Salmonella Thompson: A Case Study in Enteric Illness Outbreak Investigation

NORTH DAKOTA DEPARTMENT of HEALTH

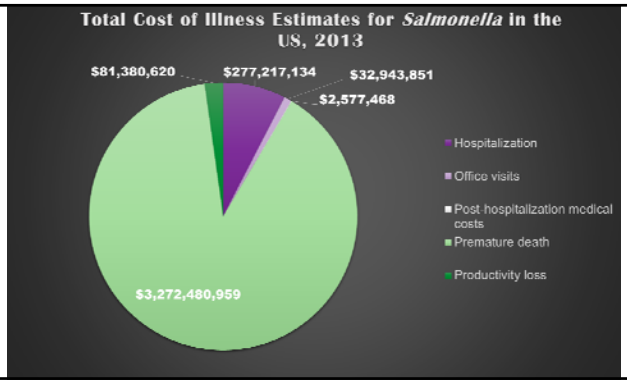
Epidemiologic Investigation

1. Confirm existence of outbreak.
2. Confirm diagnosis.
3. Determine the number of cases.
4. Orient data by time, person, and place.
5. Develop a hypothesis.
6. *Compare hypothesis with established facts.*
7. *Execute control and preventive measures.*
8. *Write a report.*

Salmonella Thompson Outbreaks

Salmonella Statistics

- Approximately 1.2 million illnesses
- Over 23,000 hospitalizations
- 450 deaths
- Estimated total cost of illness in 2013: $3.7 billion



Salmonella Risk Factors

- More common
  - Summer months
  - Children under the age of 5 years
- Certain medications can increase risk of salmonellosis
  - Antacids
  - Antibiotics
- Severe infection
  - Children under 5 years of age
  - Adults over 65 years of age
  - People who have weakened immune systems

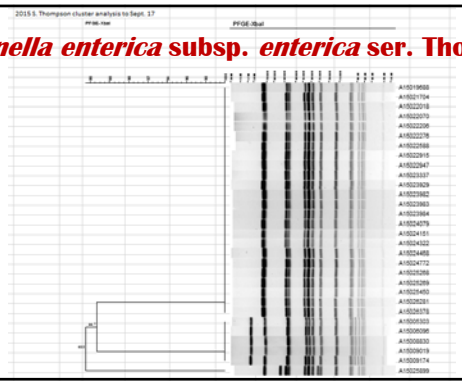
Salmonella Nomenclature

- **Family:** Enterobacteriaceae
- **Genus:** *Salmonella*
- **Species:** *enterica* or *bongori* (formerly subspecies V)
- **Subspecies of *S. enterica*:** *enterica* (I), *salamae* (II), *arizonae* (IIIa), *diarizonae* (IIIb), *houtenae* (IV), *indica* (VI)
- **Serotypes:** 2,463

Salmonella Lab Work-up

- Organism isolated from cultured specimen or Culture Independent Diagnostic Testing (CIDT) performed
- Isolate or raw specimen sent to state lab
- Serotype identification
  - Based on series of agglutination tests, phase testing
- Pulsed-Field Gel Electrophoresis (PFGE)
  - Bacterial DNA is lysed, then digested by restriction enzymes and exposed to an alternating electric field
  - DNA fragments migrate according to size

Salmonella enterica subsp. *enterica* ser. Thompson



Salmonellosis

- **Incubation period**
  - Typical: 6—72 hours
  - Most common: 12—36 hours
  - Can be as long as 16 days!
- **Symptoms**
  - Diarrhea, fever, abdominal cramps/pain, nausea, vomiting
- **Duration of illness**
  - About 4—7 days
- **Treatment**
  - Usually none

Severe Illness

- Infection can spread to blood stream and other sites
  - Bacteremia/Septicemia
  - Focal infection
- Treatment with antibiotics
  - Usually 14 days
- Relapse can occur

