The Clinical Microbiology Laboratory: Our Role in Antimicrobial Stewardship

Sukantha Chandrasekaran, Ph.D., M(ASCP)CM, D(ABMM)
Assistant Adjunct Professor
University of California, Los Angeles
Clinical Microbiology
Disclosures

• None
At the conclusion of this program, you will be able to:

• Describe the primary role of a clinical microbiology laboratory; focus on bacteriology.

• List examples of when it is appropriate to perform susceptibility testing on reported bacteria.

• Discuss tests used to determine if a bacterium is susceptible or resistant to an antimicrobial agent.
Scenario:
Physician sends a specimen to the microbiology lab.
*What does he/she want to know?*

- Does the specimen contain pathogens? What type? How many?
- What are the antimicrobial susceptibility profiles of the pathogens in the specimen?
Scenario:
IP practitioner / epidemiologist reviews microbiology laboratory reports.

What does he/she want to know?

Could the pathogens isolated have been acquired while the patient was in the facility?

What can be done to prevent further spread of the pathogens?

= some key messages!
Examining Patient Specimens for Microorganisms
Instructions for collecting / transporting specimens for microbiology tests...

O and P Exam - 2 Vials

Stool sample – Enteric PCR
Bacterial/Fungal PCR

Universal Viral Transport
Viral PCRs, GC/CT PCR, Ureaplasma

Bronchoalveolar Lavage
Viral PCRs
Bacterial Cultures

Blood culture
Aerobic and Anaerobic bacterial culture

Processing specimens in a biological safety cabinet
Perform / Report Direct Gram Stain for Bacteria

- Report results within a few hours
- Quick insight into possible cause of an infection
Gram Reactions for Select Bacteria

Gram positive
- Staphylococcus
- Streptococcus

Gram negative
- E. coli
- Klebsiella
- Pseudomonas
- Neisseria

- cocci in clusters
- cocci in chains
- rods
Direct Gram stain (pus from wound): Gram-positive cocci in clusters + white blood cells
Direct Gram stain (urethral discharge): Gram-negative diplococci (gonorrhoeae) within white blood cells
Place inoculated plates in incubator...

next day

Should I identify these bacteria? Should I perform antimicrobial susceptibility tests on them?
Criteria Used to Identify Bacteria

Traditional methods:
• Gram stain and microscopic exam
• Growth rate and colony appearance on various types of agar media
• Reactivity with various chemicals / reagents

Modern (molecular) methods:
• DNA / RNA content of microorganisms
• Protein profile (MALDI-TOF) of microorganisms

MALDI-TOF = Matrix-assisted laser desorption ionization – time of flight mass spectrometry
Sick Patient!

- 85 year old
- Sick for 3 days; getting progressively worse
  - Shortness of breath
  - Fever, chills, sweats, productive cough
- Temperature of 102°F
  - Sputum cultures
  - Blood cultures

Send sputum NOT saliva; send 2 blood cultures; appropriate volumes!
Direct Gram Stain
Assess Sputum Specimen Quality

- If saliva vs. sputum collected, may NOT recover “pathogens”
- Prepare direct Gram stain (put specimen on slide)
- Count number of squamous epithelial cells (SEC)

<table>
<thead>
<tr>
<th># SEC / low power field</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;10</td>
<td>No significant ”mouth” contamination</td>
</tr>
<tr>
<td>≥10</td>
<td>Indicates poorly collected specimen</td>
</tr>
</tbody>
</table>

GOOD!
Direct Gram Stain Results

Many WBCs
Many Gram-positive cocci in clusters
Moderate normal oral flora

Physician thinks staphylococcus!
When *Staphylococcus* suspected...

**Questions:**

- Is this *Staphylococcus aureus*?
  - If yes, is this methicillin-resistant *S. aureus* (MRSA) or methicillin-susceptible *S. aureus* (MSSA)?

- Is this another species of *Staphylococcus*, typically lumped into “coagulase-negative staphylococci” (CoNS) group?
  - Often contaminant; less clinically significant than MRSA or MSSA
For serious infections….

**MSSA**

**MRSA**

**Usual Therapy**

Oxacillin* or Nafcillin*  
Vancomycin

*Methicillin very similar but no longer available*
Blood specimen for bacterial culture: blood is injected directly into bottle of broth at bedside and sent to the lab.

