EMERGING PATHOGENS: ENVIRONMENTAL SURVIVAL AND TRANSMISSION, GERMICIDAL ACTIVITY AND CONTROL MEASURES

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Disclosures: Consultant to Germitec, PDI, Merck, Pfizer
TOPICS TO BE DISCUSSED:
EMERGING PATHOGENS REVIEWED

Topics
- Key information on each pathogen for the Infection Preventionist
- Environmental transmission and survival
- Susceptibility of each pathogen to antiseptics and disinfectants

Viruses: Ebola, MERS CoV
Bacteria: Carbapenemase-producting Enterobacteriaceae (CRE)
Fungi: Candida auris
Decreasing Order of Resistance of Microorganisms to Disinfectants/Sterilants

Most Resistant

- Prions
- Bacterial spores (*C. difficile*)
- Protozoal oocysts
- Helminth eggs
- Mycobacteria
- Small, non-enveloped viruses (*norovirus*)
- Protozoal cysts
- Fungal spores
- Gram-negative bacilli (*CRE*)
- Vegetative fungi and algae (*Candida*)
- Large, non-enveloped viruses

Most Susceptible

- Gram-positive bacteria (*MRSA, VRE*)
- Enveloped viruses (*MERS-CoV*)
MERS-CoV: HISTORY

- **Microbiology**
  - MERS is a viral respiratory disease caused by a novel coronavirus, identified 2012
  - Reservoir: Dromedary camels

- **Epidemiology**
  - As of April 2018, a total of 2,206 lab-confirmed cases of MERS had been reported globally from 27 countries; majority of cases from Saudi Arabia (1,831); 2 imported cases in US in May 2014
  - Case-fatality rate: 35.8% (deaths = 787)
  - Number of hospital-acquired cases has dropped significantly since 2015 (due to improved infection control and prevention)
  - No differences in demographic and epidemiological characteristics of recent cases
  - No sustained human-to-human transmission; however, limited non-sustained human-to-human transmission in health care facilities
  - Outbreaks in Saudi Arabia, UAE, and Korea

OUTBREAK CURVE AND COUNTRIES INVOLVED, MERS-CoV, WHO
MERS-CoV: INFECTION PREVENTION ISSUES

- Pathogen: Family *Coronaviridae* (RNA virus, enveloped)
- Endemic location: Middle East (reservoir: camels, bats)
- Transmission: Person-to-person (superspreaders); direct, indirect\(^*\), airborne\(^*\)
- Incubation period: \~ 5 days (range, 2-15 days)
- Infectivity (rho): 0.3-1.3 (infectious period, 1-11 days of illness)
- Biosafety level: 3
- Isolation: Contact, airborne (N95 plus eye protection)
- Hospital outbreaks: Well described (HCP at high risk)
- Environmental control\(^^\): Standard cleaning and disinfection procedures using an EPA-registered disinfectant (use product with MERS-CoV or coronavirus label claim)

Weber DJ, et al. AJIC 2016;44:e91-e100

\(^^\)https://www.cdc.gov/coronavirus/mers/infection-prevention-control.html

**MERS-CoV: ENVIRONMENTAL SURVIVAL**

- **Goal:** Assess stability of MERS-CoV on surfaces
- **Results:**
  - Plastic, 20°C, 40% RH; \( t_{1/2} = 0.95 \text{ hrs} \): steel, 20°C, 40% RH; \( t_{1/2} = 0.94 \text{ hrs} \)
  - MERS-CoV was more stable at low temperature/low humidity conditions and could still be recovered after 48 hours. During aerosolization of MERS-CoV, no decrease in stability was observed at 20°C – 40% RH.

van Doremalen N, et al. Eurosurveillance 2013|18L20590
MERS-CoV: ENVIRONMENTAL CONTAMINATION (KOREA)

