Hospital Epidemiology

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Disclosures of Financial Relationships with Relevant Commercial Interests

- None

TOPICS

1. Healthcare-associated Infection (HAI) Pathogens
2. Isolation Precautions
3. Device- and Procedure-related Infections
4. Antimicrobial Stewardship
5. Outbreaks
6. Occupational Health

TOPIC 1: PATHOGENS

Question #1

A 50 y.o. previously healthy woman developed a urinary tract infection after a 3-month trip to India. Symptoms persisted despite empiric antibiotic therapy. The most likely antimicrobial-resistant pathogen is:

A. Carbapenem-resistant *K. pneumoniae*
B. ESBL-producing *E. coli*
C. Multi-drug resistant *P. aeruginosa*
D. Vancomycin-resistant Enterococcus
E. Candida auris

CAUSATIVE PATHOGENS & TYPES OF INFECTION — KEY POINTS

Most Common Pathogens (% of HAIs) -- 10 states, 2011 & 2015

- *C. difficile* (12-15)
- *S. aureus* (11)
- *E. coli* (9-10)
- Candida (6)
- Klebsiella (5-10)
- Enterococcus (5-9)
- *P. aeruginosa* (5-7)
- Enterobacter (3-5)

MDR U.S. Case #s 2012-17 (hospital and community); % change

Methicillin-R *S. aureus*	400K-320K	21% decrease
Vancomycin-R Enterococci	85K-54K	39% decrease
ESBL-producing Enterobacteriaceae	130K-200K	53% increase
Carbapenem-R Enterobacteriaceae	12K-13K	no trend
Carbapenem-R *Acinetobacter spp*	12K-9K	32% decrease
MDR *P. aeruginosa*	46K-33K	30% decrease

N Engl J Med **2014**; 370:1198-1208 **2018**; 379:1732-44 **2020**; 382:1309-19

SIR, Standardized Infection Ratios; National Baseline is 2015
https://www.cdc.gov/hai/data/portal/progress-report.html
https://www.cdc.gov/HAI/pdfs/progress-report/hai-progress-report.pdf
Magill et al, *N Engl J Med* 2018; 379:1732-44

Question #2

A 40 y.o. woman was admitted via the Emergency Room to the trauma service after a motor vehicle accident. Eight days into her admission she developed fever and flu-like symptoms. An NP PCR test was positive for parainfluenza. The most likely source of infection is:

A. Community exposure before admission
B. In-hospital exposure to visitors or personnel
C. Food-borne illness in the community
D. Emergency Department exposure
E. In-hospital exposure to contaminated respiratory therapy equipment

Incubation Periods for Selected Pathogens

• Influenza	1-4 days
• Parainfluenza	2-7 days
• Norovirus	12-48 hrs
• Rotavirus	<2 days
• RSV	2-8 days
• SARS-CoV-2	mean 5-6 (up to 14) days
• Wound Infection	
• Clostridia	24-48 hrs
• Group A Strep	24-48 hrs
• *S. aureus*	5-7 days
• Gram-negative bacilli	>7 days (variable)

Characteristics of COVID-19, SARS, MERS and Influenza

Characteristic	COVID-19	SARS-CoV/MERS-CoV	Influenza
Clinical severity	Asymptomatic to severe	Mostly severe	Mostly mild
Infection fatality risk	0.5% to 1%	10% (to 30%)	Seasonal: ≤0.1% 1918/1919 pandemic: 2%
Incubation period	Mean 5-6 (up to 14) days	Mean 3-5 (up to 14) days	Mean 1 (up to 3) days
Basic reproductive number	1.5 to 3.0	SARS: 1.5 to 4 MERS: 0.5 to 1	1.5 to 2.0
Modes of transmission	Respiratory droplets > aerosols Possible spread via fomites and fecal-oral	Respiratory droplets and aerosols Possible fomites	Respiratory droplets, some aerosols & fomites
Infectiousness profile	Most infectious before illness onset	Most infectious 7-10 days after illness onset	Most infectious around time of illness onset
Location of person-to-person transmission	Mainly community and long-term care facilities	Mainly hospitals	Mainly community; also can spread in hospitals
Importance of children in transmission dynamics	Unclear	Not important	Very important
Possible to avoid widespread transmission?	Unlikely	Yes	Maybe

Adapted from Cowling & Aiello, *J Infect Dis* 2020; 221:1749-51 and Weinstein, *NEJM* 2004; 350:2332-4.

