:
  - low respiratory tract infections (47.2%)
  - urinary tract infection (12.3%),
  - upper respiratory tract infection (11.0%)
  - surgical site infection (6.2%).

Device-associated infections accounted for only 7.9% of all HCAIs (25.6%, USA).

Type of HAI

Most frequently isolated micro-organisms:

*Pseudomonas aeruginosa*,
*Klebsiella pneumoniae*,
*Escherichia coli*,
*Acinetobacter baumannii*,
*Staphylococcus aureus*

accounted for 57.4% of all
## Comparison of HAI Prevalence and Antimicrobial Drug Use

<table>
<thead>
<tr>
<th>Country /Region</th>
<th>Year of PPS</th>
<th>No. of hospitals</th>
<th>Prevalence of HAIs</th>
<th>Antimicrobial Drug Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 countries of European</td>
<td>2011-2012</td>
<td>947</td>
<td>6.0%</td>
<td>35.0%</td>
</tr>
<tr>
<td>USA</td>
<td>2011</td>
<td>183</td>
<td>4%</td>
<td>51.9%</td>
</tr>
<tr>
<td>Chinese National PPS</td>
<td>2014</td>
<td>1766</td>
<td>2.6%</td>
<td>35.1%</td>
</tr>
<tr>
<td>Our survey</td>
<td>2015</td>
<td>52</td>
<td>3.7%</td>
<td>33.8%</td>
</tr>
</tbody>
</table>

Surgical site infection

Figure 2 | Pooled incidence of SSI in mainland China at different study periods, with corresponding 95% confidence interval.
Device-associated HAI

861,284 patients, 3,506,562 ICU days.

In the medical-surgical ICUs,
- Central Line-Associated BI, 4.1 /1,000 central line-days (0.8 US)
- Ventilator-associated pneumonia 13.1 /1,000 ventilator-days (0.9 US)
- CA-UTI, 5.07 / 1,000 catheter-days (1.7 US)

From blood cultures samples: frequencies of resistance of Pseudomonas isolates to amikacin (29.87% vs 10%) and to imipenem (44.3% vs 26.1%);
- Klebsiella pneumoniae: to ceftazidime (73.2% vs 28.8%) and to imipenem (43.27% vs 12.8%)

Settings: 703 ICUs
Device-associated HAI (II)

Settings: 7 ICUs in 4 hospitals;
Time: Between August 2008 and July 2010;
Admissions: 2,631 admissions

VAP: 10.46/1,000 mechanical ventilator (MV)-days;
CLABSI: 7.66/1,000 central line (CL)-days;
CAUTI: 1.29/1,000 urinary catheter (UC)-days.

Pooled DU ratios were 0.43 for MV, 0.71 for CL, and 0.76 for UC.

extra LOS: 15 days for CLABSI, 20.5 days for VAP, and 27 days for CAUTI.

extra mortality: 14% for CLABSI; 22% for VAP; 43% for CAUTI.

Conclusions: VAP and CLABSI rates were higher than CDC/NHSN’s reported data, LOS and mortality were increased.
Bloodstream Infection

Successful reduction in central line–associated bloodstream infections in a Chinese neonatal intensive care unit

Qi Zhou MD,a Shoo K. Lee MBBS, FRCP, PhD,b Xiao-jing Hu RN, MSNC, Si-yuan Jiang MD,a Chao Chen MD, PhDb, Chuang-qing Wang PhDc, Yun Cao MD, PhDb

aDepartment of Neonatology, Children’s Hospital of Fudan University, Shanghai, China
bDepartment of Pediatrics, University of Toronto, Toronto, ON, Canada
cDepartment of Microbiology, Children’s Hospital of Fudan University, Shanghai, China

Fig 1. Significant (P < .05) decline in trends of Central Line Associated Blood Stream Infection (CLABSI) from Phase 1 to Phase 3.