<table>
<thead>
<tr>
<th>Swab Site</th>
<th>PCR Results (Positivity Percent, %)</th>
<th>Culture Results (Positivity Percent, %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bed sheet</td>
<td>3/15 (20.0)</td>
<td>1/15 (6.7)</td>
</tr>
<tr>
<td>Bedrails</td>
<td>4/15 (26.7)</td>
<td>1/15 (6.7)</td>
</tr>
<tr>
<td>Bed tables</td>
<td>2/5 (40.0)</td>
<td>0/5 (0.0)</td>
</tr>
<tr>
<td>Bed controllers</td>
<td>5/15 (33.3)</td>
<td>0/15 (0.0)</td>
</tr>
<tr>
<td>Shelves</td>
<td>0/14 (0.0)</td>
<td>0/14 (0.0)</td>
</tr>
<tr>
<td>Door buttons</td>
<td>1/10 (10.0)</td>
<td>0/10 (0.0)</td>
</tr>
<tr>
<td>Bathroom door knobs</td>
<td>1/10 (10.0)</td>
<td>0/10 (0.0)</td>
</tr>
<tr>
<td>Patient room floor</td>
<td>0/7 (0.0)</td>
<td>0/7 (0.0)</td>
</tr>
<tr>
<td>Patient monitor buttons</td>
<td>0/5 (0.0)</td>
<td>0/5 (0.0)</td>
</tr>
<tr>
<td>Thermometers</td>
<td>1/5 (20.0)</td>
<td>0/5 (0.0)</td>
</tr>
<tr>
<td>IV fluid hangers</td>
<td>5/14 (35.7)</td>
<td>2/14 (14.3)</td>
</tr>
<tr>
<td>Portable X-rays</td>
<td>1/5 (20.0)</td>
<td>0/5 (0.0)</td>
</tr>
<tr>
<td>Computed radiography cassette</td>
<td>1/1 (100.0)</td>
<td>1/1 (100.0)</td>
</tr>
<tr>
<td>Anteroom floors</td>
<td>2/14 (14.3)</td>
<td>0/14 (0.0)</td>
</tr>
<tr>
<td>Anteroom tables</td>
<td>3/7 (42.8)</td>
<td>1/7 (14.3)</td>
</tr>
<tr>
<td>Entrances of air-venting equipment</td>
<td>1/6 (16.7)</td>
<td>0/6 (0.0)</td>
</tr>
</tbody>
</table>

**Patient Data**

**Environmental Data**

<table>
<thead>
<tr>
<th>MERS-CoV PCR Results</th>
<th>Environmental Sampling</th>
<th>RT-PCR From Samples</th>
<th>RT-PCR From Viral Culture</th>
</tr>
</thead>
<tbody>
<tr>
<td>(+) at the time of sampling</td>
<td>Air sampling$^b$</td>
<td>2/2</td>
<td>1/2</td>
</tr>
<tr>
<td>(+) at the time of sampling</td>
<td>Fomites swab</td>
<td>4/6</td>
<td>2/6</td>
</tr>
<tr>
<td>(+) at the time of sampling</td>
<td>Fixed-structure swab</td>
<td>7/13</td>
<td>2/13</td>
</tr>
<tr>
<td>(+) at the time of sampling</td>
<td>Air sampling$^b$</td>
<td>2/2</td>
<td>2/2</td>
</tr>
<tr>
<td>(-) at the time of sampling</td>
<td>Fomites swab</td>
<td>4/4</td>
<td>3/4</td>
</tr>
<tr>
<td>(-) at the time of sampling</td>
<td>Fixed-structure swab</td>
<td>12/12</td>
<td>5/12</td>
</tr>
<tr>
<td>(-) at the time of sampling</td>
<td>Fixed-structure swab</td>
<td>1/5</td>
<td>0/5</td>
</tr>
<tr>
<td>(-) at the time of sampling</td>
<td>Air sampling$^d$</td>
<td>3/3$^c$</td>
<td>1/3</td>
</tr>
<tr>
<td>(-) at the time of sampling</td>
<td>Fomites swab</td>
<td>5/6</td>
<td>2/6</td>
</tr>
<tr>
<td>(-) at the time of sampling</td>
<td>Fixed-structure swab</td>
<td>8/17</td>
<td>0/17</td>
</tr>
<tr>
<td>(-) at the time of sampling</td>
<td>Fixed-structure swab</td>
<td>1/5</td>
<td>1/5</td>
</tr>
</tbody>
</table>

# EFFICACY ANTISEPTICS AND DISINFECTANTS AGAINST HCoV 229E

<table>
<thead>
<tr>
<th>Antiseptic/Disinfectant</th>
<th>Concentration (%)</th>
<th>HCoV 229E</th>
<th>Type B-Coxsackievirus</th>
<th>Type 5-Adenovirus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium hypochlorite</td>
<td>0.01</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>0.10</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>0.50</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Povidone-iodine</td>
<td>10 (1% available iodine)</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Ethanol</td>
<td>70</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>N-alkyl-dimethybenzyl chloride</td>
<td>0.04</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Chlorhexidine gluconate</td>
<td>0.05</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Efficacy validated if reduction in viral titers $\geq 3\cdot \log_{10}$ after 1 min contact time

Efficacy of phenolics varied depending on agent and additives

EBOLA VIRUS DISEASE (EBV): HISTORY

- **Microbiology**
  - EBV is a hemorrhagic severe systemic disease first reported from DRC in 1976
  - Reservoir: African fruit bats?