Topic 2: Isolation Precautions

Control & Prevention Keyed to Modes of Transmission

- Contact
  - Direct (body-to-body)
  - Indirect (e.g., fomites/environment, HCWs' hands)
- Droplet (>5 µm; travel 3-6 feet)
- Airborne (droplet nuclei ≤ 5 µm; remain aloft)
- Endogenous (auto-inoculation & device-related)
- Common source (outbreak potential)
- Vectorborne

HCW, healthcare worker

Droplet vs. Airborne Spread – Dichotomy or Continuum?

Droplet generation. A flash photo of a human sneeze, showing the expulsion of droplets that may be laden with infectious pathogens. Sneezing can produce as many as 40 000 droplets of 0.5–12 µm. These particles can be expelled at a velocity of 100 m/s, reaching distances of several metres. Smaller droplets with less mass are less influenced by gravity, and can be transported as a 'cloud' over greater distances by air flows. Larger droplets with more mass are more strongly influenced by gravity and less so by air flows, and move more 'ballistically', falling to the ground more quickly. Reproduced with the kind permission of Prof. Andrew Davidhazy, School of Photographic Arts and Sciences, Rochester Institute of Technology, Rochester NY, USA.

Tang JW et al, *J Hosp Infect* 2006; 64:100-14.

Isolation Categories & Precautions are Based on Three Modes of Transmission

		Healthcare Worker		
Category	Private Room	Gloves	Gown	Mask
Contact (Touch)	Yes*	Yes	Yes	PRN
Droplet (3-6 ft)	Yes*	PRN	PRN	W/in 3-6 ft
Airborne (Same air space)	All	PRN	PRN	N95

* When possible; cohort if not possible. Avoid rooming with immunosuppressed or high risk patients.
AII = Airborne Infection Isolation: negative pressure with no air recirculation (unless HEPA-filtered); 6-12 ACH (air changes per hour).
Hand hygiene – yes for all; eye protection – PRN for all.

Question #3

A hospitalized patient with nosocomial Influenza A was treated promptly with oseltamivir. She should be placed on:

A. Standard Precautions in any room
B. Standard Precautions in a private room
C. Contact Precautions
D. Droplet Precautions
E. Airborne Precautions

Isolation Precautions — Examples of Indications

- Standard – All patients
- Contact – Multidrug resistant bacteria, infectious diarrhea, Ebola, chickenpox
- Droplet – Bacterial meningitis, pertussis, mumps, seasonal influenza
- Airborne – Tuberculosis, measles, chickenpox
- "Opportunistic" Airborne* – SARS, MERS-CoV, SARS-CoV-2, Pandemic flu, Ebola, Some BT agents

*e.g., increased transmission risk during aerosol generating procedures (such as intubation)

TABLE
Two Perspectives on Occupational Infections

	Infection Control	Occupational Medicine
Tradition	Nosocomial infection	Occupational exposure
Focus	Patients	Workers
Setting	Hospitals	Industries
Goal	Disease transmission	Exposure prevention
Authority	CDC	OSHA
Approach	Infection control policy	Exposure control plan
Enforcement	Voluntary guidelines	Mandatory regulations
Prevention	Isolation	Hierarchy of controls
	Behaviors	Engineering
	Barrier precautions	Work practices
		Personal protective gear

Gerberding JL, *Infect Control Hosp Epidemiol* 1993; 14:686-8.

