Emerging Infections, Outbreaks, and Steps of an Outbreak Investigation Across the Healthcare Continuum

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Objectives

• Describe the SHARPPS program

• Review historic outbreak data and discuss trends in outbreaks over time

• Discuss both emerging infections & common healthcare-associated pathogens

• Discuss the public health significance of these organisms across the continuum of care

• Describe the 10 steps of an outbreak investigation

• Describe the role of public health in investigating cases and outbreaks in healthcare facilities
Mission
To work in partnerships to prevent, detect, and respond to events and outbreaks of healthcare-associated and antimicrobial resistant infections in North Carolina.
SHARPPS  Surveillance for Healthcare Associated & Resistant Pathogens Patient Safety Program

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Epidemiologist

Coming Soon!
Health Educator,
Campaigns Coordinator

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Epidemiologist

Coming Soon!
Epidemiology Program Manager
**SHARPPS** Surveillance for Healthcare Associated & Resistant Pathogens Patient Safety Program

**Surveillance, Investigation & Response**
- HAI reporting to NHSN
- CRE surveillance
- DHSR Infection Prevention Breach reporting
- Outbreak & Exposure management

**Prevention, Education & Training**
- Campaigns: One & Only, Get Smart
- Drug Diversion
- Antimicrobial resistance & stewardship
- Infection Control, Assessment & Response (ICAR)
- Partnerships

**Monitoring & Evaluation**
- Data validation
- TAP reports
- Identification, evaluation of aberrant data (CLABSI, CDI)

**Communication**
- HAI data reports
- Newsletters
- Monthly webinar updates
- Drug Diversion tabletop
Outbreak Summary
2014-2017 Outbreak Summary


A total of 901 outbreaks were reported to the Communicable Disease Branch (CD8) from January 1, 2014–December 31, 2017; an average of 225 per year. Details of those outbreaks are presented below.

As required by North Carolina Administrative Code (10A NCAC 41A .0103), local health departments must submit a written report of the investigation within 30 days of the end of the outbreak. Outbreak reports were received for 61% of 2014 outbreaks, 89% of 2015 outbreaks 84% of 2016 outbreaks, and 100% of 2017 outbreaks.

- January 1, 2014 – December 31, 2017
  - 901 Outbreaks
  - 225 Average/year
### 2014-2017 Outbreak Summary

#### Type and Etiology

<table>
<thead>
<tr>
<th>Type</th>
<th>Etiology</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>Total</th>
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<td>108</td>
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<td>57</td>
<td>66</td>
<td>25</td>
<td>165</td>
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<td>90%</td>
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<tr>
<td>Pertussis*</td>
<td></td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>8</td>
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<td>19</td>
<td>17</td>
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<td>Scabies</td>
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<td>4</td>
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<td><strong>Total</strong></td>
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<td>8</td>
<td>39</td>
<td>39</td>
<td>96</td>
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<tr>
<td><strong>Total Outbreaks</strong></td>
<td></td>
<td>197</td>
<td>185</td>
<td>199</td>
<td>320</td>
<td>901</td>
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</tbody>
</table>

*Pertussis was at epidemic levels in 2014, therefore individual outbreaks were not reported.*
2014-2017 Outbreak Summary

**SETTING**

<table>
<thead>
<tr>
<th>Setting</th>
<th>2014-2017 Outbreaks</th>
<th>2014-2017 Outbreaks by Setting and Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other</td>
<td>5%</td>
<td>2014: 30, 2015: 40, 2016: 50, 2017: 60</td>
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<tr>
<td>Total</td>
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</table>

*LTCF*† includes nursing homes, adult care homes, and assisted living facilities

NC Communicable Disease Branch - http://epi.publichealth.nc.gov/cd
2014-2017 Outbreak Summary

**Outbreaks by Setting: 2014-2017**

- Healthcare: 72%
- LTCF*: 72%
- Other: 5%
- School: 9%
- Daycare: 6%
- Community: 2%
- Restaurant: 2%
- Total: 901

*Long-term care facility (LTCF) includes nursing homes, adult care homes, and assisted living facilities.

**Outbreaks by Setting and Year: 2014-2017**

- Year 2014: 100
- Year 2015: 150
- Year 2016: 200
- Year 2017: 300

NC Communicable Disease Branch - http://epi.publichealth.nc.gov/cd
Outbreak Investigations

• 320 outbreaks reported to NC DPH in 2017
  • 6,021+ outbreak-associated cases identified
North Carolina Outbreaks By County, 2017

1 Dot = 1 Outbreak

Total reported = 320
What is a healthcare facility?