S. Thompson Outbreak

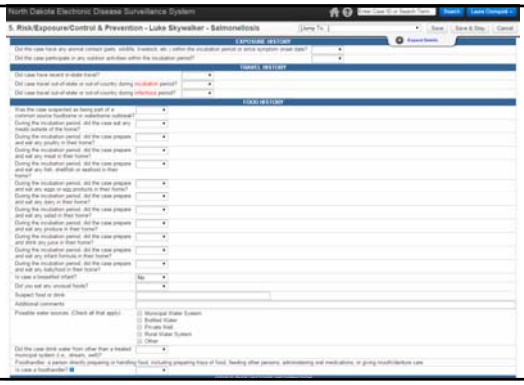
- As of July 30, 2015, **four** cases of *Salmonella* Thompson had been identified in Ward County and surrounding area
  - 2014 *S.* Thompson cases in ND: 2
  - 2013 *S.* Thompson cases in ND: 0
  - 2012 *S.* Thompson cases in ND: 1
- Field staff were alerted and the investigation into the identification of commonalities amongst cases began
- The following week, **four** additional *S.* Thompson cases were reported
  - National Hypothesis Generating Questionnaire (HGQ) implemented

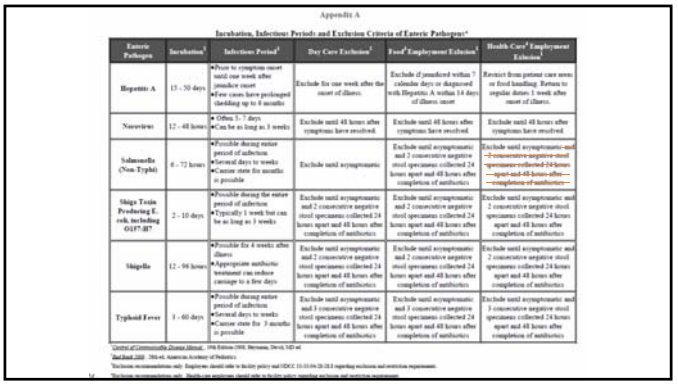
S. Thompson Outbreak Case Definition

A confirmed case is defined as a clinical case of *Salmonella* Thompson infection with isolate matching PFGE Xbal pattern JP6X01.0001 with isolation date on or after July 17, 2015 in a person who lives in or near Minot, ND, or who reported travel to Minot, ND, prior to onset of illness.

Investigation Methods

- Standard enteric illness case investigation
  - Demographic information
    - Incl. occupation
  - Clinical information
  - Exposure history
  - Travel history
  - Food history
  - Other risk history information
    - Food handler?
    - Health care worker?
    - School or day care worker?
  - Household and non-household contact information
  - Epi-linked and outbreak information