Question #4

A 55 y.o. homeowner on Martha's Vineyard is admitted with fever and pneumonia. He recalls lawn mowing over a dead rabbit a few days ago. Blood cultures – patient's, not rabbit's – grow gram-negative coccobacilli aerobically. The appropriate patient placement and specimen lab containment are:

A. Standard precautions for patient and lab containment for specimen
B. Contact precautions for patient and no lab containment for specimen
C. Droplet precautions for patient and no lab containment for specimen
D. Respiratory isolation for patient and lab containment for specimen
E. Strict (Respiratory & Contact) isolation for patient and lab containment for specimen

CDC Category A Bioterrorism Agent Infection Control

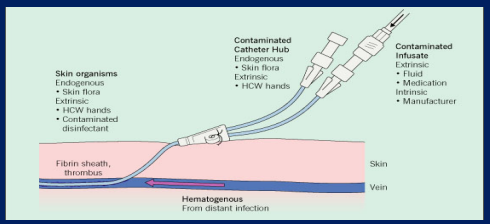
Disease	Patient Isolation	Laboratory Containment
Smallpox	All & CP	Y
Plague	All or DP	Y
Viral Hemorrhagic Fever	All & CP	Y
Anthrax	SP*	N
Botulism	SP	N
Tularemia	SP	Y

All = Airborne Infection Isolation, CP = Contact Precautions, DP = Droplet Precautions, SP = Standard Precautions

*Exception: CP if cutaneous anthrax has uncontained drainage

TOPIC 3: Devices & Procedures – Outcomes, Better

Potential Sources of Infection of a Percutaneous Intravascular Device (IVD)



Potential sources of infection of a percutaneous intravascular device (IVD). These include contiguous skin flora, contamination of the catheter hub and lumen, contamination of infusate and hematogenous colonization of the IVD from distant, unrelated sites of infection. HCW, health care worker. Adapted from Crnich and Maki, *Clin Infect Dis* 2002; 34:1232-4.

Question #5

Which one of the following measures does not reduce the risk of CVC infections?

A. Maximum barrier precautions for CVC insertion
B. Removal of idle CVCs
C. Avoiding guidewire-facilitated replacement of CVCs for infection control
D. Preference for chlorhexidine for CVC site preparation
E. Preference for placement of CVCs in operating rooms

CDC/HICPAC IV Catheter Infection Prevention Guidelines
Use this "Bundle" for a "Checklist"

- Education of personnel
- Is catheter needed?
- Avoid routine central line replacement as an infection control strategy
- Chlorhexidine skin prep (other uses of chlorhexidine?)
- Maximum barrier precautions
- Use of coated catheters (if after full implementation of above, goals are not met)

http://www.cdc.gov/hicpac/pdf/guidelines/bsi-guidelines-2011.pdf
HICPAC = Healthcare Infection Control Practices Advisory Committee

Question #6

Which of the following patient care measures is least likely to be effective for preventing ventilator-associated pneumonias?

A. Subglottic suction ports on ET tube
B. Elevation of the heads of beds to 30-45 degrees
C. Regularly scheduled changes of the ventilator tubing
D. Assessing extubation readiness daily
E. Non-invasive ventilation

Ventilator Complication Prevention Bundle – Update

DO When Possible
- Non-invasive ventilation
- Avoid sedation/ "Sedation Vacation" daily
- Assess extubation readiness daily/ breathing trials off sedatives
- Facilitate early mobility
- Use subglottic suction ports (if >48 hr intubation)
- Avoid ventilator circuit changes
- Elevate head of bed to 30-45°

Increased Interest in Non-ventilator Healthcare-associated Pneumonia

Klompas et al, *Infect Control Hosp Epidemiol* 2014; 35(8):915-36.

Ventilator Complication Prevention Bundle – Update

Special Approaches
- Selective decontamination
- Oral chlorhexidine
- UltraThin ET tube cuffs
- Auto-control ET tube cuff pressure
- Saline instillation pre-suctioning
- Mechanical tooth brushing

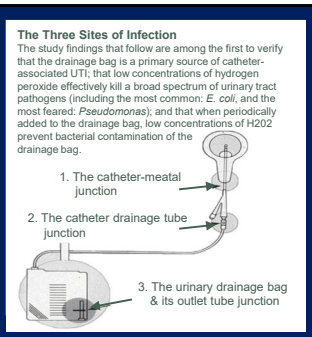
Klompas et al, *Infect Control Hosp Epidemiol* 2014; 35(8):915-36.

