



## Emerging Infections, Outbreak Investigations, and the Role of Public Health

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**North Carolina Division of Public Health**

**Fall 2023**

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## Objectives

- Describe legal framework for disease surveillance, investigation, and response
- Review outbreak surveillance data and trends over time
- Discuss emerging infections & specific healthcare-associated pathogens
- Discuss role of Public Health in infection prevention and outbreak response
- Describe the 10 steps of an outbreak investigation



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# Legal Framework



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## Public Health: Legal Framework

- Public Health Laws and Rules:
  - General Statutes
  - NC Administrative Code rules
- Health Director's Authority (State & Local)
  - Surveillance
  - Investigation
  - Control Measures



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## Public Health Law

### General Statutes §130A-144: Investigation and Control Measures

- (a) The **local health director shall investigate**... cases of communicable diseases and communicable conditions reported to the local health director
- (b) Physicians, persons in charge of medical facilities or laboratories, and other persons shall... **permit a local health director or the State Health Director to examine, review, and obtain a copy of medical or other records...**
- (d) The **attending physician shall give control measures**... to a patient with a communicable disease or communicable condition and to patients reasonably suspected of being infected or exposed to such a disease or condition.
- (e) The **local health director shall ensure that control measures**... have been given to **prevent the spread** of all **reportable communicable diseases** or **communicable conditions** and **any other communicable disease or communicable condition that represents a significant threat to the public health.**
- (f) All **persons shall comply with control measures**, including submission to examinations and tests...



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## Public Health Law

### 10A NCAC 41A .0103: Duties of local health director: report communicable diseases

- (a) Upon receipt of a report of a communicable disease or condition... the **local health director** shall:
- (1) immediately **investigate** the circumstances... [to] include the collection and submission for laboratory examination of specimens necessary to assist in the diagnosis and indicate the duration of control measures;
  - (2) determine what **control measures** have been given and ensure that proper control measures... have been given and are being complied with;
- (c) Whenever an **outbreak of a disease or condition** occurs which is not required to be reported... but **which represents a significant threat to the public health**, the local health director shall give appropriate control measures... and **inform the Division of Public Health**



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## Public Health Law

### 10A NCAC 41A .0101: Reportable diseases and conditions

- **80+ reportable diseases and conditions**
  - Timeline of reporting varies between immediately and within 7 days
- **Laboratory** reporting requirements



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## Public Health Law

- **10A NCAC 41A .0106**
  - Infection Prevention - Reporting of Healthcare Associated Infections
- **10A NCAC 41A .0206**
  - Infection Prevention - Health Care Settings, 1992
- **10A NCAC 41A .0201**
  - General Control Measures
- **10A NCAC 41A .0202 - .0205**
  - Control Measures for HIV, Hepatitis B, STDs, TB



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## Role of Public Health



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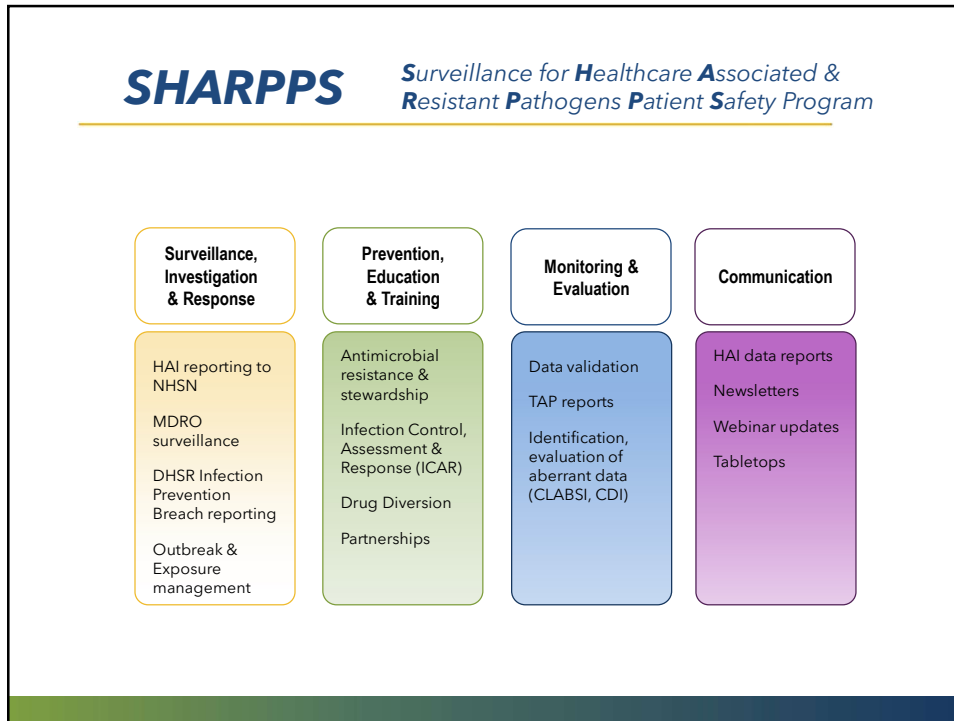
**SHARPPS**

*Surveillance for Healthcare Associated &  
Resistant Pathogens Patient Safety Program*

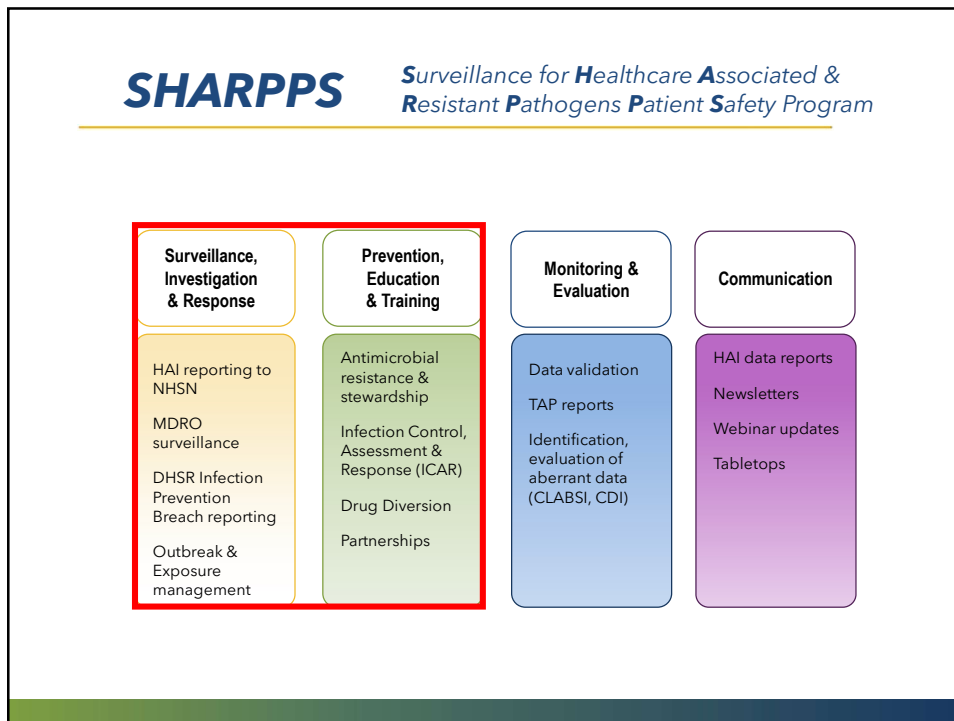
### **Mission**

To work in partnerships to prevent, detect, and respond to events and outbreaks of healthcare-associated and antimicrobial resistant infections in North Carolina.

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## When Should Public Health Be Called?

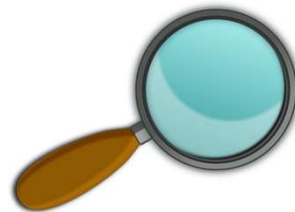
- HAI reporting questions (i.e., NHSN)
- Reportable diseases / conditions (10A NCAC 41A .0101)
  - <https://epi.dph.ncdhhs.gov/cd/report.html> (Form 2124)
- When **any** disease is above normal baseline (i.e., an “outbreak”)
- Report suspected infection prevention breach



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## What Happens When Public Health is Called?