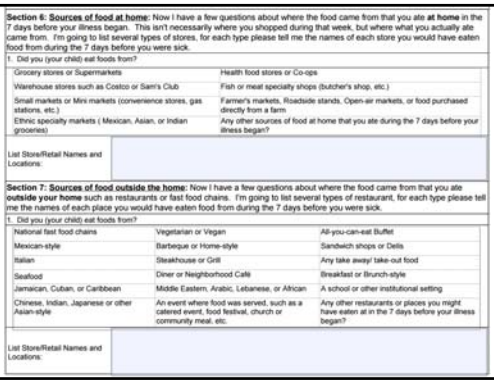
Appendix A

Incubation, Infectious Periods and Exclusion Criteria of Enteric Pathogens*

Enteric Pathogen	Incubation[1]	Infectious Period[1]	Day Care Exclusion[2]	Food[2] Employment Exclusion[3]	Health Care[4] Employment Exclusion[3]
Hepatitis A	15 - 50 days	•Prior to symptom onset until one week after jaundice onset •Few cases have prolonged shedding up to 8 months	Exclude for one week after the onset of illness.	Exclude if jaundiced within 7 calendar days or diagnosed with Hepatitis A within 14 days of illness onset	Restrict from patient care areas or food handling. Return to regular duties 1 week after onset of illness.
Norovirus	12 - 48 hours	• Often, 5 - 7 days. •Can be as long as 3 weeks	Exclude until 48 hours after symptoms have resolved.	Exclude until 48 hours after symptoms have resolved.	Exclude until 48 hours after symptoms have resolved.
Salmonella (Non-Typhi)	6 - 72 hours	•Possible during entire period of infection •Several days to weeks •Cannot state for months in possible	Exclude until asymptomatic	Exclude until asymptomatic and 2 consecutive negative stool specimens collected 24 hours apart and 48 hours after completion of antibiotics	Exclude until asymptomatic and ~~2 consecutive negative stool specimens collected 24 hours apart and 48 hours after completion of antibiotics~~
Shiga Toxin Producing E. coli, including O157:H7	2 - 10 days	•Possible during the entire period of infection •Typically 1 week but can be as long as 3 weeks	Exclude until asymptomatic and 2 consecutive negative stool specimens collected 24 hours apart and 48 hours after completion of antibiotics	Exclude until asymptomatic and 2 consecutive negative stool specimens collected 24 hours apart and 48 hours after completion of antibiotics	Exclude until asymptomatic and 2 consecutive negative stool specimens collected 24 hours apart and 48 hours after completion of antibiotics
Shigella	12 - 96 hours	•Possible for 4 weeks after illness •Appropriate antibiotic treatment can reduce carriage to a few days	Exclude until asymptomatic and 2 consecutive negative stool specimens collected 24 hours apart and 48 hours after completion of antibiotics	Exclude until asymptomatic and 2 consecutive negative stool specimens collected 24 hours apart and 48 hours after completion of antibiotics	Exclude until asymptomatic and 2 consecutive negative stool specimens collected 24 hours apart and 48 hours after completion of antibiotics
Typhoid Fever	3 - 60 days	•Possible during entire period of infection •Several days to weeks •Cannot state for 3 months in possible	Exclude until asymptomatic and 3 consecutive negative stool specimens collected 24 hours apart and 48 hours after completion of antibiotics	Exclude until asymptomatic and 3 consecutive negative stool specimens collected 24 hours apart and 48 hours after completion of antibiotics	Exclude until asymptomatic and 3 consecutive negative stool specimens collected 24 hours apart and 48 hours after completion of antibiotics

Investigation Methods

- **National Hypothesis Generating Questionnaire**
  - Standardized or "shotgun" questionnaire
  - Collects standard set of information about food and other exposures
  - 16 sections, over 200 questions
  - Data analysis is more efficient



Section 6: Sources of food at home: Now I have a few questions about where the food came from that you ate **at home** in the 7 days before your illness began. This isn't necessarily where you shopped during that week, but where what you actually ate came from. I'm going to list several types of stores, for each type please tell me the names of each store you would have eaten food from during the 7 days before you were sick.

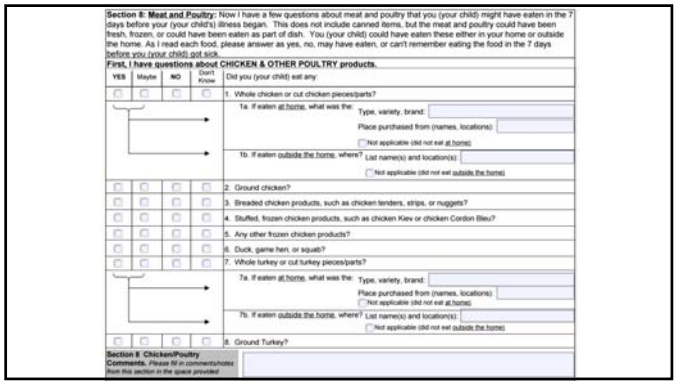
1. Did you (your child) eat foods from?

Grocery stores or Supermarkets	Health food stores or Co-ops
Warehouse stores such as Costco or Sam's Club	Fish or meat specialty shops (butcher's shop, etc.)
Small markets or Mini markets (convenience stores, gas stations, etc.)	Farmer's markets, Roadside stands, Open-air markets, or food purchased directly from a farm
Ethnic specialty markets (Mexican, Asian, or Indian groceries)	Any other sources of food at home that you ate during the 7 days before your illness began?
List Store/Retail Names and Locations:	

Section 7: Sources of food outside the home: Now I have a few questions about where the food came from that you ate **outside your home** such as restaurants or fast food chains. I'm going to list several types of restaurant, for each type please tell me the names of each place you would have eaten food from during the 7 days before you were sick.