- Long-term care
- Skilled-nursing
- Hospital
- Dental office
- Dialysis
- Outpatient
Why are investigations in healthcare facilities different?

- Vulnerable population
  - Increased Incidence
  - Higher mortality

- Common source

- Communal living

- Can be initiated or propagated by activities, staff, or other characteristics of the facility

We investigate to prevent, or stop, an outbreak
Multidrug-Resistant Organisms (MDROs)
Multidrug-Resistant Organisms (MDROs)

YOU ARE THE NEXT CLASS OF DRUG-RESISTANT BACTERIA. AS HUMAN CONTINUE TO ABUSE AND OVERUSE ANTIBIOTICS, YOUR RANKS WILL SWELL. SO, GO OUT THERE AND MUTATE! AND REMEMBER: THAT WHICH DOES NOT KILL US MAKES US STRONGER!!!
Extended-Spectrum Beta-Lactamases (ESBLs)

- Enzyme \( \rightarrow \) 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.
Public Health Significance of ESBLs

- Spread facilitated by interfacility transfer of patients
- Affects vulnerable patient populations
- Difficult to treat
- Improper treatment → organisms may produce another enzyme called carbapenemase
Carbapenem-Resistant Enterobacteriaceae (CRE)

• First recognized in US in 2001

• Enterobacteriaceae = 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-β-lactamase (NDM),
    • Verona integron encoded metallo-β-lactamase (VIM),
    • Imipenemase metallo-β-lactamase (IMP)
    • Oxacillinase-48 (OXA-48)
Public Health 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
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
• 4 cases were discussed on Friday but > 40 positive labs were waiting for us on Monday morning!
New onset ESBL and CRE cases among local hospital ED visits and admissions

First Positives by Monthly Classification (N=129)
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
Initial control measures

Gown and gloves

Hand hygiene

Prevent opportunities for transmission
Site Visit

Investigate to stop transmission & prevent future outbreaks
**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** ✗
**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
New onset ESBL and CRE cases among local hospital ED visits and admissions
**IMP outbreak case definition**

- **Confirmed:** CRE infection or colonization in a resident of North Carolina with laboratory confirmation of imipenemase (IMP) metallo-β-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-β-lactamase test, modified Hodge test, Carba NP, Carbapenem Inactivation Method (CIM), or modified CIM (mCIM)).
New onset ESBL and CRE cases among local hospital ED visits and admissions
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.
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.

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

Rapid Emergence Since 2009
Not Ears Anymore, Mostly Blood

First report of Candida auris in America:
Clinical and microbiological aspects of 18 episodes of candidemia

In the Editor: We need the report by Chokkalingam et al. (1) and report Candida auris as a causative agent of candidemia in South Africa.
Candida auris

Countries from which *Candida auris* cases have been reported, as of September 30, 2018

- Single *C. auris* case reported
- Transmission or multiple cases of *C. auris* reported
- U.S. *C. auris* cases linked to healthcare stays in these countries
C. auris: 433 confirmed, 30 suspect cases in 11 states
North Carolina

- No known *C. auris* to date

- CDC Alert – June 2016

- NC Provider Alert & Request for Reporting – June 2016

- NC Provider Memo – May 2017
  - Enhanced cleaning/disinfection of patient rooms

- CSTE position Statement – June 2017
  - Standardized case definition, goal to make *C. auris* reportable condition

- Added to NC Reportable Conditions list – October 1, 2018
Infection Prevention

- Private room, contact precautions
- Adherence to hand hygiene
- Clean with EPA approved disinfectant effective against *C. difficile* spores
- Screen contacts

Controlling the spread of *C. auris*
Responding to MDROs

• Detect MDROs
  • Increased awareness and testing
  • ARLN
  • CSTE position statement

• Ensure rapid response & containment
  • Prevent transmission
  • Inter-facility communication

• Stewardship efforts
  • Antimicrobial resistance subcommittee
  • Get Smart Campaign

• Education
  • Collaborative effort (SPICE, DPH, LHD)
More patients get infections when facilities do not work together.
(Example: 5 years after CRE enters 10 facilities in an area sharing patients)

Common Approach (status quo)
2,000 patients will get CRE.
CRE will impact 12% of patients.

Independent Efforts
1,500 patients will get CRE.
CRE will impact 8% of patients.

Coordinated Approach
400 patients will get CRE.
CRE will impact 2% of patients.

