From Pathogens to Prescriptions:

Foundations of Antimicrobial Therapy

April 2026

What does “Pathogens to Prescriptions” really mean?

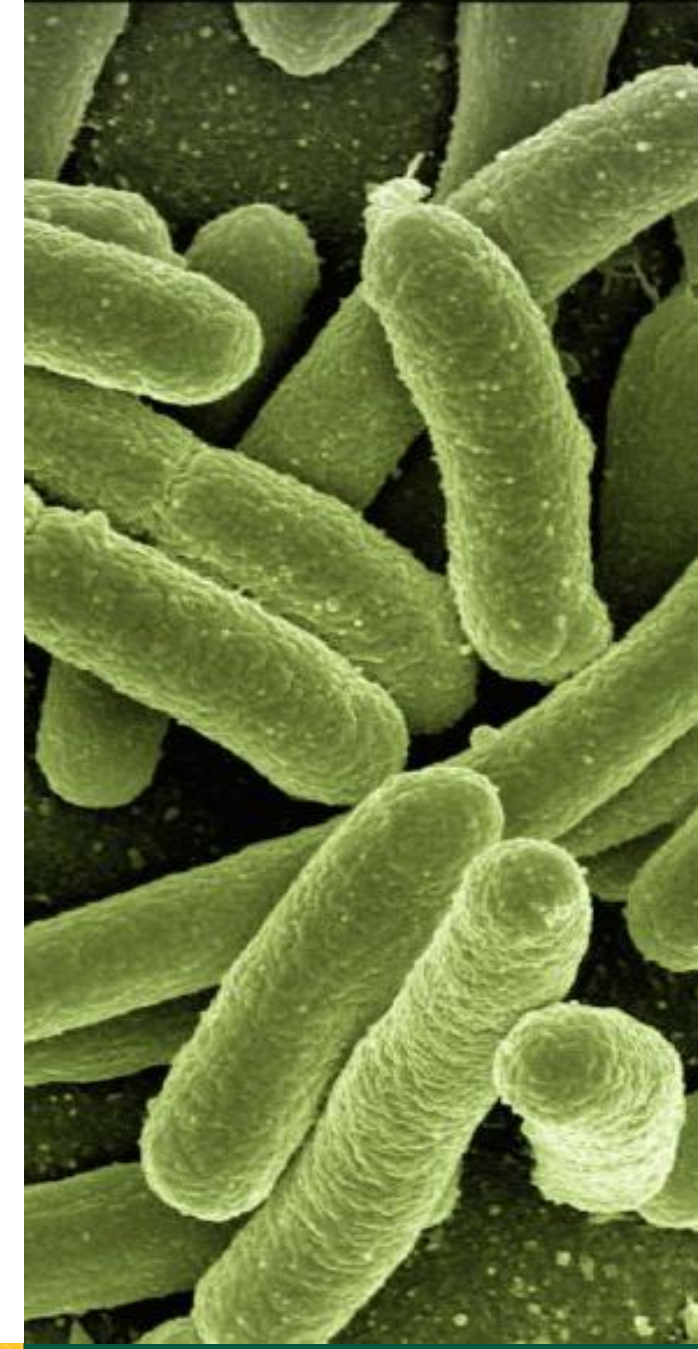
Basically: Bug to Drug

Why it matters:

- Prevents resistance
- Improves patient outcomes
- Reduces adverse effects

Objectives:

- Review principles of antibiotic selection
- Identify common pathogens and the type of infections they cause
- Analyze common outpatient antibiotics and their spectrum of activity



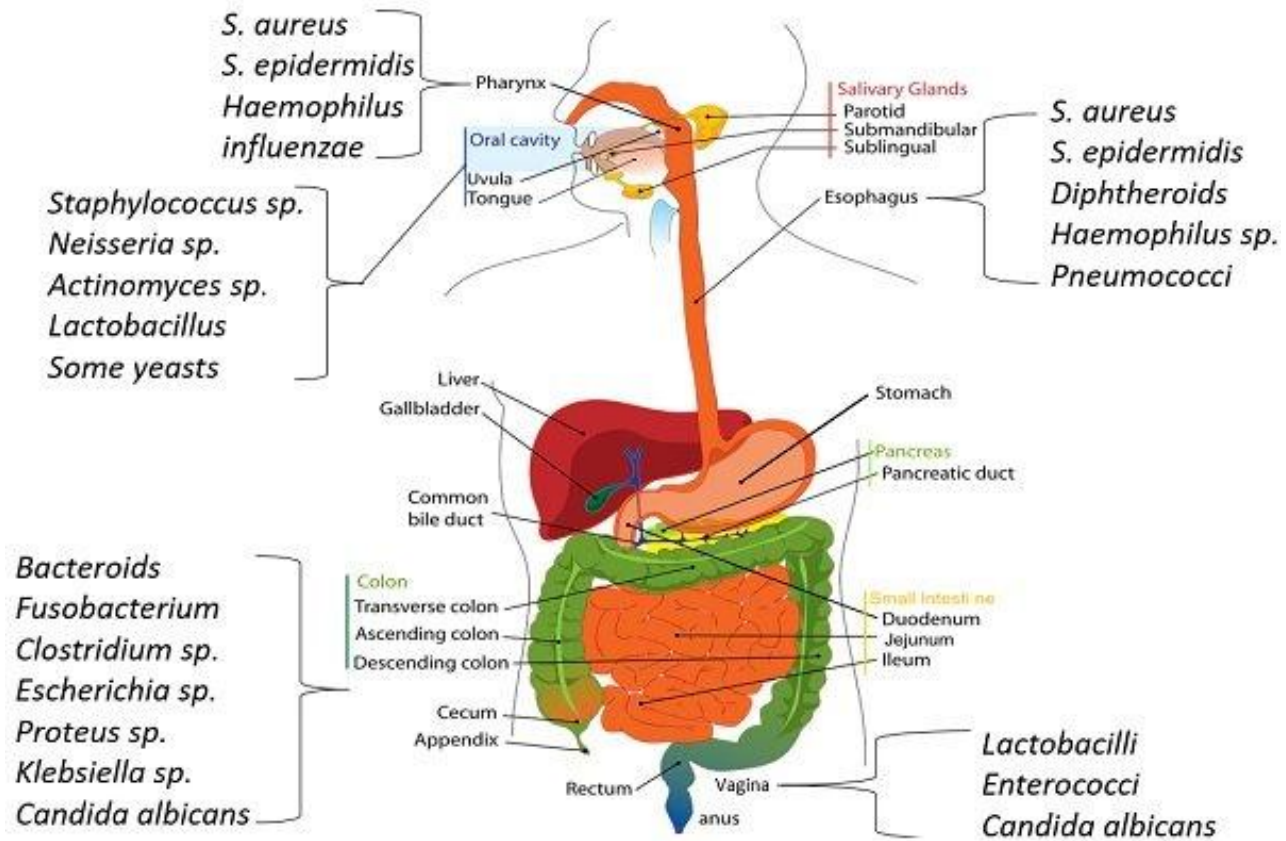
Principles of Antibiotic Selection

The 4 Moments of Antibiotic Decision-Making (per CDC framework)

1. Does the person have an infection that requires antibiotics?
2. Have appropriate cultures been collected before starting antibiotics?
3. What empiric therapy should be started?
4. Can the antibiotic be stopped or narrow therapy based on data?

Key Considerations

- Site of Infection
- Likely Pathogen
- Local Resistance Patterns
  - Review Antibiogram
- Patient Factors
  - Allergies
  - Renal/hepatic function
  - Comorbidities



Distribution of normal flora of the human body

Stages of Antimicrobial Therapy

Prophylaxis

- Antimicrobial given to prevent an infection that hasn't happened yet, but is likely to happen without medication
- Immunocompromised patients, pre-procedural

Empiric therapy

- Based upon body location, most common pathogens in that area, and symptoms

Definitive therapy

- After culture/sensitivity results are known

Common Pathogens

A little microbiology review

Microbiology Review

Gram-positive bacteria

•Thick peptidoglycan layer, retain crystal violet stain (purple)