- Data Review
- Clinical Investigation
- Environmental Investigation
- Control Measures
- Communication (Resident/Family/Public)
- Laboratory Support



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## Outbreak Assistance

We can assist with:

- Determining if it is an outbreak
- Guidance, tools and onsite support
- Facilitating and coordinate calls with partners
- Written recommendations



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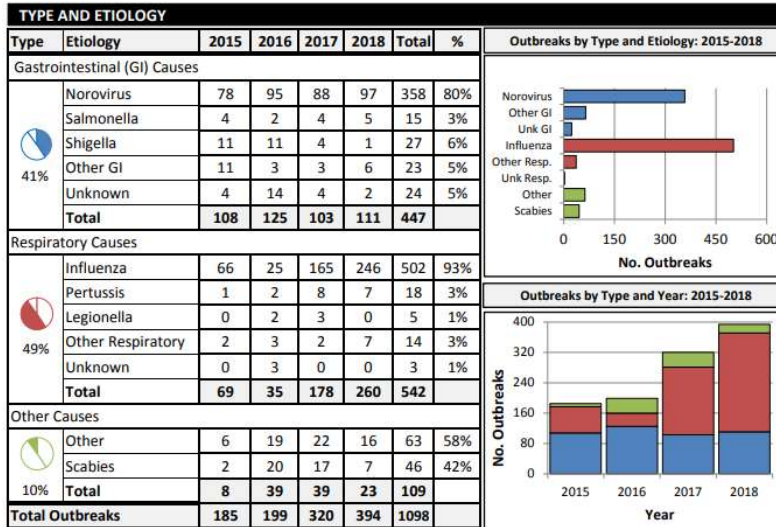
## Outbreak Summary



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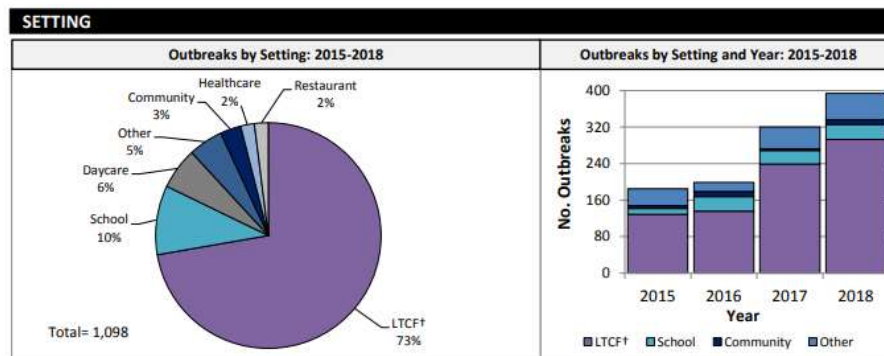


## 2015-2018 Outbreak Summary



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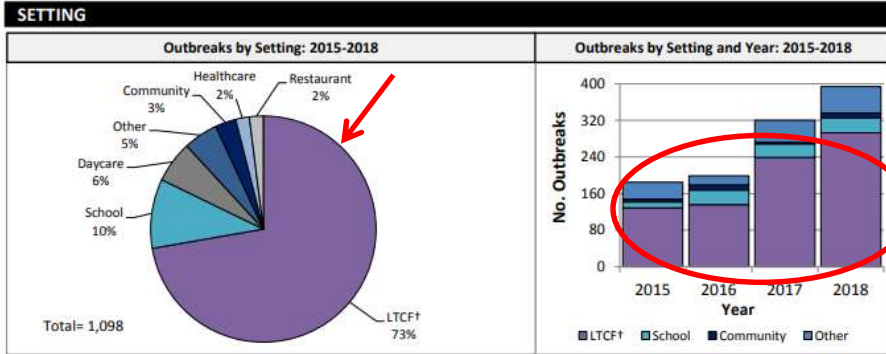


\*Long-term care facility (LTCF) includes nursing homes, adult care homes, and assisted living facilities  
 NC Communicable Disease Branch - <http://epi.publichealth.nc.gov/cd>



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## 2019-2022 Outbreak Summary

Year	# Outbreaks	# Outbreak cases
2019	347	>9,000
2020*	214	>2,800
2021*	88	>1,200
2022*	241	>5,400

\*Excluding COVID-19 outbreaks

Decrease in number of outbreaks during COVID is primarily due to fewer influenza and norovirus outbreaks in LTCFs



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## Emerging Infections & Outbreak Response



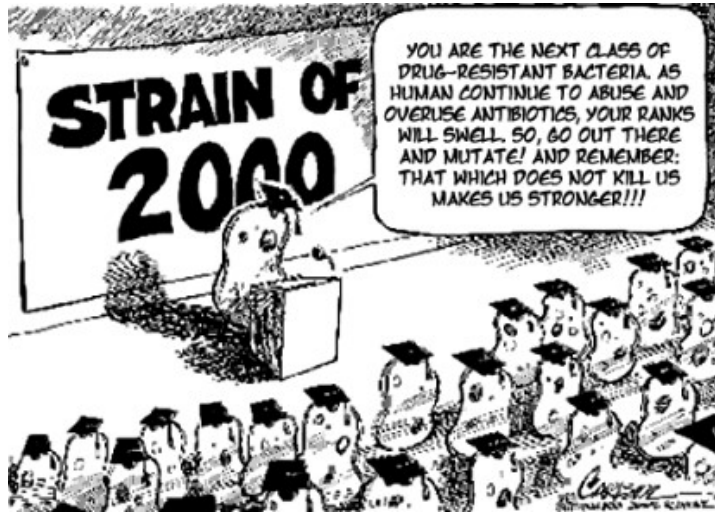
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## Multidrug-Resistant Organisms (MDROs)



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### Multidrug-resistant Organisms (MDROs)


#### WHAT YOU NEED TO KNOW ABOUT MULTIDRUG-RESISTANT ORGANISMS (MDROs)



**What Are MDROs?**  
Multidrug-resistant organisms are germs like bacteria or other microorganisms that have developed resistance to multiple antibiotics or antifungals normally used to treat them.

Each year in the U.S., at least **2.8 million people are infected** with antibiotic-resistant bacteria, and **at least 35,000 people die** as a result.

**How Does Antibiotic Resistance Occur?**



**1**  
Lots of bacteria. A few of them are resistant to antibiotics.

**2**  
Antibiotics kill bacteria causing the illness, as well as good bacteria protecting the body from infection.

**3**  
The resistant bacteria now have favorable conditions to grow and take over.

**4**  
Bacteria can even transfer their drug-resistance to other bacteria, causing more problems.



<https://epi.dph.ncdhhs.gov/cd/diseases/hai.html>

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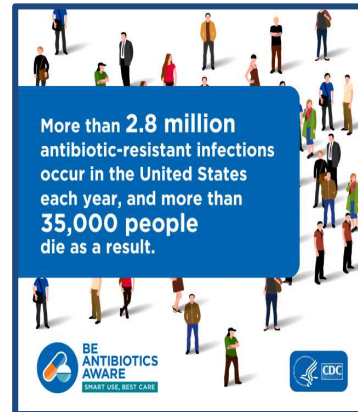
<https://epi.dph.ncdhhs.gov/cd/diseases/hai.html>



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## Significance of MDROs

- Affects vulnerable patient populations
- Are easily transmitted in and between healthcare / congregate care settings
- Difficult to treat
- Require more toxic antibiotics to treat
- Improper treatment → some organisms may produce another enzyme that makes it easier to transmit resistance
- Cause increase in
  - mortality, healthcare costs, length of stays
- Estimates of economic costs vary, up to 20 BILLION dollars in direct healthcare costs



<https://www.cdc.gov/antibiotic-use/community/about/antibiotic-resistance-faqs.html>

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## Extended-Spectrum Beta-Lactamases (ESBLs)

- Beta-lactamase → Enzyme produced by Gram-negative bacteria
  - Resistant to third-generation cephalosporins and monobactams
- Endemic in United States
  - Can be community acquired
- Spread via direct and indirect contact with colonized/infected patients and contaminated environmental surfaces.



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## Carbapenem-Resistant Enterobacterales (CRE)

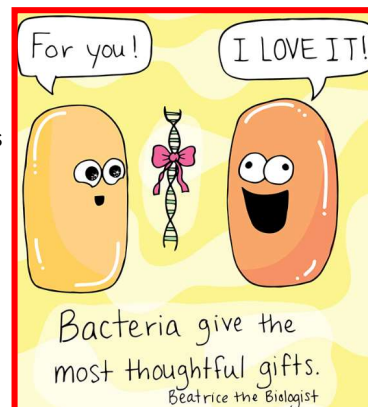
- First recognized in US in 2001
- Enterobacterales = gut bacteria
  - *Klebsiella* spp.
  - *E. Coli*
  - *Enterobacter* spp.
- Resistant to nearly all antibiotics
- Many ways to be resistant
  - Carbapenemase-producing CRE (CP CRE)
    - *Klebsiella pneumoniae* carbapenemase (KPC)
    - New Delhi metallo- $\beta$ -lactamase (NDM)
    - Verona integron encoded metallo- $\beta$ -lactamase (VIM)
    - Imipenemase metallo- $\beta$ -lactamase (IMP)
    - Oxacillinase-48 (OXA-48)



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## Significance of Carbapenemase producing CRE

- "Urgent public health threat" - CDC
- Highly resistant
- Mobile resistance elements
- >9,000 healthcare-associated infections each year
- Up to 50% mortality



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## Investigation

- Notified by LHD on April 21, 2017 (a Friday!)
  - Increase in the number infections caused by ESBL-producing organisms among patients admitted to local hospital between October 16, 2016 and April 13 2017
- Majority of cases were residents of three long-term care facilities (LTCFs)
- Coordinated an investigation to **assess infection prevention practices among these LTCFs and prevent further intra- and inter- facility spread of disease**