Table 2
Incidence density of CLABSI

<table>
<thead>
<tr>
<th>Phase no.</th>
<th>n</th>
<th>CLABSI (n)</th>
<th>CL days</th>
<th>CLABSI/1000 CL days</th>
<th>RR</th>
<th>P value</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase 1</td>
<td>29</td>
<td>8</td>
<td>480</td>
<td>16.7 (8/480)</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Phase 2</td>
<td>51</td>
<td>9</td>
<td>1,177</td>
<td>7.6 (9/1,177)</td>
<td>.455</td>
<td>.08</td>
<td>0.177-1.189</td>
</tr>
<tr>
<td>Phase 3</td>
<td>91</td>
<td>12</td>
<td>2,287</td>
<td>5.2 (12/2,287)</td>
<td>.311</td>
<td>.008</td>
<td>0.128-0.770</td>
</tr>
<tr>
<td>Phases 2 and 3</td>
<td>142</td>
<td>21</td>
<td>3,464</td>
<td>6.1 (21/3,464)</td>
<td>.365</td>
<td>.01</td>
<td>0.161-0.821</td>
</tr>
<tr>
<td>Phases 2 vs 3</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>.684</td>
<td>.17</td>
<td>0.289-1.628</td>
</tr>
</tbody>
</table>

NOTE. Phase 1 is preintervention; phase 2 is intervention; and phase 3 is follow-up.
CI, confidence interval; CL, central line; CLABSI, central line–associated bloodstream infection; NA, not applicable; RR, relative risk.
Phase 2 versus phase 1.
Phase 3 versus phase 1.
Phase 1 versus phases 2 and 3.
Bloodstream Infection

Nosocomial Bloodstream Infection Due to Candida spp. in China: Species Distribution, Clinical Features, and Outcomes

Ying Li · Mingmei Du · Liang-an Chen · Yunxi Liu · Zhixin Liang

➢ retrospective, population-based study
➢ January 2010 to December 2014
➢ 190 episodes of Candida BSI
➢ C. Albicans (38.9%)
   C. parapsilosis (23.2 %)
   C.tropicalis (20.5 %).
➢ The 30-day hospital mortality was 27.9 %,
➢ the early mortality (within 7 days) was 16.3 %.

➢ Independent risk factor:
   APACHE II score and severe sepsis
➢ catheter-related candidemia: a positive factor

Early central venous catheter removal and adequate antifungal treatment were closely related to decreased mortality in patients with primary candidemia.
Ventilator-associated pneumonia (VAP) caused by multidrug-resistant (MDR) Gram-negative bacteria (GNB)

Fourteen controlled studies involving 1167 patients

The clinical cure rate

Colistin: β-lactam antibiotics (OR = 1.00, 95% CI 0.68–1.47).

AS plus IV colistin better than IV colistin alone (OR = 2.12, 95% CI 1.40–3.20).

Compared with colistin monotherapy, colistin combined therapy (OR = 1.38, 95% CI 0.81–2.33).

no significant difference in nephro-toxicity and other secondary outcomes between the treatment groups.
Ventilator-associated pneumonia (II)

- open-label, randomized, controlled multicenter
- 235 critically ill adult patients
- 14 days, two groups (1) probiotics capsule containing live *Bacillus subtilis* and *Enterococcus faecalis* (*Medilac-S*) 0.5 g three times daily through a nasogastric feeding tube
- Microbiological confirmed VAP: significantly lower than control (36.4 vs. 50.4 %).
- No improvement: clinically suspected VAP, antimicrobial consumption, duration of mechanical ventilation, mortality and length of stay
Urinary tract infection (I)

The prevalence and predictive factors of urinary tract infection in patients undergoing renal transplantation: A meta-analysis

Xiaohui Wu MS a,b, Yanyan Dong MD c, Yinhong Liu MS b, Yingxia Li MS d, Yu Sun MS e, Jingna Wang MS f, Shuihui Wang MD a,e

a Division of Hospital Infection Management, Qilu Hospital of Shandong University, Jinan, Shandong Province, China
b School of Nursing, Shandong University, Jinan, Shandong Province, China

- the risk factors of UTIs are controversial.
- 17 studies (6,671 patients)
- January 2000-October 2014
- Prevalence of UTIs in RTx was 38.0%
- The estimated risk factors:
  - female, older age, duration of catheter, acute rejection, and receiving a kidney from a deceased donor
Urinary tract infection (II)

➢ China, Vietnam, India, Thailand and the Philippines have the highest rates of ESBL-producing GNB and cephalosporin resistance.