Ventilator Complication Prevention Bundle – Update

Don't Use (for infection prevention)
- Silver-coated ET tubes
- Kinetic beds
- Prone positioning
- Stress ulcer prophylaxis
- Early tracheotomy
- Gastric volume residual monitoring
- Early parenteral nutrition

No Recommendation
- Closed/in-line ET suctioning

Klompas et al, *Infect Control Hosp Epidemiol* 2014; 35(8):915-36.



Reduce cUTIs

- Avoid use of catheters (Key role for bladder ultrasound)
- Don't open or irrigate system
- Aseptic drainage of bag
- Bag below bladder

Reduce Surgical Site Infections

- Appropriate use of prophylactic antibiotics: start within 30-60 min of incision; stop within 24h
- Appropriate hair removal: no razors
- Surgical site skin prep – Chlorhexidine-alcohol
- Perioperative normothermia (colorectal surgery patients)*
- Post operative glucose control (major cardiac surgery patients cared for in an ICU)*
- Supplemental perioperative oxygen
- Nasal *S. aureus* decolonization
- Checklists
- Reporting of rates

*These interventions are supported by clinical trials and experimental evidence in the specified groups and may prove valuable for other surgical patients as well.

Being studied: Negative-pressure wound therapy
Not on list: Laminar air flow technologies; UV light use

Refs: *N Engl J Med* 2010; 362:18-26 and *JAMA Surg* 2017; 152:784-91 and 2020; 155:479.

What is Essential?*

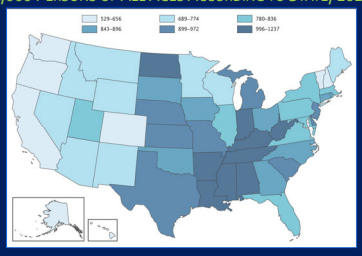
Preventing Device and Procedure Infections:

- HAND HYGIENE — Often the answer
- CVC-BSI — CHG prep, maximum barrier precautions, daily CHG bathing, CVC removal
- PIV — Observe site daily; change post ED insertion & q ≤3 days
- VAP — Oral CHG & sedation vacations (tube removal), positioning 45°
- UTI — Closed system & catheter removal
- SSI — Skin prep, antibiotic prophylaxis timing, & capable surgeon
- REPORT RATES
- As device infection rates fall, increasing attention to other HAIs

*Qualifier: RAW's views

Topic 4: Antimicrobial Stewardship

Profligate Antibacterial Use: Antibiotic Prescriptions per 1,000 Persons of All Ages According to State, 2010



Hicks et al, *N Engl J Med* 2013; 368:1461-2.

Seven Core Elements Critical to the Success of Hospital Antibiotic Stewardship Programs

- Leadership commitment: Dedicating necessary human, financial, and information technology resources
- Accountability: Appointing a single leader responsible for program outcomes. Experience with successful programs has shown that a physician leader is effective
- Drug expertise: Appointing a single pharmacist leader responsible for working to improve antibiotic use
- Action: Implementing at least one recommended action, such as systemic evaluation of ongoing treatment need after a set period of initial treatment (i.e., "antibiotic time out" after 48 hours)
- Tracking: Monitoring antibiotic prescribing and resistance patterns
- Reporting: Regular reporting information on antibiotic use and resistance to doctors, nurses and relevant staff members
- Education: Educating clinicians about resistance and optimal prescribing

Source: CDC. Core elements of hospital antibiotic stewardship programs. Atlanta GA: US Department of Health and Human Services, 2014.
Available at http://www.cdc.gov/getsmart/healthcare/implementation/core-elements.html