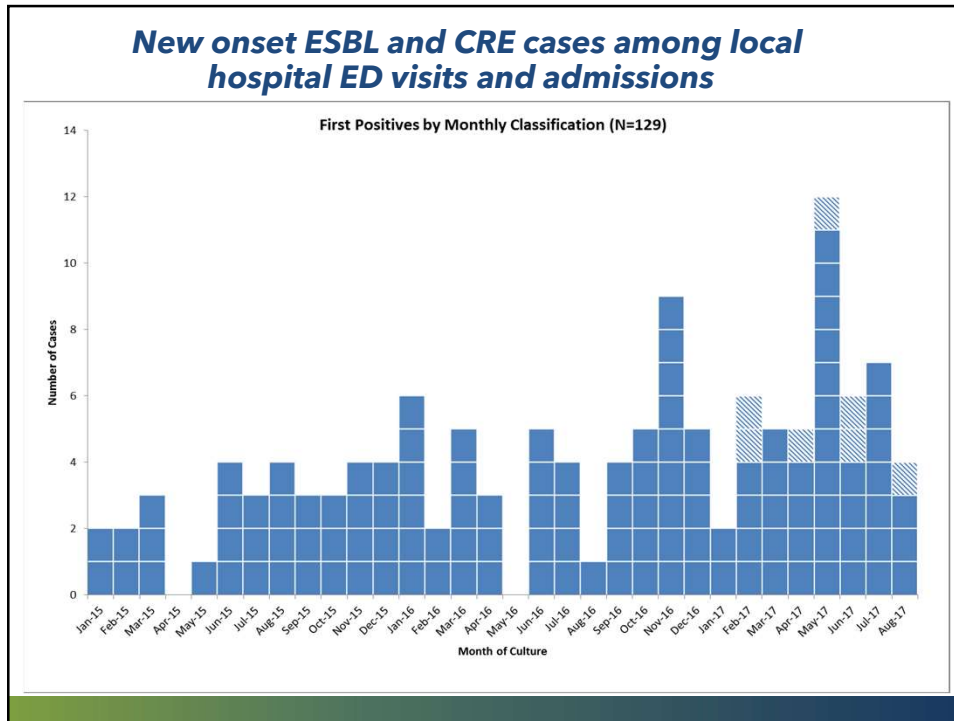
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- 4 cases were discussed on Friday but > 40 positive labs were waiting for us on Monday morning!



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## Outbreak Case Definition


Identification of new\* CRE or ESBL infection or colonization in a resident of county D County with a specimen collection date on or after October 1, 2016.

\*Different organisms/species/carbapenemases identified in a single resident counted as separate events from other organisms/species/carbapenemases




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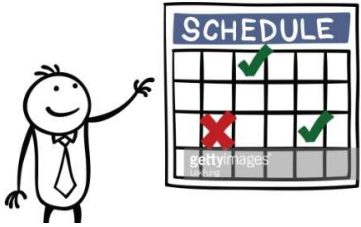
## Initial Control Measures




**Gown and gloves**



**Hand hygiene**



**Prevent opportunities for transmission**



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## Site Visit

**Investigate to stop transmission & prevent future outbreaks**



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## Major Findings

- **Hand hygiene:** inconsistent ✘
- **Wound care:** reusing scissors, interruptions in flow from clean to dirty ✘
- **OT/PT:** contact precautions not adequately maintained, lack of dedicated equipment ✘
- **Contact precautions:** implemented to varying degrees ✘
- **Lack of inter-facility notification** ✘
- **Outdated policies** ✘



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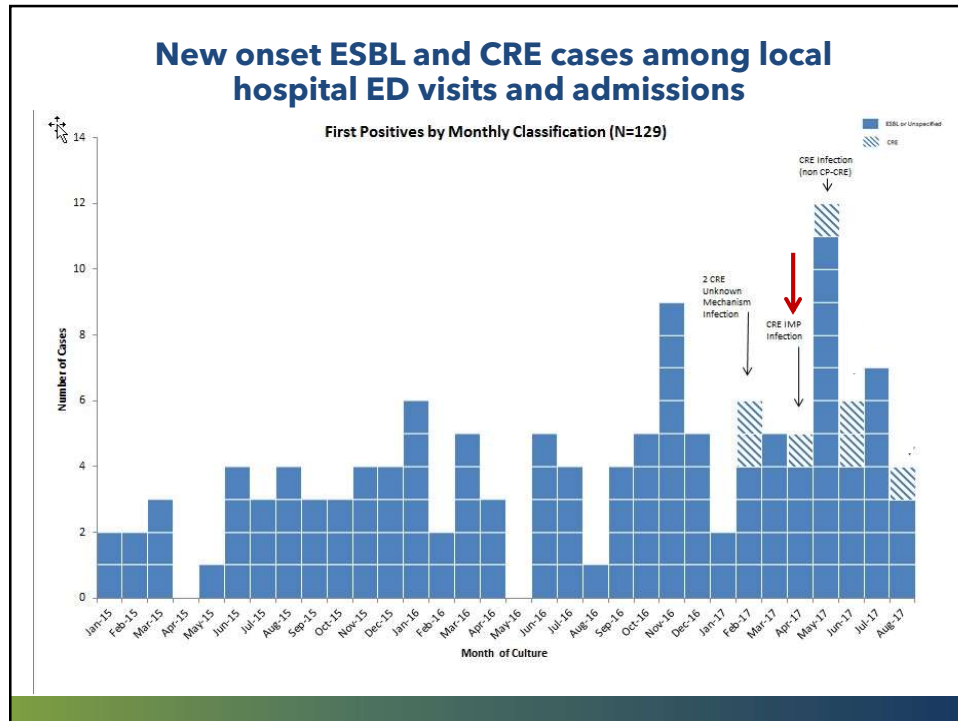
## Site Visit: Control Measures

1. Staff education
2. Laboratory notification
3. Cohort infected residents
4. Contact precautions for colonized and infected individuals at higher risk for transmission
5. Hand hygiene
6. Environmental cleaning
7. Communicate CRE status to transferring and receiving facilities
8. Review infection prevention policies and procedures
9. Antimicrobial stewardship



CRE alert

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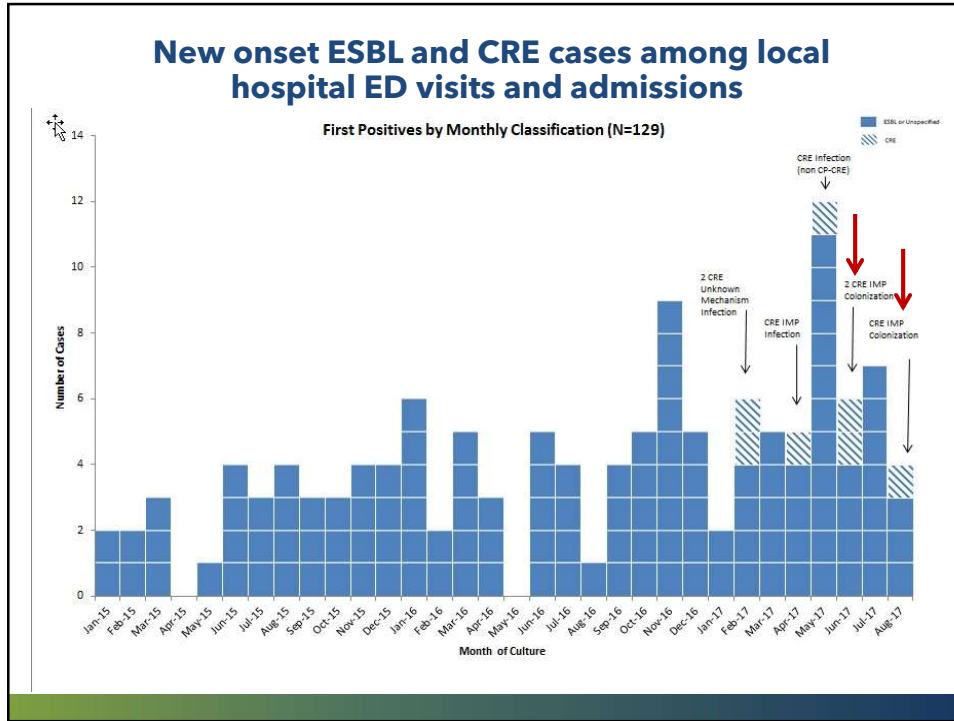