➢ Resistance of E. coli and K. pneumoniae to ciprofloxacin, levofloxacin and most β-lactams with the exception of imipenem and ertapenem.

➢ >87% of ESBL-producing E. coli strains were susceptible to amikacin and piperacillin/tazobactam.
Urinary tract infection (II)

**E. Coli**

**K. pneumonia**
Similarity and Divergence of Phylogenies, Antimicrobial Susceptibilities, and Virulence Factor Profiles of *Escherichia coli* Isolates Causing Recurrent Urinary Tract Infections That Persist or Result from Reinfection

Yanping Luo, Yanning Ma, Qiang Zhao, Lei Li Wang, Ling Guo, Liyan Ye, Youjiang Zhang, and Jiyong Yang
Department of Microbiology, Chinese PLA General Hospital, Beijing, China

TABLE 1 Number of *E. coli* isolates which belong to different phylogenetic groups and are resistant to various antimicrobials

<table>
<thead>
<tr>
<th>Item</th>
<th>No. of persistence isolates (%)</th>
<th>No. of reinfection isolates (%)</th>
<th>P value*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Phylogenetic group</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>9 (23.08)</td>
<td>20 (23.26)</td>
<td>0.9825</td>
</tr>
<tr>
<td>B1</td>
<td>4 (10.26)</td>
<td>9 (10.47)</td>
<td>0.873</td>
</tr>
<tr>
<td>B2</td>
<td>16 (41.05)</td>
<td>18 (20.93)</td>
<td>0.0193</td>
</tr>
<tr>
<td>D</td>
<td>10 (25.64)</td>
<td>39 (45.35)</td>
<td>0.0365</td>
</tr>
<tr>
<td><strong>ESBL production</strong></td>
<td>22 (56.41)</td>
<td>43 (50)</td>
<td>0.5063</td>
</tr>
<tr>
<td><strong>Antibiotics</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Piperacillin</td>
<td>29 (74.36)</td>
<td>65 (75.58)</td>
<td>0.8834</td>
</tr>
<tr>
<td>Cefuroxime</td>
<td>22 (56.41)</td>
<td>46 (53.49)</td>
<td>0.7612</td>
</tr>
<tr>
<td>Cefotaxime</td>
<td>22 (56.41)</td>
<td>45 (52.32)</td>
<td>0.6714</td>
</tr>
<tr>
<td>Ceftazidime</td>
<td>9 (23.08)</td>
<td>16 (18.61)</td>
<td>0.5625</td>
</tr>
<tr>
<td>Imipenem</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Amoxillin/clavulanic acid</td>
<td>7 (17.95)</td>
<td>16 (18.61)</td>
<td>0.9301</td>
</tr>
<tr>
<td>Trimethoprim-sulphamethoxazole</td>
<td>25 (64.11)</td>
<td>55 (63.95)</td>
<td>0.9872</td>
</tr>
<tr>
<td>Ciprofloxacin</td>
<td>32 (82.05)</td>
<td>63 (73.26)</td>
<td>0.2861</td>
</tr>
<tr>
<td>Amikacin</td>
<td>2 (5.15)</td>
<td>10 (11.65)</td>
<td>0.4149</td>
</tr>
</tbody>
</table>

* A P value of <0.05 (bold) was considered statistically significant.

