02.32 – Antimicrobial Stewardship Program

Antimicrobial Stewardship Program for the University of Texas Medical Branch (UTMB) Health System

Many bacterial infections have become untreatable due to antimicrobial resistance. The development of bacterial resistance to antibiotics has been caused by the overuse of antimicrobials given to patients with suspected but undiagnosed bacterial infections, given at the wrong dose to patients with diagnosed infections and continued for longer than necessary to treat these infections.

The national response to antimicrobial resistance has been a series of actions combined into a program referred to as Antimicrobial Stewardship Programs (ASPs). Healthcare institutions that have implemented a group of measures to combat antimicrobial resistance and developed ASPs have demonstrated the effectiveness of these programs. The UTMB Health System Antimicrobial Stewardship Program is based on evidence-based national guidelines.

Among the interventions that will be included in the UTMB ASP program include prospective audit and intervention with feedback, formulary restriction, and preauthorization requiring the prescriber to justify the use of restricted antibiotics before they are released, use of antimicrobial order forms, streamlining or de-escalation of therapy, dose optimization, and parenteral to oral conversion. (1)

Purpose	To provide an Antimicrobial Stewardship Program for the UTMB Health System which will support cost-effective use of antimicrobials while limiting their adverse impact on patient outcomes and antimicrobial resistance.
Audience	All Faculty, Nursing Staff, House staff, and Pharmacy Staff
Policy	I. Core Membership of the antimicrobial stewardship team A. Two clinically-active Infectious Diseases physicians B. Three Infectious Diseases trained pharmacists C. Infectious Diseases Pharmacy Resident D. Information system specialists E. Clinical Microbiologists F. Healthcare Epidemiologists II. Collaborations A. Pharmacy and Therapeutics Committee B. Department of Healthcare Epidemiology C. Pharmacy

D. Division of Infectious Diseases
E. Clinical Microbiology Laboratory

III. Role of institutional leadership
   A. Establish a mandate that enlists the cooperation of all healthcare faculty, house staff, nursing, and pharmacy staff in pursing antimicrobial stewardship.
   B. Provide financial resources for development and operation of the program.
   C. Authorize the Antimicrobial Stewardship Program to develop and implement measures necessary to optimizing antimicrobial use.

IV. Elements of the Antimicrobial Stewardship Program (ASP)(1)
   A. Develop evidence-based antimicrobial ordering forms that will be required for each antimicrobial order in the electronic medical record.
      1. Antimicrobial order forms will require key information for each prescription, including indication, whether therapy is empiric or for treatment of a specific condition or pathogen and duration.
      2. The stewardship program will define mechanisms to make available agents that are not preferred for general use in specific situations (e.g. require approval from the Infectious Disease service). (See Appendix A)
   B. Formulary Management
      1. The antimicrobial stewardship program will have primary responsibility for the management of all antimicrobials on the health system formulary, including selection of agents for addition, removal, or continuation on the formulary. This will include streamlining the number of agents available. Important factors in choice of agents will include proven efficacy, costs, side effects, and effects on antimicrobial resistance.
      2. Mechanisms will be implemented to allow limited use of some agents, such as requiring prior authorization, requiring authorization for use beyond a limited duration, or restricting orders to a limited number of providers. For example, certain antimicrobial agents currently require preauthorization by a member of the Division of Infectious Diseases prior to release by the Pharmacy.
      3. Monitoring resistance in unrestricted antimicrobial agents is necessary with restricted antimicrobial use policies.
      4. Post-prescription prospective audit will include feedback to providers, including discontinuation of antimicrobials when unwarranted, narrowing the spectrum of agents, and switching to oral or less expensive agents.
      5. Feedback to providers will compare their use with best

practices. (2)

C. Provider education, prospective audit, intervention, and feedback
   1. Education is considered to be an essential element of any program designed to influence prescribing behavior.
   2. Education will occur upon hire and annually thereafter.

D. Educate patients, and their families as needed, regarding the appropriate use of antimicrobial medications, including antibiotics. (See Appendix B)

E. Streamlining or de-escalation of therapy
   1. When broad antimicrobial therapy has been prescribed empirically to cover a serious illness in a patient, antimicrobial agents that are no longer indicated based on culture and antimicrobial susceptibility results should be discontinued.
   2. Discontinuing administration of antibiotics that are not needed will decrease the selection of resistant microorganisms and save money.