- **Timing**: collect before antibiotics given
- **Volume**: check instructions; 2 sets!
Bottles are placed in blood culture instrument and continuously monitored. If bacteria are present, they multiply, react with “indicator” and sound an alarm when a threshold is reached.
“Positive” blood cultures are Gram stained, subcultured and subjected to other “tests”!

Gram stain: gram-positive cocci in clusters
Blood “Traditional” Culture Workup (1)

Sheep’s Blood Agar Medium
Colonies show: Staphylococcus spp.
Perform coagulase test to determine if S. aureus

Gram Stain

Pos Blood Culture

Blood Culture
Always use PNA, RHI if rapid species identification
Blood culture turns positive
Pos
15 Min.

Pos
16-20 hours
neg pos
coagulase
Blood “Molecular” Culture Workup (2)

- **Pos Blood Culture**
  - Gram Stain
  - Pos
  - 15 Min.

- **Molecular Assay Results:**
  - MSSA or MRSA or CoNS

- **Blood Culture Workup (2):**
  - Molecular assays such as Luminex, Verigene, etc.

- **1-2 hours:**
  - i.e. Luminex Verigene
Sick Patient (Blood Culture)

Gram Stain:
Gram-positive cocci in clusters

Culture:
*Staphylococcus aureus* (MRSA)
- Clindamycin: R
- Daptomycin: S
- Linezolid: S
- Oxacillin: R
- Vancomycin: S

“MRSA isolated. Please check infection control policies.”
Blood Culture Contaminants

♦ Coagulase-negative staphylococci (CoNS)
♦ Diphtheroids
♦ Bacillus spp.
♦ Propionibacterium spp.
♦ Viridans streptococcus
♦ Micrococcus spp.

Usually, for these bacteria to be considered as causing infection, two sets of blood cultures must be positive PLUS patient must show specific signs and symptoms of bloodstream infection.
Urine Collection / Transport

- Must test within 2 hours of collection if stored at room temp
- Must test within 24 hours if refrigerated
- Must test within 2 days if in boric acid preservative

- If UTI symptoms – send for culture!
- Best if culture performed ONLY on specimens with significant pyuria (auto-reflex to culture); e.g., IF positive for leukocyte esterase and/or nitrite tests which suggest infection, THEN culture.
Most Common Pathogens
Urinary Tract Infections

- **Community acquired**
  - *E. coli* most common
  - *Klebsiella*, other Enterobacteriaceae
  - *Staphylococcus saprophyticus*

- **Hospital acquired**
  - *E. coli*, *Klebsiella*, other Enterobacteriaceae
  - *Pseudomonas aeruginosa*
  - Enterococci; staphylococci

Spot indole test (positive)
Surveillance Cultures (vs. Diagnostic Cultures)

- Lab processes differently
- Must order as “surveillance culture”
- Must send appropriate specimen
- Only tested for “targeted” pathogen (e.g. MRSA)

CRE = carbapenem-resistant Enterobacteriaceae
Tests to Detect Antimicrobial Susceptibility
When do we do antimicrobial susceptibility tests (ASTs)?

- If 1 or 2 potential pathogens isolated from culture
- If it is likely that the bacteria are causing an infection
- If bacteria have a susceptibility pattern that is unpredictable
Report:

> $10^5$ CFU/ml *E. coli*

Significant quantity of potential pathogen. *E. coli* common pathogen in urinary tract infections. No contaminants.

Perform AST!
Urine Culture

Report:

>10^5 CFU/ml *Corynebacterium spp.*

40,000 CFU/ml *E. coli*

10,000 CFU/ml *Yeast*

10,000 CFU/ml *Lactobacillus spp.*

Likely contaminated culture. (high numbers of species that are unlikely pathogens).

Do NOT perform AST!

Encourage new specimen if UTI suspected!
Sputum Culture

Gram Stain:
- Many oral flora
- Many Gram positive diplococci
- Many WBCs

Culture:
- Many Normal Flora
- Many *Streptococcus pneumoniae*

Good correlation of Gram stain with culture. Significant quantity of potential pathogen. *S. pneumoniae* relatively common pathogen in respiratory tract infections.

