Epidemiology Program: Outbreak Investigation

Bela T. Matyas, MD, MPH
Massachusetts Department of Public Health
2007

Epidemiology

- The study of the association between an exposure, risk factor or event and an outcome, illness or result:

  Exposure/
  Risk factor/
  Event  Outcome/
  Illness/
  Result

- Can study adverse health outcomes or positive health outcomes

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3. Epidemiology, cont.

Epidemiology, cont.

• Can study this association in either of two ways:
  – Compare those “exposed” to those “not exposed” to see how many of each group develop the outcome (Cohort or Follow-up approach)
  – Compare those “with the outcome” to those “without the outcome” to see how many of each group experienced the exposure (Case-Control approach)

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4. Epidemiology: Interpretation of Results

Epidemiology: Interpretation of Results

• Identifies the presence or absence of an association between an exposure and an outcome, and helps characterize the magnitude and validity of the association
• Does not establish causation:
  – Also need to consider biological plausibility, temporal elements, etc.

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5. Attributes of a Public Health Surveillance System

Attributes of a Public Health Surveillance System

- Sensitivity
- Timeliness
- Representativeness
- Predictive value
- Accuracy and completeness
- Simplicity
- Flexibility
- Acceptability

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6. Confidentiality

Confidentiality

- Public health surveillance deals with potentially sensitive information
  - Medical information
  - Some diseases are stigmatizing
- Systems need to protect confidentiality

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7. Basic Structure of Public Health Surveillance

**Basic Structure of Public Health Surveillance**

- **Core surveillance systems:**
  - Health care providers (physicians)
  - Hospitals/ICPs
  - Laboratories
- **Supplemental surveillance systems:**
  - Sentinel surveillance
  - Proxy surveillance, e.g. syndromic, risk factor

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8. Factors Affecting Occurrence of Infection

**Factors Affecting Occurrence of Infection**

- **Agent factors**
  - Virulence
  - Antibiotic resistance
- **Host factors**
  - Age, physical condition
  - Genetics
  - Immunity
- **Transmission route**

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9. How Communicable Diseases are Transmitted

How Communicable Diseases are Transmitted

- Airborne, Droplet-borne
- Person-to-person
- Waterborne, Foodborne
- Bloodborne
- Sexually transmitted
- Vehicle-borne
- Zoonotic (incl. vector-borne)

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10. General Principles of the Epi Field Investigation

General Principles of the Epi Field Investigation

Determine:
- Etiologic agent
- Source
- Mode of transmission
- Persons at risk
- Predisposing factors

Tools:
- Descriptive Epi
- Analytical Epi

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11. Steps in Conducting a Field Investigation

Steps in Conducting a Field Investigation

• Confirm the diagnosis
• Confirm the existence of an outbreak
• Determine the number of cases
• Orient the data in terms of person, place and time
• Determine who is at risk
• Develop a hypothesis; compare hypothesis to fact
• Plan a more systematic study, if necessary
• Prepare a written report
• Implement control & prevention

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12. Confirm the Diagnosis

Confirm the Diagnosis

• Use standard laboratory techniques
  — Serology
  — Culture, PFGE
  — PCR and molecular methods
• Document symptomatology
  — If most patients have similar symptoms, only
    15-20% of cases need be laboratory confirmed

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13. Confirm the Existence of an Outbreak

**Confirm the Existence of an Outbreak**

- The terms “outbreak” & “epidemic” are subjective
- Use surveillance data
- Rule out artifactual causes
  - Changes in local reporting practices
  - Increased interest in the disease
  - Changes in diagnostic methods
  - New health care provider in town

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14. Determine the Number of Cases

**Determine the Number of Cases**

- Create a workable case definition
  - Use accepted, usual disease presentation with or without lab confirmation
  - Include signs & symptoms of the disease
- Decide how to find cases
  - Routine vs. intensive
- Inquire about and count cases
- Collect basic information

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15. Develop an Initial Case Definition

Develop an Initial Case Definition

- Set of criteria for deciding whether an individual should be classified as “ill”
- Objective criteria
- Outbreak-associated vs. background
  - Primary vs. secondary cases

16. Case Definitions

Case Definitions

- Begin general; become increasingly specific as information is gathered
  - Person, place and time associations
  - Clinical criteria
- Classify cases based on certainty
  - Definite/Confirmed
  - Probable/Presumptive
  - Possible/Suspect
17. “Describe” the Outbreak

“Describe” the Outbreak

• Time
  – Epidemic Curve

• Place
  – Geographic location of the cases
  – Geographic links, if any

• Person
  – Age, gender, race/ethnicity
  – Occupation
  – Symptoms

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18. Descriptive Epidemiology

Descriptive Epidemiology

• Concerned with description rather than explanation

• Looks for associations between cases based on person, place and time considerations:
  – Person - demographics, symptoms
  – Place - location, common exposures
  – Time - onset of illness, epidemic curve

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19. **Person: Frequency Tables**

### Person: Frequency Tables

<table>
<thead>
<tr>
<th>Age</th>
<th>Freq</th>
<th>Percent</th>
<th>Cum.</th>
</tr>
</thead>
<tbody>
<tr>
<td>21</td>
<td>1</td>
<td>2.9%</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>2</td>
<td>5.7%</td>
<td>8.6%</td>
</tr>
<tr>
<td>23</td>
<td>4</td>
<td>11.4%</td>
<td>20.0%</td>
</tr>
<tr>
<td>24</td>
<td>3</td>
<td>8.6%</td>
<td>28.6%</td>
</tr>
<tr>
<td>25</td>
<td>3</td>
<td>8.6%</td>
<td>37.1%</td>
</tr>
<tr>
<td>26</td>
<td>2</td>
<td>5.7%</td>
<td>42.9%</td>
</tr>
<tr>
<td>27</td>
<td>3</td>
<td>8.6%</td>
<td>51.4%</td>
</tr>
<tr>
<td>28</td>
<td>2</td>
<td>5.7%</td>
<td>57.1%</td>
</tr>
<tr>
<td>29</td>
<td>1</td>
<td>2.9%</td>
<td>60.0%</td>
</tr>
<tr>
<td>30</td>
<td>1</td>
<td>2.9%</td>
<td>62.9%</td>
</tr>
<tr>
<td>31</td>
<td>1</td>
<td>2.9%</td>
<td>65.7%</td>
</tr>
<tr>
<td>32</td>
<td>3</td>
<td>9.6%</td>
<td>74.3%</td>
</tr>
<tr>
<td>33</td>
<td>5</td>
<td>14.3%</td>
<td>88.6%</td>
</tr>
<tr>
<td>34</td>
<td>1</td>
<td>2.9%</td>
<td>91.4%</td>
</tr>
<tr>
<td>35</td>
<td>2</td>
<td>5.7%</td>
<td>97.1%</td>
</tr>
<tr>
<td>36</td>
<td>1</td>
<td>2.9%</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

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20. **Place: Spot Maps**

### Place: Spot Maps

"...I found that nearly all the deaths had taken place within a short distance of the pump."