F. Dose optimization
   1. Optimization of antimicrobial dosing that accounts for individual patient characteristics (e.g., age, renal function, and weight), causative microorganism, and site of infection is an important part of antimicrobial stewardship.
   2. If indication for antibiotics is clearly identified, de-escalate therapy to target the susceptibilities of the pathogen.

G. Monitor for drug interactions between antimicrobials, between antimicrobials and other therapeutic agents, and between antimicrobials and food including their clinical significance and strategies to avoid them.

H. Conversion from parenteral to oral therapy
   1. This can result in reduced length of hospital stay, health care costs, and potential complications due to intravenous access.
   2. A systematic plan for parenteral to oral conversion of antimicrobials with excellent bioavailability, when the patient's condition allows, can decrease length of hospital stay and healthcare costs.
   3. A pharmacy-driven automatic parenteral to oral therapy policy is in place

I. Assess and respond to antimicrobial shortages. (3)

V. Computer Surveillance and Decision Support

A. Healthcare information technology in the form of electronic medical records and clinical decision support can improve antimicrobial decisions through the incorporation of data on patient-specific microbiology cultures and susceptibilities, hepatic and renal function, drug-drug interactions, allergies, and cost.

B. Computer-based surveillance can facilitate good stewardship by more efficient targeting of antimicrobial interventions, tracking of antimicrobial resistance patterns, and identification of nosocomial infections and adverse drug events.
C. Utilize the EHR with clinical decision support functionality to establish right dose and interval.

VI. Antimicrobial Stewardship in the Emergency Department
A. There are many restraints on the practice of antimicrobial stewardship in the Emergency Department that must be overcome. These include:
1. Shortage of time.
2. Inadequate diagnostic testing capabilities.
3. Perceived inappropriate or vague guidelines.
4. Antibiograms not easily accessible.
5. Limited time for communication between patient and provider.
6. The ED environment socializes providers to acquire specific behaviors and beliefs.
7. Colleagues opinions were perceived as more effective in modifying prescribing behavior than national guidelines.
8. More aggressive treatment with broader spectrum agents when followup uncertain. (4)
B. Improving antimicrobial stewardship in the ED
1. Solving the problem of shortage of time for each patient seen in the ED will have to be addressed to improve antimicrobial stewardship in the ED.
2. The clinical microbiology laboratory may improve rapid diagnostic capabilities to provide diagnostic results to physicians in the ED within a few hours. (5)
3. While ED physicians may have difficulty with guidelines for antimicrobial therapy, the ED pharmacist is an important component of a highly developed ED care team. (6)
4. ED physicians need to have easy access to antibiograms for treating patients from the community.
a. The Clinical Microbiology Laboratory produces antibiograms for inpatients, outpatients, and emergency department patients for both adult and pediatric patients (See Appendicies C, D and E.)
b. Antibiograms may be accessed from the UTMB Home Page.
1) Click on “Resources” just above the picture on the home page.
2) Scroll down to “Clinical” on the left side.
3) The last item at the bottom of “Clinical” is “Lab Survival

Guide”
4) Click on “Lab Survival Guide”
5) Click on “Laboratory”
6) Click on first title “Antimicrobial Susceptibility Profile”

c. The Emergency Department Pharmacist must play a key role in Antimicrobial Stewardship.
1) The clinical pharmacist in the ED should work with an ED clinician champion who can effectively communicate new initiatives and resolve disagreements.
2) The clinical pharmacist in the ED will facilitate many positive actions that will strongly support the ASP in the ED.
a) Provision of real-time educational feedback
b) Will promote medication safety
c) Provide microbiology and antimicrobial susceptibility reports
d) Provide microbiologic culture results
e) Provide a multidisciplinary approach to culture followup which is associated with a decrease in return ED visits within 72 hours and hospital readmissions within 30 days.