Gram-negative bacteria

•Thin peptidoglycan layer, stain pink on gram stain

Fungi

•Yeast & Molds

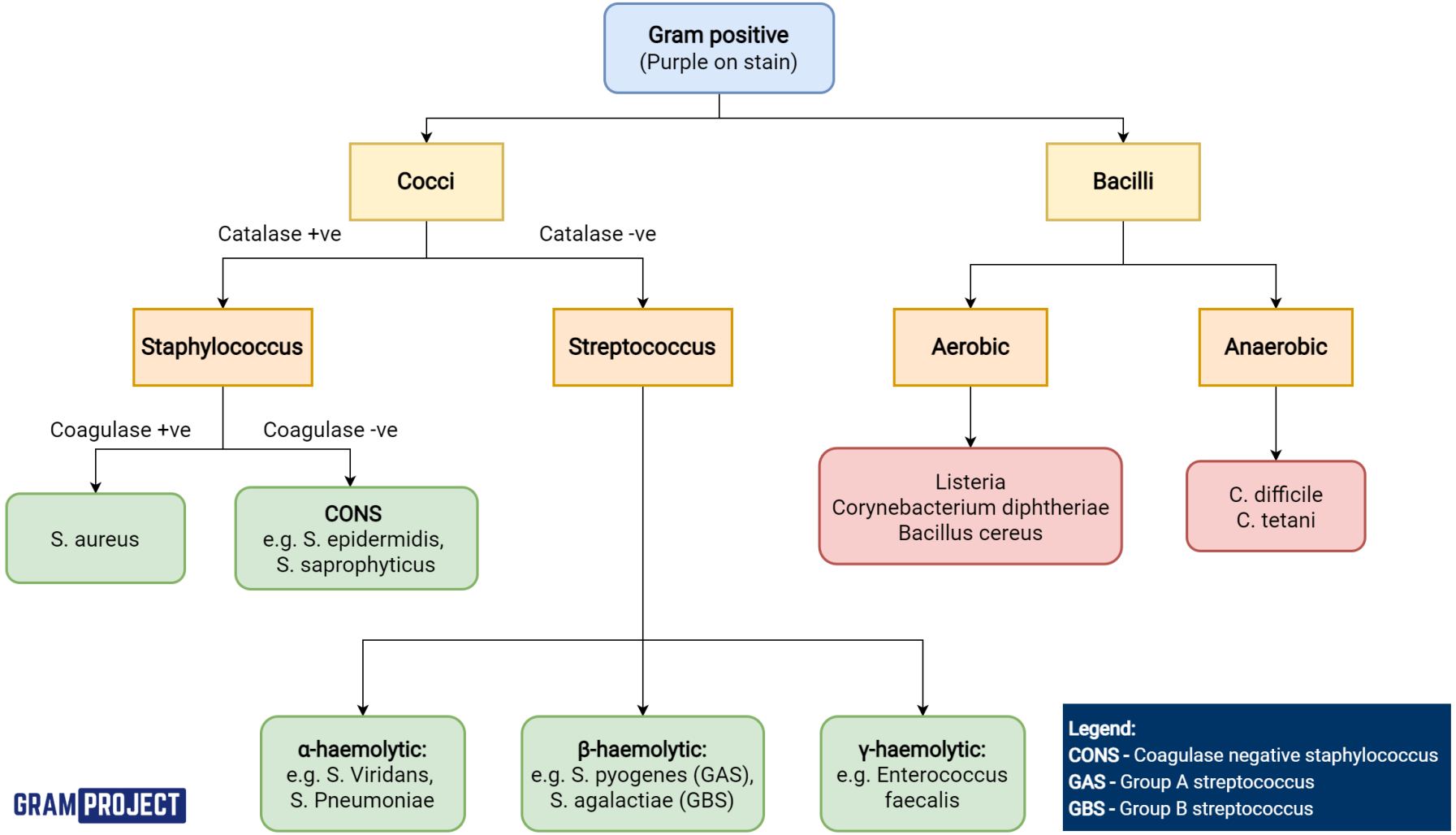
•Can be single celled or very complex multicellular organisms

Viruses

•Require a living host cell to replicate

What pathogens do you commonly encounter in your practice?

Gram Positive Bacteria



GRAM PROJECT

https://gramproject.com/diagram/gram-positive-bacteria/

Gram Positive Bacteria

Staphylococcus

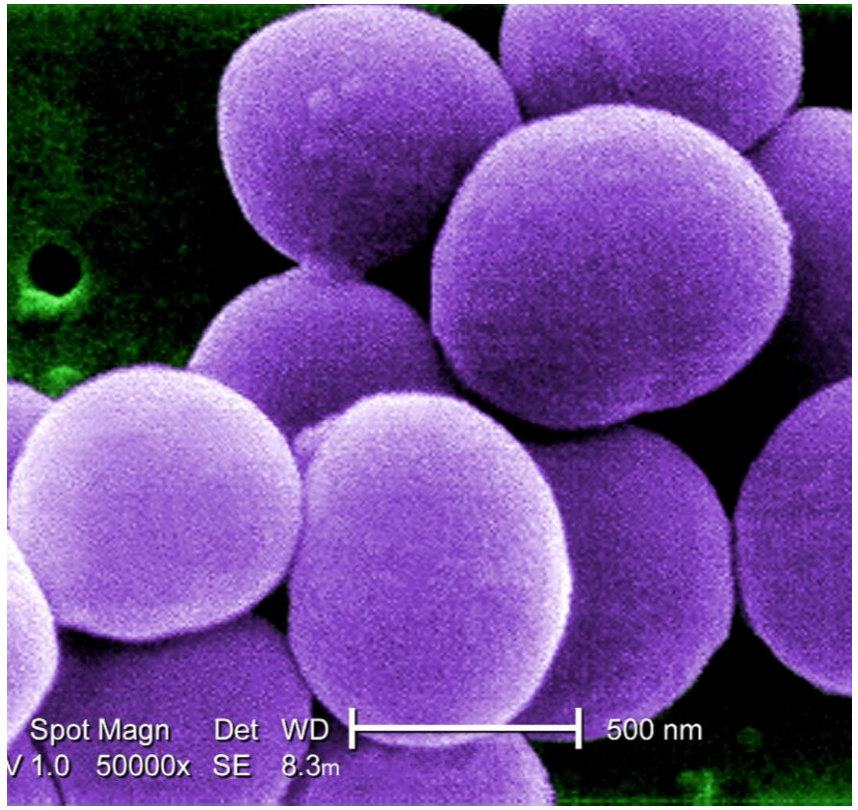
S. aureus

- Causes skin/soft tissue infections, bone/joint infections, endocarditis
- Can be methicillin susceptible or resistant (MSSA vs MRSA)

S. Epidermidis

- Usually a colonizer
- May cause infections associated with prostheses and IV lines

- Both may colonize skin and nares
- Both will produce sticky biofilm and may lead to widespread invasive infections



Treatment Options

MSSA

ORAL: Cephalexin, cefadroxil, dicloxacillin, amoxicillin/clavulanate

IV: Cefazolin, oxacillin, nafcillin

MRSA

Oral: SMX/TMP, doxycycline, clindamycin, linezolid

IV: Vancomycin, daptomycin, ceftaroline

Image from prescribingpractice.com Accessed March 2026

Infection Prevention Considerations

Staphylococcus

Transmission Based Precautions

- MSSA: Standard
- MRSA (multi-drug resistant organism): Standard and Contact precautions

Tip: Flag charts as MRSA for staff awareness

Vancomycin resistant and intermediate resistance *S. aureus* is a reportable disease

Infection/Condition	Type of Precaution	Duration of Precaution	Precautions/Comments
Staphylococcal disease (*S. aureus*) Skin, wound, or burn Major	Contact + Standard	Duration of illness	Until drainage stops or can be contained by dressing.
Staphylococcal disease (*S. aureus*) Skin, wound, or burn Minor or limited	Standard		If dressing covers and contains drainage adequately.
Staphylococcal disease (*S. aureus*) Enterocolitis	Standard		Use Contact Precautions for diapered or incontinent children for duration of illness.
Staphylococcal disease (*S. aureus*) Multidrug-resistant (see Multidrug-Resistant Organisms)			
Staphylococcal disease (*S. aureus*) Pneumonia	Standard		
Staphylococcal disease (*S. aureus*) Scalded skin syndrome	Contact + Standard	Duration of illness	Consider healthcare personnel as potential source of nursery, NICU outbreak [1095].
Staphylococcal disease (*S. aureus*) Toxic shock syndrome	Standard		

Gram Positive Bacteria

Streptococcus

Beta hemolytic

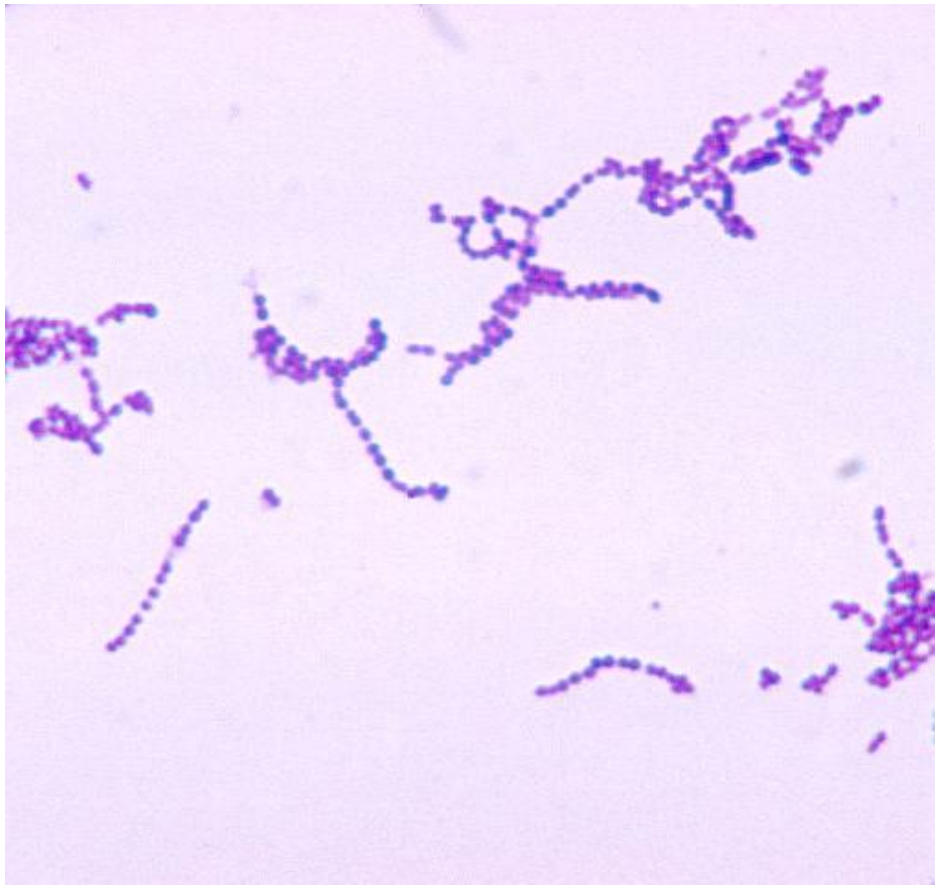
S. pyogenes (Group A strep)

