How to Measure the Effectiveness of Incorporating Antibiogram Data at Your Facility

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Conflict of Interest Disclosures

Kimberly Claeys has served on an advisory board for Melinta Therapeutics and Nabriva Therapeutics and is a speaker for Luminex Corporation.
Objectives

1. Identify properties of antibiograms that can be incorporated into facility's policies and procedures.

2. Select key concepts for optimizing use of local susceptibility data at your practice site.

3. Determine process and outcome metrics to evaluate incorporating antibiogram data at your practice site.
Lecture Outline

- Review antiobiograms
- Antibiogram challenges in LTC
- Integrating antiobiogram information
- Metrics to measure success
- Putting it all together
Recall: Susceptibility Testing

- Clinical microbiology completes susceptibility testing on individual samples
- Testing to determine minimum inhibitory concentration (MIC)
- MICs referenced against clinical breakpoints for microorganism-drug combination
  - Susceptible
  - Intermediate
  - Resistant
- Table refers to the susceptibility of the individual sample from the individual patient

<table>
<thead>
<tr>
<th>Antibiotic</th>
<th>MIC (μg/mL)</th>
<th>MIC interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceftriaxone</td>
<td>0.5</td>
<td>Sensitive</td>
</tr>
<tr>
<td>Clindamycin</td>
<td>≤0.03</td>
<td>Sensitive</td>
</tr>
<tr>
<td>Daptomycin</td>
<td>4</td>
<td>Sensitive</td>
</tr>
<tr>
<td>Erythromycin</td>
<td>0.5</td>
<td>Sensitive</td>
</tr>
<tr>
<td>Gentamicin</td>
<td>≤0.12</td>
<td>Sensitive</td>
</tr>
<tr>
<td>Linezolid</td>
<td>2</td>
<td>Sensitive</td>
</tr>
<tr>
<td>Penicillin</td>
<td>≤0.03</td>
<td>Sensitive</td>
</tr>
<tr>
<td>Vancomycin</td>
<td>1</td>
<td>Sensitive</td>
</tr>
</tbody>
</table>

MIC, minimal inhibitory concentration.
Recall: Antibiograms

• Also known as *cumulative susceptibility tests*

• Report usually generated by clinical microbiology lab
  – Bacterial isolates from patients at your facility/local facilities
  – Percent of isolates susceptible to given antibiotic agents (microorganism-drug combination)

• Goal of guiding providers *empiric* antibiotic choices based on local susceptibility data

• Can also be used to monitor trends in resistance at your facility
Recall: Antibiograms

- Culture Source
- Culture Date
- Culture ID
- Organism
- Patient ID
- Antibiotic Susceptibility
<table>
<thead>
<tr>
<th>Gram Negative Organism</th>
<th>N</th>
<th>Amikacin</th>
<th>Gentamicin</th>
<th>Ampicillin-sulbactam</th>
<th>Imipenem</th>
<th>Ertapenem</th>
<th>Piperacillin-tazobactam</th>
<th>Cefazolin</th>
<th>Ceftriaxone</th>
<th>Cefepime</th>
<th>Ciprofloxacin</th>
<th>Levofloxacin</th>
<th>Nitrofurantoin</th>
<th>Tigecycline</th>
<th>TMP/SMX</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acinetobacter baumannii</td>
<td>279</td>
<td>75</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>38</td>
<td>0</td>
<td>31</td>
<td>46</td>
<td>35</td>
<td></td>
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<td>88</td>
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<tr>
<td>Citrobacter spp</td>
<td>173</td>
<td>99</td>
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<td></td>
<td></td>
<td></td>
<td>92</td>
<td>50</td>
<td>87</td>
<td>98</td>
<td>92</td>
<td>95</td>
<td>100</td>
<td>97</td>
<td>88</td>
</tr>
<tr>
<td>Enterobacter spp</td>
<td>444</td>
<td>99</td>
<td>96</td>
<td>43</td>
<td>99</td>
<td>94</td>
<td>80</td>
<td>11</td>
<td>78</td>
<td>98</td>
<td>95</td>
<td>96</td>
<td>78</td>
<td>78</td>
<td>97</td>
</tr>
<tr>
<td>Escherichia coli</td>
<td>387</td>
<td>99</td>
<td>87</td>
<td>68</td>
<td>100</td>
<td>100</td>
<td>93</td>
<td>86</td>
<td>92</td>
<td>93</td>
<td>60</td>
<td>67</td>
<td>98</td>
<td>100</td>
<td>65</td>
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<tr>
<td>Klebsiella spp</td>
<td>76</td>
<td>95</td>
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<td>74</td>
<td>99</td>
<td>95**</td>
<td>86</td>
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<td>85</td>
<td>85</td>
<td>83</td>
<td>88</td>
<td>72</td>
<td>94</td>
<td>78</td>
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<tr>
<td>Morganella morganii</td>
<td>43</td>
<td>100</td>
<td>79</td>
<td>49</td>
<td>100</td>
<td>100</td>
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<td>93</td>
<td>100</td>
<td>76</td>
<td>72</td>
<td>6</td>
<td>6</td>
<td>63</td>
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<tr>
<td>Proteus spp</td>
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<td>99</td>
<td>90</td>
<td>88</td>
<td>100</td>
<td>100</td>
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<td>82</td>
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<td>8</td>
<td>8</td>
<td>0</td>
<td></td>
<td>77</td>
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<tr>
<td>Serratia marcescens</td>
<td>142</td>
<td>99</td>
<td>99</td>
<td>11</td>
<td>100</td>
<td>100</td>
<td>96</td>
<td>93</td>
<td>91</td>
<td>77</td>
<td>65</td>
<td>0</td>
<td>99</td>
<td>95</td>
<td></td>
</tr>
<tr>
<td>Pseudomonas aeruginosa</td>
<td>697</td>
<td>98</td>
<td>87</td>
<td>79</td>
<td>81</td>
<td></td>
<td>91</td>
<td>77</td>
<td>65</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Note: Information is based on one isolate per patient admission or visit. The most resistant result for each antibiotic per organism is collected. ** 5% of Klebsiella are considered KPC producers.
Importance of Antibiograms