Perform AST!
Foot Wound Culture

Gram Stain:
Many Gram positive cocci in clusters
Many pleomorphic Gram positive rods
No WBCs

Culture:
Many coagulase-neg staphylococci
Many diphtheroids
Few *E. coli*-like colonies
Few *Proteus*-like colonies

Poor correlation of Gram stain with culture.
Small quantity of potential pathogens.
“Skin flora” suggests likely contaminated culture.
Do **NOT** perform AST!
Throat Culture

Many Group A Streptococcus

“Group A Streptococcus is always susceptible to penicillin.”

Not necessary to perform AST on bacteria that are always (predictably) susceptible to the antimicrobial agents typically prescribed.
Why do we NOT do susceptibility tests on every potential pathogen isolated?

◆ AST results on a report suggest that bacteria are causing an infection

◆ Reporting results when NOT needed may lead to:
  – Unnecessary or inappropriate therapy
    - Selection of resistant bacteria
    - Put patient at risk for *Clostridium difficile*
  – Failure to look further to identify true cause of the patient’s problem
Antimicrobial Susceptibility Tests

Disc diffusion (Kirby Bauer)

Broth microdilution

MIC = minimal inhibitory concentration
(lowest concentration of drug that inhibits growth of the test bacteria)

Reported results:
- **Susceptible (S)** – drug likely to work providing it can get to the infection site
- **Resistant (R)** – drug won’t work
- **Intermediate (I)** – drug may or may not work depending on site of infection and patient’s status
Prepare inoculum suspension

Pick colonies

Remove sample

Swab plate

Add disks

Incubate overnight

Measure zones

Disk Diffusion Testing
### Zone Diameter “Breakpoints” (mm) Enterobacteriaceae

<table>
<thead>
<tr>
<th>Drug</th>
<th>S</th>
<th>I</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ciprofloxacin</td>
<td>≥21</td>
<td>16-20</td>
<td>≤15</td>
</tr>
<tr>
<td>Gentamicin</td>
<td>≥15</td>
<td>13-14</td>
<td>≤12</td>
</tr>
</tbody>
</table>

#### Table 2A: Enterobacteriaceae (Continued)

<table>
<thead>
<tr>
<th>Test Report Group/Agent Name</th>
<th>Disk Content (μg)</th>
<th>Interpretive Categories and Zone Diameter (mm)</th>
<th>Interpretive Categories and MIC Breakpoints, µg/mL</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Aminoglycosides</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amikacin</td>
<td>500</td>
<td>≥14 ≤17</td>
<td>6 ≤ 10</td>
<td>≥32</td>
</tr>
<tr>
<td>Gentamicin</td>
<td>1021</td>
<td>≥13 ≤14</td>
<td>5 ≤ 10</td>
<td>≥32</td>
</tr>
<tr>
<td><strong>Carboxylic Acid</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cefotaxime-Sulfadiazine</td>
<td>30/500</td>
<td>≥17 ≤19</td>
<td>7 ≤ 10</td>
<td>≥51</td>
</tr>
<tr>
<td><strong>Beta-Lactamase Inhibitors</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ceftazidime-Oxacillin</td>
<td>30/500</td>
<td>≥21 ≤20</td>
<td>10 ≤ 14</td>
<td>≥32</td>
</tr>
<tr>
<td><strong>cephem/penicillin</strong></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cephalothin-Ampicillin</td>
<td>30/500</td>
<td>≥17 ≤19</td>
<td>7 ≤ 10</td>
<td>≥51</td>
</tr>
<tr>
<td><strong>Carboxylic Acid</strong></td>
<td></td>
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#### CLSI, Clinical and Laboratory Standards Institute

This document includes validated tables for the Clinical and Laboratory Standards Institute’s antimicrobial susceptibility testing standards M100, M101, and M112 supplemented with online antibiotic stewardship resources.
MIC "Breakpoints" (µg/ml) Enterobacteriaceae

<table>
<thead>
<tr>
<th>Drug</th>
<th>S</th>
<th>I</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ciprofloxacin</td>
<td>≤1</td>
<td>2</td>
<td>≥4</td>
</tr>
<tr>
<td>Gentamicin</td>
<td>≤4</td>
<td>8</td>
<td>≥16</td>
</tr>
</tbody>
</table>