SOURCE: CDC Vital Signs, August 2015.
Group A Streptococcus (GAS)
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
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.
Recent GAS Outbreak

- January 2017,
  - 2 Facilities in County X, North Carolina
  - ‘Sister’ facilities, owned by the same company
Recent GAS Outbreak

• 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
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
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
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
*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
GAS EpiCurve, December 2016 – June 2017

Group A Streptococcus at 2 LTCFs, December 2016 – June 2017, N=24

HCW 2nd positive 1/18/17 (1st positive 1/6/17)
Summary

- 24 Cases
  - **Facility A**: 10 cases (eight residents, 2 employees)
  - **Facility B**: 14 cases (12 residents, 2 employees)

- 6 residents died (case fatality rate=25%)

- Epi, laboratory, site assessments:
  - Substantial infection prevention gaps
  - Support conclusion that these are related outbreaks
  - Shared employee link between facilities, but not source
Legionellosis
Legionellosis

• Caused by inhalation *Legionella pneumophila*

• Transmission: Inhalation of aerosolized water

• Two manifestations

<table>
<thead>
<tr>
<th></th>
<th>Legionnaires’ disease</th>
<th>Pontiac Fever</th>
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<tbody>
<tr>
<td>Incubation period</td>
<td>2–10 days</td>
<td>5–72 hours</td>
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<tr>
<td>Symptoms</td>
<td>Non-productive cough and pneumonia</td>
<td>Self-limited febrile illness; no pneumonia</td>
</tr>
<tr>
<td>Resolution</td>
<td>Typically requires antibiotics; ~15% case-fatality rate</td>
<td>Spontaneous recovery in 2–5 days</td>
</tr>
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</table>

• Risk factors
  • >50 years old, smokers, compromised immune systems
Incidence of legionellosis has been increasing in the US and North Carolina
Investigation Steps

Lab
- Urine antigen
- Other

Risk
- Travel
- Water exposures
- Healthcare exposures

Clinical
- Symptom
- Onset date
- Radiographic evidence of pneumonia
- Previous hospitalizations
Investigation Steps

Lab
- Urine antigen
- Other

Risk
- Travel
- Water exposures
- Healthcare exposures

Clinical
- Symptom
- Onset date
- Radiographic evidence of pneumonia
- Previous hospitalizations
The most important question...

Was the patient in the healthcare facility during the 10 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 10-days before symptom onset?
Healthcare-associated legionellosis

• Definite healthcare-associated case
  • Confirmed case of legionellosis in a person who has spent ≥10 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 10 days before illness onset in a healthcare facility
Other responses of interest
Other responses of interest

- TB in a NICU
- Multidrug Resistant Acinetobacter (1)
- 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
- National responses:
  - Non-tuberculosis mycobacterium (NTM) and heater-cooler units
  - B. cepacia and liquid docusate
10 Steps of an Outbreak Investigation
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!
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
10 Steps of an Outbreak Investigation

1. Identify investigation team and resources
2. Establish existence of an outbreak
3. Verify the diagnosis
4. Construct case definition
5. Find cases systematically/develop line list
6. Perform descriptive epi/develop hypotheses
7. Evaluate hypotheses/perform additional studies (if needed)
8. Implement control measures
9. Communicate findings
10. Maintain surveillance
Steps of an Outbreak Investigation

- These steps may occur simultaneously - or be repeated as new information is received
What is an Outbreak?

• Increase in cases above what is expected in that population in that area
• Occurrence of 2 or more ‘epi-linked’ cases
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
What is a Case Definition?

• Allows a simple, uniform way to identify cases

• “Standardizes” the investigation

• Is specific to the outbreak
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
Outbreak Case Definition

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

- Person
- Place

\[
\begin{align*}
\text{Line List} \\
\text{Epidemic curve (‘Epi curve’)}
\end{align*}
\]
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
Example – Line List

<table>
<thead>
<tr>
<th>Line Number</th>
<th>First-Name</th>
<th>Middle-Name</th>
<th>Last-Name</th>
<th>Date of Birth</th>
<th>Gender</th>
<th>SSN</th>
<th>Street1</th>
<th>Street2</th>
<th>City</th>
<th>State</th>
<th>Zip-Code</th>
<th>County</th>
<th>Country</th>
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<td>Ally</td>
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<td>Alligator</td>
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<td></td>
<td>100 Swamp Lane</td>
<td></td>
<td>Cedar Park, NC</td>
<td>27514</td>
<td>Escambia</td>
<td></td>
<td>302-59</td>
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<td>Female</td>
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<td>Escambia</td>
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<td></td>
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<td></td>
<td>Cedar Park, NC</td>
<td>27514</td>
<td>Escambia</td>
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</table>
**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)
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
Example Epi Curve – Point Source Outbreak

Y-axis

Number of Cases

X-axis

Time

X-axis

Y-axis
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
Example Epi Curve – Person to Person Outbreak (Propagated)
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
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
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
Communicate Findings

• Oral
  • Internally with team
  • Externally to public, media, health care providers

• Written
  • Daily updates (e.g., Situation Reports)
  • Final outbreak report
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
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
Role of the State Health Department
Outbreak Assistance

• Is it an outbreak?
  • If you aren’t sure, call Public Health!