Dr. John Snow, September 1854

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21. Place: Common Exposure Location

Place: Common Exposure Location

• Examples
  – Case 1 – rest. A, B, C, D
  – Case 2 – rest. B, E, F
  – Case 3 – rest. A, B, G, H, I
  – Case 4 – rest. B, D, J, K

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22. Place: Common Exposure Location (cont.)

Place: Common Exposure Location (cont.)

• Same restaurant
• Multiple restaurants, same chain or owner
• Multiple chains, common distributor

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23. **Point-Source Exposure**

![Point-Source Exposure](image1)

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24. **Ongoing Exposure**

![Ongoing Exposure](image2)

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25. Secondary Exposures

Secondary Exposures

Number

1 3 5 7 9 11 13 15

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26. Identify Persons At Risk

Identify Persons At Risk

- Collect & organize all information about ill individuals
  - number ill
  - general characteristics

- Use analytical techniques to confirm who is at risk

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Develop a Hypothesis

- Most challenging aspect of investigation
- Weigh clinical, laboratory, and epidemiologic features of the disease to hypothesize what exposure(s) caused the outbreak
  - E.g., GI illness: foodborne, waterborne, person-to-person, zoonotic, etc.
29. Case Definition vs. Hypothesis

Case Definition vs. Hypothesis

- Case Definition
  - Person
  - Place
  - Time
  - Symptoms
- Classifies cases vs. controls

- Hypothesis
  - Theory
  - Describes exposure to test analytically

Do NOT include hypothesis in case definition!!!

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30. Compare Hypothesis to Facts

Compare Hypothesis to Facts

- “Square” the hypothesis with clinical, laboratory and other epidemiological facts of the investigation
- Is hypothesis at least biologically possible?
- Incompatible hypotheses must be reconsidered

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31. Conduct an Analytical Study

Conduct an Analytical Study

- To test hypothesis
- Chose appropriate study design
  - Cohort
  - Case-Control

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32. Analytical Epidemiology

Analytical Epidemiology

- Helps identify direction, strength and validity of association
- Compare by exposure status
  - Cohort (Follow-up) study
  - Experimental study
- Compare by outcome status
  - Case-Control study

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33. Measures of Association Between Exposure & Disease

Measures of Association Between Exposure & Disease

• Selection of measure depends on type of study
  — “Relative risk” — cohort studies
    • Risk of developing disease given the exposure
  — “Odds ratio” — case-control studies
    • Odds of having the exposure given the disease

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34. Cohort Studies

Cohort Studies

• Groups of exposed and unexposed individuals can easily be identified

• Compare risk of illness by whether exposure did or didn’t occur (e.g., food was/wasn’t eaten)

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Attack Rate: Measure of Occurrence

Attack Rate (AR)

- Expresses occurrence of a disease among a particular at-risk population for a limited period of time, often due to a very specific exposure
- Can be event-specific or food-specific, for example

\[
AR = \frac{\text{Number of ill people with exposure}}{\text{Total number of people with exposure}}
\]

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Estimating Risks Associated with “Exposure”

Compare attack rates among exposed and unexposed

\[
\text{Relative Risk} = \frac{\text{Attack Rate (exposed)}}{\text{Attack Rate (unexposed)}}
\]

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37. Using the 2 by 2 Table to Calculate Relative Risk

Using the 2 by 2 Table to Calculate Relative Risk

\[
RR = \frac{a}{c} / \frac{a+b}{c+d}
\]

- 1 → No Association
- RR < 1 → Negative Association
- RR > 1 → Positive Association

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38. Case-Control Studies

Case-Control Studies

- Used when groups of exposed and unexposed individuals cannot easily be identified

- Compare ill with non-ill individuals to determine likelihood of having had the exposure (e.g., eating a specific food)

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39. Odds Ratio from Case-Control Studies

**Odds Ratio from Case-Control Studies**

- Measurement of the odds of having an exposure (e.g., specific food consumption) given the disease
- Estimates the Relative Risk

\[
\text{Odds Ratio (OR)} = \frac{\text{Odds of exposure among cases}}{\text{Odds of exposure among controls}} = \frac{a/c}{b/d} = \frac{ad}{bc}
\]

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40. Using the 2 by 2 Table to Calculate Odds Ratio

**Using the 2 by 2 Table to Calculate Odds Ratio**

<table>
<thead>
<tr>
<th>Disease</th>
<th>Exposure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes (+)</td>
<td>a</td>
</tr>
<tr>
<td>No (-)</td>
<td>c</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Disease</th>
<th>Exposure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes (+)</td>
<td>a</td>
</tr>
<tr>
<td>No (-)</td>
<td>c</td>
</tr>
</tbody>
</table>

\[
\text{OR} = \frac{\frac{a/c}{b/d}} = \frac{ad}{bc}
\]

OR = 1 ➞ No Association
OR < 1 ➞ Negative Association
OR > 1 ➞ Positive Association

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41. Validity of Findings

Validity of Findings

Is the observed association between exposure and disease due to alternative explanations?