- **Epidemiology**
  - Multiple outbreaks since 1976 in Africa; largest 2014-16 in West Africa with >28,600 cases (~800 HCP infected)
  - Ongoing outbreak in DRC (town, Bikoro)
  - Case-fatality rate: ~50% (range, 25% to 90%)
  - Transmission: Only while index case is symptomatic; no transmission via food (except bushmeat) or insects
    - Ebola virus can persist in certain body fluids after recovery: semen, breast milk, ocular fluid, and CSF

http://www.who.int/emergencies/mers-cov/en/
EBOLA VIRUS DISEASE DISTRIBUTION MAP: CASES OF EBV IN AFRICA SINCE 1976

https://www.cdc.gov/vhf/ebola/history/distribution-map.html
INFECTION PREVENTION ISSUES

- **Pathogen:** Family *Filoviridae* (RNA virus, enveloped)
- **Endemic location:** West and Central Africa (reservoir: bats?)
- **Transmission:** Person-to-person, direct (blood or body fluids) and indirect (contaminated needles/syringes); sexual (semen); zoonotic (nonhuman primates, bats)
- **Incubation period:** 6-12 (range, 2-21)
- **Infectivity (rho):** 1.5-2.0 (infectious period; 6-12 days, range 2-21)
- **Biosafety level:** 4
- **Isolation:** Contact (full body protection, no exposed surfaces), N95, eye protection
- **Hospital outbreaks:** Well described (HCP at high risk)
- **Environmental control:** Dedicated (preferably) disposable equipment (sterilize reusable equipment), use EPA disinfectant with non-enveloped virus claim

Weber DJ, et al. AJIC 2016;44:e91-e100
## ENVIRONMENTAL CONTAMINATION, EBOLA TREATMENT CENTER, SIERRA LEONE, DETECTION OF RNA

<table>
<thead>
<tr>
<th>Swab Location</th>
<th>Positive swab samples/Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient personal effects</td>
<td>1/5</td>
</tr>
<tr>
<td>Patient clothing</td>
<td>2/5</td>
</tr>
<tr>
<td>Patient blanket</td>
<td>1/3</td>
</tr>
<tr>
<td>Patient’s mattress</td>
<td>4/8</td>
</tr>
<tr>
<td>Floor with body fluids next to patient</td>
<td>1/4</td>
</tr>
<tr>
<td>Floor with no visible contamination next to patient</td>
<td>1/8</td>
</tr>
<tr>
<td>Head of bed rail</td>
<td>2/8</td>
</tr>
<tr>
<td>Biological waste buckets</td>
<td>2/4</td>
</tr>
<tr>
<td>IV bags and tubing</td>
<td>1/5</td>
</tr>
<tr>
<td>Urine catheter bag assembly</td>
<td>2/5</td>
</tr>
</tbody>
</table>

Sites negative for Ebola: Patient food/water, towel, toys; foot of bed rail, curtains, chairs; all general ward surfaces

SURVIVAL OF EBOLA VIRUS (Makona variant)

Coak BW, et al
Viruses 2015;7:1975-1986

**Graph:**
- **Y-axis:** Viral Titre (Log_{10} TCID_{50} Units/mL)
- **X-axis:** Time (Hours)

**Legend:**
- Plastic Gown
- Cotton Gown
- Respiratory Mask
- Stainless Steel

**Table:**

<table>
<thead>
<tr>
<th>Tested Surface</th>
<th>Decay Constant (k)/1 Hour</th>
<th>Decay Constant (k)/24 Hours</th>
<th>R^2</th>
<th>One-Log Reduction (TCID_{50}/mL)</th>
<th>Time (Hours)</th>
<th>Four-Log Reduction (TCID_{50}/mL)</th>
<th>Time (Hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plastic Gown</td>
<td>0.0117</td>
<td>0.28</td>
<td>0.96</td>
<td>6.3</td>
<td>24</td>
<td>3.3</td>
<td>285</td>
</tr>
<tr>
<td>Cotton Gown</td>
<td>0.6395</td>
<td>15.35</td>
<td>0.99</td>
<td>6.3</td>
<td>0.24</td>
<td>3.3</td>
<td>1.24</td>
</tr>
<tr>
<td>Stainless Steel</td>
<td>0.0091</td>
<td>0.22</td>
<td>0.90</td>
<td>6.3</td>
<td>30</td>
<td>3.3</td>
<td>365</td>
</tr>
<tr>
<td>Respiratory Mask</td>
<td>0.0113</td>
<td>0.27</td>
<td>0.97</td>
<td>6.3</td>
<td>20</td>
<td>3.3</td>
<td>147</td>
</tr>
</tbody>
</table>
SUSCEPTIBILITY OF EBOLA VIRUS TO ANTISEPTICS AND DISINFECTANTS