1. Did you (your child) eat foods from?

National fast food chains	Vegetarian or Vegan	All-you-can-eat Buffet
Mexican-style	Barbeque or Home-style	Sandwich shops or Delis
Italian	Steakhouse or Grill	Any take away/ take-out food
Seafood	Diner or Neighborhood Café	Breakfast or Brunch-style
Jamaican, Cuban, or Caribbean	Middle Eastern, Arabic, Lebanese, or African	A school or other institutional setting
Chinese, Indian, Japanese or other Asian-style	An event where food was served, such as a catered event, food festival, church or community meal, etc.	Any other restaurants or places you might have eaten at in the 7 days before your illness began?
List Store/Retail Names and Locations:		

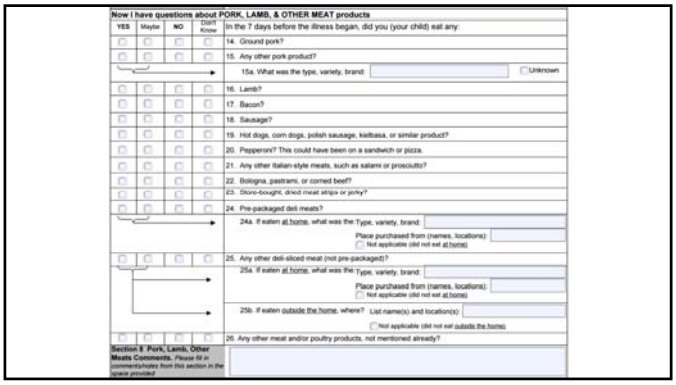


Section 8: Meat and Poultry: Now I have a few questions about meat and poultry that you (your child) might have eaten in the 7 days before your (your child's) illness began. This does not include canned items, but the meat and poultry could have been fresh, frozen, or could have been eaten as part of dish. You (your child) could have eaten these either in your home or outside the home. As I read each food, please answer as yes, no, may have eaten, or can't remember eating the food in the 7 days before you (your child) got sick.

First, I have questions about CHICKEN & OTHER POULTRY products.

YES	Maybe	NO	Don't Know	Did you (your child) eat any:
☐	☐	☐	☐	1. Whole chicken or cut chicken pieces/parts?
				1a. If eaten at home, what was the: Type, variety, brand: ☐ Not applicable (did not eat at home)
				Place purchased from (names, locations):
				1b. If eaten outside the home, where? List name(s) and location(s): ☐ Not applicable (did not eat outside the home)
☐	☐	☐	☐	2. Ground chicken?
☐	☐	☐	☐	3. Breaded chicken products, such as chicken tenders, strips, or nuggets?
☐	☐	☐	☐	4. Stuffed, frozen chicken products, such as chicken Kiev or chicken Cordon Bleu?
☐	☐	☐	☐	5. Any other frozen chicken products?
☐	☐	☐	☐	6. Duck, game hen, or squab?
☐	☐	☐	☐	7. Whole turkey or cut turkey pieces/parts?
				7a. If eaten at home, what was the: Type, variety, brand: Place purchased from (names, locations): ☐ Not applicable (did not eat at home)
				7b. If eaten outside the home, where? List name(s) and location(s): ☐ Not applicable (did not eat outside the home)
☐	☐	☐	☐	8. Ground Turkey?

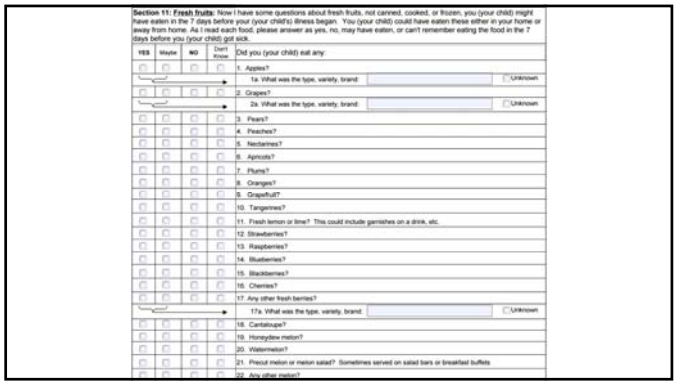
Section 8 Chicken/Poultry Comments. *Please fill in comments/notes from this section in the space provided*