**TABLE 2** Prevalence of VFs among UPEC causing RUTIs that persist and result from reinfection

<table>
<thead>
<tr>
<th>Virulence factor</th>
<th>No. of persistence isolates (%)</th>
<th>No. of reinfection isolates (%)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Adhesins</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>afa</em></td>
<td>4 (10)</td>
<td>11 (13)</td>
<td>0.9148</td>
</tr>
<tr>
<td><em>fimH</em></td>
<td>33 (86)</td>
<td>72 (84)</td>
<td>0.8994</td>
</tr>
<tr>
<td><em>iha</em></td>
<td>19 (49)</td>
<td>24 (28)</td>
<td>0.0233</td>
</tr>
<tr>
<td><em>papA</em></td>
<td>1 (3)</td>
<td>8 (9)</td>
<td>0.4316</td>
</tr>
<tr>
<td><em>papEF</em></td>
<td>3 (8)</td>
<td>2 (2)</td>
<td>0.3006</td>
</tr>
<tr>
<td><strong>papG allele I’</strong></td>
<td>20 (51)</td>
<td>21 (24)</td>
<td>0.0030</td>
</tr>
<tr>
<td><strong>papG allele II</strong></td>
<td>0 (0)</td>
<td>9 (10)</td>
<td>0.0848</td>
</tr>
<tr>
<td><strong>sfa</strong></td>
<td>6 (15)</td>
<td>5 (6)</td>
<td>0.1588</td>
</tr>
<tr>
<td><strong>Iron-related</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>chuA</em></td>
<td>27 (69)</td>
<td>57 (66)</td>
<td>0.7447</td>
</tr>
<tr>
<td><em>teoB</em></td>
<td>39 (100)</td>
<td>81 (94)</td>
<td>0.2964</td>
</tr>
<tr>
<td><strong>fimA</strong></td>
<td>33 (85)</td>
<td>50 (58)</td>
<td>0.0037</td>
</tr>
<tr>
<td><em>ireA</em></td>
<td>0 (0)</td>
<td>6 (7)</td>
<td>0.2153</td>
</tr>
<tr>
<td><em>irp-2</em></td>
<td>34 (87)</td>
<td>56 (65)</td>
<td>0.0109</td>
</tr>
<tr>
<td><em>iroN</em></td>
<td>6 (15)</td>
<td>11 (13)</td>
<td>0.6951</td>
</tr>
<tr>
<td><em>iucC</em></td>
<td>37 (95)</td>
<td>67 (78)</td>
<td>0.0187</td>
</tr>
<tr>
<td><em>iutA</em></td>
<td>34 (87)</td>
<td>50 (58)</td>
<td>0.0014</td>
</tr>
<tr>
<td><em>sitA</em></td>
<td>31 (79)</td>
<td>66 (77)</td>
<td>0.7333</td>
</tr>
<tr>
<td><strong>Protectins</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>cvaC</em></td>
<td>4 (10)</td>
<td>6 (7)</td>
<td>0.7868</td>
</tr>
<tr>
<td><em>iss</em></td>
<td>5 (13)</td>
<td>14 (16)</td>
<td>0.6178</td>
</tr>
<tr>
<td><em>traT</em></td>
<td>33 (85)</td>
<td>69 (80)</td>
<td>0.5579</td>
</tr>
<tr>
<td><strong>PAI</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>malX</em></td>
<td>9 (23)</td>
<td>17 (20)</td>
<td>0.6728</td>
</tr>
<tr>
<td><strong>CVP region</strong></td>
<td>4 (10)</td>
<td>9 (10)</td>
<td>0.9717</td>
</tr>
</tbody>
</table>

* A P value of <0.05 (bold) was considered statistically significant. PAI, pathogenicity-associated island; CVP, conserved virulence plasmidic.
Challenges

- Insufficient investment on prevention & control of HAI;
- Difficulty in strict Implementation on guidelines;
- Low and inconsistent Hand hygiene compliance;
- Insufficient Education & Training;
- Less team stability of infection control professionals;
- Less multicenter, good designed clinical study
- ......
Our Mission

- Surveillance on healthcare-associated infections
- Investigations on nosocomial infection Outbreak
- Generation of recommendations and Standards
- Perform Intervention Implementation
- Research:
  Epidemiological analysis of MDRO;
  Infection mechanism, especially in the lung
Move of a surgical ICU