VII. The role of nursing in antimicrobial stewardship programs (ASP)
A. From a workflow analysis perspective, the staff nurse is the operational and communications person for all of the multidisciplinary participants in the typical ASP model.
B. Timely antibiotic ordering and administration is typically viewed purely as a physician prescribing event. (7)
C. The roles of nurses in ASPs.
1. As the most consistent providers of care at the bedside, and medication chart review being part of routine professional practice, nurses are in an ideal position to enhance antimicrobial management through multidisciplinary collaboration. (8)
2. Education on ASP for nurses will include the following:
a. Understanding the proper techniques for obtaining good culture samples and how the microbiology laboratory processes those samples.
b. Nurses need skills in the interpretation of basic microbiology laboratory results, including the differences between gram-positive and gram-negative microorganisms and how an antibiogram should be used for selection of antibiotics.
c. Basic knowledge regarding when and which intravenous

antibiotics can be switched to oral antibiotics and how and when broad-spectrum antibiotics should be de-escalated to narrow spectrum antibiotics.

d. An understanding and recognition of the difference between colonization and infection with a microorganism.
e. Skills in recognizing subtle, early signs of infection.
f. With mastery of the above skills, nurses should have confidence in asking physicians and other antibiotic prescribers questions about the use of antibiotics. (9)
g. Bedside nursing representation is present at our antimicrobial stewardship meetings.

VIII. Antimicrobial Stewardship in Pediatrics

A. When an antimicrobial has been prescribed for 2 days, a review is performed by an ASP pharmacist and/or by an Infectious Diseases Physician who does a medical chart review to assess the appropriateness of the prescribed antimicrobial. (10).
   1. The review considers indication, dose and duration of the antibiotic prescribed.
   2. All prescribed antimicrobials are assessed during the review process.
B. A record for each antimicrobial reviewed will be entered into an electronic database.
   1. Antimicrobial
   2. Planned duration of therapy
   3. Type of ASP recommendation
   4. Adherence to recommendation(s)
   5. Review by an ASP pharmacist to check on adherence to ASP recommendation(s).
C. Core principles of pediatric antimicrobial stewardship
   1. Timely management of therapy
   2. Appropriate selection of antimicrobials
   3. Appropriate administration and de-escalation of antimicrobial therapy
   4. Use of available expertise and resources at point of care
   5. Transparent monitoring of antimicrobial use data (11)
D. Targets for Pediatric Stewardship
   1. Diagnoses such as pneumonia, appendicitis, infections in patients with cystic fibrosis and skin and soft tissue infections are frequently seen and there are large variations in antimicrobial prescribing for children.
   2. Linezolid, carbapenems, vancomycin and fluoroquinolones are commonly targeted antimicrobials among pediatric stewardship programs.
   3. Antimicrobials that are commonly used and frequently

complicated be either selection or dosing errors such as third generation cephalosporins should be considered targets in pediatric ASPs (12).

IX. Role of Pharmacy Department in Antimicrobial Stewardship
- A. The department will provide three clinical pharmacists with Infectious Diseases training.
- B. The Pharmacy Department will have the Sentri7 Pharmacy computer program that interfaces with the Sentri7 infection control system. The latter systems will interface with the EPI electronic medical record system.
- C. Duties of the Antimicrobial Stewardship Program (ASP) pharmacists
  1. Each weekday and Saturday (excluding holidays), the ASP pharmacists will review customized alerts that include bug/drug mismatches (e.g. positive cultures that are not being treated), treatment without infection markers (e.g., asymptomatic bacteriuria or *Candida* in urine or respiratory samples, which usually require no treatment), the potential to deescalate therapy (i.e., continued broad spectrum drugs when published data, culture results, or the clinical course indicate that therapy can be narrowed), and unnecessary double coverage (i.e., the use of 2 antibiotics targeting anaerobic bacteria or cultured Gram negative rods).
  2. The ASP pharmacists screen the large number of daily alerts and select approximately 30 to 50 charts for review. (13)

X. Microbiology Laboratory
- A. The Clinical Microbiology Laboratory should be actively involved in resistance surveillance.
- B. Differential reporting of antimicrobial susceptibilities
  1. Only susceptibilities of first generation antibiotics' are reported if the isolate is susceptible to most or all of these antibiotics.
  2. If the isolate is resistant to the first generation of antibiotics, susceptibilities of the second generation of antibiotics are reported. Reporting of the second generation of antibiotics is accompanied by instructions on how best to report them. See Appendix F.
  3. The clinical microbiology laboratory plays a critical role in antimicrobial stewardship by providing patient specific culture and susceptibility data to optimize individual antimicrobial management and by assisting infection control efforts in the surveillance of resistant microorganisms and in the molecular

epidemiologic investigation of outbreaks.