Now I have questions about PORK, LAMB, & OTHER MEAT products

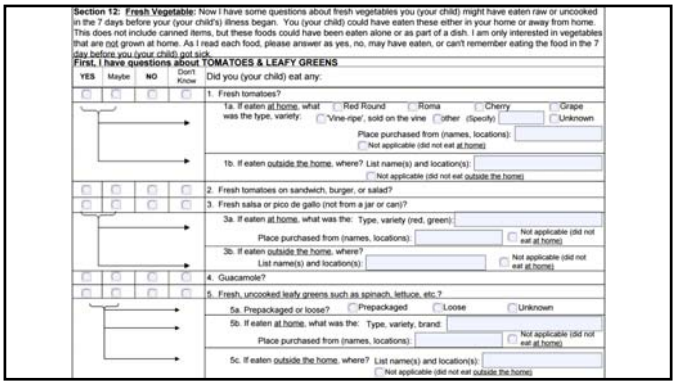
YES	Maybe	NO	Don't Know	In the 7 days before the illness began, did you (your child) eat any:
☐	☐	☐	☐	14. Ground pork?
☐	☐	☐	☐	15. Any other pork product?
				15a. What was the type, variety, brand: ☐ Unknown
☐	☐	☐	☐	16. Lamb?
☐	☐	☐	☐	17. Bacon?
☐	☐	☐	☐	18. Sausage?
☐	☐	☐	☐	19. Hot dogs, corn dogs, polish sausage, kielbasa, or similar product?
☐	☐	☐	☐	20. Pepperoni? This could have been on a sandwich or pizza.
☐	☐	☐	☐	21. Any other Italian-style meats, such as salami or prosciutto?
☐	☐	☐	☐	22. Bologna, pastrami, or corned beef?
☐	☐	☐	☐	23. Store-bought, dried meat strips or jerky?
☐	☐	☐	☐	24. Pre-packaged deli meats?
				24a. If eaten at home, what was the Type, variety, brand: Place purchased from (names, locations): ☐ Not applicable (did not eat at home)
☐	☐	☐	☐	25. Any other deli-sliced meat (not pre-packaged)?
				25a. If eaten at home, what was the Type, variety, brand: Place purchased from (names, locations): ☐ Not applicable (did not eat at home)
				25b. If eaten outside the home, where? List name(s) and location(s): ☐ Not applicable (did not eat outside the home)
☐	☐	☐	☐	26. Any other meat and/or poultry products, not mentioned already?

Section 8 Pork, Lamb, Other Meats Comments. *Please fill in comments/notes from this section in the space provided*



Section 11: Fresh fruits: Now I have some questions about fresh fruits, not canned, cooked, or frozen, you (your child) might have eaten in the 7 days before your (your child's) illness began. You (your child) could have eaten these either in your home or away from home. As I read each food, please answer as yes, no, may have eaten, or can't remember eating the food in the 7 days before you (your child) got sick.

YES	Maybe	NO	Don't Know	Did you (your child) eat any:
☐	☐	☐	☐	1. Apples?
				1a. What was the type, variety, brand: ☐ Unknown
☐	☐	☐	☐	2. Grapes?
				2a. What was the type, variety, brand: ☐ Unknown
☐	☐	☐	☐	3. Pears?
☐	☐	☐	☐	4. Peaches?
☐	☐	☐	☐	5. Nectarines?
☐	☐	☐	☐	6. Apricots?
☐	☐	☐	☐	7. Plums?
☐	☐	☐	☐	8. Oranges?
☐	☐	☐	☐	9. Grapefruit?
☐	☐	☐	☐	10. Tangerines?
☐	☐	☐	☐	11. Fresh lemon or lime? This could include garnishes on a drink, etc.
☐	☐	☐	☐	12. Strawberries?
☐	☐	☐	☐	13. Raspberries?
☐	☐	☐	☐	14. Blueberries?
☐	☐	☐	☐	15. Blackberries?
☐	☐	☐	☐	16. Cherries?
☐	☐	☐	☐	17. Any other fresh berries?
				17a. What was the type, variety, brand: ☐ Unknown
☐	☐	☐	☐	18. Cantaloupe?
☐	☐	☐	☐	19. Honeydew melon?
☐	☐	☐	☐	20. Watermelon?
☐	☐	☐	☐	21. Precut melon or melon salad? Sometimes served on salad bars or breakfast buffets
☐	☐	☐	☐	22. Any other melon?