S. agalactae (Group B strep)

Alpha hemolytic

S. viridans

- Colonize skin, mouth (*S. viridans*), and female reproductive tract (*S. agalactae*)
- Infections:
  - Skin and soft tissue infections
  - Neonatal sepsis
  - Bone/joint infection
  - Endocarditis
  - Upper respiratory (pharyngitis, otitis media, sinusitis, bronchitis)
  - Pneumonia



Gram Positive Bacteria

Streptococcus pneumoniae

Transmission Based Precaution

- Dependent on source

Prevent infection with pneumococcal conjugate vaccine (PCV)

Infection/Condition	Type of Precaution	Duration of Precaution	Precautions/Comments
Streptobacillus moniliformis disease (rat-bite fever)	Standard		Not transmitted from person to person.
Streptococcal disease (group A *Streptococcus*) Skin, wound, or burn Major	Contact + Droplet + Standard	Until 24 hours after initiation of effective therapy	Until drainage stops or can be contained by dressing.
Streptococcal disease (group A *Streptococcus*) Skin, wound, or burn Minor or limited	Standard		If dressing covers and contains drainage.
Streptococcal disease (group A *Streptococcus*) Endometritis (puerperal sepsis)	Standard		
Streptococcal disease (group A *Streptococcus*) Pharyngitis in infants and young children	Droplet + Standard	Until 24 hours after initiation of effective therapy	
Streptococcal disease (group A *Streptococcus*) Pneumonia	Droplet + Standard	Until 24 hours after initiation of effective therapy	
Streptococcal disease (group A *Streptococcus*) Scarlet fever in infants and young children	Droplet + Standard	Until 24 hours after initiation of effective therapy	
Streptococcal disease (group A *Streptococcus*) Serious invasive disease	Droplet + Standard	Until 24 hours after initiation of effective therapy	Outbreaks of serious invasive disease have occurred secondary to transmission among patients and healthcare personnel [162, 972, 1096-1098]. Contact Precautions for draining wound as above; follow recommendations for antimicrobial prophylaxis in selected conditions [160].
Streptococcal disease (group B *Streptococcus*), neonatal	Standard		
Streptococcal disease (not group A or B) unless covered elsewhere Multidrug-resistant (see Multidrug-Resistant Organisms)			

Gram Positive-Enterococci

E. Faecalis

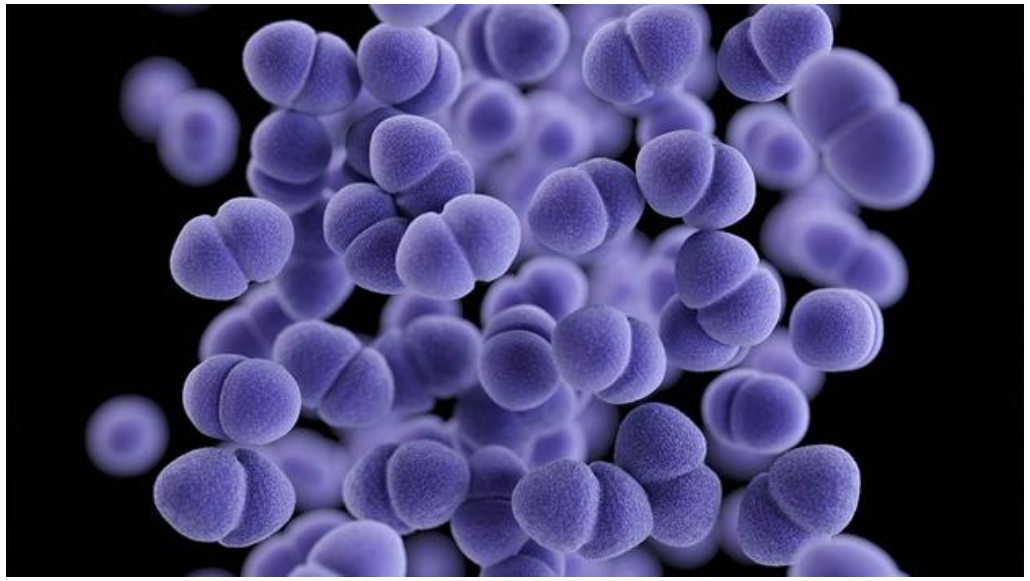
More common

Less likely to be vancomycin resistant (VRE)

E. Faecium

Less common

More likely to be VRE



- May colonize lower GI tract
- May cause UTI, intraabdominal infections, meningitis, and endocarditis
- Susceptible to only a selected number of antibiotics

  Especially *E. faecium*

Antibiogram

INPATIENT ORGANISMS	Isolates Tested	PCN G IV (nonmeningitis)	PCN (meningitis and PO dosing)	Ampicillin	Oxacillin	Ampicillin/sulbactam	Piperacillin/tazobactam	Cefazolin (non-urine)	Cefazolin (urine)	Ceftriaxone (non-meningitis)	Ceftriaxone (Meningitis)	Ceftazidime	Cefepime	Meropenem	Gentamicin1	Tobramycin	Levofloxacin	Ciprofloxacin	Vancomycin	Clindamycin	TMP/SMX	Doxycycline	Nitrofurantoin (Urine isolates only)
Enterococcus faecalis	87			100											80		85	85	100				100
Enterococcus faecium	24			13											96		9	9	50				39

Gram-positive % susceptible	No. Isolates	Penicillin IV (non-meningitis/ meningitis)	Penicillin	Ampicillin	Oxacillin	Piperacillin/tazobactam	Cefotaxime/Ceftriaxone (non-meningitis/meningitis)	Erythromycin	TMP/SXT	Clindamycin	Doxycycline/Tetracycline	Vancomycin	Linezolid	Daptomycin[4]	Nitrofurantoin (Urine only)
E. faecalis	359			100		See amp						99	98	100	100
E. faecium	57			28								61	97	Not tested	30

Infection Prevention Considerations

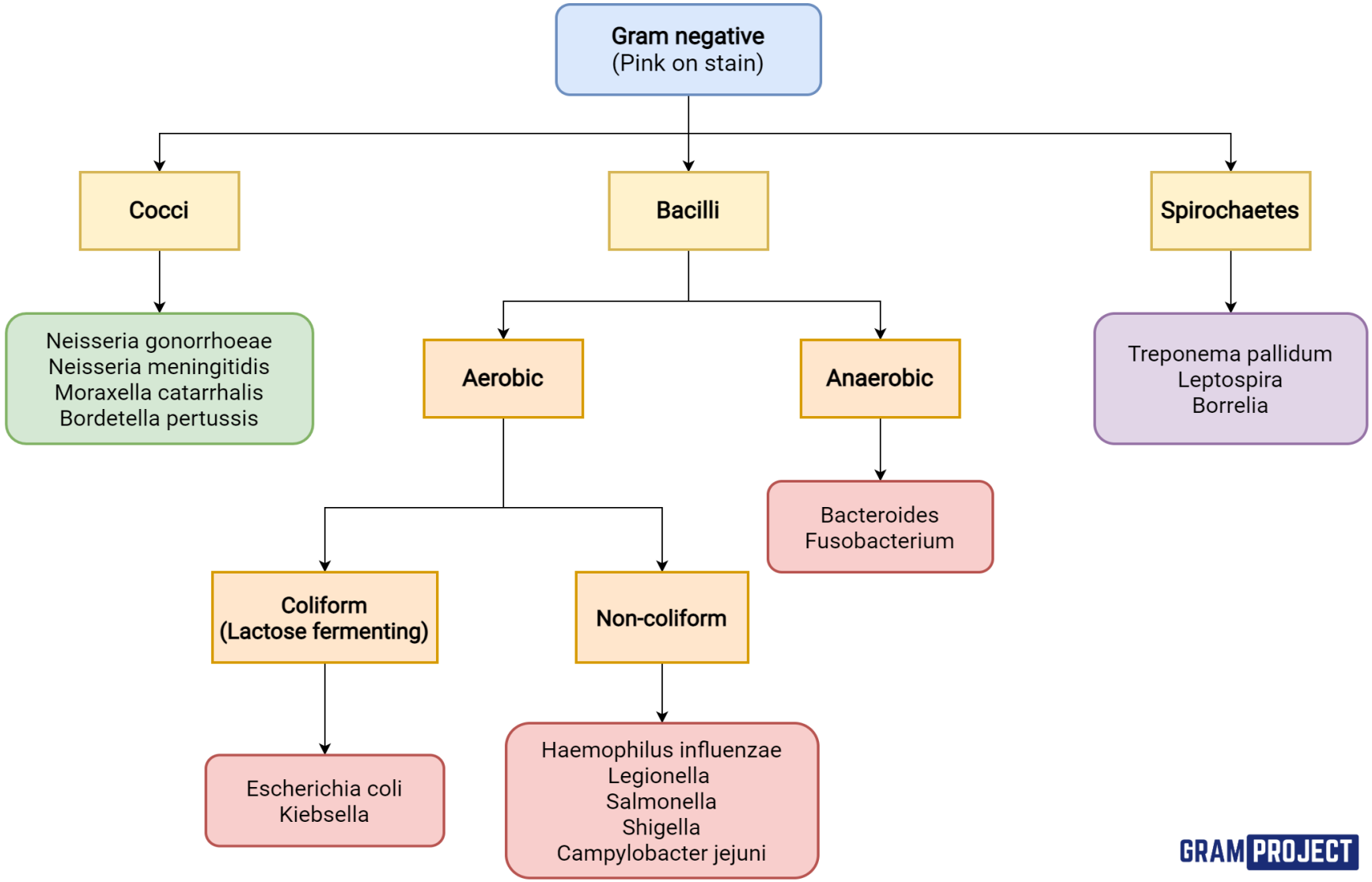
Enterococci

Transmission Based Precautions

- Non-vancomycin resistant enterococci
  - Standard precautions
- VRE
  - Standard and contact precautions
  - Reportable to NDHHS
  - Flag chart for staff awareness