Old ward

New ward

$N_h/N_p \ 2.0$

$N_h/N_p \ 1.2$
**ICU Settings**

- 4000-beds tertiary-care hospital
- Surgical ICU

<table>
<thead>
<tr>
<th>Characters</th>
<th>Old ward (6-beds)</th>
<th>New ward (20-beds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average distance between beds (m)</td>
<td>0.9</td>
<td>1.8</td>
</tr>
<tr>
<td>Areas around each bed (m²)</td>
<td>5.8</td>
<td>10.5~15.2</td>
</tr>
<tr>
<td>Number of single-bed room</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Number of couple room</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Number of multi-bed room</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Number of water taps</td>
<td>3</td>
<td>18</td>
</tr>
<tr>
<td>The ratio of N. of taps to N. of Nurses</td>
<td>0.2(3/15)</td>
<td>0.8(17/21)</td>
</tr>
<tr>
<td>Number of monitors</td>
<td>6 fixed and 2 moved</td>
<td>20 fixed and 6 moved</td>
</tr>
<tr>
<td>Number of ventilators</td>
<td>5 moved</td>
<td>20 fixed</td>
</tr>
<tr>
<td>Number of hand disinfectants</td>
<td>6</td>
<td>20</td>
</tr>
</tbody>
</table>
## ICU Settings

<table>
<thead>
<tr>
<th>Characters</th>
<th>Old ward (6-beds)</th>
<th>New ward (20-beds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of infusing pumps</td>
<td>Total 20, used crossing</td>
<td>Total 160, 8 fixed every bed</td>
</tr>
<tr>
<td>Temperature (°C)</td>
<td>28~31</td>
<td>25~27</td>
</tr>
<tr>
<td>Number of staffs</td>
<td>25</td>
<td>40</td>
</tr>
<tr>
<td>Ratio of nurses to patients</td>
<td>2.0</td>
<td>1.2</td>
</tr>
<tr>
<td>The main patient sources</td>
<td>General Surgery, Hepatobiliary and Hematology surgery</td>
<td>General Surgery, Hepatobiliary, Hematology, Bone, Urology, Chest, gynaecology and obstetrics surgery</td>
</tr>
<tr>
<td>Frequency of disinfection (per day)</td>
<td>Twice</td>
<td>Thrice</td>
</tr>
</tbody>
</table>
## Detection of MRSA in patients, HCWs and environment

<table>
<thead>
<tr>
<th>Sites</th>
<th>Old ward</th>
<th>MRSA positive</th>
<th>New ward</th>
<th>MRSA positive</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Samples taken n</td>
<td>%</td>
<td>Samples taken n</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td><strong>Patients</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anterior nares</td>
<td>273</td>
<td>47(17.2)</td>
<td>2555</td>
<td>85(3.3)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Total four sites</td>
<td>1,098</td>
<td>115(10.5)</td>
<td>10,261</td>
<td>195(1.9)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Sampling density</td>
<td>1.96 (1098/560)</td>
<td>1.82 (10261/5636)</td>
<td>0.17</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Health care workers</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hand</td>
<td>284</td>
<td>23(8.1)</td>
<td>379</td>
<td>9(2.4)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Anterior nares</td>
<td>86</td>
<td>1(1.2)</td>
<td>139</td>
<td>1(0.7)</td>
<td>0.999</td>
</tr>
<tr>
<td>Total</td>
<td>370</td>
<td>24(6.6)</td>
<td>518</td>
<td>10(1.9)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>Environment</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bed sheet</td>
<td>249</td>
<td>13(5.2)</td>
<td>1290</td>
<td>23(1.8)</td>
<td>0.001</td>
</tr>
<tr>
<td>Dispensing station</td>
<td>163</td>
<td>4(2.5)</td>
<td>756</td>
<td>4(0.5)</td>
<td>0.037</td>
</tr>
<tr>
<td>Water tap</td>
<td>132</td>
<td>2(1.5)</td>
<td>983</td>
<td>1(0.1)</td>
<td>0.039</td>
</tr>
<tr>
<td>Air</td>
<td>273</td>
<td>14(5.1)</td>
<td>1332</td>
<td>7(0.5)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>2053</td>
<td>83(4.0)</td>
<td>10811</td>
<td>98(0.9)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>
## MRSA prevalence, acquisition and transmission in ICUs