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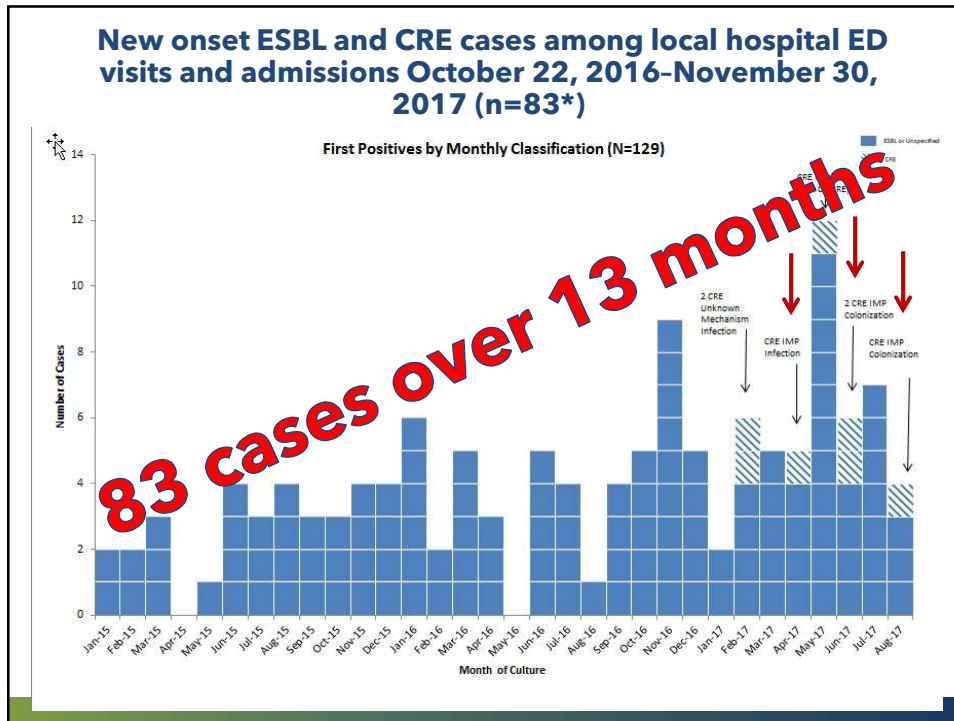
### ***IMP outbreak case definition***

- Confirmed: CRE infection or colonization in a resident of North Carolina with laboratory confirmation of imipenemase (IMP) metallo- $\beta$ -lactamase production by a CDC-recognized test.
- Probable: A resident of North Carolina with CRE infection or colonization with a positive phenotypic test for carbapenemase production (e.g, metallo- $\beta$ -lactamase test, modified Hodge test, Carba NP, Carbapenem Inactivation Method (CIM), or modified CIM (mCIM)).

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***Candida auris:***  
A drug-resistant germ that spreads in healthcare facilities

*Candida auris* (also called *C. auris*) is a fungus that causes serious infections. Patients with *C. auris* infection, their family members and other close contacts, public health officials, laboratory staff, and healthcare workers can all help stop it from spreading.




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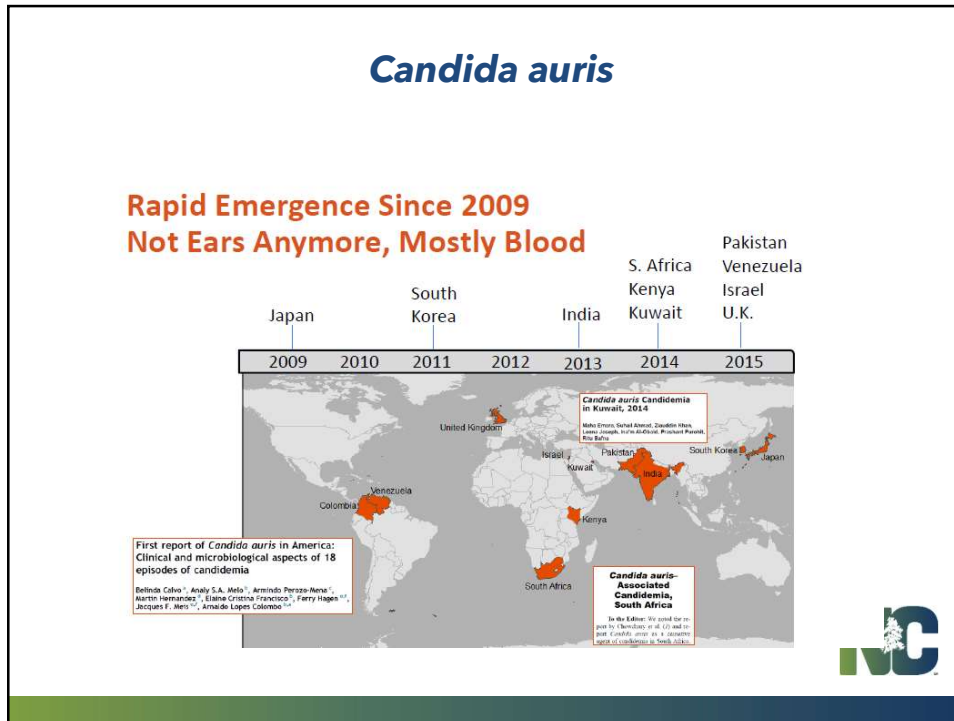
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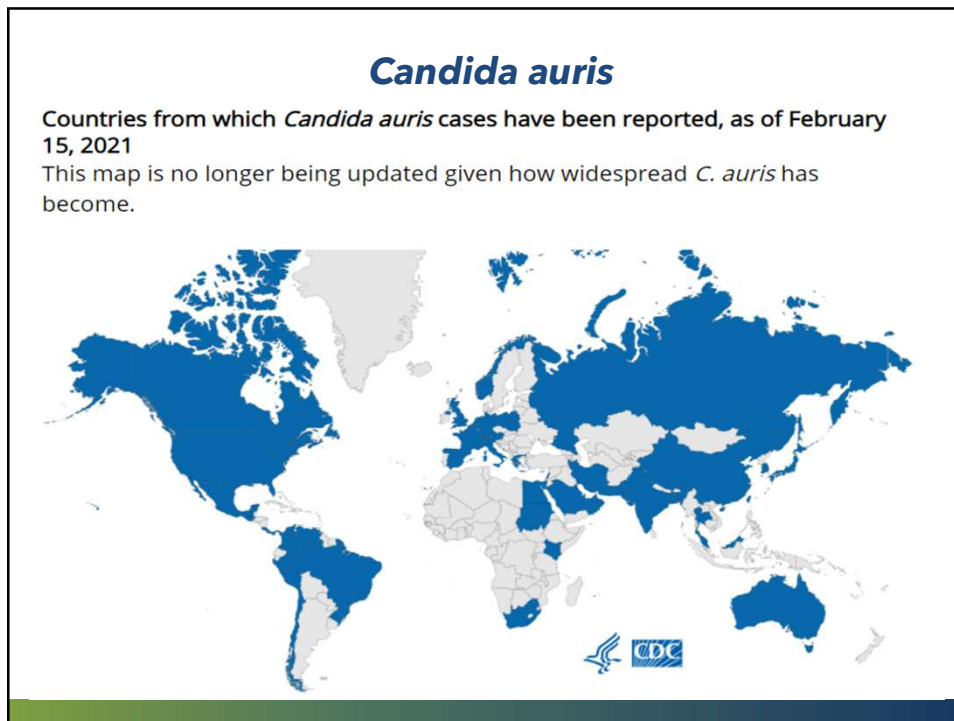
- Difficult to identify
- Global health threat
- Invasive infections
- ~ 60% mortality
- Environmental persistence
- Easily transmissible in the healthcare setting