Infection/Condition	Type of Precaution	Duration of Precaution	Precautions/Comments
Multidrug-resistant organisms (MDROs), infection or colonization (e.g., MRSA, VRE, VISA/VRSA, ESBLs, resistant *S. pneumoniae*)	Contact + Standard		MDROs judged by the infection control program, based on local, state, regional, or national recommendations, to be of clinical and epidemiologic significance. Contact Precautions recommended in settings with evidence of ongoing transmission, acute care settings with increased risk for transmission or wounds that cannot be contained by dressings. See recommendations for management options in Management of Multidrug-Resistant Organisms In Healthcare Settings, 2006 [870]. Contact state health department for guidance regarding new or emerging MDRO.

Gram Negative Bacteria



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https://gramproject.com/diagram/gram-negative-bacteria/

Gram Negative Bacilli

Endogenous

Part of normal GI tract

May colonize upper respiratory tract of hospitalized patients

May cause:

- UTIs
- Respiratory tract infection
- Intra-abdominal infections
- Diabetic lower extremity infections

Escherichia coli

Serratia sp.

Citrobacter sp.

Klebsiella sp.

Proteus sp.

Enterobacter sp.

Gram Negative Bacteria

Exogenous

NOT colonizers

Contracted from other sources

May cause:

- Upper and lower respiratory infections
  - *H. influenzae*
  - *M. catarrhalis*
  - *Acinetobacter sp.*
- Sexually transmitted disease
  - *N. gonorrhea*
- Bacterial meningitis
  - *N. meningitidis*

Haemophilus influenzae

Moraxella catarrhalis

Acinetobacter sp.

Neisseria meningitidis

Neisseria gonorrhea

Gram Negative Pseudomonas

Pseudomonas aeruginosa

- Not a normal human colonizer
  - May colonize GI tract in 10-20%
  - May colonize respiratory tract of some patient
    - Cystic fibrosis
    - Hospitalized patients
- Colonizes inanimate objects
  - Water
  - Medical equipment
- Opportunistic pathogen

Gram Negative Pseudomonas

Pseudomonas aeruginosa

May cause

- UTI's
- Pneumonia
- Intra-abdominal infections
- Diabetic lower extremity infections

"Hospital bug"

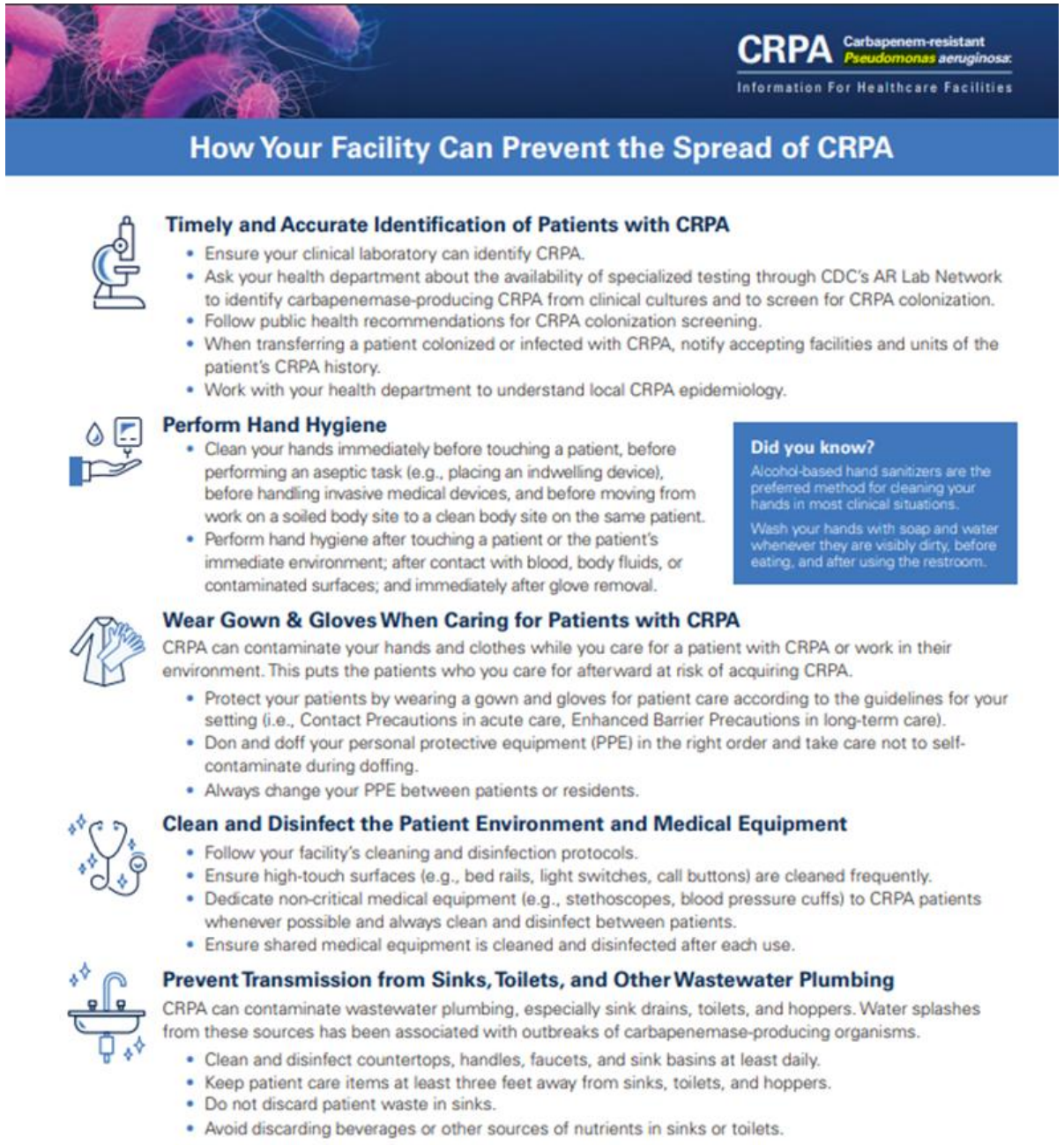
- More common in patients who have received multiple courses of antibiotics or exposed to the healthcare system

Infection Prevention Considerations

Pseudomonas aeruginosa

Transmission Based Precautions:

- Contact vs Enhanced Barrier Precautions
- If carbapenem resistant, reportable to NDHHS
- Important to clean and disinfect patient environment and medical equipment
- Prevent transmission from sinks, toilets, and other wastewater plumbing



CRPA Carbapenem-resistant *Pseudomonas aeruginosa*: Information For Healthcare Facilities

How Your Facility Can Prevent the Spread of CRPA

Timely and Accurate Identification of Patients with CRPA

- Ensure your clinical laboratory can identify CRPA.
- Ask your health department about the availability of specialized testing through CDC's AR Lab Network to identify carbapenemase-producing CRPA from clinical cultures and to screen for CRPA colonization.
- Follow public health recommendations for CRPA colonization screening.
- When transferring a patient colonized or infected with CRPA, notify accepting facilities and units of the patient's CRPA history.
- Work with your health department to understand local CRPA epidemiology.

Perform Hand Hygiene

- Clean your hands immediately before touching a patient, before performing an aseptic task (e.g., placing an indwelling device), before handling invasive medical devices, and before moving from work on a soiled body site to a clean body site on the same patient.
- Perform hand hygiene after touching a patient or the patient's immediate environment; after contact with blood, body fluids, or contaminated surfaces; and immediately after glove removal.

Did you know?

Alcohol-based hand sanitizers are the preferred method for cleaning your hands in most clinical situations.

Wash your hands with soap and water whenever they are visibly dirty, before eating, and after using the restroom.

Wear Gown & Gloves When Caring for Patients with CRPA

CRPA can contaminate your hands and clothes while you care for a patient with CRPA or work in their environment. This puts the patients who you care for afterward at risk of acquiring CRPA.

- Protect your patients by wearing a gown and gloves for patient care according to the guidelines for your setting (i.e., Contact Precautions in acute care, Enhanced Barrier Precautions in long-term care).
- Don and doff your personal protective equipment (PPE) in the right order and take care not to self-contaminate during doffing.
- Always change your PPE between patients or residents.