• After collection of specimen, organism ID can take several days
  – Susceptibility results may take an additional day
• Cannot target/tailor antibiotics until results are known

Traditional Micro Lab Workflow

Blood Cx drawn, sent to lab

BacT Alert detects organisms

Gram-stain of sample

Culture, organism ID and AST

Day 0
Day 1
Day 2
Day 3

18-24 hrs
~1 hr
24-48 hrs
Importance of Antibiograms

• CDC Core Elements for ASP in Long-Term Care

**Leadership commitment**
Demonstrate support and commitment to safe and appropriate antibiotic use in your facility

**Accountability**
Identify physician, nursing and pharmacy leads responsible for promoting and overseeing antibiotic stewardship activities in your facility

**Drug expertise**
Establish access to consultant pharmacists or other individuals with experience or training in antibiotic stewardship for your facility

**Action**
Implement at least one policy or practice to improve antibiotic use

**Tracking**
Monitor at least one process measure of antibiotic use and at least one outcome from antibiotic use in your facility

**Reporting**
Provide regular feedback on antibiotic use and resistance to prescribing clinicians, nursing staff and other relevant staff

**Education**
Provide resources to clinicians, nursing staff, residents and families about antibiotic resistance and opportunities for improving antibiotic use

• Excellent tool to monitor trends in antibiotic resistance
Antibiogram Limitations

• Not generalizable
• Only report phenotypic susceptibility
  – No MIC data, no data on intrinsic resistance
• Does not take in to account individual patient factors
  – History of drug resistance (i.e. prior ESBL)
  – Surveillance culture at other body site
  – Past antibiotic exposure
  – Patient comorbidities (risk for resistance)
  – Patient acuity (level of critical illness)
Antibiogram Challenges in Long-Term Care

• Long-term care facilities have unique challenges when developing antibiograms
  – Facility with small number of patients
  – Limited number of diagnostic isolates
  – Working with multiple laboratories
  – Lack of electronic medical records
## Antibiogram Challenges in Long-Term Care

<table>
<thead>
<tr>
<th>Approach</th>
<th>Advantages/Disadvantages</th>
</tr>
</thead>
</table>
| Extending the antibiogram data beyond 1 year | Technically simple/easy to create  
Resistant patterns may change from year to year                                                                                               |
| Creating a regional antibiogram      | Helpful if residents access facilities throughout the region  
Requires coordination between multiple laboratories and facilities                  |
| Using antibiograms of nearby hospitals | Antibiograms created annually by hospitals  
Bacteria that infect LTCF residents may not have similar antimicrobial susceptibilities to those of the hospital population |
| Collapsed antibiograms               | Help guide infection-specific antibiotic choices  
Intrinsic resistance of some bacteria to specific antibiotics would not be listed                                                                 |
Incorporating Antibiogram Information