<table>
<thead>
<tr>
<th>Variables</th>
<th>Old ward (n=64)</th>
<th>New ward (n=454)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive on admission, no. (%)</td>
<td>9(14.1)</td>
<td>8(1.8)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>ICU acquisition, no. (%)</td>
<td>13(23.6)</td>
<td>33(7.4)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Patient-days at-risk</td>
<td>318</td>
<td>3782</td>
<td>-</td>
</tr>
<tr>
<td>ICU acquisition per 1,000 patient-days at-risk</td>
<td>40.9</td>
<td>8.7</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>Number of new cases per imported case</strong></td>
<td><strong>1.4</strong></td>
<td><strong>4.1</strong></td>
<td>-</td>
</tr>
</tbody>
</table>

Hand hygiene compliance                              | 31.3%           | 18.2%            |
Nursing cohorting level                               | 0.62            | 0.47             |
MDR-Ab prevalence, acquisition and transmission in ICUs

<table>
<thead>
<tr>
<th>Variables</th>
<th>Old ward (n=64)</th>
<th>New ward (n=454)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive on admission, no. (%)</td>
<td>19(29.7)</td>
<td>49(10.8)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>ICU acquisition, no. (%)</td>
<td>17(37.8)</td>
<td>84(20.7)</td>
<td>0.009</td>
</tr>
<tr>
<td>ICU acquisition per 1,000 patient-days at-risk</td>
<td>70.0</td>
<td>34.9</td>
<td>0.015</td>
</tr>
<tr>
<td>Number of new cases per imported case</td>
<td>0.9</td>
<td>1.7</td>
<td>-</td>
</tr>
</tbody>
</table>

The nurse cohorting level and hand hygiene compliance are strong predictors of MDROs transmission in ICUs
MDR-Ab prevalence, acquisition and transmission in ICUs

Figure 1: (a) Time series of numbers of colonized and uncolonized patients per day. Red lines, colonized patients; blue lines, uncolonized patients. (b) Detection rates of MRAB throughout the ward. (c) Correlations between detection rates and number of colonized patients. Gray stars - data; green stars - mean detection rate; the line - fitted curve.
Ross-Macdonald Model

Uncolonized admission

Uncolonized patients (Xp)

Colonization

Antibiotic restriction

Colonized patients (Yp)

Cohorting of staff

Discharge

Colonized admission

Uncontaminated HCWs (Xh)

Contamination

Hand hygiene

Uncontaminated HCWs (Yh)

Grundmann et al. 2002
New model?

- Role of environmental factors?
- Difference between MRSA and MRAB?

Mean-field model

\[
\begin{align*}
\frac{d[D_C]}{dt} &= (\beta_1 P^C + v_1 W(t)) D^S - \gamma D^C \\
\frac{d[H_C]}{dt} &= (\beta_2 P^C + v_2 W(t)) H^S - \gamma H^C \\
\frac{d[P^S]}{dt} &= (1 - \phi) \Lambda - (\beta_3 D^C + \beta_4 H^C) P^S - d_1 P^S \\
\frac{d[P^C]}{dt} &= \phi \Lambda + (\beta_3 D^C + \beta_4 H^C) P^S - d_2 P^C
\end{align*}
\]

Pair-approximation model

\[
\begin{align*}
\frac{d[D_C]}{dt} &= \tau_1 [P^C D^S] + v_1 (N_D - [D^C]) W - \gamma [D^C] \\
\frac{d[H_C]}{dt} &= \tau_2 [P^C H^S] + v_2 (N_H - [H^C]) W - \gamma [H^C] \\
\frac{d[P^S]}{dt} &= (1 - \phi) \hat{\Lambda} [\phi] - \tau_3 [D^C P^S] - \tau_4 [H^C P^S] - d_1 [P^S] \\
\frac{d[P^C]}{dt} &= \phi \hat{\Lambda} [\phi] + \tau_3 [D^C P^S] + \tau_4 [H^C P^S] - d_2 [P^C] \\
\frac{d[D_C P^C]}{dt} &= \tau_3 ([D^C P^S D^C] + [D^C P^S]) + \tau_4 [D^C P^S H^C] - \gamma [D^C P^C] + \phi \hat{\Lambda} [D^C \phi] \\
&\quad - d_2 [D_C P^C] + \tau_1 ([P^C D^S P^C] + [D^S P^C]) + v_1 [D^S P^C] W \\
\frac{d[H_C P^C]}{dt} &= \tau_4 ([H^C P^S H^C] + [H^C P^S]) + \tau_3 [H^C P^S D^C] - \gamma [H^C P^C] + \phi \hat{\Lambda} [H^C \phi] \\
&\quad - d_2 [H_C P^C] + \tau_2 ([P^C H^S P^C] + [H^S P^C]) + v_2 [H^S P^C] W
\end{align*}
\]
A large cohorting rate potentially control disease transmission