Clean and Disinfect the Patient Environment and Medical Equipment

- Follow your facility's cleaning and disinfection protocols.
- Ensure high-touch surfaces (e.g., bed rails, light switches, call buttons) are cleaned frequently.
- Dedicate non-critical medical equipment (e.g., stethoscopes, blood pressure cuffs) to CRPA patients whenever possible and always clean and disinfect between patients.
- Ensure shared medical equipment is cleaned and disinfected after each use.

Prevent Transmission from Sinks, Toilets, and Other Wastewater Plumbing

CRPA can contaminate wastewater plumbing, especially sink drains, toilets, and hoppers. Water splashes from these sources has been associated with outbreaks of carbapenemase-producing organisms.

- Clean and disinfect countertops, handles, faucets, and sink basins at least daily.
- Keep patient care items at least three feet away from sinks, toilets, and hoppers.
- Do not discard patient waste in sinks.
- Avoid discarding beverages or other sources of nutrients in sinks or toilets.

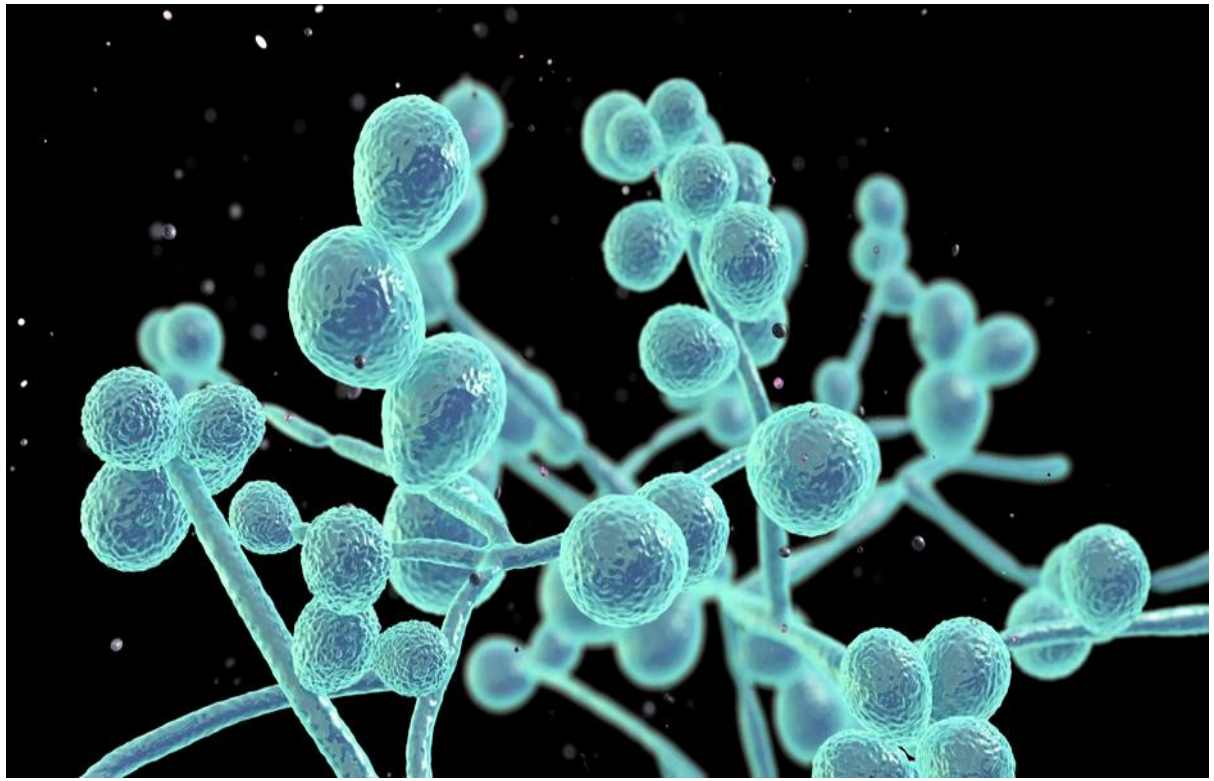
Fungi

Candida Auris

Can live on surfaces for a long time

Transmitted person-to-person, via contaminated surfaces or medical equipment

Causes ear infections, UTIs, wound infections, or bloodstream infections



Infection Prevention Considerations

C. auris

Immediately report any confirmed *C. auris* test results to the public health department.

Transmission Based Precautions

- Contact precautions/Enhanced barrier precautions
- Dedicated medical equipment
- Flag charts for staff awareness and communicate *C. auris* status during transfers
- Ensure cleaning/disinfecting agents are on EPA list P

Outbreaks

- May need to screen patients/residents for *C. auris* colonization
- Use the same infection control measures for patients found to be colonized.

Common Antibiotics

What antibiotic does your facility use the most?

Common Antibiotics

Beta-lactam antibiotics

Beta-lactam Antibiotics

Penicillin & cephalosporins

Tend to accumulate well at sites of infection:

- Respiratory tract
- Urinary tract (most in very high concentrations)

Toxicity is pretty minimal

- Diarrhea is fairly common
- Allergy is the most common major issue

Most are inexpensive, available in liquid, usually taste OK to good

Beta-Lactam Antibiotic

Amoxicillin

Dosing: Usually twice daily
Toxicity: Minimal (Allergy)
C. Diff risk: Low

Guideline Recommendations
First line for:

- Pediatric acute otitis media
- Pediatric acute bacterial sinusitis
- Streptococcal pharyngitis
- CAP (if "healthy" individual)

Should be most commonly prescribed antibiotic, especially in pediatrics

Beta-Lactam Antibiotic

Amoxicillin-Clavulanate

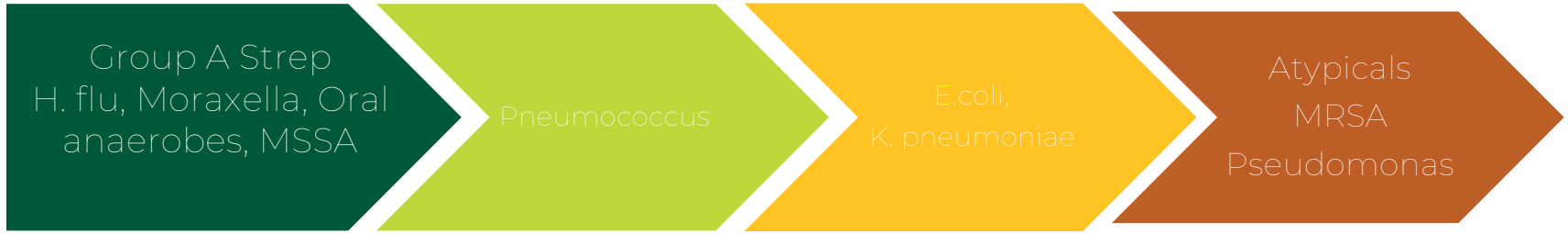
Dosing: Usually twice daily
Toxicity: Allergy/Diarrhea
C. Diff risk: Low-moderate

Guideline Recommendations
First line for:

- Acute bacterial sinusitis
- Adult CAP
- COPD exacerbation
- Bite wound (prophylaxis or treatment)

*Should be commonly prescribed

*Adds H. flu, Moraxella and anaerobic coverage to Amoxicillin



Beta-Lactam Antibiotic

Cephalexin

Dosing: Three to four time a day dosing (twice daily for strep throat)
Toxicity: Well tolerated
C. Diff risk: Low

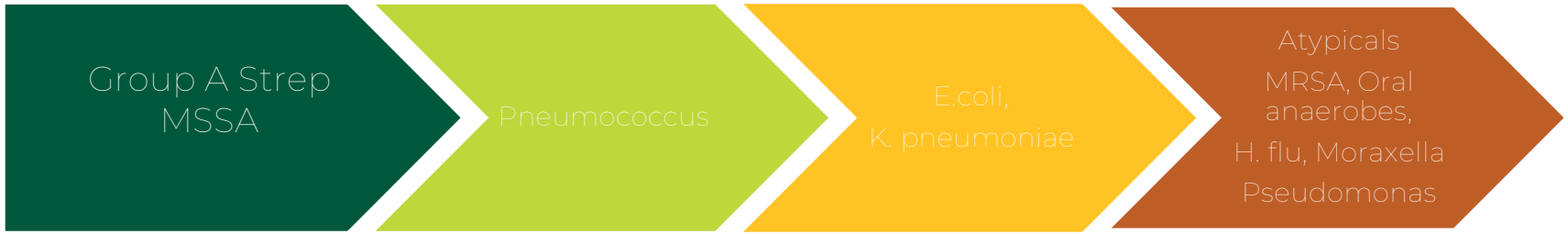
Guideline Recommendations
First line for:

- Cellulitis and erysipelas
- Abscess with low risk of MRSA

Also commonly used for:

- Non severe UTI
- Streptococcal pharyngitis

*High urinary concentrations thus can use for E.coli and other gram negative UTI's.