**CRE: INFECTION PREVENTION**

- Definition (CDC): Carbapenem-resistant *Enterobacteriaceae* (CRE) are resistant to imipenem, meropenem, doripenem, or ertapenem OR documentation that the isolate possess a carbapenemase.
  - This is a phenotypic definition (i.e., based on the antibiotic susceptibility pattern of the organism) and it includes bacteria that are not susceptible to carbapenems via more than one type of mechanism including enzymatic destruction of antibiotics and alterations in the bacteria's cell membrane (e.g., porin mutations)
- Associated with antibiotic failures and higher mortality rate
- Control: Contact isolation; Prevalence surveys for colonization may be indicated

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**CRE Trend Line, DICON**

Anderson D, et al
ICHE 2014; 35:978-83
### CRE: FREQUENCY OF ENVIRONMENTAL CONTAMINATION

**Table 1. Contamination on Surfaces in Rooms Housing a Patient with CRE**

<table>
<thead>
<tr>
<th>Room Site Cultured (No.)</th>
<th>CRE Positive, No. (%)&lt;sup&gt;a&lt;/sup&gt;</th>
<th>CRE, mean CFU (range)&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bed rail (15)</td>
<td>2 (13.3)</td>
<td>45 (43–47)</td>
</tr>
<tr>
<td>Overbed table (15)</td>
<td>1 (6.7)</td>
<td>3</td>
</tr>
<tr>
<td>Chair #1 arm (12)</td>
<td>0 (0.0)</td>
<td>...</td>
</tr>
<tr>
<td>Sink (15)</td>
<td>2 (13.3)</td>
<td>14.5 (11–18)</td>
</tr>
<tr>
<td>Toilet (11)</td>
<td>2 (18.2)</td>
<td>7 (4–10)</td>
</tr>
<tr>
<td>Bathroom floor (10)</td>
<td>1 (10.0)</td>
<td>5</td>
</tr>
<tr>
<td>Supply cart (11)</td>
<td>1 (9.1)</td>
<td>2</td>
</tr>
<tr>
<td>Linen hamper (12)</td>
<td>0 (0.0)</td>
<td>...</td>
</tr>
<tr>
<td>Mobile computer (3)</td>
<td>0 (0.0)</td>
<td>...</td>
</tr>
<tr>
<td>Chair #2 arm (3)</td>
<td>0 (0.0)</td>
<td>...</td>
</tr>
<tr>
<td>Bedside table (3)</td>
<td>0 (0.0)</td>
<td>...</td>
</tr>
<tr>
<td>Toilet cabinet (4)</td>
<td>0 (0.0)</td>
<td>...</td>
</tr>
<tr>
<td>Floor outside toilet cabinet (4)</td>
<td>1 (25.0)</td>
<td>2</td>
</tr>
<tr>
<td>Ventilator counter (1)</td>
<td>0 (0.0)</td>
<td>...</td>
</tr>
<tr>
<td><strong>Total (119)&lt;sup&gt;c&lt;/sup&gt;</strong></td>
<td>10 (8.4)</td>
<td>5.1 (2–47)</td>
</tr>
</tbody>
</table>

CFU, colony forming units; CRE, carbapenem-resistant *Enterobacteriaceae*.

<sup>a</sup>Considered positive if ≥1 of the 5 Rodac plates had positive growth (ie, area sampled = 120 cm²).

<sup>b</sup>Mean and range calculated only for CRE culture positive sites.

<sup>c</sup>For one site cultured, technical difficulties prevented assessing growth. Thus total was 119 sites instead of 120 sites.
CRE: SURVIVAL ON ENVIRONMENTAL SURFACES