• CDB can assist with guidance, tools and onsite support

• Facilitating and coordinate calls with partners

• Provide written recommendations
What Happens When Public Health is Called?

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

• MDROs
  • Management of Multidrug Resistant Organisms in Healthcare Settings, 2006
    https://www.cdc.gov/hicpac/mdro/mdro_toc.html
  • CDC Facility Guidance for Control of CRE, November 2015 Update
  • 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
Questions?

NCHAI@DHHS.NC.GOV
Case Study
Oswego – An Outbreak of Gastrointestinal Illness following a Church Supper

Case Study No. 401-303
Centers for Disease Control and Prevention
Epidemiology Program Office
10 Steps of an Outbreak Investigation

1. Identify investigation team and resources
2. Establish existence of an outbreak
3. Verify the diagnosis
4. Construct case definition
5. Find cases systematically/develop line list
6. Perform descriptive epi/develop hypotheses
7. Evaluate hypotheses/perform additional studies (if needed)
8. Implement control measures
9. Communicate findings
10. Maintain surveillance
Cases of Gastrointestinal Illness
by Time of Onset of Symptoms (Hour Categories)
Oswego County, New York, April 18-19, 1940
## Incubation Period

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Cases of Gastrointestinal Illness by Incubation Period in Hours
Oswego County, New York; April 18-19, 1940

Y-axis: Cases
X-axis: Incubation Period (Hours)
<table>
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<tr>
<th>Food Items Served</th>
<th>Number of persons who ATE specified food</th>
<th>Number of persons did NOT eat specified food</th>
<th>Attack Rate Ratio</th>
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* Excludes 1 person with indefinite history of consumption of that food.

1. Food with highest attack rate among consumers: vanilla ice cream (80%)
2. Food with lowest attack rate among non-consumers: vanilla ice cream (14%)
3. Proportion of cases exposed to vanilla ice cream: 43/46 = 93%.
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3. Proportion of cases exposed to vanilla ice cream: 43/46 = 93%.
Measures of Association

Odds ratio, Risk ratio, Rate ratio

1 = null

<1 = less likely  >1 = more likely
<table>
<thead>
<tr>
<th>Food Items Served</th>
<th>Number of persons who ATE specified food</th>
<th>Number of persons did NOT eat specified food</th>
<th>Attack Rate Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>III</td>
<td>Not III</td>
<td>Total</td>
</tr>
<tr>
<td>Baked ham</td>
<td>29</td>
<td>17</td>
<td>46</td>
</tr>
<tr>
<td>Spinach</td>
<td>26</td>
<td>17</td>
<td>43</td>
</tr>
<tr>
<td>Mashed potato*</td>
<td>23</td>
<td>14</td>
<td>37</td>
</tr>
<tr>
<td>Cabbage salad</td>
<td>18</td>
<td>10</td>
<td>28</td>
</tr>
<tr>
<td>Jello</td>
<td>16</td>
<td>7</td>
<td>23</td>
</tr>
<tr>
<td>Rolls</td>
<td>21</td>
<td>16</td>
<td>37</td>
</tr>
<tr>
<td>Brown bread</td>
<td>18</td>
<td>9</td>
<td>27</td>
</tr>
<tr>
<td>Milk</td>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Coffee</td>
<td>19</td>
<td>12</td>
<td>31</td>
</tr>
<tr>
<td>Water</td>
<td>13</td>
<td>11</td>
<td>24</td>
</tr>
<tr>
<td>Cakes</td>
<td>27</td>
<td>13</td>
<td>40</td>
</tr>
<tr>
<td>Ice cream, vanilla</td>
<td>43</td>
<td>11</td>
<td>54</td>
</tr>
<tr>
<td>Ice cream, chocolate*</td>
<td>25</td>
<td>22</td>
<td>47</td>
</tr>
<tr>
<td>Fruit salad</td>
<td>4</td>
<td>2</td>
<td>6</td>
</tr>
</tbody>
</table>

* Excludes 1 person with indefinite history of consumption of that food.

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