Beta-Lactam Antibiotic

Cefdinir

Dosing: Usually twice daily, may be daily
Toxicity: Diarrhea (turns stool red)
C. Diff risk: Moderate

Guideline Recommendations
First line for:

- NOTHING

Commonly used when amox or amox/clav is first line but there is a penicillin allergy

Only 10-20% is excreted in urine but is often used for UTIs

Other Common Antibiotics

Macrolide Antibiotic

Azithromycin

Dosing: Long half life Max duration 5 days
Toxicity: Some nausea, vomiting, diarrhea, QT prolongation
C. Diff risk: Very low

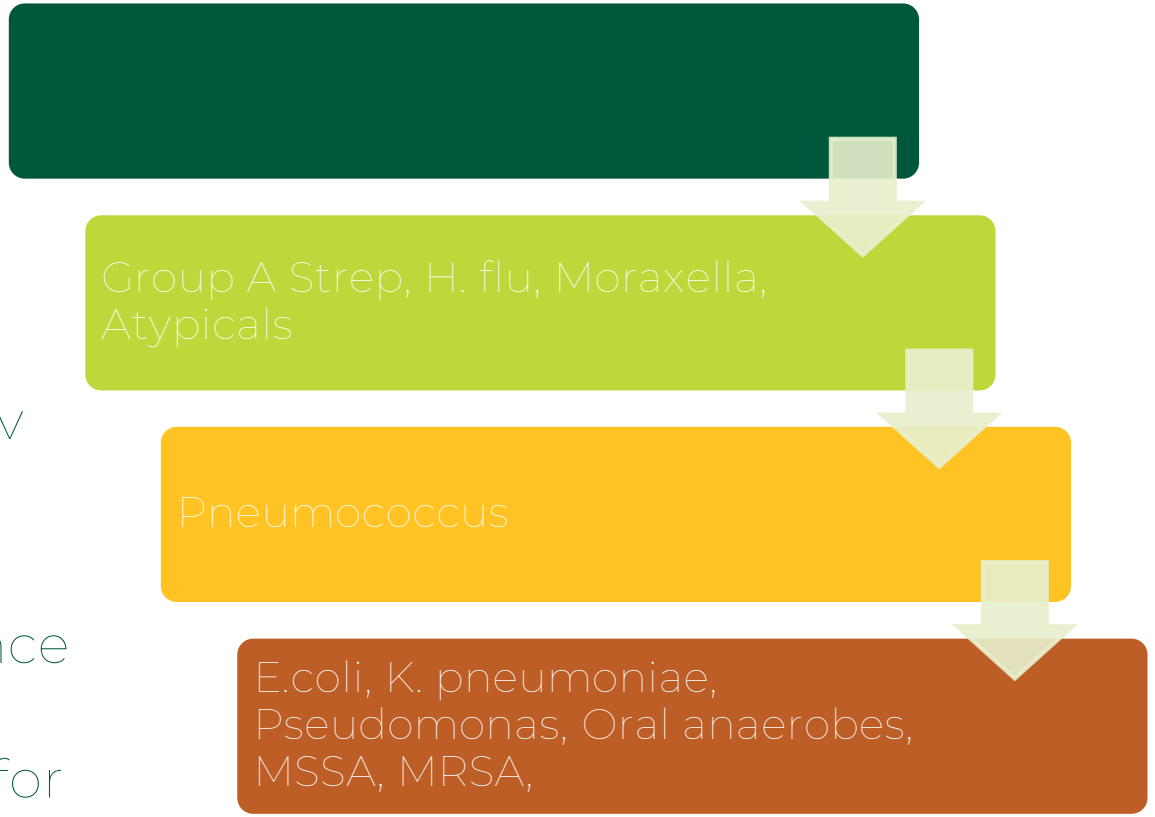
Guideline Recommendations
First line for:

- Adult CAP in combination with Amox/clav
- COPD Exacerbation
- Pertussis

Commonly used for:

- Bacterial Diarrhea
- Streptococcal pharyngitis (watch resistance rates)

Used for atypical coverage and in combination for respiratory infections



Lincosamide Antibiotic

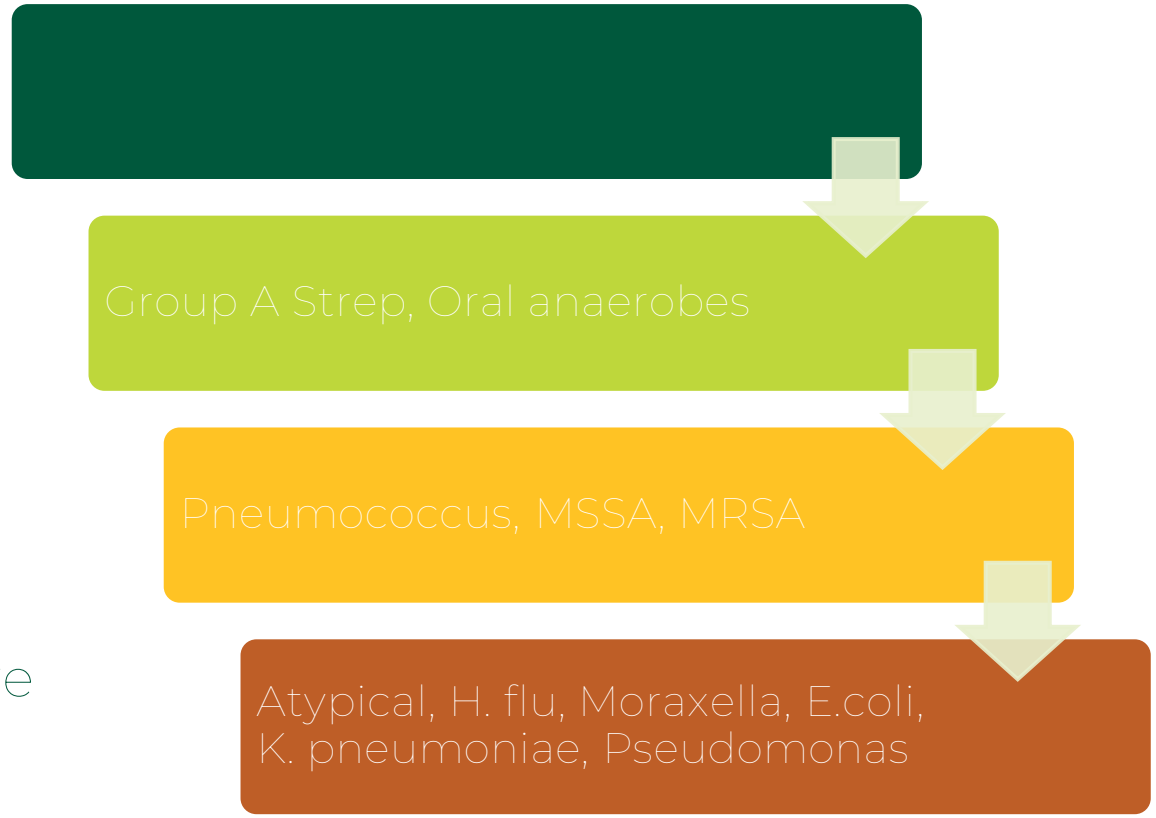
Clindamycin

Dosing: Three times a day
Toxicity: GI intolerance and diarrhea common
C. Diff risk: HIGH

Guideline Recommendations
Commonly used for:

- Dental infections and streptococcal pharyngitis when a beta-lactam alternative needed
- Skin and soft-tissue infections

NOTE: Rising resistance in *S. aureus*



Folate Antagonist Antibiotic

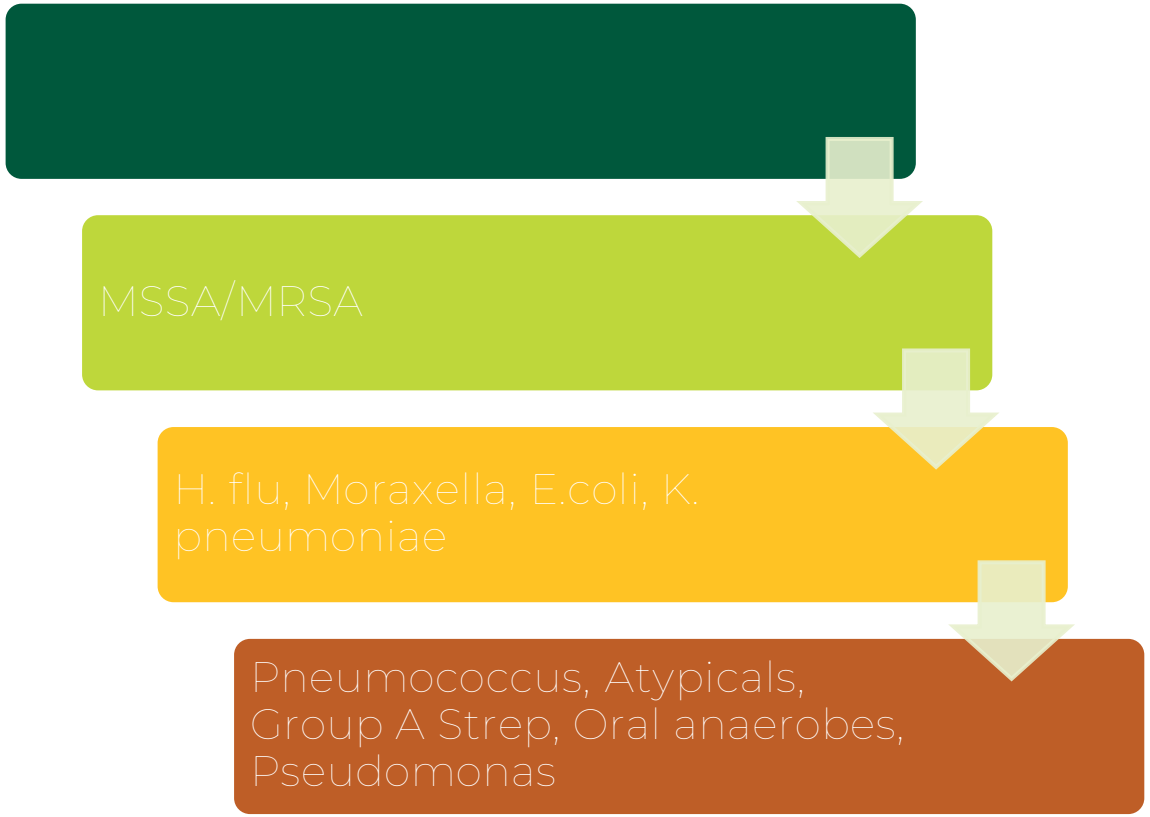
Trimethoprim-Sulfamethoxazole

Dosing: Twice a day
Need to adjust if GFR <30
Toxicity: Rare/severe (Stevens-Johnson, neutropenia, anaphylaxis), Hyperkalemia(esp. in renal dysfunction)
C. Diff risk:Low