- Bias: systematic error (selection, information {recall, interviewer, misclassification})
- Confounding
- Chance: sampling variability and sampling size

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42. Examples of Bias

Examples of Bias

- Random misclassification of cases vs. controls or exposed vs. unexposed
  - Categories of persons less “clean”
  - Biases OR or RR toward “1.0”
- Recall bias
  - Cases better remember exposures than do controls
  - Problem with retrospective studies
  - May result in inflated OR

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43. Confounding

Confounding

- Alternative explanation for the association, linked to both exposure and outcome

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44. Evaluating the Role of Chance

Evaluating the Role of Chance

- $P$ value
  - Probability a given association could have occurred by chance alone
  - “Statistically significant” defined as $p \leq 0.05$
  - Consider all available evidence when interpreting $P$ values

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45. Evaluating the Role of Chance, cont.

Evaluating the Role of Chance, cont.

- 95% Confidence Interval
  - Range within which the true association lies, based on 95% assurance

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46. P Values and Confidence Intervals, Example 1

P Values and Confidence Intervals, Example 1

\[
RR = \frac{5}{(5 + 10)} = \frac{9}{(9 + 11)} = 0.3333
\]

\[
RR = 0.74
\]

95% confidence limits for RR:

\[
0.43 < RR < 2.79
\]

Uncorrected \( P \)-value = 0.486

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47. **P Values and Confidence Intervals, Example 2**

\[
RR = \frac{11 / (11 + 4)}{3 / (3 + 17)} = \frac{7.333}{.15}
\]

\[
RR = 4.89
\]

95% confidence limits for RR:

\[
1.65 < RR < 14.50
\]

Uncorrected \(P\)-value = \(0.000490\)

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48. **P Value: Effect of Sample Size**

\[
\text{Exposure} \quad + \quad - \quad \text{Total}
\]

\[
\begin{array}{ccc}
\text{Disease} & + & - & \text{Total} \\
+ & 4 & 1 & 5 \\
- & 1 & 2 & 3 \\
\end{array}
\]

Fisher's Exact \(P\)-value = .46

\[
OR = 8/1 = 8
\]

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49. P Value: Effect of Sample Size, cont.

**P Value: Effect of Sample Size, cont.**

<table>
<thead>
<tr>
<th>Exposure</th>
<th>Disease</th>
<th>+</th>
<th>-</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>+</td>
<td>+</td>
<td>8</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>2</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10</td>
<td>6</td>
<td>16</td>
</tr>
</tbody>
</table>

Fisher’s Exact $P$-value = 0.12

$OR = \frac{32}{4} = 8$

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**P Value: Effect of Sample Size, cont.**

<table>
<thead>
<tr>
<th>Exposure</th>
<th>Disease</th>
<th>+</th>
<th>-</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>+</td>
<td>+</td>
<td>12</td>
<td>3</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>3</td>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15</td>
<td>9</td>
<td>24</td>
</tr>
</tbody>
</table>

Fisher’s Exact $P$-value = 0.04

$OR = \frac{72}{9} = 8$

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51. The Significance of “Significance”

The Significance of “Significance”

“Not significant” does not necessarily mean “no association”… it may reflect a study size too small to detect a true association in the source population

Field Epidemiology, 1986, Michael B. Gregg

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52. Implement Control & Prevention Measures

Implement Control & Prevention Measures

- Remove (embargo) or recall contaminated food products
- Remove infectious foodhandlers or employees
- Propose new methods of operating
- Re-emphasize proper procedures or behavioral practices
- Recommend educational courses
- Close facilities

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53. Outbreak Investigation and Control

Outbreak Investigation and Control

- Relationship with:
  - Local health departments
  - Neighboring states
  - CDC, FDA, USDA
  - Hospitals & health care providers

54. Foodborne Diseases

Foodborne Diseases

- Well established surveillance methods
  - Core systems
  - Sentinel systems
- Changing nature of foodborne diseases
  - Foodhandler hygiene
  - Regional & international outbreaks
- New advances in lab testing (e.g. PFGE)
Foodborne Disease: Factors Affecting Epidemiology & Surveillance

- Public health infrastructure
- Large exposed populations - case dilution
- Jurisdictional boundaries
- Laboratory utilization - managed care
- New pathogens and reporting constraints
- Lack of agency communication

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Foodborne Diseases: Scope

- Isolated, sporadic cases
- Local, point-source outbreaks
  - Restaurant, caterer, party, “church supper”
- Widespread food item
  - e.g., *E. coli* 0157 in ground beef
- Imported (international supermarket)
  - e.g., cyclospora in raspberries, salmonella in sprouts

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57. Transmission of Foodborne Diseases

Transmission of Foodborne Diseases

• Contaminated food
  – Ready-to-eat
  – Under-cooked
• Cross-contamination of food
• Infectious foodhandler with poor hygiene
• Exacerbated by time-temperature abuse

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58. Foodborne Disease Agents

Foodborne Disease Agents

• Bacteria
  – May reproduce in food
  – Moderate incubation periods
• Viruses
  – Require host to reproduce
• Toxins
  – Short incubation period; no reproduction
• Parasites
  – Longer incubation periods

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59. Non-Foodborne Routes of Disease Transmission

Non-Foodborne Routes of Disease Transmission

Images courtesy of National Environmental Health Assoc.

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60. A Foodborne Outbreak of Shigellosis

A Foodborne Outbreak of Shigellosis

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61. Notification

**Notification**

- Jan. 29, 1998 → state notified by local Board of Health
- Multiple persons ill with GI disease
- Stool cultures revealed *Shigella sonnei*
- Common history: Restaurant X

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62. Case Ascertainment

**Case Ascertainment**

- Through self-report or provider report to local Board of Health
- Through positive *S. sonnei* lab cultures
- Through GI case report forms
- Through credit card receipts
- Via interviews with cases
- Through interviews of staff at Restaurant X

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Interviews

- 99 customers interviewed
  - 77 identified via self or provider report, including 65 cases (84%)
  - 22 were not self or lab-reported, including 14 cases (64%)

- 16 staff interviewed

Case Definition

- Outbreak case definition:
  - Ate at Restaurant X on 1/22, 1/23 or 1/24
  - Developed diarrhea during the following 5 days and/or lab-confirmed with S. sonnei
65. Outbreak Cases: Patrons

Outbreak Cases: Patrons

♦ 79 customer cases
♦ 23 lab-confirmed *S. sonnei*
♦ 30 separate groups
♦ exposed over 3-day period (1/22-1/24)

