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Comparison of National and Regional Nonsusceptibilities of *Staphylococcus aureus, Escherichia coli,* and *Pseudomonas aeruginosa* to Commonly Prescribed Antibiotics: Results of the Antimicrobial Resistance Management (ARM) Program, 1997-2004

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UPDATED ABSTRACT

BACKGROUND: ARM Program is an ongoing project of the University of Florida to document trends in antimicrobial susceptibility patterns in inpatient/outpatient isolates and track antibiotic resistance as it occurs. To date, 359 institutions have been enrolled at no charge. Each provides at least 3 years of antibiogram/sensitivity report data in a HIPAA-compliant non-identifying format, which comprise a national aggregate database containing 28.6 million isolates. For comparative purposes, the US is divided into 6 geographic regions.

METHODS: The database was interrogated at www.armprogram.com to determine national and regional resistance patterns for S aureus *isolates vs nafcillin/oxacillin;* E coli *vs ampicillin, ampicillin/sulbactam, ciprofloxacin, and levofloxacin; and* P aeruginosa *vs amikacin, gentamicin, tobramycin, ceftazidime, and ciprofloxacin from 1997-2004.*

RESULTS: For S aureus*, national nonsusceptibility to nafcillin/oxacillin was 40.5% (range, 25.7% in Northwest to 46% in Southwest). For* E coli*, national nonsusceptibility to ampicillin was 37.8% (range, 33.8% in Northwest to 40.7% in Southwest); to ampicillin/sulbactam, 33.4% (range, 30.6% in Northwest to 35.5% in Southeast); to ciprofloxacin, 6.3% (range, 2.4% in Northwest to 7.3% in Northeast) and to levofloxacin, 7.3% (range, 3.0% in Northwest to 7.9% in both the Northeast/Southeast). For* P aeruginosa*, national nonsusceptibility to amikacin was 8.2% (range, 6.2% in South Central to 11.3% in Southwest); to gentamicin, 26.9% (range, 15.2% in Northwest to 27.5% in Southwest); to tobramycin, 11.1% (range, 3.2% in Northwest to 16.1% in Southwest); to ceftazidime, 16.4% (range, 10.9% in Northwest to 20.8% in Southwest); and to ciprofloxacin, 33.6% (range, 26.7% in Northwest to 39.5% in Southwest).*

CONCLUSION: National and regional nonsusceptibility patterns for antibiotics and infectious disease organisms can be compared at www.armprogram.com, allowing modification of use of antibacterial therapy as needed.

BACKGROUND

- Growing concern about microbial drug resistance and patient safety has led to the promotion of good antimicrobial stewardship[1]
- In 1997, ARMP was established at the University of Florida to document trends in antimicrobial susceptibility patterns in inpatient/outpatient isolates
- By tracking isolate susceptibility patterns over time, it is possible to identify whether resistance to specific antibiotics is occurring
  - Qualifying hospitals/systems participate in ARMP at no cost
  - Each provides a minimum of 3 years of antibiogram or sensitivity report data
  - Hospitals/systems receive a customized Antibiogram Report and Analysis detailing antimicrobial susceptibility trends within their institutions benchmarked against national, regional, and state comparators

NATIONAL AGGREGATE DATABASE

- As of August 2005, ARMP has enrolled 359 US institutions
  - 282 (79%) nonteaching
  - 77 (21%) teaching
- 28.6 million isolate-drug combinations are represented in the database
- Individual antibiotics and organisms captured include
  - 48 antibiotics
  - 19 organisms
- The most significant organisms are summarized in Table 1

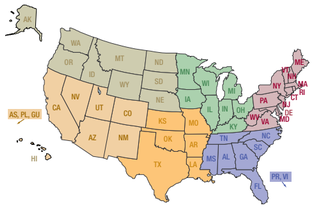
Table 1. Significant Organisms in the ARMP Aggregate Resistance Database*

Organism	Isolates (n)
Escherichia coli	11,616,270
Staphylococcus aureus	4,960,753
Pseudomonas aeruginosa	2,747,553
Klebsiella pneumoniae	2,775,697
Proteus mirabilis	1,781,652

*as of August 25, 2005

- For the purposes of comparison, institutions are grouped in 6 geographic regions (Figure 1)

Figure 1. Geographic Distribution of Institutions



METHODS

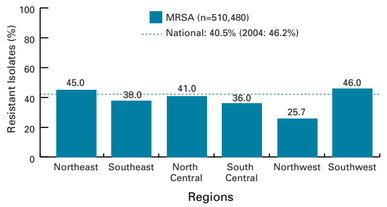
- The database was interrogated at www.armprogram.com to determine national and regional resistance patterns for the years 1997-2004 collectively for the following:
  - *S aureus* isolates vs nafcillin/oxacillin
  - *E coli* vs ampicillin, ampicillin/sulbactam, ciprofloxacin, and levofloxacin
  - *P aeruginosa* vs amikacin, gentamicin, tobramycin, ceftazidime, cefepime, ciprofloxacin, levofloxacin, and ofloxacin
- Given that resistance is increasing annually, data for the year 2004 were also reviewed to determine to what extent these rates would correlate with the past 8 years overall

RESULTS

S AUREUS

- Under the assumption that the reciprocal to nafcillin/oxacillin susceptibility data is accepted as methicillin-resistant *S aureus* (MRSA) activity, *S aureus* isolate data were reviewed for susceptibility to nafcillin/oxacillin
- Nationally, nonsusceptibility to nafcillin/oxacillin was 40.5%, with the most resistant isolates seen in the Southwest and the least resistant isolates seen in the Northwest (Figure 2)