Guideline Recommendations
Commonly used for:

- UTI
- Purulent Skin and soft-tissue infections

Excellent for *S. aureus*, including MRSA



Tetracycline Antibiotic

Doxycycline

Dosing: Twice a day
Toxicity: Teeth staining in children (rare) May be teratogenic (rare)
C. Diff risk: Low

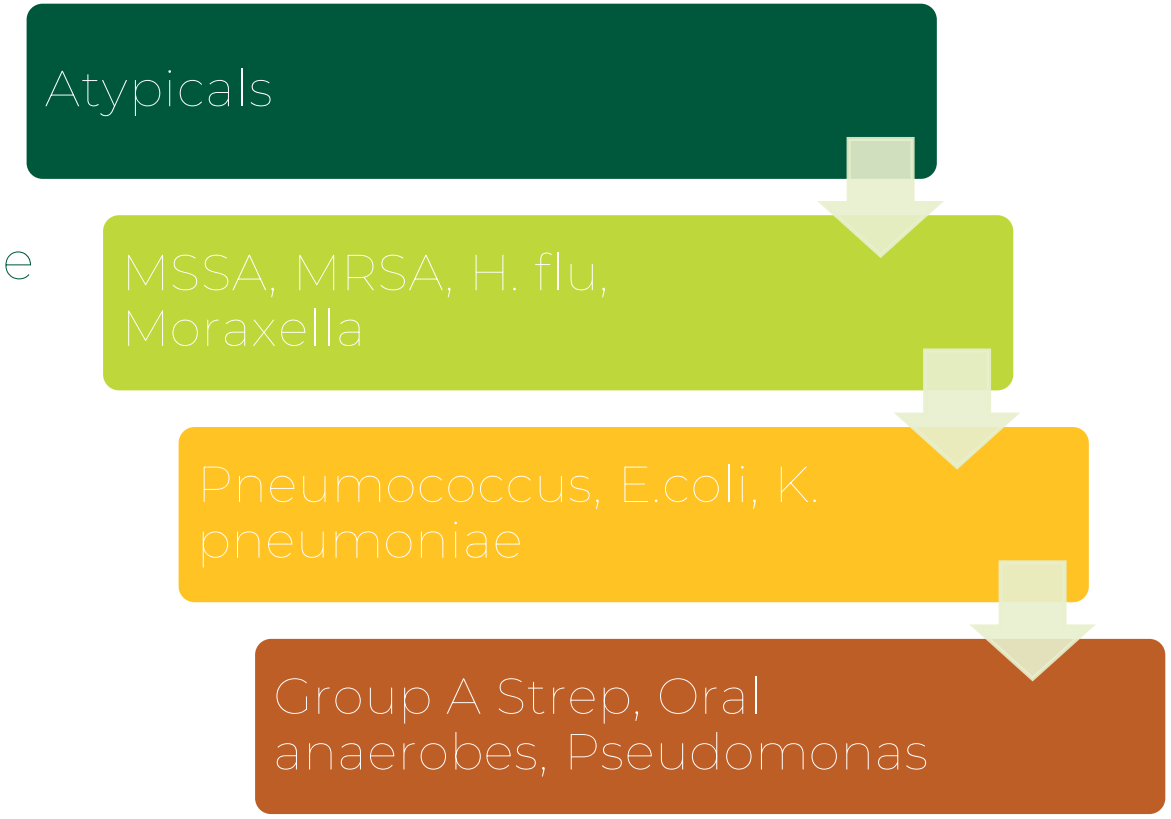
Guideline Recommendations
First line for:

- Ehrlichiosis and Lyme
- Chlamydia

Commonly used for:

- CAP
- Acute bacterial sinusitis
- Syphilis
- Skin and soft-tissue infections

Gram negative coverage is questionable



Fluoroquinolones

Advantages

Excellent oral bioavailability and good half-life

Favorable dosing schedules:

- Ciprofloxacin twice daily
- Levofloxacin daily

Adverse effects uncommon

Good distribution, great for urine

Oral option for pseudomonas coverage

Disadvantages

Rapid development of resistance

- Typically via target mutation
- S. aureus can develop resistance on therapy → AVOID

High risk for C. difficile

Toxicity is rare but can be severe:

- QT prolongation
- Aortic aneurysm or dissection
- Tendinopathy, tendon rupture
- Neurologic adverse effects – seizures, hallucinations, delirium, peripheral neuropathy

Fluoroquinolone Antibiotic

Ciprofloxacin

Dosing: Twice a day
Toxicity: Several
C. Diff risk: HIGH

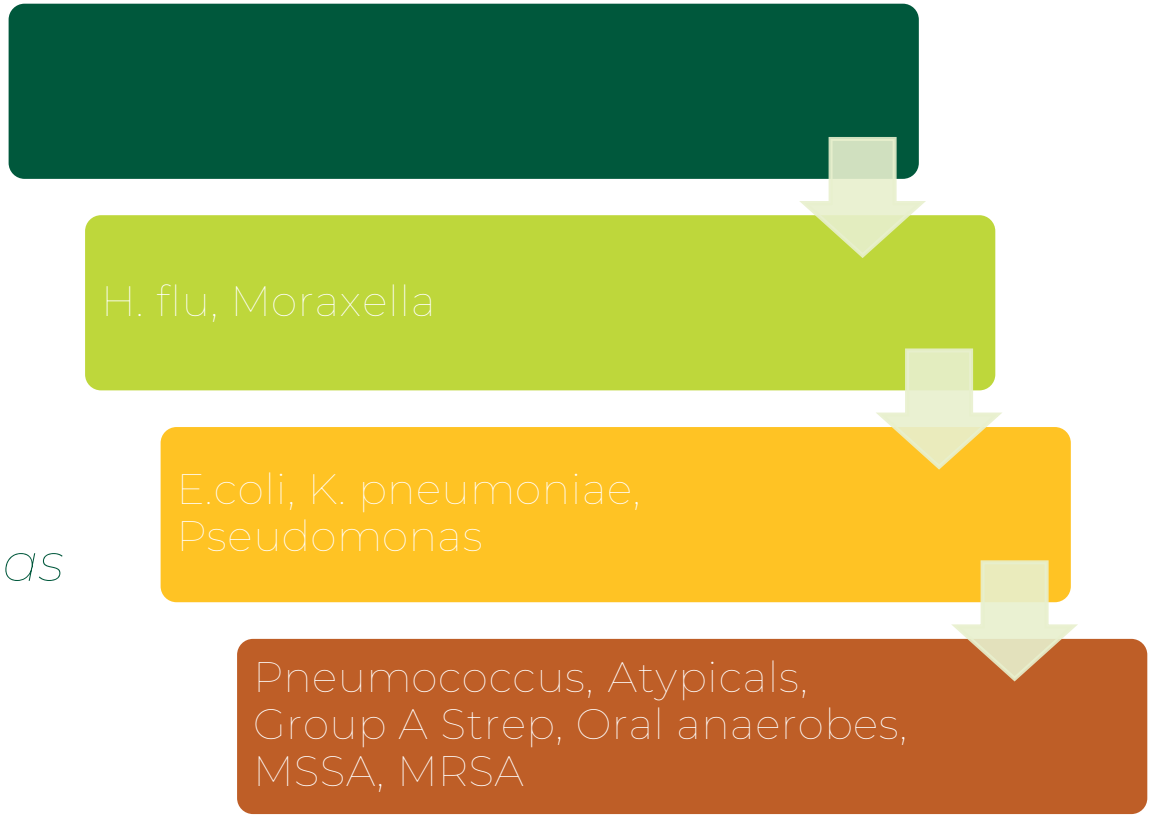
Guideline Recommendations
First line

- Only if allergy or need ORAL *pseudomonas* coverage

Commonly used for:

- UTI, especially pyelonephritis
- Intra-abdominal infections
- Wounds with *Pseudomonas* risk