Weber DJ, Rutala WA, et al. ICHE 2015;36:590-593
<table>
<thead>
<tr>
<th>Germicide name</th>
<th>Manufacturer, location</th>
<th>Active ingredient</th>
<th>Formulation tested</th>
<th>Classification</th>
<th>Efficacy (mean log$_{10}$ reduction) with*:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purell Advanced Instant hand sanitizer</td>
<td>GOJO, Akron, OH</td>
<td>70% ethanol</td>
<td>Undiluted</td>
<td>Antiseptic</td>
<td>KPC E. coli: 4.6, KPC K. pneumoniae: 3.5, KPC E. cloacae: 4.1, MCR-1 E. coli: 4.2</td>
</tr>
<tr>
<td>Betadine solution</td>
<td>Purdue Products L.P., Stamford, CT</td>
<td>10% povidone-iodine/1% tetrabutylammonium iodine</td>
<td>Undiluted</td>
<td>Antiseptic</td>
<td>KPC E. coli: 3.4, KPC K. pneumoniae: 2.9, KPC E. cloacae: 3.5</td>
</tr>
<tr>
<td>Medicated Soft ‘N Sure</td>
<td>Steris Corp., St. Louis, MO</td>
<td>0.5% chlorhexidine</td>
<td>Undiluted</td>
<td>Antiseptic/handwash</td>
<td>KPC E. coli: 2.3, KPC K. pneumoniae: 3.3, KPC E. cloacae: 3.8</td>
</tr>
<tr>
<td>Avagard</td>
<td>3 M, St. Paul, MN</td>
<td>1% chlorhexidine gluconate solution, 61% ethyl alcohol</td>
<td>Undiluted</td>
<td>Antiseptic/surgical hand scrub</td>
<td>KPC E. coli: 2.6, KPC K. pneumoniae: 3.3, KPC E. cloacae: 3.7</td>
</tr>
<tr>
<td>Scrub-Stat 2%</td>
<td>Ecolab, St. Paul, MN</td>
<td>2% chlorhexidine gluconate solution</td>
<td>Undiluted</td>
<td>Antiseptic/surgical hand scrub</td>
<td>KPC E. coli: 3.4, KPC K. pneumoniae: 3.4</td>
</tr>
<tr>
<td>Scrub-Stat 4%</td>
<td>Ecolab, St. Paul, MN</td>
<td>4% chlorhexidine gluconate solution</td>
<td>Undiluted</td>
<td>Antiseptic/surgical hand scrub</td>
<td>KPC E. coli: 3.1, KPC K. pneumoniae: 3.5</td>
</tr>
<tr>
<td>Isopropyl rubbing alcohol 70% USP</td>
<td>Medichoce, Mechanicsville, VA</td>
<td>70% isopropyl alcohol</td>
<td>Undiluted</td>
<td>Antiseptic/disinfectant</td>
<td>KPC E. coli: 4.6</td>
</tr>
<tr>
<td>Austin’s A-1 bleach 1:10</td>
<td>James Austin Company, Mars, PA</td>
<td>5.25% sodium hypochlorite</td>
<td>1:10 dilution</td>
<td>Disinfectant</td>
<td>KPC E. coli: 4.9, KPC K. pneumoniae: 5.9</td>
</tr>
<tr>
<td>Austin’s A-1 bleach 1:50</td>
<td>James Austin Company, Mars, PA</td>
<td>5.25% sodium hypochlorite</td>
<td>1:50 dilution</td>
<td>Disinfectant</td>
<td>KPC E. coli: 4.9, KPC K. pneumoniae: 3.4</td>
</tr>
<tr>
<td>Vespara lise</td>
<td>Steris Corp., St. Louis, MO</td>
<td>9.09% α-phenylphenol, 7.66% p-tertiary amphotericin</td>
<td>1:128 dilution</td>
<td>Disinfectant</td>
<td>KPC E. coli: 4.9, KPC K. pneumoniae: 5.6</td>
</tr>
<tr>
<td>Solution of hydrogen peroxide</td>