C. Because diagnostic uncertainty is a major contributor to the overuse of antibiotics, microbiologists must also advocate for the introduction of new technologies as appropriate to enhance patient care.
    1. ASP physicians must provide support for acquisition of new capital equipment to support rapid detection of microorganisms in the Clinical Microbiology Laboratory.
    2. Rapid identification of microorganisms in the laboratory can result in earlier antimicrobial identification and more rapid treatment of infections.
    3. Significant hospital savings may result from decreased lengths of hospital stay. (13)

D. Rapid Diagnostic Techniques (RDTs)
    1. RDTs are available for many species of common pathogenic microorganisms.
        a. *Staphylococcus* species
        b. *Enterococcus faecalis*
        c. *Enterococcus faecium*
        d. *Escherichia coli*
        e. *Klebsiella pneumoniae*
        f. *Pseudomonas aeruginosa*
        g. *Clostridium difficile*
        h. *Candida* species
    2. Published studies documenting the influence of antimicrobial stewardship program utilization of rapid diagnostic tests on time to effective therapy, hospital length of stay, mortality and hospital costs are summarized in the Table in Appendix G. (14)

XI. Antimicrobial Stewardship (AS) for Outpatient Clinics

A. Most common infections seen in outpatient clinics and appropriate management of these infections.
    1. Rhinosinusitis
        a. Approximately 80% of adults with rhinosinusitis are prescribed antimicrobials while most of these infections are caused by viruses. (15)
        b. Children 6-35 months of age have 6 episodes of viral rhinosinusitis per patient year. (16)
    2. Acute bronchitis in adults and children is uncommonly caused by bacteria but patients are frequently treated with broad spectrum antibiotics such as quinolones, macrolides and aminopenicillins. (17)
    3. Skin and soft tissue infections
        a. Nearly half of uncomplicated skin infections do not require

antibiotic therapy.

b. Up to 48% of cases of abscess that were treated with antibiotics were candidates for drainage alone.
c. For the entire study cohort, an estimated 3159 antibiotic-days were prescribed. Utilization of the four short-course, single-antibiotic treatment strategies would have resulted in 1420 to 2548 antibiotic-days, representing 19-55% reductions in antibiotic use. (18)

4. Urinary tract infections
   a. Broad-spectrum antibiotics are frequently (69% of cases) prescribed for UTIs.
   b. Nitrofurantoin may be the antibiotic of choice for treatment of uncomplicated UTIs. (19)

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Appendix A

UTMB Restricted Anti-infectives

Purpose: To ensure the appropriate use of anti-infectives. These agents are restricted due to their broad spectrum activity, high cost, or drug shortages.

Guidance: The following medications require ID approval. An ID faculty member or fellow is required to provide verbal or documented approval before verification by a pharmacist.