Of note: Increasing resistance developing



Fluoroquinolone Antibiotic

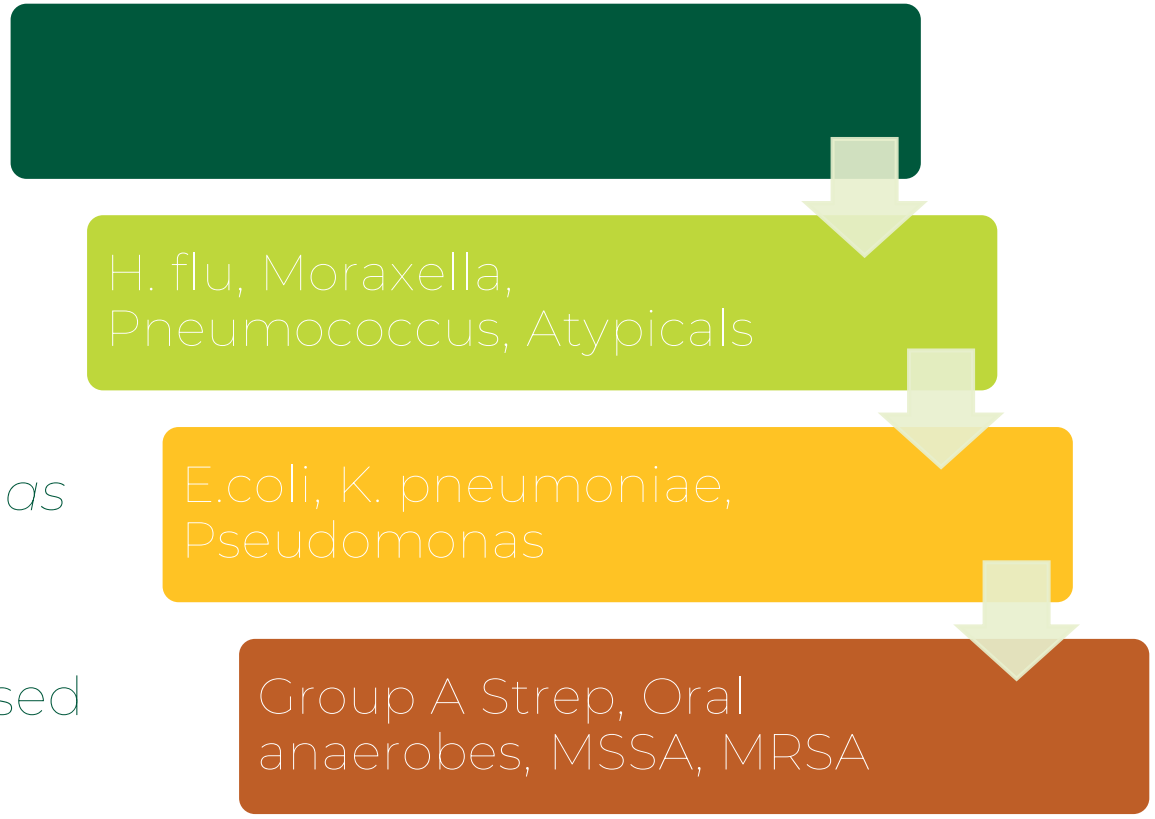
Levofloxacin

Dosing: Once a day
Toxicity: Several
C. Diff risk: HIGH

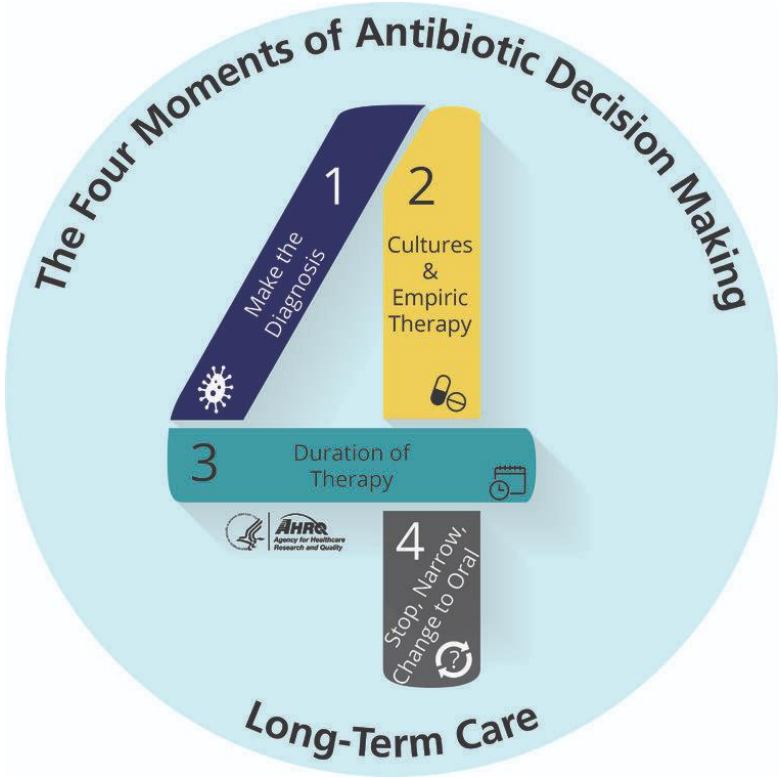
Guideline Recommendations
First line
- Only if allergy or need ORAL *pseudomonas* coverage

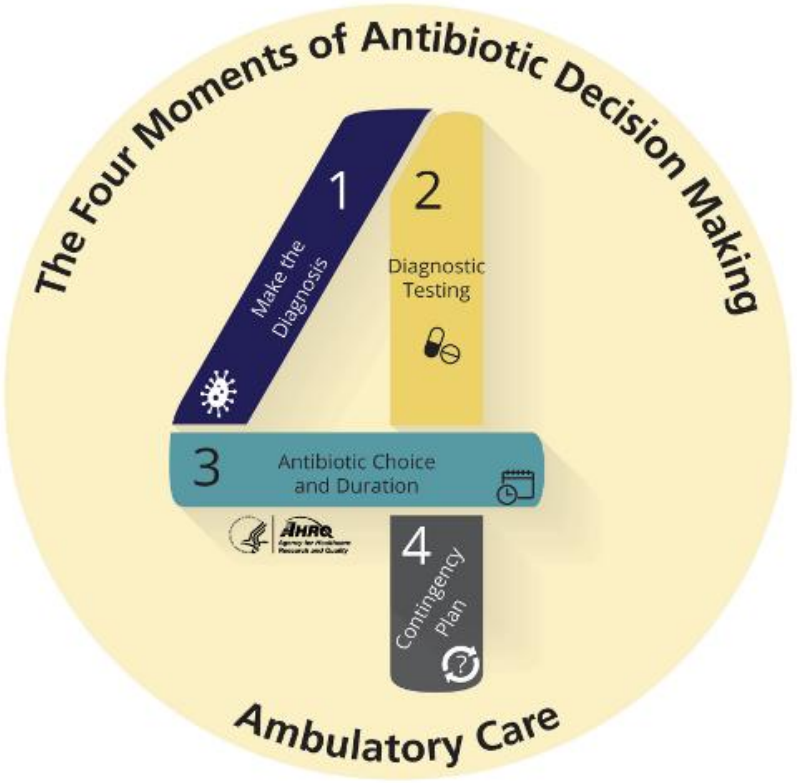
Commonly used for:
- CAP
- Acute bacterial sinusitis (beta-lactam based therapy preferred)

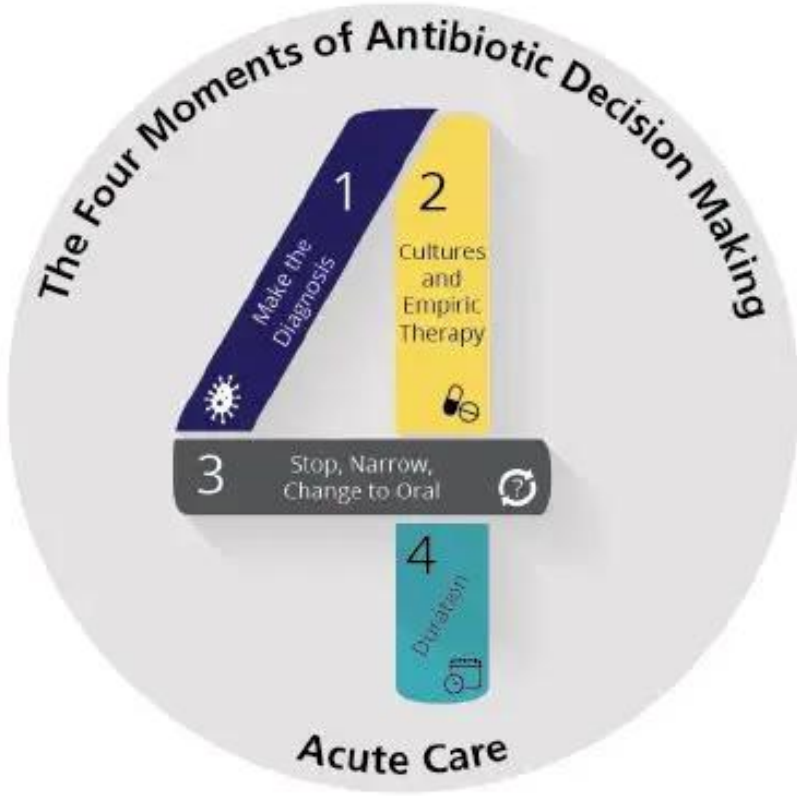
Slightly less gram negative coverage then ciprofloxacin, better gram positive



Principles of Antibiotic Selection







From Pathogens to Prescriptions:

Foundations of Antimicrobial Therapy

Thank you

Question: Emily.perry@ndsu.edu

Resources:

- CDC Guideline for Isolation Precautions: https://www.cdc.gov/infection-control/media/pdfs/Guideline-Isolation-H.pdf

- Reportable disease: https://www.hhs.nd.gov/sites/www/files/documents/DOH%20Legacy/Reportable%20Conditions%20-%20Dec%202023.pdf