Learning Objectives

- List strategies to confirm an outbreak of typhoid fever (Salmonella Typhi infection)
- Describe the laboratory’s role in an outbreak investigation
- Construct and interpret an epidemiological curve
- Generate hypotheses about the source of a typhoid fever outbreak
- Describe three (3) prevention and control strategies for typhoid fever outbreaks

Instructions

For this exercise, you will work to complete a case study investigation. Each segment of case study information will be followed by a series of questions and activities. You should read the information and then work to answer each question and complete each activity.

Time Allotted: 2.0 hours

Background

Typhoid fever is an infection that is caused by the Salmonella Typhi bacteria. These bacteria are found only in humans and are spread by food and water that is polluted by the feces of infected persons. The time between infection and onset of illness (incubation period) usually is 1 to 2 weeks but can be as long as 6 weeks. The diagnosis of typhoid fever is difficult. Patients have a high fever lasting several days; other symptoms may include headache, stomach pain, constipation, diarrhea, and/or loss of appetite. The disease is confirmed if the laboratory grows the bacteria from blood or stool. The illness can last for several weeks and, without treatment, up to 10% of the patients may die. Even when symptoms have gone, about 1 in 10 people who have been infected continue to carry S. Typhi, and can transmit it to others.

Typhoid is constantly present (endemic) on “Marisol”, a Pacific island nation of 170,000. The island is divided into 3 districts (western, southern, and northern). On January 3, 1991, Typhoon Owen hit the island. Most areas had severe flooding and almost half of the island was without electricity for 2-3 days. Most government buildings, including schools, were closed due to damages until March 1st, four weeks after the typhoon.

March 12, 1991

It is March 12th, about 9 weeks after Typhoon Owen, and you are working in the Western District Health Department (WDHD). You receive two phone calls from area doctors about patients with fever, headache, abdominal pain, and constipation. Based on these symptoms, both doctors suspect that their patients may have typhoid fever. You remember that you talked with a clinic nurse 2 days ago, who also reported two patients with a fever and abdominal pain.
1. Are health care providers required to report possible cases of typhoid fever?
   
   Suggested answer: In most countries, typhoid fever is a reportable disease. Ideally, reports should be sent by mail or phone to the national Ministry of Health within 24 hours after a case or suspected case is examined and/or diagnosed, but the specific reporting requirements may vary by country. Public health officials then decide whether the cases should be reported to the World Health Organization as part of the International Health Regulations (IHR). The IHRs are legally binding regulations adopted by most countries to contain the threats from diseases that may rapidly spread from one country to another. Under the IHR, countries must report any event that may be a “public health emergency of international concern.”

2. As a public health worker at the WDHD, what information should you gather about the suspect cases? Consider demographic, epidemiologic, and clinical information.

   Suggested Answer: You should begin by gathering the following information:
   
   - Demographic: Name, Address, Age, Gender, Occupation, Phone Number
   - Clinical: Symptoms, Symptom Onset Date, Treatment, Clinical Samples Collected, Laboratory Tests Conducted, Laboratory Test Results, Dates of Laboratory Tests
   - Epidemiologic: Possible exposures to S. Typhi (e.g. water sources, food exposures, ill family members or friends)

   Some of this information may be available from medical records, or from the health care providers who are treating these people. Other information may need to be obtained through interviews with patients, family members, and laboratory staff. As you create you line listing, look for connections between the patients—do any of the patients know each other or are they related to each other?

3. Are the typhoid fever cases related to the typhoon? Why or why not?

   Suggested answer: In general, it is likely that there will be an increase in the number of patients admitted to local hospitals, partly due to typhoon-related physical injuries. However, since the cases occurred about 9 weeks after the typhoon (outside the usual incubation period for S. Typhi), there may not be a relationship between these two events. At this point, you cannot say for sure whether the possible typhoid outbreak is related to the typhoon.

March 12-24, 1991

Over the next 2 weeks, the WDHD observes 50 suspect cases of typhoid. Blood cultures and stool samples are collected from 42 of the suspect cases. The WDHD laboratory isolates S. Typhi from the samples. Officials are waiting on further serotyping results from the Marisol National Reference Laboratory (NRL).

Update

You are assigned to investigate the cases. You start by looking at surveillance information for the region to determine if an outbreak has occurred.
4. Why would you need surveillance data to determine whether the increase in reported cases of typhoid fever is considered an outbreak?