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66. Outbreak Cases: Staff

Outbreak Cases: Staff

♦ All staff interviewed & required to submit stool
♦ 8 staff cases
♦ 7 lab-confirmed *S. sonnei*
♦ All wait staff (not kitchen staff)

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Estimated Attack Rate

- 318 customers ate at Restaurant X over 3-day period
- 318 x 64% estimate → >200 ill

Epidemic Curve

Day of Illness Onset by Day Customers Exposed  (n=79)

Number of Cases

Date of Onset

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69. Foodborne Disease Outbreak

**Foodborne Disease Outbreak**

- Point source epidemic
- Restaurant X only common link
- Possible modes of transmission:
  - improper food preparation (contaminated source)
  - cross contamination
  - foodhandler (bare hand) contamination

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70. Exposure Assessment

**Exposure Assessment**

- Case-Control study
- 79 cases, 20 controls
- 41 food items/groups analyzed

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Exposure Assessment, cont.

- Potato basil garlic spread
  - OR = 20.7
  - 95% CI = 1.63, 579.5
  - p-value = 0.01
  - definitely consumed by 76/77 (99%)

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Exposure Assessment, cont.

- Ice water also significant
  - OR = 6.70
  - p-value = 0.01

- No common wait person

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73. Lab Results: Pulsed-Field Gel Electrophoresis

Lab Results: Pulsed-Field Gel Electrophoresis

- 30 customer/staff isolates analyzed
  - Visual: 5 patterns, all \( \leq 3 \) band difference
  - Computer: 3 patterns, \( \leq 1.5\% \) tolerance
- Multiple patterns observed:
  - 2 Cases \( \rightarrow \) 2 specs \( \rightarrow \) 2 patterns
  - 1 Case \( \rightarrow \) 1 spec \( \rightarrow \) 2 patterns

74. Environmental Findings

Environmental Findings

- Potato basil garlic spread
  - Bare hand contact (prep. and service)
  - Inadequate cooling
  - Provided to all tables
  - Stnd plate count = 2,300,000
- Wait staff
  - Reportedly ill prior to customers
  - Worked while ill during 3-day period
Conclusions

- Reminder of significant foodborne outbreak potential of *S. sonnei* (low infectious dose)
- Most probable cause of outbreak: infected worker with poor hygiene → bare hand contact

Policy Implications

- FDA Food Code
  - No bare hand contact with Ready-to-Eat foods permitted
- Shifting pattern of foodborne outbreaks
  - Role of food handler hygiene
78. Giardiasis: Epidemiology

Giardiasis: Epidemiology

- Infectious agent: *Giardia lamblia*
  - Trophozoite (mature)
  - Cyst (infectious)
- Zoonotic infection
  - Mammals a major reservoir
- Human infection
  - Direct: person-to-person
  - Indirect: fecally-contaminated water or food
- 857 cases in Massachusetts in 2003

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79. Giardiasis: Epidemiology, cont.

Giardiasis: Epidemiology, cont.

- Outbreaks
  - Contaminated drinking water
  - Recreational water (few)
  - Foodborne (few)
- Individual cases
  - Person-to-person (e.g., day care centers)
- Incubation period: mean 7 d. (range 1–4 wks)
- Communicable as long as excreting cysts
  (up to 1 month)

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80. Giardiasis: Clinical

Giardiasis: Clinical

- Broad spectrum of symptoms
  - Watery diarrhea
  - Abdominal pain
  - Foul smelling stool
  - Flatulence
  - Abdominal distention
  - Anorexia
- Asymptomatic infection is common

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81. Background: Outbreak

Background: Outbreak

- **September 16, 2003**: First case reported to Milton Board of Health & Massachusetts Department of Public Health
- **September 22, 2003**: 5 more cases reported from same town, onsets Aug. 28–Sept. 4, 2003
- All cases linked to swimming pools at a country club in the town
- Cases continue even 1 month after pools closed for season on Sept. 5, 2003

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82. Background: Country Club

Background: Country Club

- Located in Milton
  - Population 26,700
- Privately owned
- 2 outdoor pools (Adult and Kiddy)
  - Separate filtering systems
  - 1 certified pool operator
- Snack bar
- Diaper-changing stations
- Handwashing signs

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Water Supply for Milton

- Water supplied by the Massachusetts Water Resources Authority (MWRA):
  - Provides water to 46 cities/towns in Massachusetts
  - All 46 cities and towns receive same water
- No increase in giardiasis reported by these other cities and towns

Objectives of Investigation

- Determine extent of outbreak
- Determine source of outbreak
- Identify risk factors for illness
- Recommend appropriate prevention and control measures
Method: Retrospective Cohort Study

- Questionnaires mailed to member-households of country club
- Swimming pools suspected as result of hypothesis generating interviews

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Questionnaire

- Demographics
- Symptoms
- Time spent in kiddy pool or adult pool at club
- Food bought at club
- Diaper changing stations used at club
- Summer camping or hiking
- Children who play with other children or baby-sit for other children

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Case Definitions

Person / Place

• Member or guest of the country club

Clinical

• Confirmed Case
  — Laboratory diagnosed (with or without symptoms)

• Probable Case
  — Diarrhea

• Suspect Case
  — Loss of appetite and cramps and gas

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Results of Questionnaire

| Households sent questionnaires | 498 |
| Households returning questionnaires | 175 |
| Household response rate | 35% |
| Number of people in responding households | 584 |
| Total cases | 149 |
| Overall attack rate | 149 / 584 (25%) |

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89. Breakdown of Cases (n = 149)

90. Symptoms of Cases (N = 149)

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Count (Percentage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diarrhea</td>
<td>92 (62%)</td>
</tr>
<tr>
<td>Foul Smelling Stool</td>
<td>83 (56%)</td>
</tr>
<tr>
<td>Cramps</td>
<td>81 (54%)</td>
</tr>
<tr>
<td>Gas</td>
<td>78 (52%)</td>
</tr>
<tr>
<td>Loss of Appetite</td>
<td>57 (38%)</td>
</tr>
<tr>
<td>Weight loss</td>
<td>39 (26%)</td>
</tr>
<tr>
<td>Fever</td>
<td>30 (20%)</td>
</tr>
<tr>
<td>Asymptomatic</td>
<td>31 (21%)</td>
</tr>
</tbody>
</table>
91. Symptoms of Cases (N = 149)