- Validated available antibiogram
- Policies & procedures for antibiogram
- Educate nursing and prescribers
- Disseminate antibiogram
Ways to Integrate Antibiogram Information

• Nursing and provider education is key

• Need to make aware of antibiogram and application of data
  – Available through institutional webpage
  – Hand out pocket cards with most recent antibiogram
  – Provide in-services when new antibiogram becomes available
Incorporating Antibiogram Information

• Do not reinvent the wheel

• AHRQ Toolkit 3, Phase 3: Implementation
  – Provides sample policies and procedures
  – Educational materials
  – Draft emails and communications

• AHRQ Toolkit 3, Phase 4: Monitoring
  – Antibiotic use tracking forms
  – Antibiogram feedback survey

Policies & Procedures for Antibiogram

1. Development of facility-specific policies, procedures, and clinical pathways
2. Changes in order-sets and/or clinical decision support services
3. Decisions regarding changes in facility formulary
4. Outcome metrics
5. Frequency of updating data
Example – Incorporating Local Susceptibility Information

• An antibiogram for Gram-negative microorganisms with data over the last calendar year has been developed and validated for your facility

• You are developing a new treatment pathway for management of UTIs

<table>
<thead>
<tr>
<th>Gram Negative Organism</th>
<th>Aminoglycoside</th>
<th>Cephalosporins</th>
<th>Quinolones</th>
<th>Others</th>
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</thead>
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<tr>
<td></td>
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<td>Cefazolin</td>
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<td>73</td>
</tr>
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<td>57</td>
<td>95</td>
<td>94</td>
<td>78</td>
</tr>
<tr>
<td>Proteus spp.</td>
<td>31</td>
<td>95</td>
<td>94</td>
<td>84</td>
</tr>
<tr>
<td>Serratia marcescens</td>
<td>21*</td>
<td>94</td>
<td>96</td>
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</tr>
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<td>13*</td>
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Note: Information is based on one isolate per patient admission or visit.
* Fewer than 30 isolates available, use caution when interpreting results.
Example – Incorporating Local Susceptibility Information

• *Draft pathway based on IDSA guidelines*

Suspected UTI:
EITHER:
1. Fever
2. Leukocytosis

AND ONE OR MORE**
1. Costovertebral tenderness
2. Increased suprapubic tenderness
3. Gross hematuria
4. Increased incontinence
5. Increased urinary urgency
6. Change in urine characteristics + mental status change

Urine culture $\geq 10^5$ cfu/ml OR $\geq 10^3$ cfu/mL if receiving antibiotics

Yes

Persistent Urinary Tract Symptoms

- Uncomplicated UTI
  - Nitrofurantoin x 5 days
  - Cephalexin x 5 days
  - Amoxicillin-clavulanic acid x 5
  - Trimethoprim-sulfamethoxazole x 3 days

- Complicated UTI
  - Ceftriaxone 1 g IV x 1 dose
  - Followed by oral therapy

- Pyelonephritis
  - Ceftriaxone 1g IV q24h
  - After 48 hours or until afebrile switch to oral therapy (beta-lactam, fluoroquinolone)

No

NOT A UTI
Monitor symptoms, repeat test if suspicion for UTI remains
**Example – Incorporating Local Susceptibility Information**

- How well is *E. coli* covered by antibiotics recommended on your facility formulary?

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* Fewer than 30 isolates available, use caution when interpreting results.
Incorporate Local Susceptibility Information in Pathways

Suspected UTI:  
EITHER:  
1. Fever  
2. Leukocytosis  

AND ONE OR MORE**  
1. Costovertebral tenderness  
2. Increased suprapubic tenderness  
3. Gross hematuria  
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5. Increased urinary urgency  
6. Change in urine characteristics + mental status change

Urine culture $\geq 10^5$ cfu/ml OR $\geq 10^3$ cfu/mL if receiving antibiotics

Persistent UTI Symptoms

Uncomplicated UTI  
Nitrofurantoin x 5 days  
Cephalexin x 5 days  
Amoxicillin-clavulanic acid x 5  
Trimethoprim-sulfamethoxazole x 3 days

Complicated UTI  
Ceftriaxone 1 g IV x 1 dose  
Followed by oral therapy

Pyelonephritis  
Ceftriaxone 1g IV q24h  
After 48 hours or until afebrile switch to oral therapy (beta-lactam, fluoroquinolone, nitrofurantoin or cephalexin)

Tailor your antibiotic recommendations to optimize empiric coverage

NOT A UTI  
Monitor symptoms, repeat test if suspicion for UTI remains
Measuring Success - Metrics

• After implementation, measure success through process and outcomes metrics

• Process metrics

• Outcomes metrics

• CMS State Operations Manual
  – Tracking of *C. difficile*, MRSA, CRE
  – Monitoring of antibiotic use
Measuring ASP Success – Metrics

Least to Most Difficult...