**CR=50%**

**CR=75%**

**CR=100%**

ITR=48.9% Indirect transmission rate

ITR=0%

Figure 3 | The average number of colonized patients in a period of 500 days versus the nurse-patient ratio when the cohorting rate was 50% ((a), (d)), 75% ((b), (e)), or 100% ((c), (f)). Figures in the first line (a), (b) and (c) show the results when the indirect transmission rate was 48.9, while those in the second line show the results when the indirect transmission rate was 0. Blue circles show simulation results for the pairwise model. Blue (red) stars show simulation results on the random network (the strict cohering network). All other parameter values are as listed in Table 1.
In the contaminated environment, hygiene is more effective than cohorting.

Figure 4 | (a) The average number of colonized patients over a period of 500 days versus indirect transmission rate and cohorting rate simulated by the pairwise model. (b) (c) The average number of colonized patients over a period of 500 days versus handwashing rate and cohorting rate when the

NH/NP=15/20
Effectiveness of hand hygiene and cohorting is greatly affected by the environmental contamination.

ITR=0%

ITR=48.9%

Figure 4 | (a) The average number of colonized patients over a period of 500 days versus **indirect transmission rate** and cohorting rate simulated by the pairwise model. (b) ((c)) The average number of colonized patients over a period of 500 days versus handwashing rate and cohorting rate when the indirect transmission rate was zero (b) or 48.9 (c) simulated by the pairwise model. All other parameter values are as listed in Table 1.
Establishment of the Africa CDC

January 31st, 2017

January 30th, 2018
Plague Outbreak in Madagascar - October 2017

Africa CDC’s Actions:
- Strengthen public health emergency management system
- Develop data analysis tool
- Provide financial support
Major cholera outbreaks 2017*

Data as of end October 2017

Haiti:
12,167 cases
138 deaths

Nigeria (Borno):
5,336 cases
61 deaths

Sudan:
35,354 cases
800 deaths
Since August ‘16

DRC:
42,334 cases
838 deaths

Ethiopia:
47,711 cases
877 deaths

South Sudan:
21,439 cases
461 deaths
Since August ‘16

Yemen:
926,084 cases
2,202 deaths

Somalia:
60,678 cases
820 deaths

*Data as of end October 2017
 Threats from Antimicrobial Resistance by 2050

- Attribute to 4.1 Million death per year
- Highest Mortality will be in Africa
- Estimated $42 trillion lost to African economy by 2050

Source: O’neill report 2014
Africa CDC Strategic Focus

Five Strategic Pillars

1. Surveillance and Disease Intelligence
2. Emergency Preparedness and Response
3. Laboratory Systems and Network
4. Information Systems
5. National Public Health Institutes and Research

Finance • Leadership • Management • Partnership • Governance • Innovation

http://www.africacdc.org/
Africa CDC Operating Model – Networking at different levels

Mandate from the African Union

Africa CDC secretariat (Within the AUC)

Regional Collaborating Centers (RCCs)

Egypt  Gabon  Kenya  Nigeria  Zambia

National Public Health Institutes in each African country

Note: Roughly 24 African countries have formally established NPHIs and joined the International Association of National Public Health Institutes (IANPHI)
Acknowledgements

Major Fundings:

NSFC (National Nature Scientific Foundation Committee of China);

National Key Program for Infectious Diseases of China;

Major Partners:

Uni. Communication of Xi’an General Hospital of Chinese PLA;
Dr. Jiyong Yang; Dr. Peifu Tang; Dr. Qing Song
Dr. Lihai Zhang; Dr. Daohong Liu

University of Essen;
Dr. Walter Popp

University Medical Centre Groningen;
Dr. Hajo Grundmann

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Thanks for your attention!