<td>Medichoce, Mechanicsville, VA</td>
<td>3% hydrogen peroxide</td>
<td>Undiluted</td>
<td>Disinfectant</td>
<td>KPC E. coli: 2.2, KPC K. pneumoniae: 3.5</td>
</tr>
<tr>
<td>3% USP</td>
<td>Clorox Company, Oakland, CA</td>
<td>1.4% hydrogen peroxide</td>
<td>Undiluted</td>
<td>Disinfectant</td>
<td>KPC E. coli: 4.9, KPC K. pneumoniae: 5.8</td>
</tr>
<tr>
<td>Hydrogen peroxide cleaner disinfectant</td>
<td>Reckitt Benkiser, Parsipanny, NJ</td>
<td>0.1% QAC$^b$</td>
<td>1:256 dilution</td>
<td>Disinfectant</td>
<td>KPC E. coli: 4.9, KPC K. pneumoniae: 3.5</td>
</tr>
<tr>
<td>Lysol disinfectant spray A-436 ll disinfectant cleaner</td>
<td>Ecolab, St. Paul, MN</td>
<td>58% ethanol, 0.1% QAC$^b$</td>
<td>Undiluted</td>
<td>Disinfectant</td>
<td>KPC E. coli: 4.9, KPC K. pneumoniae: 4.4</td>
</tr>
<tr>
<td>Super San-Cloth wipe</td>
<td>PDI, Orangeburg, NY</td>
<td>55% isopropyl alcohol, 0.5% QAC$^d$</td>
<td>Undiluted</td>
<td>Disinfectant</td>
<td>KPC E. coli: 4.9, KPC K. pneumoniae: 5.2</td>
</tr>
<tr>
<td>Super San-Cloth wipe</td>
<td>PDI, Orangeburg, NY</td>
<td>55% isopropyl alcohol, 0.5% QAC$^d$</td>
<td>Undiluted</td>
<td>Disinfectant</td>
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<td>Prime San-Cloth wipe</td>
<td>PDI, Orangeburg, NY</td>
<td>55% isopropyl alcohol, 0.5% QAC$^d$</td>
<td>Undiluted</td>
<td>Disinfectant</td>
<td>KPC E. coli: 4.9, KPC K. pneumoniae: 5.2</td>
</tr>
<tr>
<td>S40 Sterilant concentrate S4000</td>
<td>Steris Corp., Mentor, OH</td>
<td>35% peracetic acid</td>
<td>0.20%</td>
<td>High-level disinfectant/ chemical sterilant</td>
<td>KPC E. coli: 4.9, KPC K. pneumoniae: 5.6</td>
</tr>
<tr>
<td>Cidex OPA</td>
<td>Advanced Steril. Prod., Irvine, CA</td>
<td>0.55% ortho-phthalaldehyde</td>
<td>Undiluted</td>
<td>High-level disinfectant/ chemical sterilant</td>
<td>KPC E. coli: 2.4, KPC K. pneumoniae: 3.4</td>
</tr>
<tr>
<td>Cidex</td>
<td>Advanced Steril. Prod., Irvine, CA</td>
<td>2.4% glutaraldehyde</td>
<td>Undiluted</td>
<td>High-level disinfectant/ chemical sterilant</td>
<td>KPC E. coli: 4.9, KPC K. pneumoniae: 5.6</td>
</tr>
<tr>
<td>Oxycide</td>
<td>Ecolab, St. Paul, MN</td>
<td>27.5% hydrogen peroxide, 1.5% peroxycetic acid</td>
<td>Undiluted</td>
<td>High-level disinfectant/ chemical sterilant</td>
<td>KPC E. coli: 4.9, KPC K. pneumoniae: 5.6</td>
</tr>
<tr>
<td>Revital-Ox Resort</td>
<td>Steris Corp., Mentor, OH</td>
<td>2% accelerated hydrogen peroxide</td>
<td>Undiluted</td>
<td>High-level disinfectant/ chemical sterilant</td>
<td>KPC E. coli: 5.2, KPC K. pneumoniae: 5.9</td>
</tr>
</tbody>
</table>