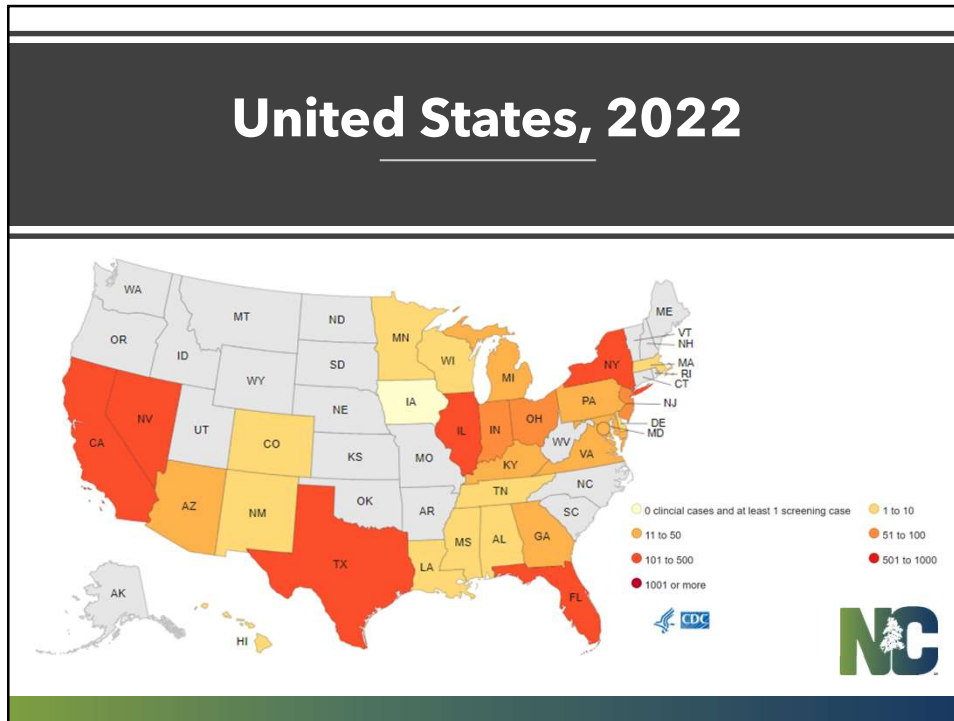
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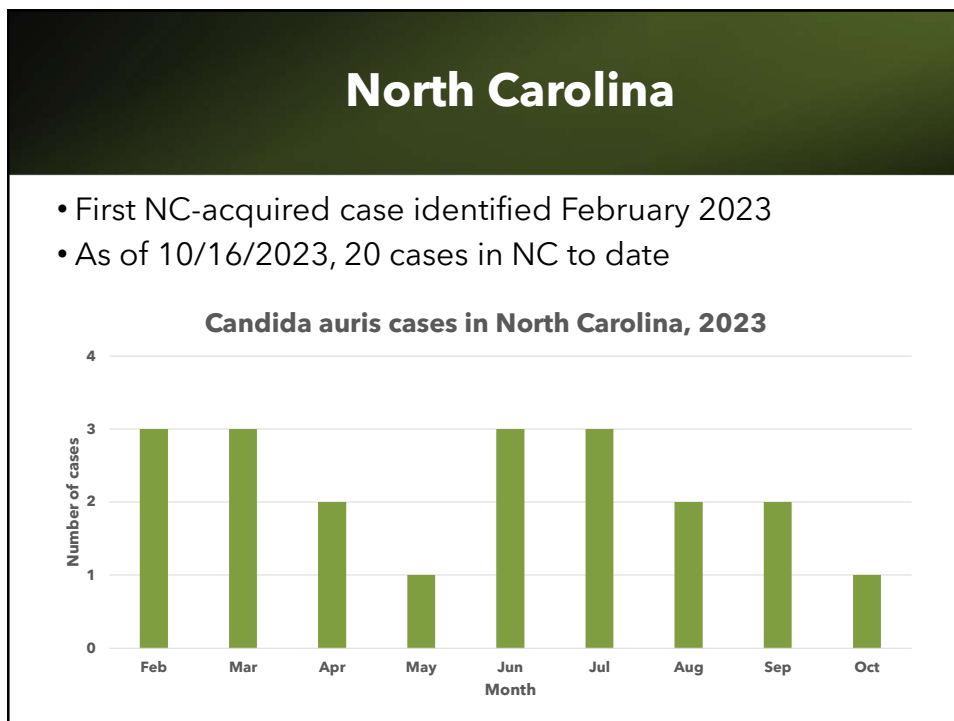
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## Infection Prevention

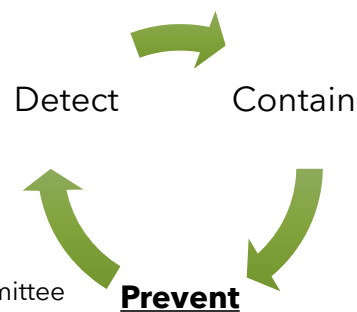
- Private room, indefinite contact precautions (enhanced barrier precautions in long-term care)
- Adherence to hand hygiene, transmission-based precautions
- Clean with [List P](#) disinfectant
- Conduct screening
- Educate staff about organism and reasons for precautions
  - Including non-clinical staff like EVS
- Communicate diagnosis with other facilities on transfer or discharge



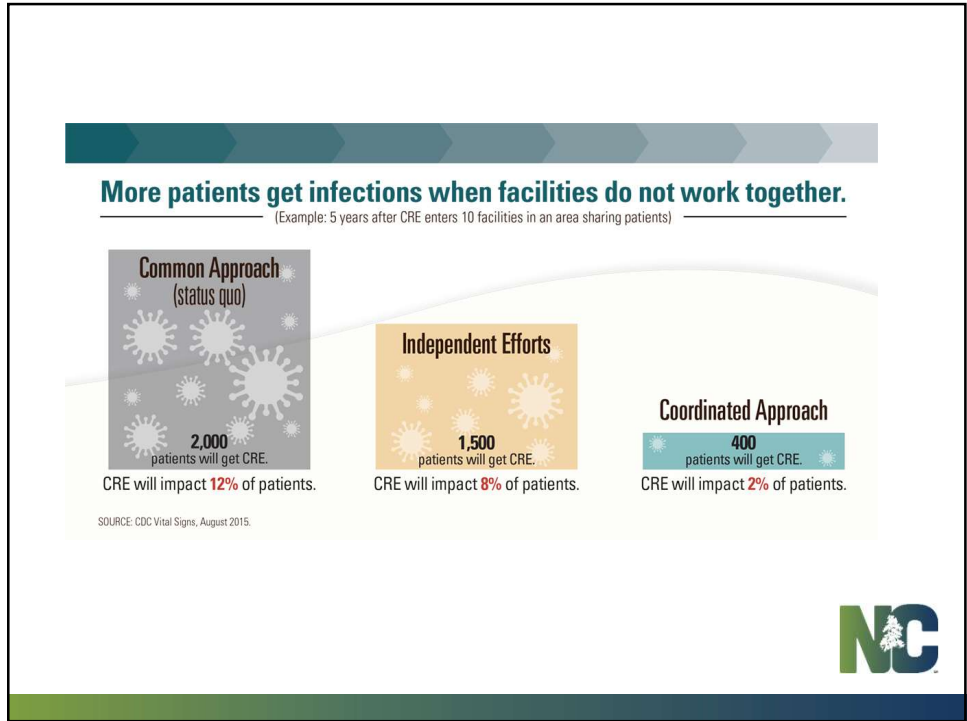
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## Responding to MDROs

- Detect MDROs
  - Increased awareness and testing
  - ARLN
  - Nationally notifiable
- Ensure rapid response & containment
  - Prevent transmission
  - Inter-facility communication
- Stewardship efforts
  - Antimicrobial resistance subcommittee
  - Get Smart Campaign
  - STAR Partners
- Education
  - Collaborative effort (SPICE, DPH, LHD)




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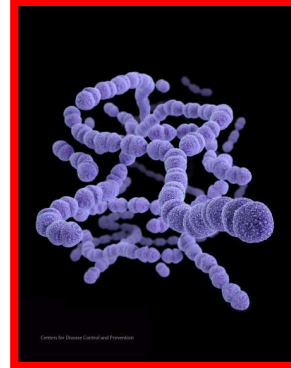
# Group A Streptococcus (GAS)



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## Group A Streptococcus (GAS)

- A group of gram-positive bacteria
- Spherical shape and divide by fission, but remain attached and grow in beadlike chains
- Commonly found in the throat and on the skin
- Illness varies depending on site of infection



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## LTCF Mortality Risks

- Between 1,100 and 1,600 people die as a result of invasive GAS disease annually in the US
- LTCF residents 1.5 times more likely to die from invasive GAS infections than the average population
- 10-15% of LTCF residents who acquire a GAS infection will die.



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## ***GAS Outbreak, 2017***

- January 2017,
  - 2 Facilities in County X, North Carolina
  - 'Sister' facilities, owned by the same company



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## ***GAS Outbreak, 2017***

- Case definition:  
  
New GAS infection or colonization identified by culture in a resident or symptomatic staff member of facility A or facility B with a specimen collection date on or after December 1, 2016



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## ***Public Health Response***

- Retrospective chart review
- Survey healthcare workers for GAS symptoms
- Culture close contacts
- 4 months active surveillance
- Site visit to assess infection control



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## ***Site Visit Findings: Infection Risk Factors***

- Increased staff contact linked to illness
  - Significant nursing needs
  - Non-intact skin/wound care
  - Immobility/bed baths
- Link to inadequate infection control
  - Poor hand hygiene
  - Staff working while sick



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## Whole Genome Sequencing, GAS

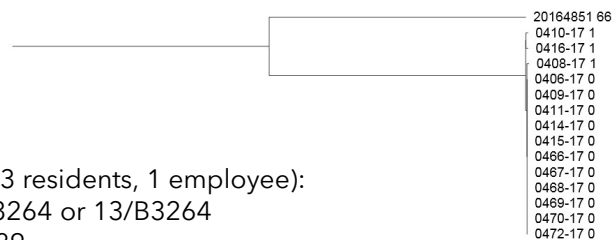
- Submitted isolates from 15 (14 residents & 1 employee) of 24 cases to CDC to determine strain relatedness
- Serologic and molecular typing, whole genome sequencing



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## Whole Genome Sequencing, GAS