![Bar chart showing symptoms of cases (N = 149)]

92. Duration of Symptoms for Cases (n = 80)

**Duration of Symptoms for Cases (n = 80)**

- **Median**: 28 days
- **Range**: 1–139 days
- **Interquartile range**: 14–53 days

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93. Age and Sex

Age and Sex

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Median</th>
<th>Mean</th>
<th>Range</th>
<th>% Female</th>
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</thead>
<tbody>
<tr>
<td>Cases n = 125</td>
<td>6</td>
<td>17</td>
<td>&lt;1 - 74</td>
<td>50</td>
</tr>
<tr>
<td>Non-cases n = 289</td>
<td>23</td>
<td>27</td>
<td>&lt;1 - 87</td>
<td>48</td>
</tr>
</tbody>
</table>

94. Percent Cases by Age Group

Percent Cases by Age Group

- 0–5 years: 50%
- 6–18 years: 17%
- ≥ 19 years: 33%

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95. Epidemic Curve (n = 135)

Epidemic Curve (n = 135)

Pools closed for season September 5

May Jun Jul Aug Sept Oct Nov Dec
2003

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96. Newspaper Heading

Newspaper Heading

Pool blamed for outbreak of giardia

Golf club official says person responsible will be punished...

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97. Epidemiology Program: Outbreak Investigation: Slide 97

Epi Curve: Cases by Week of Illness Onset

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98. Further Case Definitions

Further Case Definitions

• Primary case
  — Onset of illness June 1–October 4, 2003  AND
  — No contact with another ill individual during that person's shedding period

• Secondary case
  — Onset of illness on or after October 5, 2003  OR
  — Onset of illness before October 5, but within 60 days of ill contact's onset of illness

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99. Rationale for 60-Day Time Frame for Secondary Cases before October 5

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100. Cases by Status

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101. Epidemic Curve (n = 135)

Epidemic Curve (n = 135)

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102. Possible Fecal Shedding

Possible Fecal Shedding

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103. Risk Factors for Illness Among Primary Cases (N = 30)

Risk Factors for Illness Among Primary Cases (N = 30)

<table>
<thead>
<tr>
<th>Exposure</th>
<th>Exposed</th>
<th>Not Exposed</th>
<th>RR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td># Ill (%)</td>
<td>Total</td>
<td># Ill (%)</td>
</tr>
<tr>
<td>Kiddy Pool</td>
<td>16 (13)</td>
<td>124</td>
<td>14 (4)</td>
</tr>
<tr>
<td>Adult Pool</td>
<td>12 (5)</td>
<td>225</td>
<td>18 (7)</td>
</tr>
<tr>
<td>Child (vs. Adult)</td>
<td>16 (9)</td>
<td>184</td>
<td>14 (5)</td>
</tr>
<tr>
<td>Camp / Hike</td>
<td>1 (4)</td>
<td>28</td>
<td>29 (6)</td>
</tr>
<tr>
<td>Daycare</td>
<td>5 (10)</td>
<td>51</td>
<td>25 (6)</td>
</tr>
</tbody>
</table>

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104. Primary Cases (exposure to pools)

Primary Cases (exposure to pools)

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### 105. Stratified Analysis: Kiddy Pool Exposure and Giardiasis by Age Group

<table>
<thead>
<tr>
<th></th>
<th>Kids</th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>III</td>
<td></td>
<td>Total</td>
<td>AR%</td>
<td>RR</td>
<td>95% CI</td>
<td>P</td>
</tr>
<tr>
<td>Kiddy Pool</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>+</td>
<td></td>
<td>12</td>
<td></td>
<td>88</td>
<td>13.6</td>
<td>3.3</td>
<td>(1.1, 9.8)</td>
<td>.02</td>
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<tr>
<td>-</td>
<td></td>
<td>4</td>
<td></td>
<td>96</td>
<td>4.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adults</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kiddy Pool</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>+</td>
<td></td>
<td>4</td>
<td></td>
<td>36</td>
<td>11.1</td>
<td>2.9</td>
<td>(0.95, 6.7)</td>
<td>.06</td>
</tr>
<tr>
<td>-</td>
<td></td>
<td>10</td>
<td></td>
<td>259</td>
<td>3.9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RR_{Crude}</td>
<td></td>
<td>3.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(1.7, 6.5)</td>
<td></td>
</tr>
<tr>
<td>RR_{MH}</td>
<td></td>
<td>3.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(1.4, 5.9)</td>
<td></td>
</tr>
</tbody>
</table>

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### 106. Stratified Analysis: Age Group and Giardiasis by Kiddy Pool Exposure

<table>
<thead>
<tr>
<th>Kiddy Pool Exposure</th>
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<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>III</td>
<td></td>
<td>Total</td>
<td>AR%</td>
<td>RR</td>
<td>95% CI</td>
<td>P</td>
</tr>
<tr>
<td>Child</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>+</td>
<td></td>
<td>12</td>
<td></td>
<td>88</td>
<td>13.6</td>
<td>1.2</td>
<td>(0.4, 3.6)</td>
<td>.7</td>
</tr>
<tr>
<td>-</td>
<td></td>
<td>4</td>
<td></td>
<td>36</td>
<td>11.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No Kiddy Pool</td>
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<td></td>
</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Child</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>+</td>
<td></td>
<td>4</td>
<td></td>
<td>92</td>
<td>4.2</td>
<td>1.1</td>
<td>(0.4, 3.4)</td>
<td>.9</td>
</tr>
<tr>
<td>-</td>
<td></td>
<td>10</td>
<td></td>
<td>259</td>
<td>3.9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RR_{Crude}</td>
<td></td>
<td>1.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(1.7, 6.5)</td>
<td></td>
</tr>
<tr>
<td>RR_{MH}</td>
<td></td>
<td>1.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.5, 2.5)</td>
<td></td>
</tr>
</tbody>
</table>