Generic Medication	Additional Restriction(s)	Standard Dose	Cost ($) /day‡
Liposomal Amphotericin B		3-5 mg/kg q24h IV	426
Artemether/lumefantrine		4 tablets at hour 0 and hour 8, then 4 tablets twice daily on day 2 and day 3	38
Ceftaroline		600 mg q12h IV	374
Ceftazidime/avibactam	Requires mandatory ID consult Patient must meet following criteria: Documented infection that is nonsusceptible to cefepime, ceftazidime, piperacillin/tazobactam, and meropenem	2.5 g q8h IV	1076
Ceftolozane/tazobactam	Requires mandatory ID consult Patient must meet following criteria: Documented infection that is nonsusceptible to cefepime, ceftazidime, piperacillin/tazobactam, and meropenem	1.5 – 3 g q8h IV	353-706
Cefotaxime	Pediatric use only Must meet one of the following indications or have Pedi ID approval 1. ISCU < 28 days or 42 week PMA sepsis 2. ISCU infant < 1000 grams and sepsis 3. Infant sepsis and high hyperbilirubin risk Pedi < 14 days sepsis evaluation	100-150 mg/kg/day IV	10-20
Ciprofloxacin	Restricted in JEN8B and JEN8C only	PO: 500 mg Q12h IV: 400 mg Q12h	
Clindamycin	OB/Gyn Faculty, Pediatric faculty, Orthopedic faculty for use in surgical prophylaxis up to 24 hrs in patients with penicillin or cephalosporin allergies; Preapproved indications: 1. Necrotizing fasciitis, SSTI, Fournier's gangrene 2. SSTI w/ penicillin allergy 3. Maxillofacial infections w/ penicillin allergy 4. Toxic shock syndrome	PO: 300-450 mg q6h IV: 600-900 mg q8h	PO: 1-2 IV: 32-39
Colistin	1. Burn service	IV: 340 mg/day divided in 2-3 doses (maximum) Inhalation: 75-150 mg q12h	79 53
Daptomycin		4-6 mg/kg q24h IV	94
Eravacycline		1 mg/kg Q12h IV	198
Ertapenem	Preapproved indications: 1. Documented ESBL 2. History of ESBL in past 3 months	1 g Q24h IV	60
Fidaxomicin		200 mg q12h PO	187
Flucytosine		25 mg/kg q6h PO	617
Fosfomycin		3 g once PO	82
Ganciclovir	Solid organ transplant faculty	5 mg/kg q12h IV	94
Levofloxacin	Restricted in JEN8B and JEN8C only	500-750mg Q24h PO/IV	

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Appendix A (cont.)

UTMB Restricted Anti-infectives

Linezolid	Preapproved indications: 1. Documented or suspected MRSA pneumonia 2. VRE infection 3. Mycobacterium infection 4. Allergy to vancomycin 5. AKI due to vancomycin 6. Necrotizing fasciitis, SSTI, Fournier's gangrene 7. Complicated intra-abdominal infection	600 mg q12h PO/IV	PO: 11 IV: 95
Meropenem	ICU (JEN 8th floor, TDC 4A, J2D) *Requires ID consult for >72h of use*	500 mg Q6h IV – 2 g q8h IV	20-60
Micafungin	ICU (JEN 8th floor and TDC 4A)	100 mg q24h IV	62
Moxifloxacin		400 mg q24h PO/IV	PO: 5 IV: 48
Peramivir		600 mg once IV	969
Polymyxin B		15000 units/kg q12h IV (=1.5 mg/kg IV q12h)	17
Posaconazole	Hematology/Oncology faculty	Suspension: Prophylaxis: 200 mg q8h PO Treatment: 200 mg q6h PO	193
		IV and PO tablet: LD: 300 mg BID PO on day 1 MD: 300 mg Q24h PO	PO: 193 IV: 499
Pyrimethamine		LD: 200 mg x 1 PO MD: 50-75 mg Q24h PO	>1000
Rifampin IV	Infectious Diseases faculty	300-600 mg Q12-24 h IV	63
Tobramycin	Inhalational only	300 mg q12h inhaled	123
Valganciclovir	Solid organ transplant faculty	450 mg Q24h - 900 mg q12h PO	25-99
Voriconazole	Burn service patients up to 48 hrs	LD: 6 mg/kg x 2 doses PO/IV MD: 4 mg/kg q12h PO/IV	PO: 47 IV: 85

‡70 kg patient when considering mg/kg dosing Rev. 4/2021

LD=Loading dose, MD=Maintenance dose

Appendix B

Viruses or Bacteria
What's got you sick?

Antibiotics only treat bacterial infections. Viral illnesses cannot be treated with antibiotics. When an antibiotic is not prescribed, ask your healthcare professional for tips on how to relieve symptoms and feel better.