- COST
- PROCESS
- OUTCOMES
- RESISTANCE

Examples of Metrics from the CDC

– Process metrics:
  • Review resident medical records for new antibiotics
  • Adherence to antibiotic prescribing policies
  • Acceptance of antibiotic stewardship interventions
  • Duration of antibiotic courses

– Outcomes metrics:
  • Monitor institutional rates of *C. difficile* infection
  • Record incidence of antibiotic-related adverse drug events
## Antibiotic Consumption Metrics

<table>
<thead>
<tr>
<th>Metric</th>
<th>Definition</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Incidence</strong></td>
<td>• Number of antibiotic courses started per 1000 resident care days</td>
<td>• Useful to monitor impact of interventions to lower use</td>
<td>• Doesn’t measure duration</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Requires resident-level data</td>
</tr>
<tr>
<td><strong>Antibiotic utilization ratio</strong></td>
<td>• Ratio of total antibiotic days to total resident care days</td>
<td>• Most common metric used in published studies (usually expressed as total days per 1000 resident days)</td>
<td>• Doesn’t measure duration</td>
</tr>
<tr>
<td>(AUR)</td>
<td></td>
<td>• Used by CDC NHSN</td>
<td>• Requires resident-level data</td>
</tr>
<tr>
<td><strong>Cost per antibiotic day</strong></td>
<td>• Ratio of total antibiotic cost to total antibiotic days</td>
<td>• May provide insight into prescribing of high cost antibiotics</td>
<td>• Requires cost data and resident-level data</td>
</tr>
<tr>
<td><strong>Cost per resident care day</strong></td>
<td>• Ratio of total antibiotic cost to total resident care days</td>
<td>• May appeal to administrators because it relates cost to whole population</td>
<td>• Requires cost data</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Not all residents treated with an antibiotic</td>
</tr>
</tbody>
</table>
# Antibiotic Consumption Metrics

<table>
<thead>
<tr>
<th></th>
<th>DOTs</th>
<th>DDD</th>
<th>SAAR</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>EXPLANATION</strong></td>
<td>• Days patients received at least one dose of antimicrobial</td>
<td>• Maintenance dose for average weight/renal function adult</td>
<td>• Observed-to-predicted ratio of antimicrobial days (DOTs) by national benchmark</td>
</tr>
<tr>
<td><strong>UNIT MEASURED</strong></td>
<td>• DOT/1000 patient days</td>
<td>• DDD/1000 patient days</td>
<td>• Ratio of observed antibiotic use to predicted</td>
</tr>
<tr>
<td><strong>ADVANTAGES</strong></td>
<td>• Standardization and benchmarking within and between facilities</td>
<td>• Does not require patient levels data</td>
<td>• Indirect standardization metric</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Can be used for benchmarking</td>
<td>• Benchmarking by agent category or patient location</td>
</tr>
<tr>
<td><strong>DISADVANTAGES</strong></td>
<td>• Requires patient-level data</td>
<td>• Assumes standard dosing and under or over-estimate based on clinical scenario</td>
<td>• Uses NHSN AUR</td>
</tr>
<tr>
<td></td>
<td>• Can be technically difficult (i.e. IT)</td>
<td></td>
<td>• Certain locations not included (i.e. ED, oncology units)</td>
</tr>
<tr>
<td><strong>ENDORSEMENTS</strong></td>
<td>• CDC/NHSN AUR Module</td>
<td>• World Health Organization</td>
<td>• National Quality Forum</td>
</tr>
</tbody>
</table>

DOT = days of therapy; DDD = defined daily dose; SAAR = standardized antibiotic administration ratio; P/T = piperacillin/tazobactam; HO/MDRO = hospital onset/multi-drug resistant organisms; NHSN = National Healthcare Safety Network; AUR = Antibiotic Use Resistance Module

Antibiotic days of therapy (DOT) helps monitor use over time.

- Antibiotic day = each calendar day a resident receives the antibiotic
- Antibiotic DOT = sum of all antibiotics for all residents in a given time frame

**Example:**
- Resident received 7 days of cephalexin = 7 DOTs
  - Count each day they received at least one dose
- Received azithromycin AND ceftriaxone for 5 days = 10 DOTs
  - Each antibiotic has its own count!