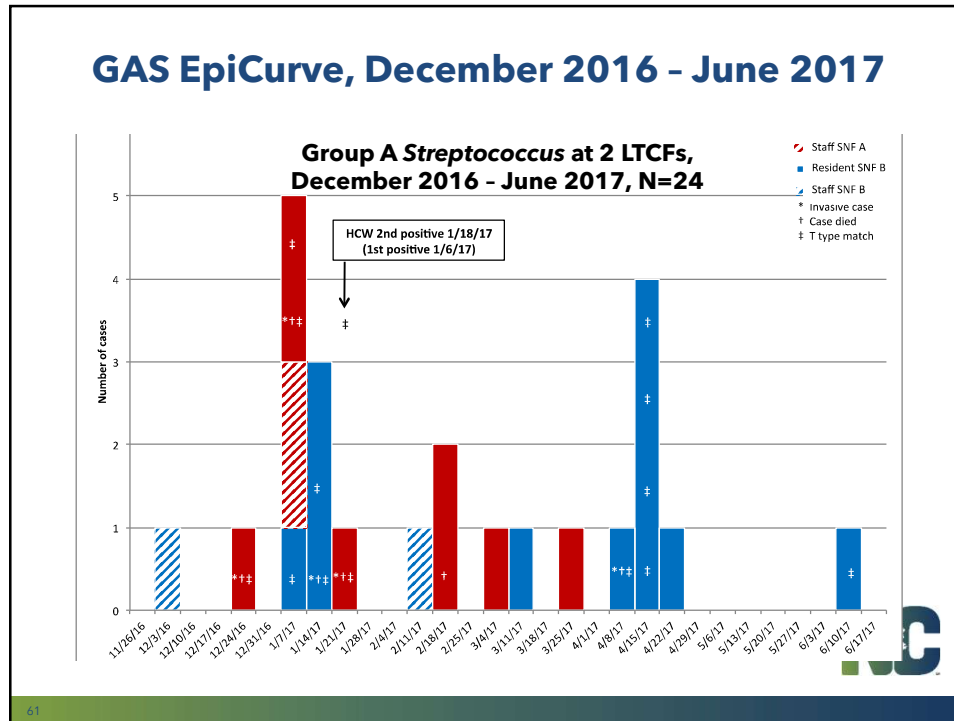
Tree scale: 0.1



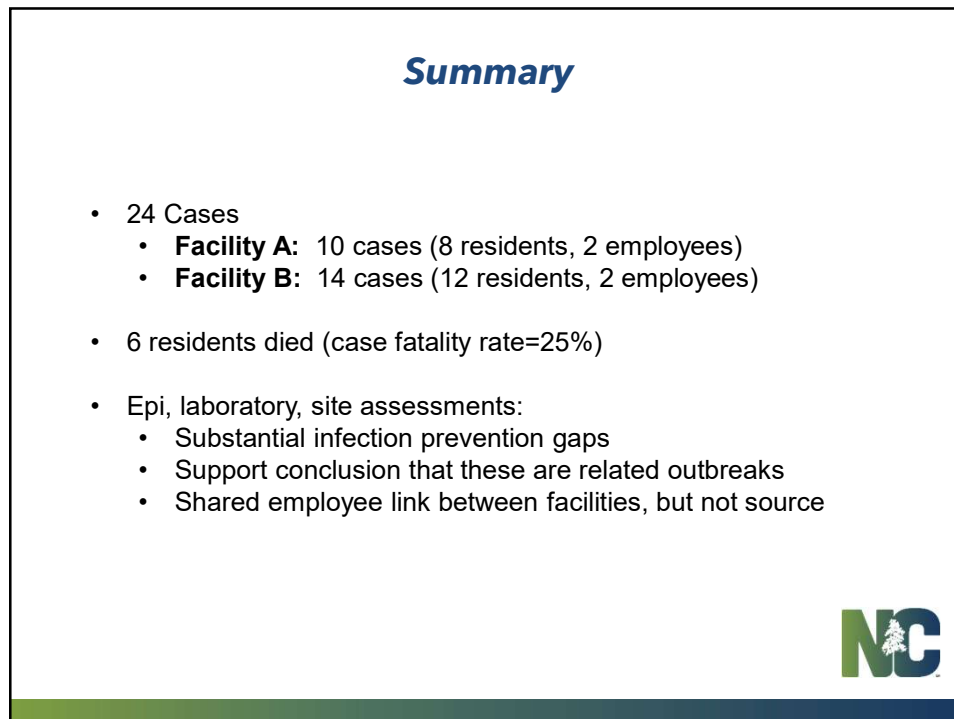
- \*14/15 isolates (13 residents, 1 employee):
  - ~T type 3/13/B3264 or 13/B3264
  - ~All *emm* type 89
- \*WGS: closely related, maximum difference of 3 single nucleotide polymorphisms b/w sequences



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# Legionellosis



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## Legionellosis

- Caused by inhalation *Legionella pneumophila*
- Transmission: Inhalation of aerosolized water
- Two manifestations

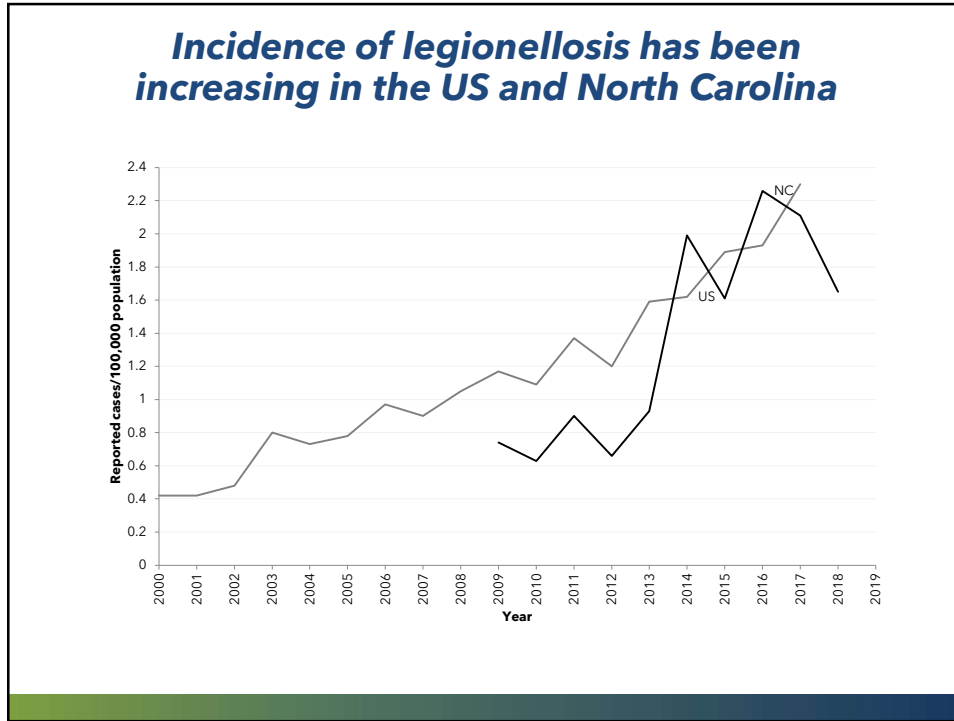
	Legionnaires' disease	Pontiac Fever
Incubation period	2-14 days	5-72 hours
Symptoms	Non-productive cough and <b>pneumonia</b>	Self-limited febrile illness; no pneumonia
Resolution	Typically requires antibiotics; ~15% case-fatality rate	Spontaneous recovery in 2-5 days

- Risk factors
  - >50 years old, smokers, compromised immune systems




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### Investigation Steps




Lab

- Urine antigen
- Other



Risk

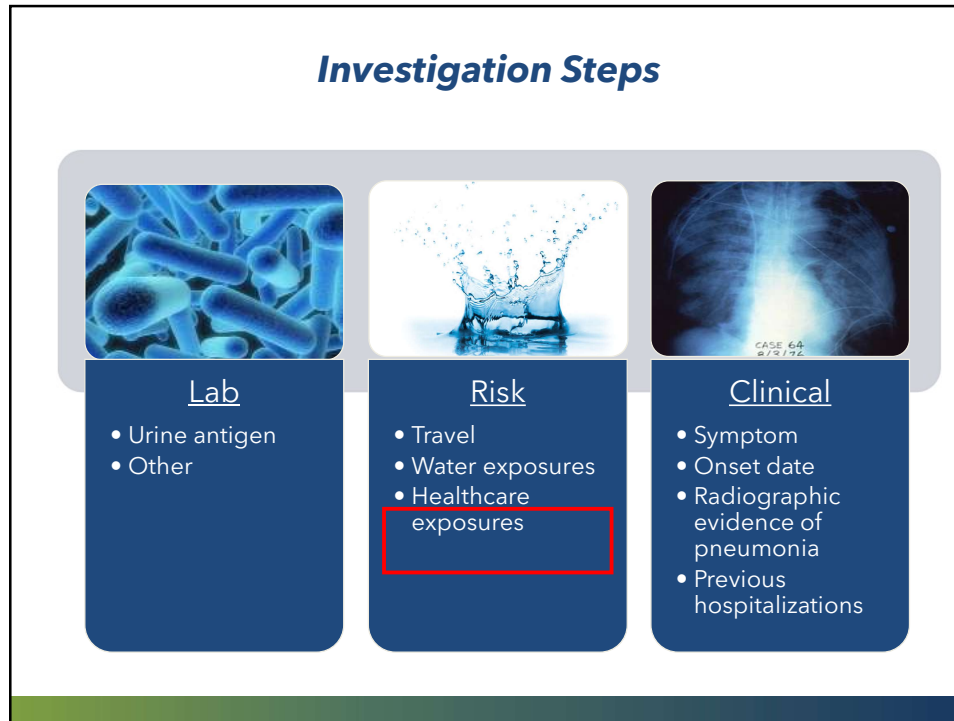
- Travel
- Water exposures
- Healthcare exposures



Clinical

- Symptom
- Onset date
- Radiographic evidence of pneumonia
- Previous hospitalizations

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### The most important question...