Illness	Usual Cause		Antibiotic Needed
	Viruses	Bacteria	
Cold/Runny Nose	✓		NO
Bronchitis/Chest Cold (in otherwise healthy children and adults)	✓		NO
Whooping Cough		✓	Yes
Flu	✓		NO
Strep Throat		✓	Yes
Sore Throat (except strep)	✓		NO
Fluid in the Middle Ear (otitis media with effusion)	✓		NO
Urinary Tract Infection		✓	Yes

Antibiotics Aren't Always the Answer

www.cdc.gov/getsmart

GET SMART
Know When Antibiotics Work

CDC U.S. Department of Health and Human Services
Centers for Disease Control and Prevention

Appendix C

Antimicrobial Susceptibility Profile

The antimicrobial susceptibility data for **January through December 2013** can be found by clicking on each of the following.

Preface

Pharmacy

Adult Inpatient

Adult Intensive Care Units

Adult Outpatient

Pediatric Inpatient

Pediatric Intensive Care Unit and Infant Special Care Unit

Pediatric Outpatient

TDCJ Hospital

Mycobacterium tuberculosis Data - All Patients

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Appendix D

ADULT OUTPATIENT SUSCEPTIBILITY PROFILE _ Percent Susceptible

GRAM NEGATIVE BACILLI	Amikacin	Ampicillin	Ampicillin/sulbactam	Aztreonam	Cefazolin	Cefepime	Cefotaxime	Ceftazidime	Ceftriaxone	Gentamicin	Imipenem	Levofloxacin	Nitrofurantoin[1]	Piperacillin/ tazobactam	Tobramycin	Trimethoprim/sulfamethoxazole
Acinetobacter baumanni (n = 10)	_	_	80	_	_	70	40	70	_	_	_	70	_	60	80	70
Citrobacter (diversus) koseri (n = 38)	100	_	_	97	94	100	100	97	100	97	100	89	62	100	97	100
Citrobacter freundi (n = 14)	100	_	_	100	_	100	100	100	85	100	100	85	100	100	100	78
Enterobacter aerogenes (n =34)	100	_	_	85	_	100	91	86	91	91	100	97	3	88	91	100
Enterobacter cloacae (n =36)	100	_	_	94	_	100	94	94	94	100	100	97	40	94	100	97
Escherichia coli (n = 2,120)	99	48	58	96	93	97	97	96	96	89	99	77	92	95	91	68
Klebsiella pneumoniae (n = 329)	99	_	85	95	94	95	94	95	95	96	99	95	34	92	96	86
Morganella morgani (n=16)	100	_	_	93	_	100	100	93	100	86	_	81	_	100	100	75
Proteus mirabilis (n =153)	100	71	79	94	94	94	95	95	95	87	_	85	_	100	88	73
Pseudomonas aeruginosa (n = 102)	92	_	_	40	_	86	_	87	_	_	76	66	_	92	95	_

1_ Urine isolates only

GRAM POSITIVE COCCI	Ampicillin	Clindamycin	Erythromycin	Levofloxacin[5]	Oxacillin	Rifampin	Tetracycline	Trimethoprim/sulfamethoxazole	Vancomycin
Enterococcus Group D (n = 42)	97	_	_	_	_	_	_	_	100
Staphylococcus aureus (n = 330)	_	78	43	78	58[6]	98	91	96	100
Staphylococcus spp., coagulase neg. (n = 63)	_	61	44	53	49[7]	92	68	83	100
Streptococcus Group B (n = 11)[2]	_	46[3]	38[4]	_	_		_	_	_

2_Only tested for penicillin allergic patients
3_54% resistant
4_62% resistant
5_*Staphylococcus* spp. may develop resistance during prolonged therapy with quinolones.
6_42 % oxacillin (methicillin) resistant
7_51% oxacillin (methicillin) resistant