MIC Testing

- 0.5 µg/ml
- 1 µg/ml
- 64 µg/ml
- >64 µg/ml
Commercial Antimicrobial Susceptibility Test Systems

- Etest
- Vitek 2
- MicroScan
- Sensititre
- Phoenix
Review of S, I, R most important for IP

For MIC tests, must report S, I, R with or without MIC value.
<table>
<thead>
<tr>
<th>Agent</th>
<th>#1</th>
<th>#2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ampicillin</td>
<td>S</td>
<td>R</td>
</tr>
<tr>
<td>Cefazolin</td>
<td>S</td>
<td>R</td>
</tr>
<tr>
<td>Cefepime</td>
<td></td>
<td>R</td>
</tr>
<tr>
<td>Ceftriaxone</td>
<td></td>
<td>R</td>
</tr>
<tr>
<td>Ciprofloxacin</td>
<td>S</td>
<td>R</td>
</tr>
<tr>
<td>Ertapenem</td>
<td></td>
<td>S</td>
</tr>
<tr>
<td>Gentamicin</td>
<td>S</td>
<td>S</td>
</tr>
<tr>
<td>Meropenem</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nitrofurantoin</td>
<td>S</td>
<td>R</td>
</tr>
<tr>
<td>Piper-tazo</td>
<td></td>
<td>S</td>
</tr>
<tr>
<td>Trimeth-sulfa</td>
<td>S</td>
<td>R</td>
</tr>
</tbody>
</table>

"Typical" *E. coli* - NO "R"!

Acquired "R" to all PO agents. Request fosfomycin – usually not tested routinely!

2 urine *E. coli* isolates

Broad Spectrum drug results suppressed when “S” to narrow spectrum drugs!
### Potential outbreak?

<table>
<thead>
<tr>
<th>Agent</th>
<th>#1</th>
<th>#2</th>
<th>#3</th>
<th>#4</th>
<th>#5</th>
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</thead>
<tbody>
<tr>
<td>Ampicillin</td>
<td>S</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>Cefazolin</td>
<td>S</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>Cefepime</td>
<td></td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>Ceftriaxone</td>
<td></td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>Ciprofloxacin</td>
<td>S</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>Ertapenem</td>
<td></td>
<td>S</td>
<td>R</td>
<td>R</td>
<td>R</td>
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<tr>
<td>Gentamicin</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>S</td>
</tr>
<tr>
<td>Meropenem</td>
<td></td>
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<td>R</td>
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<td>S</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
</tr>
</tbody>
</table>

3 more *E. coli* isolates

**ALL CRE!**

**CRE = carbapenem-resistant Enterobacteriaceae**

**CRE = R to**

doripenem, ertapenem, imipenem **OR** meropenem
# Bacterial Culture Urine (Edited)

**Morganella morganii**<sup>1</sup>

<table>
<thead>
<tr>
<th>Susceptibility</th>
<th>MIC (MICM/L)</th>
<th>Sensitivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amikacin</td>
<td>16</td>
<td>S</td>
</tr>
<tr>
<td>Ampicillin</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>Azithromycin</td>
<td>&gt;32</td>
<td>%</td>
</tr>
<tr>
<td>Cefepime</td>
<td>&lt;=1</td>
<td>S</td>
</tr>
<tr>
<td>Cefazidime</td>
<td>&gt;32</td>
<td>R</td>
</tr>
<tr>
<td>Cefotaxime/Aztrexidine</td>
<td>&lt;=2</td>
<td>S</td>
</tr>
<tr>
<td>Ceftriaxone</td>
<td>&gt;32</td>
<td>R</td>
</tr>
<tr>
<td>Ciprofloxacin</td>
<td>&gt;=4</td>
<td>R</td>
</tr>
<tr>
<td>Colistin</td>
<td>&lt;=2</td>
<td>WT&lt;sup&gt;1&lt;/sup&gt;</td>
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<tr>
<td>Ertapenem</td>
<td>&lt;=0.5</td>
<td>S</td>
</tr>
<tr>
<td>Gentamicin</td>
<td>&lt;=1</td>
<td>S</td>
</tr>
<tr>
<td>Imipenem</td>
<td>&gt;8</td>
<td>R</td>
</tr>
<tr>
<td>Meropenem</td>
<td>&gt;16</td>
<td>R</td>
</tr>
<tr>
<td>Minocycline</td>
<td>16</td>
<td>R</td>
</tr>
<tr>
<td>Moxifloxacin</td>
<td>&gt;8</td>
<td>%</td>
</tr>
<tr>
<td>Nitrofurantoin</td>
<td>64</td>
<td>I</td>
</tr>
<tr>
<td>Oral Cephalosporins</td>
<td>&lt;=4</td>
<td>S</td>
</tr>
<tr>
<td>Piperacillin +</td>
<td>&lt;=128</td>
<td>R</td>
</tr>
<tr>
<td>Tobramycin</td>
<td>16</td>
<td>R</td>
</tr>
<tr>
<td>Trimethoprim/Sulfamethoxazole</td>
<td>&gt;320</td>
<td>R</td>
</tr>
</tbody>
</table>