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107. Dose Response

Dose Response

<table>
<thead>
<tr>
<th>Kiddy Pool Use</th>
<th># Ill (%)</th>
<th>Total</th>
<th>RR</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>12 (3.6)</td>
<td>333</td>
<td>1.0 (Ref.)</td>
<td></td>
</tr>
<tr>
<td>&lt;1 x/ week</td>
<td>5 (10)</td>
<td>50</td>
<td>2.8</td>
<td>(1.0, 7.5)</td>
</tr>
<tr>
<td>1-3 x/ week</td>
<td>7 (12.3)</td>
<td>57</td>
<td>3.4</td>
<td>(1.4, 8.3)</td>
</tr>
<tr>
<td>≥ 4x/ week</td>
<td>4 (22.2)</td>
<td>18</td>
<td>5.1</td>
<td>(1.8, 14.4)</td>
</tr>
</tbody>
</table>

Mantel Haenszel test for trend

P < .0001

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108. Household-Level Risk Factors

Household-Level Risk Factors

<table>
<thead>
<tr>
<th>Exposure</th>
<th>Exposed</th>
<th>Not Exposed</th>
<th>RR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Primary Case</td>
<td>Primary Case</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Households (%)</td>
<td>Households (%)</td>
<td></td>
</tr>
<tr>
<td>Food</td>
<td>12 (23)</td>
<td>18 (17)</td>
<td>1.3 (0.7, 2.5)</td>
</tr>
<tr>
<td>Changing Station</td>
<td>6 (32)</td>
<td>24 (18)</td>
<td>1.8 (0.8, 3.8)</td>
</tr>
</tbody>
</table>

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109. Recommendations

**Recommendations**

- Club should review all protocols for pool maintenance and response to fecal accidents

- Members of the community should be vigilant in making sure that family members wash their hands properly
  - Handwashing educational campaign
  - Attention to families with children

110. Follow-Up

**Follow-Up**

- Club hired private firm (March 2004) to evaluate its pools
  - Incorrect chemicals being used
  - Inadequate care in monitoring the pools
  - Equipment not up to standard
  - Insufficiencies affected water quality

- Club purchased new equipment, re-wrote protocols

- Three fecal accidents during Summer 2004
  - LBH notified each time
  - Pools temporarily closed
111. Confirmed Cases of Giardia, Milton, 1999-2004

![Confirmed Cases of Giardia, Milton, 1999–2004](image)

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112. Conclusions

Conclusions

- Large community outbreak of giardiasis
- Kiddy pool risk factor for primary cases
- Person-to-person spread accounted for the majority of cases

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A Foodborne Outbreak of Hepatitis A

Notification

- Late Feb. 2004, MDPH notified by local health dept. of several cases of hepatitis A in residents of the town; onsets in Feb.
- Initial interviews implicated a specific restaurant
- 5 additional cases of hepatitis A reported the following week
Initial Investigation

• Is this an outbreak of hepatitis A?

— Statewide have 100-200 cases reported annually
— Possible common link reported by cases
Initial Investigation

- Is this an outbreak of hepatitis A?
  - Statewide have 100-200 cases reported annually
  - Possible common link reported by cases
- Is the diagnosis confirmed?

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Initial Investigation

- Is this an outbreak of hepatitis A?
  - Statewide have 100-200 cases reported annually
  - Possible common link reported by cases
- Is the diagnosis confirmed?
  - Hepatitis A diagnosed by serology: IgM + in the presence of compatible symptoms
  - Results reported by laboratories

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Initial Investigation, cont.

• Case ascertainment
  – How can additional cases be identified?
    • Case reports of hepatitis A
    • Laboratory reports of hepatitis A
    • Contact local health departments in area
  – 33 cases identified
    • 24 in the town
    • 9 in neighboring towns
121. Initial Investigation, cont.

Initial Investigation, cont.

• Case interviews
  – What questions should be asked?

122. Initial Investigation, cont.

Initial Investigation, cont.

• Case interviews
  – What questions should be asked?
    • Date of onset of symptoms?
    • Symptoms?
    • Where did you eat during the incubation period (2 weeks-2 months pre-onset)?
    • What were your food preferences during the incubation period (same period)?
    • Occupation?
Initial Investigation, cont.

- Case interviews yielded the following:
  - Onsets: 2/12 – 3/10
  - Age range 18-76 years
  - Gender: 21 male, 12 female
  - 24 cases from same town
  - 9 cases from neighboring towns
  - Multiple restaurants and grocery stores named, many more than once

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Hepatitis A Cases Associated with Marshfield Outbreak February-March 2004

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Initial Investigation, cont.

• What do the epi curve and onset dates tell us about the likely time period of exposure?
  – Hint: incubation period for hepatitis A is 15-50 days
• Can all of the cases potentially be linked to a common exposure in time?
• What does the shape of the epi curve tell us?

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Initial Investigation, cont.

• How might these cases be linked?
Initial Investigation, cont.

- How might these cases be linked?
  - Common restaurant exposure
  - Common food exposure
  - ? secondary spread
- How can we assess this possible link?

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Initial Investigation, cont.

• How might these cases be linked?
  – Common restaurant exposure
  – Common food exposure
  – ? secondary spread

• How can we assess this possible link?
  – Analytical study: query for common source and/or common food
  – Food distribution pattern vs. case pattern

• Why not just go with initial case interviews?
  – Possible biases; popular restaurant; etc.

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Initial Investigation, cont.

• What is our hypothesis?

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131. Initial Investigation, cont.

Initial Investigation, cont.

- What is our hypothesis?
  - The hepatitis A outbreak was caused by exposure to a common source, namely, a restaurant
- Is this hypothesis reasonable?
- Is this hypothesis testable?

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132. Analytical Investigation

Analytical Investigation

- What type of analytical study is appropriate for this setting?
  - Case-Control?
    - If so, how would controls be identified?
    - Would controls be matched or unmatched?
    - If matched, for what criteria?
  - Cohort?
    - If so, how would cohorts be identified?
- Note: value of outliers (non-town residents)

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Analytical Investigation, cont.