Appendix E

PEDIATRIC OUTPATIENT SUSCEPTIBILITY PROFILE _ Percent Susceptible

GRAM NEGATIVE BACILLI	Amikacin	Ampicillin	Ampicillin/sulbactam	Aztreonam	Cefazolin	Cefepime	Cefotaxime	Ceftazidime	Ceftriaxone	Gentamicin	Imipenem	Levofloxacin	Nitrofurantoin[2]	Piperacillin/ tazobactam	Tobramycin	Trimethoprim/sulfamethoxazole
Enterobacter cloacae (n = 12)	100	25	66	100	8	100	100	100	58	100	91	100	50	100	100	91
Escherichia coli (n = 523)	100	49	58	98	95	98	98	97	93	93	99	88	94	94	94	65
Haemophilus influenzae (n =174)	_	71[1]	_	_	_	_	_	_	_	_	_	_	_	_	_	_
Klebsiella pneumoniae (n = 38)	100	_	92	100	97	100	100	100	92	100	100	100	21	97	100	86
Moraxella catarrhalis (n = 276)	_	1[1]	_	_	_	_	_	_	_	_	_	_	_	_	_	_
Proteus mirabilis (n =38)	100	81	86	97	94	97	97	97	97	100	_	97	_	100	100	89
Pseudomonas aeruginosa (n = 50)	100	_	_	_	_	94	_	94	_	_	94	88	_	96	100	_

1_ Based on beta-lactamase testing

2_ Urine isolates only

GRAM POSITIVE COCCI	Ampicillin	Cefotaxime CSF[4]	Cefotaxime Non- CSF[4]	Ceftriaxone CSF[4]	Ceftriaxone Non-CSF[4]	Clindamycin	Erythromycin	Levofloxacin[11]	Oxacillin	Penicillin CSF[4]	Penicillin Non_CSF[4]	Tetracycline	Trimethoprim/sulfamethoxazole	Vancomycin
Enterococcus Group D (n = 13)	100	_	_	_	_	_	_	_	_	_	_	_	_	100
Staphylococcus aureus (n = 344)	_	_	_	_	_	79	38	75	54[12]	_	_	93	98	100
Staphylococcus spp.,coagulase neg. (n = 19)	_	_	_	_	_	47	26	92	63[13]	_	_	84	73	100
Streptococcus pneumoniae (n = 193)	_	79[5]	97[6]	88[7]	97[8]	53	56	100	_	39[14]	75[15]	_	_	100
Streptococcus Group A (n = 34)[3]	_	_	_	_	_	91[9]	91[10]	_	_	_	_	_	_	_

3_Only tested for penicillin allergic patients.
4_Interpretive criteria for susceptibility of *S. pneumoniae* to penicillin and cephalosporins are different for CSF and non-CSF isolates.
5_18% intermediate;3% resistant
6_1% intermediate; 2% resistant
7_ 9% intermediate; 3% resistant
8_ 2 % intermediate;1% resistant
9,10_9% resistant
11_*Staphylococcus* spp. may develop resistance during prolonged therapy with quinolones.
12_46% oxacillin (methicillin) resistant
13_37% oxacillin (methicillin) resistant
14_61% resistant
15_3% intermediate; 19% resistant

Appendix F
Antimicrobial Susceptibilities

Organism Group	Antibiotic	Mnemonic	Reporting		
			Always Report	2nd Level Reporting	2nd Level Reporting Condition
Enterobacteriaceae (Gram Negative Bacilli)	amikacin	an		x	Report if Tobramycin AND Gentamicin are intermediate or resistant
Non-Urine Cx	amoxicillin/ clavulanic acid	amc		x	Report if Ampicillin is intermediate or resistant
	ampicillin	am	x		
	ampicillin/ sulbactam	sam		x	Report if Ampicillin is intermediate or resistant
	aztreonam	atm		x	Report if penicillin allergy, per physician request
	cefazolin	cz	x		
	cefepime	fep		x	Report if Cefotaxime is intermediate or resistant
	cefotaxime	ctx	x		
	ceftazidime	caz		x	Report if Cefotaxime is intermediate or resistant
	ceftriaxone	cro		x	Report for pediatrics, per physician request

Organism Group	Antibiotic	Mnemonic	Reporting		
			Always Report	2nd Level Reporting	2nd Level Reporting Condition
Enterobacteriaceae (Gram Negative Bacilli)	amikacin	an		x	Report if Tobramycin AND Gentamicin are intermediate or resistant
Urine Cx Only	amoxicillin/ clavulanic acid	amc		x	Report if Ampicillin is intermediate or resistant
	ampicillin	am	x		
	ampicillin/ sulbactam	sam		x	Report if Ampicillin is intermediate or resistant
	aztreonam	azm		x	Report if penicillin allergy, per physician request
	cefazolin	cz	x		
	cefepime	fep		x	Report if Cefotaxime is intermediate or resistant
	cefotaxime	ctx	x		
	ceftazidime	caz		x	Report if Cefotaxime is intermediate or resistant
	ceftriaxone	cro		x	Report for pediatrics, per physician request

Appendix F (cont.)