**Klebsiella pneumoniae**<sup>2</sup>

<table>
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<td>Trimethoprim/Sulfamethoxazole</td>
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</tbody>
</table>

Nitrofurantoin should not be used in patients with impaired renal function (Creatinine Clearance <60 mL/min) or in patients with suspected or confirmed pyelonephritis.

This *Klebsiella Pneumoniae* has unusual Carbapenem results; Infectious Disease consult suggested.
Additional ESBL testing

• Cefazolin, cefotaxime, ceftazidime, ceftriaxone, and aztreonam are resistant

• Additional testing for Extended-Spectrum Beta-lactamases (ESBL) is not necessary if current break points are implemented
  • Published in January 2010 (M100-S20)

• Suggested methods for ESBL testing (if old breakpoints are used)
  • Disk Diffusion
  • MIC

• Clinical Organisms
  • E. coli
  • K. pneumoniae
  • K. oxytoca
  • Proteus mirabilis
ESBL Testing

- Ceftazidime
- Ceftazidime-clavulanate
- Cefotaxime
- Cefotaxime-clavulanate

ESBL + Results:
- MIC = $\geq 3$ twofold concentration decrease
  - i.e. Ceftazidime MIC = 8 µg/ml
  - Ceftazidime-clavulanate MIC = 1µg/ml
- Disk Diffusion = $\geq 5$ mm increase in zone size
Additional Carbapenamase Testing

• Carbapenemase-producing isolates test Intermediate or Resistant to 1 or more carbapenems using the current breakpoints
  • Ertapenem is the most sensitive indicator; imipenem and meropenem
  • Also test resistant to 1 or more 3rd generation cephalosporins

• If using breakpoints from 2010, mCIM +/- eCIM, the CarbaNP test or a molecular assay should be used to detect resistance

• Not recommended for routine use if using the current breakpoints
  • Infection control or epidemiology

• *Enterobacteriaceae* and *Pseudomonas aeruginosa*
## Carbapenemase Testing

<table>
<thead>
<tr>
<th>CarbaNP</th>
<th>mCIM</th>
<th>mCIM w/ eCIM</th>
<th>Molecular Assay</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Organisms</strong></td>
<td><strong>Enterobacteriaceae</strong></td>
<td><strong>Enterobacteriaceae</strong></td>
<td><strong>Enterobacteriaceae</strong></td>
</tr>
<tr>
<td>and <em>Pseudomonas aeruginosa</em></td>
<td>and <em>Pseudomonas aeruginosa</em></td>
<td>that are + by mCIM</td>
<td>and <em>Pseudomonas aeruginosa</em></td>
</tr>
<tr>
<td><strong>Strengths</strong></td>
<td>Rapid</td>
<td>No special reagents needed</td>
<td>No special reagents needed</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Determines the type of carbapenemase</td>
</tr>
<tr>
<td><strong>Limitations</strong></td>
<td>-Special reagents are needed (in-house and short shelf life)</td>
<td>Requires overnight incubation</td>
<td>Requires overnight incubation</td>
</tr>
<tr>
<td></td>
<td>-Invalid results occur with some isolates</td>
<td></td>
<td>Special reagents and equipment are needed Specific to targeted genes</td>
</tr>
</tbody>
</table>

M100 – S28 edition
The Cumulative Antibiogram Report

Antibiogram = report that lists percent of isolates of common species susceptible (%S) to individual antimicrobial agents.