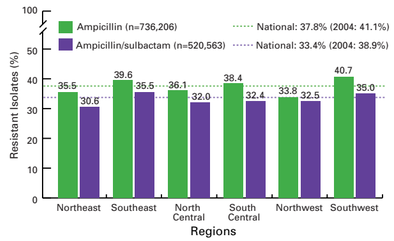
Figure 2. National and Regional MRSA Activity, 1997-2004



E COLI

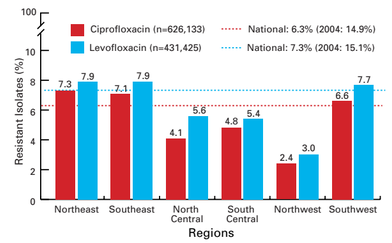
- For *E coli*, national nonsusceptibility of isolates was 37.8% to ampicillin and 33.5% to ampicillin/sulbactam (Figure 3A)
- There is a strong correlation between nonsusceptibilities to ampicillin and ampicillin/sulbactam, providing surrogate evidence that the majority of ampicillin-resistant *E coli* isolates are hyperproducing beta lactamase

Figure 3A. National and Regional* E coli *Isolate Resistance to Ampicillin and Ampicillin/Sulbactam, 1997-2004



- Nationally, *E coli* isolate resistance was 6.3% to ciprofloxacin and 7.3% to levofloxacin, with the Northwest having the least resistance and the Northeast the most resistance to both fluoroquinolones (Figure 3B)
- Resistance to levofloxacin in the Southeast and Southwest was also high (Figure 3B)
- The close similarities in resistance patterns between the fluoroquinolones suggest that *E coli* resistance to fluoroquinolones within regions is class-mediated

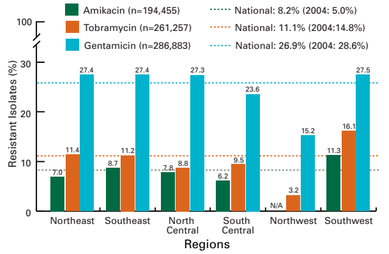
Figure 3B. National and Regional* E coli *Isolate Resistance to Selected Fluoroquinolones, 1997-2004



P AERUGINOSA

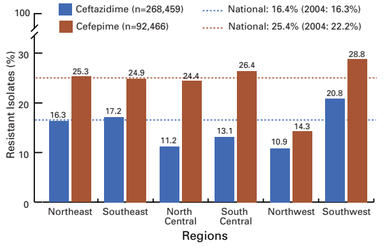
- National nonsusceptibility of *P aeruginosa* isolates to the aminoglycosides ranged from 8.2% for amikacin to 11.1% for tobramycin and 26.9% for gentamicin (Figure 4A)
- The widest range in resistance was seen for tobramycin, with 3.2% of isolates resistant in the Northwest to 16.1% resistant in the Southwest (Figure 4A)
- Gentamicin susceptibilities nationally and regionally are suppressed compared to those of tobramycin or amikacin; this is to be expected, since it is assumed that gentamicin is the preferred-use aminoglycoside

Figure 4A. National and Regional* P aeruginosa *Isolate Resistance to Selected Aminoglycosides, 1997-2004



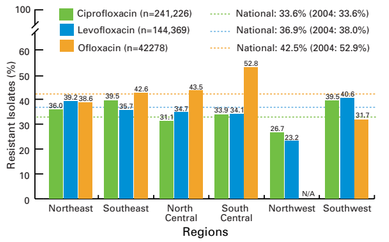
- Nationally, *P aeruginosa* isolate resistance was 16.4% to ceftazidime and 25.4% to cefepime (Figure 4B)
- Regionally, the least resistant isolates to both cephalosporins were in the Northwest (Figure 4B)

Figure 4B. National and Regional* P aeruginosa *Isolate Resistance to Selected Cephalosporins, 1997-2004



- Nationally, *P aeruginosa* isolate resistance to the fluoroquinolones ranged from 33.6% to ciprofloxacin to 36.9% for levofloxacin and 42.5% for ofloxacin (Figure 4C)
- The most resistant isolates were those to ofloxacin in the South Central region (52.8%); the least resistant were those to levofloxacin in the Northwest (23.2%)
- As with *E coli*, similarities in resistance patterns among the fluoroquinolones suggest that *P aeruginosa* resistance to fluoroquinolones nationally and regionally is class-mediated
- Furthermore, with the introduction of each new fluoroquinolone, resistance within the class appears to increase, as observed with ofloxacin

Figure 4C. National and Regional* P aeruginosa *Isolate Resistance to Selected Fluoroquinolones, 1997-2004



CONCLUSION

- The ARMP national aggregate database at www.armprogram.com allows susceptibility patterns for antibiotics and infectious disease organisms to be compared nationally and regionally
- In addition to providing an overview of resistance rates for a given period of time, individual years can also be compared to identify trends
- ARMP can work with individual institutions to delineate occurrence and extent of antimicrobial resistance before it becomes significant
  - Allows modification of use of antibacterial therapy, where necessary
  - Has potential to reduce costs of antibiotics associated with inappropriate use
  - Provides data for local, regional, national benchmarks

References

Owens RC Jr., Fraser GL, Stogsdill P. Antimicrobial stewardship programs as a means to optimize antimicrobial use. *Pharmacotherapy.* 2004;24:896-908.

Acknowledgments

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www.armprogram.com

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