Topic 5: Outbreaks

Question #7

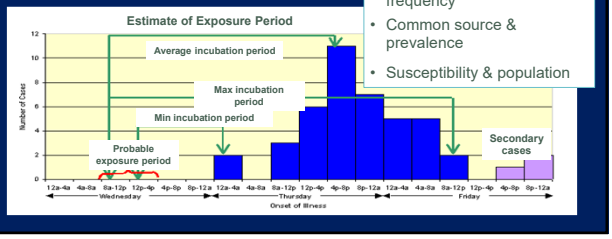
During a 1 week period, 5 of 15 ICU patients developed fulminant sepsis. Blood cultures from each grew *Serratia marcescens*; cultures of respiratory secretions and urine were normal flora and negative, respectively. No Serratia infections had occurred in this ICU in the past 3 months. On a general medical ward 2 months ago a patient had a Serratia cUTI.
The evaluation most likely to explain this ICU cluster of infections is a(n):

A. Assessment of ICU staff hand hygiene adherence
B. Whole genome sequence (WGS) analysis of the ICU Serratia isolates
C. Case-control study focused on IV medications
D. Rectal swab culture survey of patients in the ICU
E. Environmental cultures of the ICU rooms of the infected and control patients

Steps In *This* Outbreak Investigation

1. Establish existence of outbreak: *Easily ID'd bacteria; unexpected change*
2. Verify diagnosis: *Serratia "primary (i.e., no apparent source) bacteremia"*
3. Case count: *5*
4. Orient data into time, place, person: *1 week, ICU, ICU patients*
5. Determine size of population at risk: *15 patients in ICU (5/15 = 33% AR)*
6. Develop hypothesis regarding source & mode of spread, e.g., indirect person-to-person, common source, personnel carrier: *Primary bacteremia – possible contaminated IV medications/infusions; high AR = common item?*
7. Test hypothesis, refine above, plan and implement control measures. Test may be typing (such as PFGE or WGS) of epidemic isolates; case-control study: *Assess IV exposures of infected and uninfected patients*

Interpreting Epidemic Curves



Infer from size, shape, & repetition of curves:

- Person-to-person spread & frequency
- Common source & prevalence
- Susceptibility & population

Some Outbreak Associations

- Unusual bug (esp. if BSI): Think common-source contamination, e.g., *Pantoea agglomerans,* Pseudomonas spp, Flavobacterium from IV fluids or propofol; product contamination (extrinsic > instrinsic)
- *Burkholderia cepacia* – Contaminated iodophors, benzalkonium chloride
- *Cronobacter* (formerly *Enterobacter*) *sakazakii* – yellow pigment, powdered infant formula
- Listeria – foodborne (soft cheese, dairy, cabbage); miscarriages; a psychrophile
- Yersinia – blood products, pork, hot dogs; post-infectious reactive arthritis; a psychrophile

Key Emerging Outbreak Pathogens

- ***Candida auris***
  - Multi-continent emergence in "unrelated" outbreaks (different clades)
  - Heavy environmental contamination in affected nursing home and hospital wards
  - Some clades resistant to anti-fungals
- Mycobacteria (***M. chimera***) in CV surgery heater-cooler devices

Dry & Wet Environmental Contamination Increasingly Implicated in Outbreaks of Some Nosocomial Pathogens

Bacteria	*C. difficile,* VRE, MRSA, Acinetobacter, *P. aeruginosa,* "Water Bugs" (various gram-negative bacilli)
Virus	Norovirus, HBV, HCV; SARS-CoV-2 unlikely
Fungi	Aspergillus, Mucor, Rhizopus, *Candida auris*
Mycobacterium	*M. chimera*

Topic 6: Occupational Health

Question #8

Your neighbor in posh Scarsdale asks you about his TB test results. Testing was required so that he could assist in a cooperative nursery school that his 3-year-old daughter attends. He was told that he had 10 mm of induration at 48 hours around his PPD skin test and a "blood test" was indeterminant. His chest x-ray had no active disease. Which of the following is the most appropriate prophylaxis in this case:

A. 2 months of daily rifampin and pyrazinamide
B. 3 months of weekly isoniazid and rifapentine
C. 6 months of daily isoniazid
D. 9 months of daily isoniazid
E. Because no known exposure, not needed unless PPD ≥ 15 mm

MMWR Recomm Rep Feb 14, 2020; 69:1-11.