• Analyzes data from routine antimicrobial susceptibility tests performed in the clinical laboratory
• Separate report prepared for each healthcare facility
• Primarily used to guide empiric therapy
• Sometimes used to monitor resistance
  • Changes in %S from year to year
• Highly impacted by culturing practices
  • If cultures only done when patients fail therapy, antibiogram will...
    • not be representative of all isolates causing infection in a facility
    • overestimate “resistant” bacteria causing infection in a facility
Recommendations
Preparation of Cumulative Antibiogram

- Analyze/present data at least annually
- Include only species with $\geq 30$ isolates of each species
- Include diagnostic (not surveillance) isolates
- Include the 1st isolate/patient; no duplicate patient isolates

Often difficult to get 30 isolates in LTCFs
Appendix E1. Cumulative Antimicrobial Susceptibility Report Example – Antimicrobial Agents Listed Alphabetically (Hypothetical Data)

Memorial Medical Center
1 January – 31 December 2012 Cumulative Antimicrobial Susceptibility Report

<table>
<thead>
<tr>
<th>Percent Susceptible</th>
<th>No. Strains</th>
<th>Amikacin</th>
<th>Ampicillin</th>
<th>Ceftazidime</th>
<th>Ceftriaxone</th>
<th>Ciprofloxacin</th>
<th>Nitrofurantoin*</th>
<th>Gentamicin</th>
<th>Meropenem</th>
<th>Piperaamil</th>
<th>Tobramycin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acinetobacter baumannii</td>
<td>32</td>
<td>80</td>
<td>R</td>
<td>R</td>
<td>34</td>
<td>52</td>
<td>51</td>
<td>60</td>
<td>80</td>
<td>46</td>
<td>58</td>
</tr>
<tr>
<td>Citrobacter freundii</td>
<td>49</td>
<td>100</td>
<td>R</td>
<td>R</td>
<td>72</td>
<td>67</td>
<td>78</td>
<td>80</td>
<td>99</td>
<td>99</td>
<td>74</td>
</tr>
<tr>
<td>Enterobacter aerogenes</td>
<td>31</td>
<td>100</td>
<td>R</td>
<td>R</td>
<td>68</td>
<td>69</td>
<td>92</td>
<td>85</td>
<td>91</td>
<td>99</td>
<td>74</td>
</tr>
<tr>
<td>Enterobacter cloacae</td>
<td>76</td>
<td>99</td>
<td>R</td>
<td>R</td>
<td>61</td>
<td>62</td>
<td>92</td>
<td>81</td>
<td>90</td>
<td>99</td>
<td>77</td>
</tr>
<tr>
<td>Escherichia coli</td>
<td>1433</td>
<td>99</td>
<td>36</td>
<td>68</td>
<td>96</td>
<td>94</td>
<td>98</td>
<td>91</td>
<td>99</td>
<td>99</td>
<td>51</td>
</tr>
<tr>
<td>Klebsiella pneumoniae</td>
<td>543</td>
<td>99</td>
<td>R</td>
<td>72</td>
<td>91</td>
<td>92</td>
<td>84</td>
<td>74</td>
<td>94</td>
<td>95</td>
<td>86</td>
</tr>
<tr>
<td>Morganella morganii</td>
<td>44</td>
<td>100</td>
<td>R</td>
<td>R</td>
<td>85</td>
<td>81</td>
<td>99</td>
<td>100</td>
<td>99</td>
<td>99</td>
<td>64</td>
</tr>
<tr>
<td>Proteus mirabilis</td>
<td>88</td>
<td>100</td>
<td>87</td>
<td>80</td>
<td>99</td>
<td>99</td>
<td>89</td>
<td>R</td>
<td>90</td>
<td>100</td>
<td>70</td>
</tr>
<tr>
<td>Pseudomonas aeruginosa</td>
<td>397</td>
<td>97</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Salmonella spp.</td>
<td>32</td>
<td>–</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Serratia marcescens</td>
<td>50</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shigella spp.</td>
<td>33</td>
<td>–</td>
<td>54</td>
<td></td>
<td>100</td>
<td>100</td>
<td>95</td>
<td>–</td>
<td>100</td>
<td>84</td>
<td>69</td>
</tr>
<tr>
<td>Stenotrophomonas maltophilia</td>
<td>72</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>63</td>
<td>6</td>
<td>R</td>
<td>R</td>
<td>98</td>
<td></td>
</tr>
</tbody>
</table>