**Antibiotic DOT/1000 resident days (based on monthly DOT report)**
- \(\frac{\text{Total monthly antibiotic DOT}}{\text{total monthly resident days}} \times 1000\)

**Antibiotic utilization ratio (AUR)**
- \(\frac{\text{Total monthly antibiotic DOT}}{\text{total monthly resident days}}\)
Application – Metrics to Assess?

Over a one-month period:

1. Proportion (%) of antibiotic orders adherent to pathway recommendations

2. How many antibiotic orders with indication for UTI?

3. DOTs for specific antibiotics (i.e. fluoroquinolones)

Uncomplicated UTI
- Nitrofurantoin x 5 days
- Cephalexin x 5 days
- Amoxicillin-clavulanic acid x 5
- Trimethoprim-sulfamethoxazole x 3 days

Complicated UTI
- Ceftriaxone 1 g IV x 1 dose
  Followed by oral therapy

Pyelonephritis
- Ceftriaxone 1g IV q24h
  After 48 hours or until afebrile
  switch to oral therapy (beta-lactam, fluoroquinolone, nitrofurantoin or cephalexin)
Examples of Metrics from the CDC

- Process metrics can include looking at all the patients in your facility on one day or week (point prevalence)
  - How many residents are receiving an antibiotic?
  - How many courses of antibiotics have an indication? Is the documentation complete?
  - Is empiric antibiotic selection in agreement with facility guidelines/pathways and antibiogram data?
Examples of Metrics from the CDC

- Outcomes metrics are more difficult to assess and harder to show change
- Important metrics from regulatory standpoint include tracking *C. difficile* infection (CDI)
  
  - Incidence of CDI = number of new cases (confirmed by laboratory) / number of residents (over time period, i.e. months)

Refer to Laboratory-identified Event module in NHSN (http://www.cdc.gov/nhsn/ltc/cdiffmrssa/index.html)
Application – Metrics to Assess?

Compare time period before and after implementation:

1. Incidence of CDI

2. Adverse antibiotic events in those being treated for UTI

3. Proportion resistant to empiric antibiotic therapy

- **Uncomplicated UTI**
  - Nitrofurantoin x 5 days
  - Cephalexin x 5 days
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Trends in Antibiotic Resistance

• Resistance trends can be difficult to measure

• Use annual antibiograms to track resistance of certain drug-microorganism combinations
  – Rates of MRSA – resistant *Staphylococcus aureus*
  – Rates of CRE – resistant *Enterobacteriaceae*
  – Rates of VRE – resistant *Enterococci*
Example: Incorporating Antibiogram Information

- Antibiograms help guide antibiotic choices before patient specific culture/susceptibility information is available
- Guide initial *empiric* therapy recommendations

Using Antibiograms to Improve Antibiotic Prescribing in Skilled Nursing Facilities

Jon P. Furuno, PhD;1 Angela C. Comer, MPH;2,3 J. Kristie Johnson, PhD, D(ABMM);2,4 Joseph H. Rosenberg, BS;2 Susan L. Moore, PhD, MSPH;5 Thomas D. MacKenzie, MD, MSPH;5 Kendall K. Hall, MD, MS;6 Jon Mark Hirshon, MD, MPH, PhD2,3,7
Using Antibiograms to Improve Antibiotic Prescribing in Skilled Nursing Facilities

- Quasi-experimental study of implementation of SNF-specific antibiograms at three facilities in Maryland

- Evaluate effectiveness through assessment of changes in empiric antibiotic prescribing (SNF 1,118 beds)

Empiric Antibiotic Appropriateness

<table>
<thead>
<tr>
<th></th>
<th>Pre-implementation</th>
<th>Post-implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Empiric</td>
<td>32%</td>
<td>45%</td>
</tr>
</tbody>
</table>

\[ P = 0.32 \]

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• To receive CE credit (1.0 contact hours), learners must complete the Activity Evaluation.
MEET OUR FACULTY EXPERTS WHO ARE WELL VERSED IN THE FIELD OF ANTIMICROBIAL STEWARDSHIP

FACULTY OFFICE HOURS

When: WEDNESDAY, FEBRUARY 20TH 1 – 2 PM
Where: ONLINE
Why: ASK QUESTIONS ABOUT ANTIBIOGRAMS
Type your Questions in the Chat box.
If you are using the conference phone line for your audio unmute your microphone.
How to Measure the Effectiveness of Incorporating Antibiogram Data at Your Facility

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