*Test condition of 10⁶ test organisms with 5% FCS and 1 min contact time.

$^b$QAC (quaternary ammonium compounds): alkyl (C₁₄ 50%, C₁₂ 40%, C₁₀ 10%) dimethyl benzyl ammonium saccharinate 0.1%.

$^b$QAC: octyl decyl dimethyl ammonium chloride 6.51%, diocetyl dimethyl ammonium chloride 2.604%, didecyl dimethyl ammonium chloride 3.906%, alkyl (C₁₄ 50%, C₁₂ 40%, C₁₀ 10%) dimethyl benzyl ammonium chloride 8.68%.

$^d$QAC: n-alkyl (C₁₂ 68%, C₁₄ 32%) dimethyl ethyl benzyl ammonium chlorides 0.25%, n-alkyl (C₁₄ 60%, C₁₂ 30%, C₁₀ 5%, C₈ 5%) dimethyl benzyl ammonium chloride 0.25%.

$^d$QAC: didecyl dimethyl ammonium chloride 0.61%.

*Extract from cloth. We did not quantify QAC adhering to the cloth that is used to apply that particular germicide and may release smaller amounts of active QAC (17), but our data were not affected by this possibility because the extract was tested.
Candida auris: History

- First identified as a new species in 2009 from the external ear canal of a Japanese patient.
- Microbiology
  - Cannot be identified by commercial methods for yeast identification.
  - Usually resistant to fluconazole, often resistant to amphotericin B, exhibits reduced susceptibility to voriconazole and itraconazole; resistance may develop on therapy.
- Epidemiology
  - Transmission: Person-to-person (direct and indirect via environment); also via donor derived lung transplant (Azar 2017).
  - Most commonly clinical syndromes: fungemia, otologic infections.
  - Nosocomial outbreaks have been reported in a number of countries.
  - Risk factors for infection: immunosuppression, comorbidities, central lines, Foley catheters, recent surgery, parental nutrition, broad spectrum antibiotics, ICU care, and residence in a skilled nursing home.
  - Mortality (fungemia): 28%-66% (Sears 2017).
GEOGRAPHICAL DISTRIBUTION OF *CANDIDA AURIS*

C. AURIS, CLINICAL CASES, US
(as of 30 April 2018)

Confirmed cases = 279
Probable cases = 29
Colonized = 517
States = 11

Colonization of patients
- Colonization of patients is common; multiple sites involved (Biswal 2017)

Role of HCP
- HCP may be colonized; uncommon (Schelenz 2017)
- HCP hands may transiently carry C. auris (Biswal 2017)

Role of environment
- Environmental contamination common (Lesho 2018, Biswal 2017, Schelenz 2017, Valladhaneni 2016): mattresses, furniture, sinks, and medical equipment
- Prolonged environmental survival on environmental surfaces; >14 days (Piedrahita 2017, Welsh 2017)
- Prolonged survival (>7 days) on contaminated bedding (Biswal 2017)
NOSOCOMIAL OUTBREAK OF C. auris
(Biswal M, et al. JHI 2017;97:363-370)

Figure 3. Time to Candida auris acquisition after intensive care unit admission.

Contamination of Candida auris on environmental samples and carriage on healthcare workers’ hands

<table>
<thead>
<tr>
<th>Samples</th>
<th>MICU</th>
<th>CCU</th>
<th>Trauma ICU</th>
<th>NSW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environmental</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of samples</td>
<td>68</td>
<td>10</td>
<td>189</td>
<td>37</td>
</tr>
<tr>
<td>C. auris-positive samples</td>
<td>7</td>
<td>0</td>
<td>17</td>
<td>0</td>
</tr>
<tr>
<td>Handwash samples (HCWs)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of samples</td>
<td>41</td>
<td>13</td>
<td>79</td>
<td>12</td>
</tr>
<tr>
<td>C. auris-positive samples</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>0</td>
</tr>
</tbody>
</table>

MICU, medical intensive care unit; CCU, cardiac care unit; ICU, intensive care unit; NSW, neurosurgical ward; HCW, healthcare worker.

Colonization rate by Candida auris of different body sites

<table>
<thead>
<tr>
<th>Site</th>
<th>Oral</th>
<th>Rectal</th>
<th>Axilla</th>
<th>Groin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trauma ICU</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of samples</td>
<td>89</td>
<td>83</td>
<td>158</td>
<td>168</td>
</tr>
<tr>
<td>Growth of C. auris</td>
<td>4 (4.4%)</td>
<td>15 (18%)</td>
<td>62 (39.2%)</td>
<td>34 (20.2%)</td>
</tr>
<tr>
<td>MICU</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of samples</td>
<td>38</td>
<td>35</td>
<td>38</td>
<td>38</td>
</tr>
<tr>
<td>Growth of C. auris</td>
<td>6 (15.7%)</td>
<td>3 (8.5%)</td>
<td>10 (26.3%)</td>
<td>2 (5.2%)</td>
</tr>
<tr>
<td>Total</td>
<td>10/95 (10.5%)</td>
<td>18/118 (15.2%)</td>
<td>72/196 (36.7%)</td>
<td>36/206 (17.4%)</td>
</tr>
</tbody>
</table>

ICU, intensive care unit; MICU, medical intensive care unit.
ENVIRONMENTAL SURVIVAL OF CANDIDA AURIS

Piedrahita C, et al. ICHE 2017;38:1107-1109

In laboratory testing, sporicidal and improved hydrogen peroxide disinfectants were highly effective against *C. auris*, *C. glabrata*, and *C. albicans*. The widely used quaternary ammonium disinfectants exhibited relatively poor activity against all of the *Candida* species. Cadnum et al. ICHE 2017;38:1240
EFFICACY OF ANTISEPTICS AND DISINFECTANTS AGAINST C. AURIS