*The percent susceptible for each organism/antimicrobial combination was generated by including the first isolate of that organism encountered on a given patient.
* Nitrofurantoin data from testing urine isolates only.
* (-) drug not tested or drug not indicated.

Abbreviations: No., number; R, intrinsic resistance.

“Routine” Cumulative antibiogram
Generally…all isolates from a facility

**E. coli - % Susceptible**

<table>
<thead>
<tr>
<th>Category</th>
<th>N</th>
<th>Cip</th>
<th>FM</th>
<th>T-S</th>
<th>CZ</th>
</tr>
</thead>
<tbody>
<tr>
<td>All isolates</td>
<td>4167</td>
<td>77</td>
<td>93</td>
<td>71</td>
<td>92</td>
</tr>
<tr>
<td><strong>18-40 yo female outpatient urine</strong></td>
<td>797</td>
<td>90</td>
<td>95</td>
<td>79</td>
<td>96</td>
</tr>
<tr>
<td><strong>&gt;65 yo outpatient urine</strong></td>
<td>1260</td>
<td>70</td>
<td>91</td>
<td>68</td>
<td>92</td>
</tr>
</tbody>
</table>

1 First isolate/pt (CLSI M39-A4)

Cip, ciprofloxacin  
FM, nitrofurantoin  
T-S, trimethoprim-sulfamethoxazole  
CZ, cefazolin as surrogate for cephalexin  
(oral cephalosporins)
**Routine Cumulative Antibioticogram**

**% Susceptible**

<table>
<thead>
<tr>
<th>Organism</th>
<th>N</th>
<th>Amp</th>
<th>P-T</th>
<th>Ceftriax</th>
<th>Ertapenem</th>
<th>Meropenem</th>
<th>Amikacin</th>
<th>Gentamicin</th>
<th>Ciprofloxacin</th>
<th>T-S</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>K. pneumoniae</em></td>
<td>450</td>
<td>R</td>
<td>88</td>
<td>85</td>
<td>95</td>
<td>98</td>
<td>98</td>
<td>92</td>
<td>88</td>
<td>82</td>
</tr>
</tbody>
</table>

- **Meropenem = carbapenem**
- **98% “S”**
- **≈ 2% CRE**

CRE = carbapenem-resistant Enterobacteriaceae
Examine all isolates (not just first isolate/patient).
Number of Enterobacteriaceae/year tested = approximately 5000 isolates.

CRE = carbapenem-resistant Enterobacteriaceae
# 2015 Los Angeles County Acute Care Hospital Antibiogram