Employee Health – Common Question
Classification of the Tuberculin Reaction
Reaction of ≥ 10 mm is positive in:

- Recent PPD converters (≥10mm increase within 2 years)
- Persons with medical risk factors (diabetes, silicosis, CKD, gastrectomy, j-i bypass, malnutrition, immunosuppressive therapy)
- Foreign-born persons from high prevalence countries
- Intravenous drug users or alcoholics

Classification of the Tuberculin Reaction (continued)
A reaction of ≥ 10 mm is positive in:

- Residents of long-term-care facilities, such as correctional institutions and nursing homes or homeless individuals
- Other high risk populations identified locally, e.g., healthcare workers

Classification of the Tuberculin Reaction (continued)
A reaction of ≥ 5 mm is positive in:

- Close contacts to patients with infectious tuberculosis
- Persons with HIV infection
- Persons who have CXRs with fibrotic lesions consistent with healed TB
- Organ transplant recipients
- Persons on ≥15mg/day of prednisone for ≥1 month
- Persons on TNF-α antagonist treatment

Classification of the Tuberculin Reaction (continued)
A reaction of ≥ 15 mm is positive in:

- Persons with no additional risk factors for tuberculosis

But PPD tests now often replaced by IGRAs

IGRAs = Interferon gamma release assays

Question #9

A health care worker who is planning international travel as the COVID-19 pandemic wanes gets a booster dose of MMR vaccine. His work restrictions during the 2 weeks after vaccination should be:

A. Furlough
B. Work in non-patient contact area
C. No contact with immunosuppressed patients
D. No restrictions unless there is evidence of vaccine-related fever or rash
E. No restrictions

Question #10

A hospital policeman was stabbed with a used IV needle by a combative patient. The patient was in the hospital for treatment of secondary syphilis (RPR 1:128); the patient also had positive tests for HIV antibody, HCV antibody, and HBs Ag. MRI of the patient's brain showed extensive white matter disease without edema. The policeman was a new hire; his recent serologic tests for HBV and HCV were negative.

Question #11

The pathogen most likely to be transmitted by this blood exposure is:

A. JC Virus
B. HBV
C. HIV
D. HCV
E. Treponema pallidum

Healthcare Worker Post Exposure Prophylaxis (PEP)

Pathogen or Disease	Mode of Transmission	High-risk HCW	PEP	Modifying Factors
HIV	Percutaneous, splash — Blood or sterile body fluid or bloody fluids **Risk 0.3%**	Seronegative	ARVs for 4 weeks; serologic follow-up for 6 months	Sharp type, puncture depth, contaminating fluid, patient, VL & treatment, duration after exposure (24-36h or longer); pregnancy
Hepatitis C	Percutaneous **Risk 3%**	Seronegative	Pre-emptive therapy vs watchful waiting	Serologic follow-up
Hepatitis B	Percutaneous **Risk 30%**	Seronegative	HBIG & vaccine	Duration after exposure (24-48h)

Healthcare Worker PEP (continued)

Pathogen or Disease	Mode of Transmission	High-risk HCW	PEP	Modifying Factors
Hepatitis A	Fecal-oral	Seronegative	Vaccine; IG	Duration after exposure (14 days)
Parvovirus B19	Droplet, contact	Seronegative and pregnant, HIV, or hemoglobinopathy	No PEP	Exclude pregnant HCW from patient care
Pertussis	Droplet, contact	Seronegative or waned immunity	Macrolide	Duration after exposure (3 weeks)

Healthcare Worker PEP (continued)

Pathogen or Disease	Mode of Transmission	High-risk HCW	PEP	Modifying Factors
N. meningitidis	Droplet	Close contact	Ciprofloxacin, rifampin, ceftriaxone, or azithromycin (or sulfa if S)	Duration & proximity of contact
VZV	Contact, airborne	Negative VZV history or seronegative and immunocompromised or pregnant	VZIG or valacyclovir; VZV vaccine (Furlough day 10-21 PE; 10-28 if VZIG used)	Duration of, and after, exposure
Tuberculosis	Airborne, rarely contact	PPD- or IGRA-negative	Several regimens if PPD conversion	PPD results (baseline;12 weeks post-exposure)

Thank You