Section 12: Fresh Vegetable: Now I have some questions about fresh vegetables you (your child) might have eaten raw or uncooked in the 7 days before your (your child's) illness began. You (your child) could have eaten these either in your home or away from home. This does not include canned items, but these foods could have been eaten alone or as part of a dish. I am only interested in vegetables that are not grown at home. As I read each food, please answer as yes, no, may have eaten, or can't remember eating the food in the 7 day before you (your child) got sick.

First, I have questions about TOMATOES & LEAFY GREENS

YES	Maybe	NO	Don't Know	Did you (your child) eat any:
☐	☐	☐	☐	1. Fresh tomatoes?
				1a. If eaten at home, what was the type, variety: ☐ Red Round ☐ Roma ☐ Cherry ☐ Grape ☐ 'Vine-ripe', sold on the vine ☐ other (Specify) ☐ Unknown Place purchased from (names, locations): ☐ Not applicable (did not eat at home)
				1b. If eaten outside the home, where? List name(s) and location(s): ☐ Not applicable (did not eat outside the home)
☐	☐	☐	☐	2. Fresh tomatoes on sandwich, burger, or salad?
☐	☐	☐	☐	3. Fresh salsa or pico de gallo (not from a jar or can)?
				3a. If eaten at home, what was the: Type, variety (red, green): Place purchased from (names, locations): ☐ Not applicable (did not eat at home)
				3b. If eaten outside the home, where? List name(s) and location(s): ☐ Not applicable (did not eat at home)
☐	☐	☐	☐	4. Guacamole?
☐	☐	☐	☐	5. Fresh, uncooked leafy greens such as spinach, lettuce, etc.?
				5a. Prepackaged or loose? ☐ Prepackaged ☐ Loose ☐ Unknown
				5b. If eaten at home, what was the: Type, variety, brand: Place purchased from (names, locations): ☐ Not applicable (did not eat at home)
				5c. If eaten outside the home, where? List name(s) and location(s): ☐ Not applicable (did not eat outside the home)

Section 16: Animal contact and Pets: Now I have some questions about contact with pets or other animals in the 7 days before your (your child's) illness began. This could have been at your home or another home, at a pet store, petting zoo, school, or other location.

YES	Maybe	NO	Don't Know	Did you (your child) visit or go to:
☐	☐	☐	☐	1. A petting zoo or farm with livestock like cattle, sheep, goats, etc.?
☐	☐	☐	☐	2. Agricultural 'Farm and Feed' stores?
☐	☐	☐	☐	3. Pet stores, swap meets, other places where animals/birds were sold or shown?
☐	☐	☐	☐	4. County/State fairs, 4-H events, or similar event where animals were present?
☐	☐	☐	☐	5. School events, birthday parties, or similar events with animals/pets?
				Did you (your child) have any contact with:
☐	☐	☐	☐	6. Dogs or puppies?
☐	☐	☐	☐	7. Cats or kittens?
☐	☐	☐	☐	8. Baby chicks, ducklings, or other baby poultry?
☐	☐	☐	☐	9. Live chickens, turkeys, ducks or other adult poultry?
☐	☐	☐	☐	10. Turtles or tortoises?
☐	☐	☐	☐	11. Snakes?
☐	☐	☐	☐	12. Frozen mice, rats, or similar pet food for snakes?
☐	☐	☐	☐	13. Other reptiles, such as lizards, geckos, etc.?
☐	☐	☐	☐	14. Amphibians, such as frogs, toads, or salamanders?
☐	☐	☐	☐	15. Water pets in an aquarium (goldfish, aquatic frogs, snails, etc.)?
☐	☐	☐	☐	16. Rats, mice, gerbils, or hamsters?
☐	☐	☐	☐	17. "Pocket" or "exotic" pets (ferrets, pygmy hedgehogs, rabbits, sugar gliders, guinea pigs, etc.)?
☐	☐	☐	☐	18. Prepackaged pet food?
				18a. What was the type, variety, brand: ☐ Unknown
☐	☐	☐	☐	19. Pet treats or chews (pig-ears, pizzles, rawhide, hooves, etc.)?
☐	☐	☐	☐	20. Dried animal droppings or pellets (e.g., owl pellets for science projects)?