- **Study design:** In vitro study of germicide efficacy against C. auris and C. albicans
- **Method:** Disc-based quantitative carrier test with an inoculum of ~10^6 organisms with 5% fetal calf serum and 1 minute exposure time at room temperature (challenging test conditions)
- **Results:**
  - Study demonstrated $\geq 3\log_{10}$ reduction (12/22, 55%) and $2\log_{10}$ reduction (15/22, 68%) for C. auris
  - C. auris was less susceptible to 0.55% ortho-phthalaldehyde, 2% chlorhexidine, 4% chlorhexidine, and 1% chloroxylenol compared to C. albicans.
  - C. auris was more susceptible to 70% ethanol, compared to C. albicans.
  - Several germicides (21.7% QAC [1:50 dilution], 3% hydrogen peroxide, 5.25% sodium hypochlorite [1:50 dilution], 0.5% triclosan) had $< 2\log_{10}$ reduction for both C. auris and C. albicans

EFFICACY OF ANTISEPTICS AND DISINFECTANTS AGAINST C. AURIS
**EFFICACY OF ANTISEPTICS AND DISINFECTANTS AGAINST C. AURIS**

- Effectiveness of surface disinfectants (level of evidence)
  - **Effective**: Chlorine $\geq$1000 ppm (good); hydrogen peroxide 1.4% (moderate); phenolics 5%? (low); alcohols 29.4% (low); peracetic acid 2000 ppm (low)
  - **Ineffective**: Quats - 2% didecylidimethyl ammonium chloride; alkyl dimethyl ammonium chlorides; didecylidimethyl ammonium chloride/dimethylbenzyl ammonium chloride

---

<table>
<thead>
<tr>
<th>Disinfectant</th>
<th>Concentrations tested (contact time in minutes used)</th>
<th>Effective</th>
<th>Level of Evidence</th>
<th>Comments</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chlorhexidine gluconate</td>
<td>$&lt;0.02%$ (1440), $0.5%$ (0.5), $2%$ (2), $4%$ (3, 180, 1800)</td>
<td>Yes</td>
<td>Good</td>
<td>Most studied antiseptic. Limited clinical evaluation.</td>
<td>Schelenz et al., 2016; Abdolrasouli et al., 2017; Moore et al., 2017; Sherry et al., 2017</td>
</tr>
<tr>
<td>Chlorhexidine gluconate in isopropyl alcohol</td>
<td>$2%$/70$%$ (2)</td>
<td>Yes</td>
<td>Low</td>
<td>In vitro testing only.</td>
<td>Moore et al., 2017</td>
</tr>
<tr>
<td>Povidone-Iodine</td>
<td>$10%$ (2, 3, 180, 1800)</td>
<td>Yes</td>
<td>Moderate</td>
<td>In vitro testing only.</td>
<td>Abdolrasouli et al., 2017; Moore et al., 2017</td>
</tr>
<tr>
<td>Alcohol</td>
<td>$70%$</td>
<td>Yes</td>
<td>Low</td>
<td>Limited clinical evaluation.</td>
<td>Biswal et al., 2017</td>
</tr>
</tbody>
</table>

EFFICACY OF UVC TO INACTIVATE C. AURIS

- **Goal:** Assess inactivation by UVC
- **Methods:** UVC (Optimum) used at 5 ft for specified time; $10^6$ CFU with 5% FCS applied to stainless-steel carriers.
- **Results:** *C. auris* less susceptible to UVC than other *Candida* spp.
- **Conclusion:** Use *C. difficile* cycle time (data) to inactivate *C. auris*

C. AURIS: INFECTION PREVENTION

- Place patients in a single room using standard and contact isolation
- Emphasize hand hygiene
- Screen roommates; consider point prevalence surveys (swab patient’s axilla and groin)
- Flag patient in case of re-admission
- Environmental infection control
  - EVS should use proper PPE
  - Monitor cleaning practices
  - Avoid quaternary ammonia products for surface disinfection; use a disinfectant EPA registered against C. difficile (Like K)

https://www.cdc.gov/fungal/candida-auris/c-auris-infection-control.html#disinfection
CONCLUSIONS

- **MERS-CoV**
  - Environmental contamination: Yes (low frequency)
  - Environmental survival: Hours
  - Environmental transmission: Probable
  - Antisepsis and disinfection: Standard

- **Ebola**
  - Environmental contamination: Yes (Frequent)
  - Environmental survival: Hours to days
  - Environmental transmission: Yes
  - Antisepsis and disinfection: Standard
CONCLUSIONS

- **CRE**
  - Environmental contamination: Yes (low frequency)
  - Environmental survival: Hours
  - Environmental transmission: Yes
  - Antisepsis and disinfection: Standard

- **C. auris**
  - Environmental contamination: Yes (frequent)
  - Environmental survival: Hours to days
  - Environmental transmission: Yes
  - Antisepsis and disinfection: Standard antisepsis (CHG or EtOH); Avoid quaternary ammonium compounds for surface disinfection
THANK YOU!!