## Gram-Negative Organisms

<table>
<thead>
<tr>
<th>Percent Susceptible (Number of Isolates Tested)</th>
<th>Penicillins</th>
<th>Cephalosporins</th>
<th>Carbapenems</th>
<th>Aminoglycosides</th>
<th>Quinolone</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Enterobacter sp.</strong> 3189 (66)</td>
<td>-</td>
<td>(1,873)</td>
<td>(1,275)</td>
<td>-</td>
<td>(1,864)</td>
<td>(53)</td>
</tr>
<tr>
<td><strong>Citrobacter freundii</strong> 1975 (43)</td>
<td>-</td>
<td>(1,873)</td>
<td>(1,275)</td>
<td>-</td>
<td>(1,864)</td>
<td>(53)</td>
</tr>
<tr>
<td><strong>Citrobacter amnii</strong> 631 (23)</td>
<td>-</td>
<td>(1,873)</td>
<td>(1,275)</td>
<td>-</td>
<td>(1,864)</td>
<td>(53)</td>
</tr>
<tr>
<td><strong>Enterobacter aerogenes</strong> 8122 (64)</td>
<td>-</td>
<td>(1,873)</td>
<td>(1,275)</td>
<td>-</td>
<td>(1,864)</td>
<td>(53)</td>
</tr>
<tr>
<td><strong>Escherichia coli</strong> 139212 (71)</td>
<td>(25,534)</td>
<td>(115,157)</td>
<td>(100,312)</td>
<td>(79,427)</td>
<td>(84,318)</td>
<td>(100)</td>
</tr>
<tr>
<td><strong>Alcaligenes faeundi</strong> 30655 (72)</td>
<td>-</td>
<td>(1,873)</td>
<td>(1,275)</td>
<td>-</td>
<td>(1,864)</td>
<td>(53)</td>
</tr>
<tr>
<td><strong>Morganella morganii</strong> 2235 (52)</td>
<td>-</td>
<td>(1,873)</td>
<td>(1,275)</td>
<td>-</td>
<td>(1,864)</td>
<td>(53)</td>
</tr>
<tr>
<td><strong>Proteus sp.</strong> 16908 (66)</td>
<td>-</td>
<td>(1,873)</td>
<td>(1,275)</td>
<td>-</td>
<td>(1,864)</td>
<td>(53)</td>
</tr>
<tr>
<td><strong>Providencia sp.</strong> 1613 (46)</td>
<td>-</td>
<td>(1,873)</td>
<td>(1,275)</td>
<td>-</td>
<td>(1,864)</td>
<td>(53)</td>
</tr>
<tr>
<td><strong>Pseudomonas aeruginosa</strong> 22804 (73)</td>
<td>-</td>
<td>(1,873)</td>
<td>(1,275)</td>
<td>-</td>
<td>(1,864)</td>
<td>(53)</td>
</tr>
<tr>
<td><strong>Serratia sp.</strong> 2876 (58)</td>
<td>-</td>
<td>(1,873)</td>
<td>(1,275)</td>
<td>-</td>
<td>(1,864)</td>
<td>(53)</td>
</tr>
<tr>
<td><strong>Enterobacter cloacae</strong> 1719 (50)</td>
<td>-</td>
<td>(1,873)</td>
<td>(1,275)</td>
<td>-</td>
<td>(1,864)</td>
<td>(53)</td>
</tr>
</tbody>
</table>

Data not collected or excluded by **.**

### 2015 LA County Antibiogram

Composite Data from Antibiotics from Acute Care Hospitals
Society of Infectious Diseases Pharmacists
&
American Society of Consultant Pharmacists

Recommendations for Antibiogram Development
Long-Term Care Facility (LTCF) Addendum

The ability to generate an accurate annual cumulative susceptibility report (anti-biogram) according to CLSI M39 guidelines is challenging for many LTCF due to selective culturing practices, small numbers of isolates, and ambiguity with regard to who should be responsible for antibiogram development for each LTCF (e.g., the LTCF contracted lab, the LTCF medical director, the LTCF consultant pharmacist, etc.). Similar to acute care hospitals, the first step in the process of antibiogram development for LTCFs is to have a multidisciplinary planning meeting with all of the stakeholders in the LTCF in order to discuss and formulate a plan to meet the needs of each individual LTCF. For LTCF antibiogram development, this multidisciplinary group should be comprised of LTCF leadership, the LTCF medical director, LTCF consultant pharmacist, the LTCF lab provider, and representatives from the LTCF Antibiotic Stewardship Committee and local hospital, if applicable. Areas that should be addressed at the planning meeting include identification of:

1) the person responsible for preparing the anti-biogram
Summary

• Assessment of patient’s clinical symptoms together with reliable clinical microbiology laboratory results are essential for accurate diagnosis of infections.
  • Reliable clinical microbiology laboratory results are dependent on:
    • appropriate collection and transport of specimens.
    • accurate identification and antimicrobial susceptibility testing.
    • good communication between healthcare providers and lab.

• Review of clinical microbiology laboratory results is key to identification of potential nosocomial transmission of microbes.

• Additional clinical microbiology laboratory tests may be needed for epidemiological investigations.

• A local cumulative antibiogram can help guide empiric therapy decisions and monitor “%S” for antimicrobial agents appropriate for common pathogens.
Thank You!