Organism Group	Antibiotic	Mnemonic	Reporting		
			Always Report	2nd Level Reporting	2nd Level Reporting Condition
	cefuroxime sodium	cxm		x	Report if Cefazolin is intermediate or resistant
	ertapenem	etp	x		
	gentamicin	gm	x		
	imipenem	imi		x	Report if Ceftazidime is intermediate or resistant
	levofloxacin	lev	x		
	piperacillin/ tazobactam	tzp	x		
	tobramycin	tm		x	Report if Gentamicin is resistant
	trimethoprim/ sulfamethoxazole	sxt	x		

Organism Group	Antibiotic	Mnemonic	Reporting		
			Always Report	2nd Level Reporting	2nd Level Reporting Condition
	cefuroxime sodium	cxm		x	Report if Cefazolin is intermediate or resistant
	ertapenem	etp	x		
	gentamicin	gm	x		
	imipenem	imi		x	Report if Ceftazidime is intermediate or resistant
	levofloxacin	lev	x		
	nitrofurantoin	ft	x		
	piperacillin/ tazobactam	tzp	x		
	tobramycin	tm		x	Report if Gentamicin is resistant
	trimethoprim/ sulfamethoxazole	sxt	x		

Appendix G

Table 1. Examples of Rapid Molecular Assays for Detection of Microorganisms

Organisms/Antimicrobial Resistance Targets	Antimicrobial Stewardship Program References	Detection Time (hrs)	Technology	Manufacturer	FDA Cleared	Trade Name
Staphylococcus aureus, CoNS	9–11	1.5	PNA FISH	AdvanDx	Yes	*S. aureus*/CNS PNA FISH
MSSA, MRSA, CoNS		2	PCR	BD GeneOhm	Yes	BD GeneOhm StaphSR
MSSA, MRSA, CoNS	12, 13	1	PCR	Cepheid	Yes	Xpert MRSA/SA BC
MSSA, MRSA		5.5	Bacteriophage amplification	MicroPhage	Yes	KeyPath MRSA/MSSA Blood Culture
Staphylococcus aureus, *Staphylococcus epidermidis*		2.5	Nucleic acid	Nanosphere	Yes	Verigene
Enterococcus faecalis, *Enterococcus faecium*	14	1.5	PNA FISH	AdvanDx	Yes	*Enterococcus faecalis*/OE PNA FISH
Escherichia coli, *Pseudomonas aeruginosa*, *Klebsiella pneumoniae*		1.5	PNA FISH	AdvanDx	Yes	GNR Traffic Light PNA FISH
Clostridium difficile		1	LAMP	Meridian Bioscience	Yes	illumigene *C. difficile*
Clostridium difficile		2	PCR	BD GeneOhm	Yes	BD GeneOhm Cdiff
Clostridium difficile		0.75	PCR	Cepheid	Yes	Xpert *C. difficile*
Clostridium difficile		0.75	PCR	Cepheid	Yes	Xpert *C. diff*/Epi
Clostridium difficile		3	PCR	Gen-Probe desse	Yes	Progastro Cd
Candida albicans, *Candida parapsilosis*, *Candida tropicalis*, *Candida glabrata*, *Candida krusei*	15, 16	1.5	PNA FISH	AdvanDx	Yes	Yeast Traffic Light PNA FISH
Multiple bacterial and fungal pathogens		6 (direct from blood prior to culture)	PCR	Roche Molecular Systems	No	LightCycler SeptiFast Test MGRADE
Multiple bacterial and fungal pathogens		0.2	MALDI-TOF	Bruker Daltonics Inc.	No	*MALDI* Biotyper

PNA = peptide nucleic acid; FISH = fluorescence in situ hybridization; CoNS = coagulase-negative staphylococci; PCR = polymerase chain reaction; MSSA = methicillin-susceptible *S. aureus*; MRSA = methicillin-resistant *S. aureus*; LAMP = loop-mediated isothermal amplification; MALDI-TOF = matrix-assisted laser desorption ionization-time of flight.