- For Case-Control study:
  - Interviewed 19 cases
  - Interviewed 36 matched controls
  - Assessed exposure to 9 restaurants and to multiple food items
  - Conducted telephone interviews
  - Potential for recall bias
  - Assessed using Odds Ratios and 95% Confidence Intervals

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Analytical Investigation, cont.

- What is an Odds Ratio?
- How is an Odds Ratio interpreted?
- What is a 95% Confidence Interval?
- How is an Odds Ratio calculated?
Analytical Investigation, cont.

• Restaurant 1:
  − OR = 0.94; 95%CI = 0.16-5.67
• Restaurant 2:
  − OR = 0.28; 95%CI = 0.07-1.15
• Restaurant 3:
  − OR = 2.42; 95%CI = 0.65-9.01
• Restaurant 4:
  − OR = 74.57; 95%CI = 8.46-657.25
• Restaurant 5:
  − OR = 1.14; 95%CI = 0.34-3.81

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Analytical Investigation, cont.

• Restaurant 6:
  − OR = 2.0; 95%CI = 0.63-6.35
• Restaurant 7:
  − OR = 3.46; 95%CI = 1.07-11.17
• Restaurant 8:
  − OR = 3.58; 95%CI = 0.86-14.82
• Restaurant 9:
  − OR = 0.78; 95%CI = 0.17-3.43

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137. Restaurant 4 Odds Ratio

Restaurant 4 Odds Ratio

<table>
<thead>
<tr>
<th>EXPOSURE</th>
<th>CASE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

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138. Restaurant 4 Odds Ratio

Restaurant 4 Odds Ratio

<table>
<thead>
<tr>
<th>EXPOSURE</th>
<th>CASE</th>
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</tr>
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<td>No</td>
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<tr>
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</tr>
<tr>
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<td>No</td>
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</tbody>
</table>

(c) 2008, Bela T. Matyas, MD, MPH
Restaurant 4 Odds Ratio

<table>
<thead>
<tr>
<th></th>
<th>CASE</th>
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<tbody>
<tr>
<td>Yes</td>
<td>18</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td></td>
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<tr>
<td>Total</td>
<td>19</td>
<td>36</td>
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</table>

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141. Restaurant 4 Odds Ratio

Restaurant 4 Odds Ratio

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
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<td>Case</td>
<td>18</td>
<td>7</td>
</tr>
<tr>
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<td>Yes</td>
<td>No</td>
</tr>
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<td></td>
<td>1</td>
<td>29</td>
</tr>
<tr>
<td></td>
<td>19</td>
<td>36</td>
</tr>
</tbody>
</table>

142. Restaurant 4 Odds Ratio

OR = (18 \times 29)/(7 \times 1) = 74.57
143. Further Investigation

Further Investigation

• What do these data mean?

144. Further Investigation

Further Investigation

• What do these data mean?
  – Restaurant 4 is statistically significantly associated with the hepatitis A outbreak
• Who is at risk?
Further Investigation

What do these data mean?
- Restaurant 4 is statistically significantly associated with the hepatitis A outbreak

Who is at risk?
- Patrons of restaurant 4, at least those who ate sometime during January
- Foodhandlers at restaurant 4
- Contacts of cases

Further Investigation, cont.

What’s next?
Further Investigation, cont.

- What’s next?
  - Inspection of restaurant 4, looking for violations and risk factors
  - Interviews of staff
  - Implementation of prevention and control measures

Further Investigation, cont.

- Inspection identified some violations
- Staff interviews:
  - Staff denied having had symptoms in January
  - Risk factors for hepatitis A include diarrhea, bare hand contact with ready-to-eat foods, poor hygiene
Control & Prevention

- Immune globulin (Ig) for staff
- Correction of violations
- Exclusion of infectious staff, if any (i.e., monitor staff for symptoms)
- Ig for contacts of all cases
- If any case is a foodhandler, consider patron Ig

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Tularemia

Tularemia

• Bacterial zoonosis
• Caused by *Francisella tularensis*
  — Small, Gram-negative coccobacillus
• Maintained and amplified in nature
  — Vertebrate reservoirs
  — Arthropod vectors
• 100-200 cases annually in the U.S.
153. Tularemia on Martha’s Vineyard

Tularemia on Martha’s Vineyard

- Only previous pneumonic outbreak in the U.S., 1978
  - 7 patients from 1 cottage
  - Uncertain exposure source
- On average, 0 or 1 case reported annually

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154. Recognition of the Outbreak, July 2000

Recognition of the Outbreak, July 2000

- 5 cases of pneumonic tularemia
- All residents of or visitors to Martha’s Vineyard (MV)
- 3 used a lawn mower or brush-cutter prior to onset
- Could mowing or brush-cutting aerosolize F. tularensis?

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155. Methods

Methods

• Case finding
  – MV, Cape Cod, Nantucket Island
• Active surveillance
• Case-control study
• Environmental investigation

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156. Case Definition

Case Definition

• MV resident or visitor, $\geq 18$ yrs old
• Primary pneumonic presentation
• Onset between May 1 and October 31, 2000
• One of the following
  – Four-fold rise in titer
  – A single titer $\geq 1:128$
  – Positive culture
  – Positive DFA test

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Case-Control Study – Methods

- Random-digit-dialing to enroll controls
  - MV residents, ≥ 18 yrs old
  - ≥ 15 days on MV since May 15

- Questionnaire
  - Since May 15
  - 2 week period
    - Prior to onset for cases
    - Prior to interview for controls

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Environmental Investigation

- Possible exposure sites
  - Collected environmental samples
  - Re-created possible exposure activities
- 1978 outbreak site

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Results

• 10 patients met the case definition
  – All male
  – Median age: 43 yrs (range: 23-59 yrs)
  – 1 fatality in a 43 yr old previously healthy male; *F. tularensis* type A isolated
• No cases identified on Nantucket or Cape Cod

Pneumonic Tularemia, By Week of Illness Onset – Martha’s Vineyard, 2000
## Characteristics of Cases and Controls, MV, 2000