Was the patient in the healthcare facility during the 14 days before symptom onset?

Create a timeline:

- When was the patient admitted to the facility?
- When did symptoms start?
- Where did the patient go during the 14 days before symptom onset?



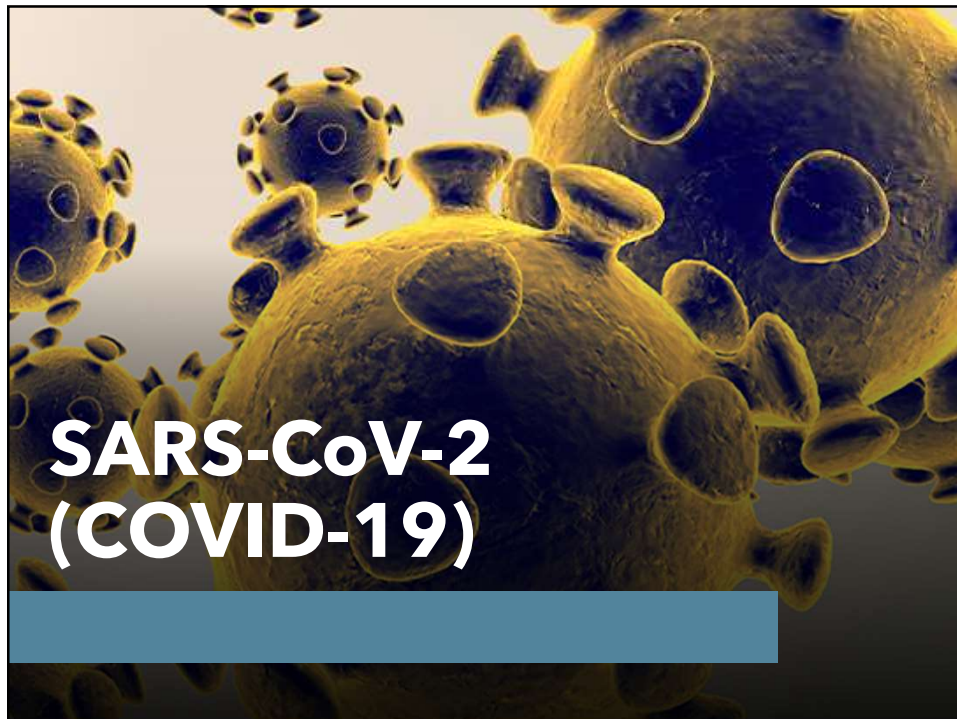
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## Healthcare-associated legionellosis

- Definite healthcare-associated case
  - Confirmed case of legionellosis in a person who has spent  $\geq 14$  days **continuously** in a healthcare facility before illness onset
- Possible healthcare-associated case
  - Confirmed case of legionellosis in a person who has spent **part but not all** of the 14 days before illness onset in a healthcare facility



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## NC Public Health Actions



Contact tracing



Develop, disseminate guidance



Rule change to require reporting



Develop and implement control measures



Develop laboratory testing capacity



Vaccine planning, distribution



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## Partnerships



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## Tis the (respiratory virus) season!

- Encourage vaccine uptake
- Provide face masks, tissues and hands-free trash can, hand sanitizer
- Post signs with respiratory hygiene/cough etiquette reminders
- Ensure staff do not work while sick



[CDC: Preventing Transmission of Viral Respiratory Pathogens in Healthcare Settings](#)



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## Other responses of interest



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## Other responses of interest

- TB in a NICU
- Multidrug Resistant Acinetobacter
- Scabies in long-term care facilities
- Acute Hepatitis B (orthopedic clinic)
- Potential Hepatitis B transmission in dialysis facility & plasma donation center
- Drug Diversion among healthcare providers
- Peritonitis among patients receiving peritoneal dialysis
- Enterovirus in a NICU
- Legionellosis associated with a fair
- National responses:
  - Non-tuberculosis mycobacterium (NTM) and heater-cooler units
  - B. cepacia and liquid docusate



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## 10 Steps of an Outbreak Investigation



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## Reasons to Investigate an Outbreak

- Identify, describe the source
- Describe new diseases / learn more about known diseases
- Identify populations at risk
- Evaluate existing prevention strategies
  - e.g., immunization requirement
- Opportunity to educate public about disease prevention
- Address public concern
- Develop strategies to prevent future outbreaks
- Fulfill legal obligation and duty to care for the public
- End the outbreak!



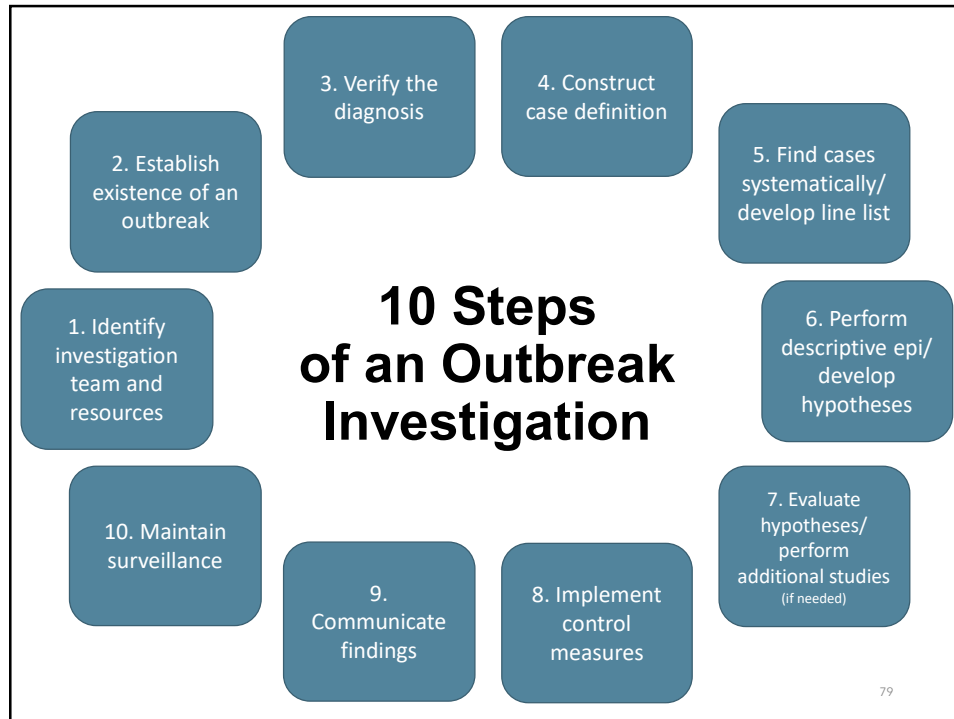
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## Principles of Outbreak Investigations

- Be systematic
  - Follow the same steps for every type of outbreak
  - Write down case definitions
  - Ask the same questions of everybody
- Stop often to re-assess what you know
  - Line list and epidemic curve provide valuable information
  - Consider control measures to be applied
- Coordinate with partners




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## Steps of an Outbreak Investigation

- These steps may occur simultaneously - or be repeated as new information is received



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## What is an Outbreak?

- Anything above what is normally seen for any given time period
- If you aren't sure, call us!
- In a facility setting, an outbreak is generally defined as two or more individuals with the same illness
- Two or more 'epi-linked' cases
  - **Caveat to this rule:**
    - One case of certain diseases = Outbreak
    - Disease not normally seen (Avian Flu, SARS, Ebola)



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## Verify the Diagnosis

- Review medical records, laboratory reports
- Talk with patients
- Request additional testing if needed
- Consult with local health department, communicable disease branch, state public health lab



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## What is a Case Definition?