Section 16 Comments. *Please fill in comments/notes from this section in the space provided*

Case-Control Study

- Gather food history information from well people in the community
  - 30 mi radius of Minot
  - 18—69 yoa
- Compare data from cases to that from controls
- What's different?

Control Data

- 8/14/2015
  - Attempted to gather information from well family members and/or friends of cases
  - Ran frequency analysis against data from MN's FoodNet survey
- 9/28/2015
  - News release about MPH students contacting people in the Minot area via random digit dialing
- Now
  - Focused online questionnaire
  - Minot State University
  - Minot AFB

Case Re-interviews

- **Re-interview #1 on 8/4/15**
  - HGQ for early cases
- **Re-interview #2 on 9/8/15**
  - Detailed restaurant history for eight of the most frequently mentioned restaurants
  - Menu items
- **Re-interview #3 on 9/30/15**
  - Specific questions about five of the most frequently mentioned restaurants
  - Location
  - Date
  - Menu items

Restaurants of Particular Interest

- **Restaurant A**
  - Before re-interview #2, **nine** cases reported eating here
  - After, **18** cases reported eating here
- **Restaurant B**
  - Before re-interview #2, **seven** cases reported eating here
  - After, **nine** cases reported eating here
- **Restaurant C**
  - Before re-interview #2, **four** cases reported eating here
  - After, **six** cases reported eating here

Spot Map

- Place dot or symbol on map showing where case lives, works, or may have been exposed
- Clusters or patterns may reflect water supplies or proximity to restaurant or grocery store
- Can also be done for hospitals or LTC facilities
  - Cluster indicates focal source or person to person spread
  - Scattering may indicate widely disseminated vehicle or source common to all residents

Epidemic Curve

- Shows progression of illnesses in an outbreak or cluster over time
  - Updated as new data becomes available
- X-axis is the date/time when a person became ill
  - Day/Week of illness onset
  - Hour if very short incubation period (e.g., *S. aureus*)
- Y-axis is the number of cases per unit of time

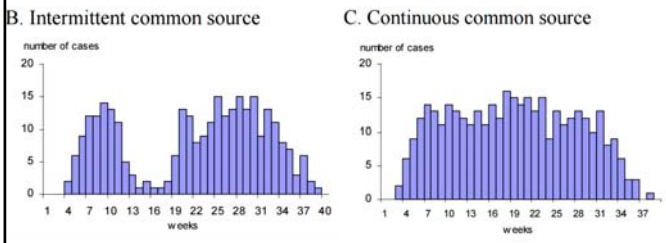
Benefits of an Epi Curve

- Pattern of spread
- Magnitude of outbreak
- Outliers
- Time trend
- Exposure and/or incubation period

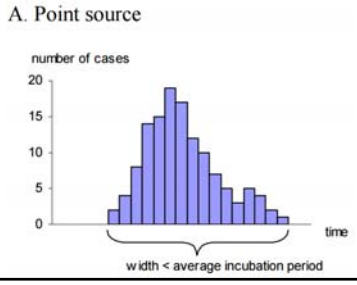
Epi Curve: Pattern of Spread

- Overall shape may reveal type of outbreak
  - **Common source**
    - Intermittent exposure
    - Continuous exposure
  - **Point source**
    - Common source outbreak with a brief exposure period and all cases occur within one incubation period
  - **Propagated**
    - Spread from person to person
    - May include secondary and tertiary cases
  - **Mixed**