### MV, 2000

<table>
<thead>
<tr>
<th>Potential Risk Factor</th>
<th>Cases (N=10)</th>
<th>Controls (N=99)</th>
<th>OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Landscaper</td>
<td>5 (50)</td>
<td>3 (3)</td>
<td>32.0 (4.6, 257.2)</td>
</tr>
<tr>
<td>Lawnmower or brush-cutter (2 weeks)</td>
<td>8 (80)</td>
<td>30 (30)</td>
<td>9.2 (1.6, 68.0)</td>
</tr>
<tr>
<td>Lawnmower or brush-cutter (summer)</td>
<td>10 (100)</td>
<td>48 (48)</td>
<td>Undefined</td>
</tr>
<tr>
<td>Mowed over rabbit (2 weeks)</td>
<td>1 (10)</td>
<td>0 (0)</td>
<td>Undefined</td>
</tr>
</tbody>
</table>

## Characteristics of Cases and Controls, MV, 2000, cont.

### MV, 2000, cont.

<table>
<thead>
<tr>
<th>Potential Risk Factor</th>
<th>Cases (N=10)</th>
<th>Controls (N=99)</th>
<th>OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Worked with bark (2 weeks)</td>
<td>3 (30)</td>
<td>5 (5)</td>
<td>8.1 (1.2, 53.7)</td>
</tr>
<tr>
<td>Worked with weed whacker (summer)</td>
<td>7 (70)</td>
<td>27 (27)</td>
<td>6.2 (1.3, 33.6)</td>
</tr>
<tr>
<td>Worked with lumber (summer)</td>
<td>7 (70)</td>
<td>29 (29)</td>
<td>5.6 (1.2, 30.3)</td>
</tr>
</tbody>
</table>

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163. Time Spent Outdoors - Martha’s Vineyard, 2000

Time Spent Outdoors
Martha’s Vineyard, 2000

Daily hours outside | Mean | p-value
--- | --- | ---
Cases | 8.4 | 
Controls | 5.2 | 0.01

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164. Logistic Regression

Logistic Regression

<table>
<thead>
<tr>
<th>Potential Risk Factor</th>
<th>AOR</th>
<th>95% CI</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Used lawnmower or brush-cutter</td>
<td>6.7</td>
<td>(1.1, 39.9)</td>
<td>0.04</td>
</tr>
<tr>
<td>Worked with bark</td>
<td>5.1</td>
<td>(0.7, 39.8)</td>
<td>0.12</td>
</tr>
<tr>
<td>Average hours outside</td>
<td>1.1</td>
<td>(0.8, 1.4)</td>
<td>0.59</td>
</tr>
<tr>
<td>Smoked in last 2 wks</td>
<td>3.0</td>
<td>(0.6, 14.7)</td>
<td>0.18</td>
</tr>
<tr>
<td>Dog at MV residence</td>
<td>2.4</td>
<td>(0.4, 14.4)</td>
<td>0.33</td>
</tr>
</tbody>
</table>

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Environmental Results

40 animals trapped
• 2 seropositive
  – 1 striped skunk (*Mephitis mephitis*)
  – 1 Norway rat (*Rattus norvegicus*)
• All culture negative
• All DFA negative

Environmental Results

• Culture negative:
  – Lawn mower filters
  – Grass clippings
  – Air
  – Water
  – Soil samples

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Conclusions

- Second U.S. outbreak of pneumonic tularemia
- First time mowing and brush-cutting are risk factors
- 30% of MV residents cut or mowed in last 2 weeks; 48% cut or mowed since May 15
- Ecologic determinants of transmission remain unknown

Limitations

- Small number of cases
- Possible recall bias
- Using “last 2 weeks” as exposure proxy
- Controls not tested serologically
- Might not have accurately re-created exposure conditions
Recommendations

- Persons who brush-cut or mow in endemic areas should be made aware of risk
- Health-care providers should be aware of this possible mode of transmission
- Where possible, exposures to aerosols while landscaping should be minimized
- Active surveillance for tularemia should be continued

Challenges in Recognizing a Bioterrorist Attack

- Delayed onset - hours to weeks
- Early signs/symptoms nonspecific
- Physicians/laboratorians not familiar with rare diseases/organisms
- Current public health surveillance may not be adequate for early detection
171. Some Indicators of Bioterrorism Events

Some Indicators of Bioterrorism Events

- Point-source exposure pattern
- Compressed epidemic curve
- Geographic correlates of exposure
- High attack rate among exposed
- “Exotic” disease for area
- Low attack rates in “protected” areas
- Animals also acquiring disease

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172. Public Health Bioterrorism Surveillance Plan

Public Health Bioterrorism Surveillance Plan

- Enhanced traditional surveillance for all potential BT agents and unusual illnesses
- Novel surveillance methods:
  - Hospital diversion data
  - Medical examiner data
  - Syndrome-based ER/ICU admissions
  - School absences
  - Animal disease surveillance

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Early Detection of a BT Event: Finding a Zebra Among Horses

- Early detection and control of bioterrorism will depend on alert clinicians reporting unusual illnesses or patterns of illness to Public Health
  - BEFORE definitive diagnosis
- “When you hear hoof beats, think “zebras” (as well as horses)

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Salmonellosis in Oregon, 1984

- Recognition: Over a two week period, hundreds of persons in The Dalles, a small town of 10,000 people, developed salmonellosis
- Detailed investigation at 4 of 10 affected restaurants implicated:
  - Rest A - macaroni and 3 bean salad; blue cheese dressing
  - Rest B - lettuce
  - Rest C - lettuce
  - Rest D - potato salad

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Salmonellosis in Oregon, cont.

- Traceback of foods: no suppliers in common to all
- Interviews with all the food workers in affected restaurants
  - No preceding illness, no links
  - Their illness was associated with eating from salad bars
- Reviewed with law enforcement - they did not see a crime

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Salmonellosis in Oregon, cont.

- In June 1985, a nearby commune of 3000 collapsed
- Run by Baghwan Shree Rajneesh (“live, love, laugh”)
- Investigation by State Health Department and FBI found a clinical lab at the commune, with QC strain of *Salmonella* that exactly matched the outbreak strain

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Salmonellosis in Oregon, cont.

- Clinical microbiologist at commune confessed to poisoning the salad bars; served approximately 4 years
- Were planning to infect the town on election day, so commune could take over the entire county
- Stymied by closure of salad bars