- Allows a simple, uniform way to identify cases
- “Standardizes” the investigation
- Is specific to the outbreak



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## Case Definition

- 3 components:
  - Person..... Type of illness, characteristics (e.g., “a person with...”)
  - Place..... Location of suspected exposure
  - Time..... When exposure or illness occurred



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## Outbreak Case Definition

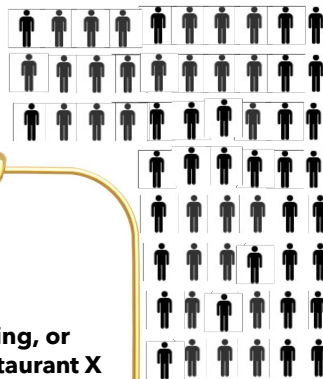
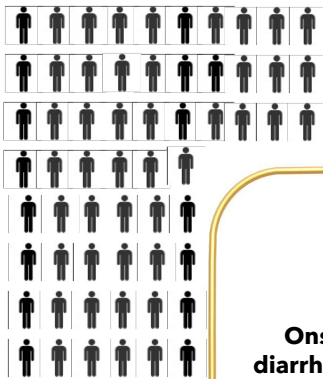


**Your case definition determines who goes in the box of people you need to investigate further**



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## Outbreak Case Definition



**Outbreak Case Definition:**


**Onset of nausea, vomiting, or diarrhea in a patron of restaurant X within 7 days of eating or drinking food/beverage from restaurant X**



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## Outbreak Case Definition


**Onset of nausea, vomiting, or diarrhea in a patron of restaurant X within 7 days of eating or drinking food/beverage from restaurant X**



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## Descriptive Epidemiology

- What and why?
  - Provides systematic method
  - Characterize, or describe what has occurred
  - Person, place, time
- Components
  - Line list
  - Epi curve
  - Others, but we will focus on line list and epi-curve



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## Descriptive Epidemiology

- Person
  - Place
- } Line List
- Time
- } Epidemic curve ('Epi curve')



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## Line List

- Method to systematically record information
- Simple to review, update, summarize
- Each row represents data for a single 'case'
- Information to include:
  - Identifying information
  - Demographics
  - Clinical
  - Exposure/risk factor
- Paper or electronic



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## Example - Line List

Demographic Information														
Line Number	First Name	Middle Name	Last Name	Date of Birth	Gender	BSN	Street1	Street2	City	State	Zip-Code	County	Country	Home Phone
1	Ally		Alligator	1/2/1986	Female		100 Swamp Lane		Cedar Par	NC	27514	Escambia		302-59
2	Benjamin		Bear	12/1/1988	Male		506 Forest Road		Cedar Par	NC	27514	Escambia		336-28
3	Cane		Cat	5/7/1992	Female		52 House Circle		Cedar Par	NC	27514	Escambia		678-98
4	Donald		Duck	4/4/1973	Male		200 Disney Way		Cedar Par	NC	27514	Escambia		301-66
5	Emaly		Elephant	6/18/1979	Female		64 Safari Ave		Cedar Par	NC	27514	Escambia		838-66
6	Farah		Fox	8/24/1982	Female		182 Tree Farm Road		Cedar Par	NC	27514	Escambia		276-96
7	Gary		Gornlia	11/25/1981	Male		70 Jungle Drive		Cedar Par	NC	27514	Escambia		704-33
8	Henry		Horse	9/11/2001	Male		300 Farm Court		Cedar Par	NC	27514	Escambia		225-92
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## Epidemic 'Epi' Curve

- Visual representation of
  - Ill persons (cases) over time
  - Magnitude of outbreak
  - Number of cases on the vertical (y) axis
  - Time period (or date of illness onset) on the horizontal (x) axis
  - Type of outbreak
    - Point source
    - Propagated (person-to-person)

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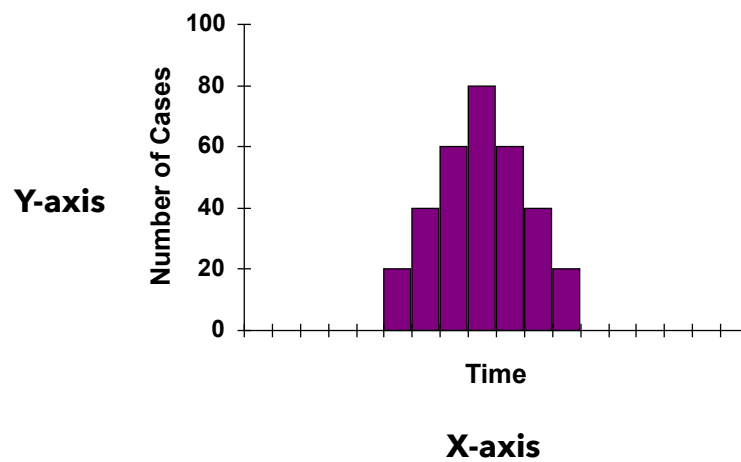
## *Epi Curves*

- Point source
  - Sharp upward slope and a gradual downward slope
  - Common source outbreak
  - Period of exposure is brief
  - Cases occur within one incubation period

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## *Example Epi Curve - Point Source Outbreak*



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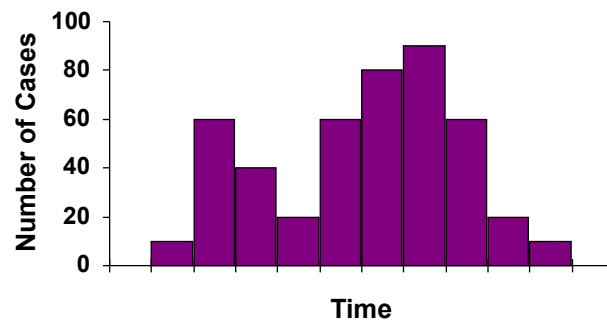
## *Epi Curves*

- Propagated (person-to-person)
  - Progressively taller peaks, an incubation period apart
  - Person to person transmission
  - May last a long time
  - May have multiple waves

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### *Example Epi Curve - Person to Person Outbreak (Propagated)*



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## What are Hypotheses?

- Statements which help us describe why and how the outbreak occurred (i.e., educated guess)
- How do you generate hypotheses?
  - Review the existing body of knowledge
  - Examine line list, epi-curve
  - Conduct open-ended interviews with few case-patients



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## Evaluating the Hypotheses

- Two methods:
  - Compare hypothesis with established facts
  - Perform additional studies (e.g., analytic)
    - Cohort or case-control
    - Assess exposures equally among ill and non-ill persons



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## Control Measures

- When should control measures be implemented *immediately*
  - Source is known
  - Continued risk of either exposing others or being exposed (e.g., HCW diverting injectable drugs)
- Control measures:
  - Are applied as soon as possible
  - May change during investigation



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## Communicate Findings

- Oral
  - Internally with team
  - Externally to public, media, health care providers
- Written
  - Daily updates (e.g., Situation Reports)
  - Final outbreak report



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## Maintain Surveillance

- Evaluate / document effectiveness of control measures
- To ensure outbreak is over
- To ensure secondary outbreak is not occurring
  
- Maintain surveillance for 2 average incubation periods following the last date of illness onset



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## Conclusions

- Epidemiologic investigations essential component of public health, present opportunities to:
  - Characterize diseases
  - Identify populations at risk
  - Evaluate programs, policies, or existing prevention strategies
  - Train public health staff
  - Educate the public
  - Fulfill legal obligations and duty of care for the public
  
- 10 steps provide systematic framework necessary to investigate any outbreak

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## Resources

- **MDROs**
  - Management of Multidrug Resistant Organisms in Healthcare Settings, 2006  
[https://www.cdc.gov/hicpac/mdro/mdro\\_toc.html](https://www.cdc.gov/hicpac/mdro/mdro_toc.html)
  - CDC Facility Guidance for Control of CRE, November 2015 Update  
<https://www.cdc.gov/hai/pdfs/cre/CRE-guidance-508.pdf>
  - CDC Interim Guidance for a Public Health Response to Contain Novel or Targeted MDROs  
<https://www.cdc.gov/hai/pdfs/containment/Health-Response-Contain-MDRO-H.pdf>
  - NC DPH CRE information for Long-Term Care Facilities  
<http://epi.publichealth.nc.gov/cd/hai/docs/CREinfoLTCfacilities.pdf>
- **Exposure Investigations**
  - NC ADMINISTRATIVE CODE, TITLE 10A, SUBCHAPTER 41A  
<https://www.cdc.gov/niosh/topics/bbp/guidelines.html>
- **Injection Safety**
  - One and Only Campaign <http://www.oneandonlycampaign.org/partner/north-carolina>
- **Antimicrobial Stewardship**
  - Be Antibiotics Aware Campaign  
<https://epi.publichealth.nc.gov/cd/antibiotics/campaign.html>
  - NC DPH Antimicrobial Stewardship  
<https://epi.publichealth.nc.gov/cd/antibiotics/stewardship.html>
  - NC DPH STAR Partners [https://epi.publichealth.nc.gov/cd/antibiotics/star\\_partners.html](https://epi.publichealth.nc.gov/cd/antibiotics/star_partners.html)



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## Questions?

## Comments!

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