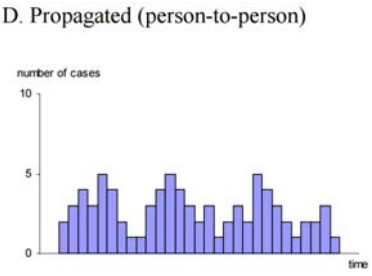
Common Source Epi Curve



Point Source Epi Curve

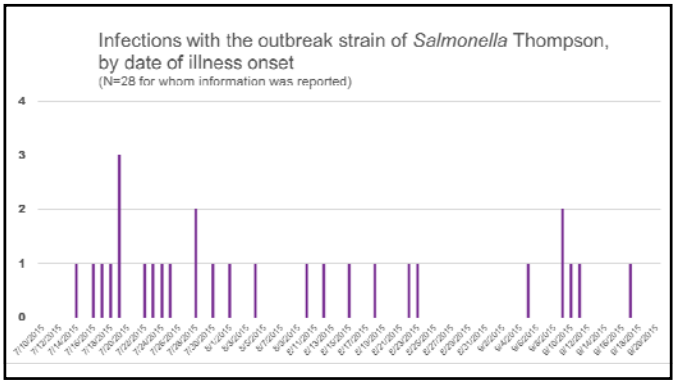


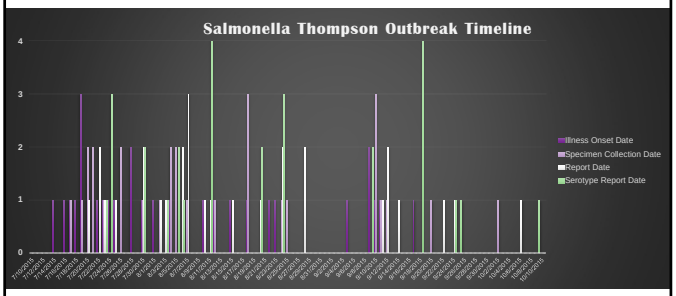
Propagated Epi Curve



Reporting Delay

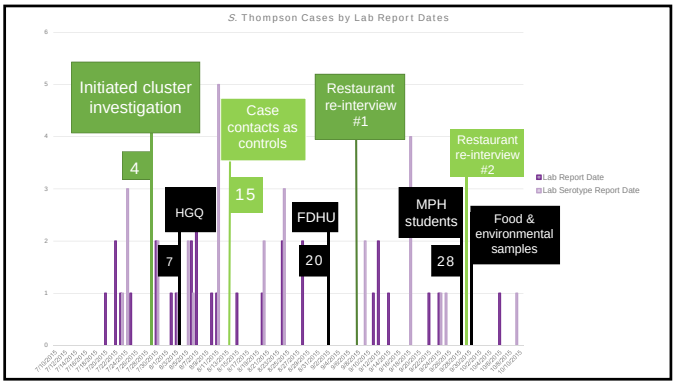
- Delay between the date an illness starts and the date the case is reported to public health authorities
  - *Salmonella* infections: typically 2—3 weeks
- E.g., someone who got sick last week is unlikely to have their infection reported to public health authorities by now, and someone who got sick 3 weeks ago may just be reported now





Environmental Health

- Gathered information on restaurant suppliers
- Conducted investigations and inspections at many area restaurants
  - Interviewed managers about any ill food workers
  - Interviewed food workers
  - Gathered contact information and work schedules
  - Collected food and environmental samples for testing



Overview of *S.* Thompson Outbreak

- **Number of PFGE matched cases: 29**
- **Onset**
  - Range: 7/14/15—9/17/2015*
- **Age**
  - Range: 3—71 years
  - 66% of cases are between 18—40 yoa
- **Gender**
  - Female: 17
  - Male: 12

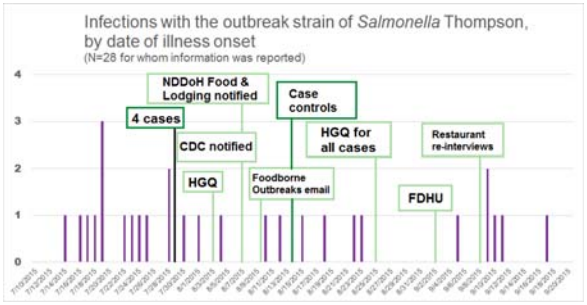
**Onset unknown for last case, specimen collected 10/2/2015*

Challenges

- Many cases are not recognized
  - Not all ill people seek medical attention
  - Health care providers do not always collect specimens
  - Lab may not perform necessary testing
- Culture Independent Diagnostic Testing (CIDT)
  - Raw specimen is tested
  - Some labs use CIDT as “preliminary result” and do not report
  - State lab must culture isolate from specimen to serotype

Challenges

- Obtaining good control data
- Inherent delay between onset and reporting
  - Memory recall decreases dramatically
- Nature of the food industry
  - Low wages
  - Few, if any, benefits
    - Sick leave?
    - Health insurance?



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