Suggested answer: An outbreak is defined as an increase in cases over the expected number of cases for a particular area over a particular period of time. To determine if these recent cases are part of an outbreak, you first need to determine the expected number of cases for this area. If the current surveillance data is not available, you can also look instead at historical data collected from the past 3-5 years to determine the baseline rate of disease. Other ways to determine the expected number of cases are to review medical records or to interview health care providers or the general public. Some questions to consider are: Have there been any previous outbreaks of typhoid fever in this area and what are the trends in the region? Are clinicians in the other districts also seeing an increase in typhoid fever cases at the present time?

If you observe an increase in cases over the usual rate of disease, keep in mind the increased number of cases may be due to other factors such as changes in reporting practices or case definitions, changes in access to medical care or access to laboratory testing, changes in laboratory diagnostic practices or technologies, or changes in clinic or hospital staff.

---

**Update**

Luckily, historical data is available from 1988 to the present for the island of Marisol. The graph below shows the number of confirmed cases of typhoid fever, by month, from January 1988 through March 1991. The red arrows indicate major storms that hit the island, Cyclone Tita and Typhoon Owen.
5. How would you explain the history of typhoid in Marisol? Specifically, what happens after strong storms hit the area, and what could be the reason for the change in the number of cases?

Suggested answer: There were few cases before Cyclone Tita. The average number of cases during 1988 and 1989 appears to be about 21 per year (less than 5 per month). The frequency of cases increased after both major storms. An explanation could be that waste disposal systems were destroyed by the first storm and some of the water sources became contaminated, allowing transmission to occur. Afterwards, the number of ill people increased. These ill people could be responsible for infecting others. Typhoon Owen could have also introduced a new type of S Typhi to the area, and fewer people may have been immune to that strain. It is also possible that after the second storm greater awareness among the health personnel may have contributed to the increase of reported cases.

6. Based on the graph above, do you think an outbreak is occurring?

Suggested answer: Yes. The frequency of reported cases is much higher than usual, even when compared to the time period following another serious storm, Cyclone Tita. An outbreak is defined as an increase in the observed number of cases of a disease or health problem compared with the expected number either among a specific group of people, for a given place, or over a particular period of time. At this point, since the number of observed cases is nearly double the number observed the previous year, it would likely be considered an outbreak.

March 25, 1991

The Western District Health Department sends an epidemiology alert to all hospitals and clinics in the Western District to increase typhoid fever surveillance activities. They also recommend starting prevention activities to control the spread of the disease to other districts on the island. In order to identify cases and make sure that all hospitals and staff are looking for the same illness in patients, you are asked to develop a standard case definition.

7. What type of surveillance activities should occur in this situation?

Suggested answer: It is important that public health officials conduct active surveillance. When conducting active surveillance, public health officials do not wait for reports of disease. Instead, they contact hospitals, health-care providers, and the general public to find possible cases. One strategy for active surveillance is to interview family members and other close contacts of ill people, to determine whether they may be ill. Another strategy is to search through hospital records to find people that match the typhoid fever case definition. The public in the area should also be informed about the outbreak, and should be instructed to contact a clinic or doctor if they have the symptoms.

8. What criteria would you use to develop the case definition in this situation? Create case definitions for a suspect case and a confirmed case. A case definition is a set of criteria used to determine if a person should be classified as having the disease of interest. All case definitions must include person, place, and time. You can use the table below.
**Typhoid Fever Suspect Case Definition**

<table>
<thead>
<tr>
<th>Clinical Signs and Symptoms</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Person</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Place</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Time</strong></td>
<td></td>
</tr>
</tbody>
</table>

Suggested answer: In this situation, a suspect case may be defined as:

<table>
<thead>
<tr>
<th>Typhoid Fever Suspect Case Definition</th>
<th></th>
</tr>
</thead>
</table>
| **Clinical Signs and Symptoms**      | Fever of 38°C or higher  
  AND  
  One of the following symptoms: loss of appetite, weakness, headaches, abdominal pain, diarrhea, or constipation  |
| **Person**                           | Any resident  |
| **Place**                            | Western District of Marisol  |
| **Time**                             | between 1 February, 1991 and the present  |

A confirmed case may be defined as:  
A suspect case with laboratory-confirmed *S. Typhi* present in blood and/or stool samples between February 1, 1991 and the current date.
9. Using the chart below, create a line list from the information that you have received.

<table>
<thead>
<tr>
<th>Case #</th>
<th>Name</th>
<th>Date of birth</th>
<th>Gender</th>
<th>Date of onset</th>
<th>Type of case</th>
</tr>
</thead>
</table>

Suggested answer: In a line listing, each column represents an important variable, such as name or identification number, age, sex, case classification, etc., while each row represents a different case.

10. What other information could you include in a line listing?
Suggested answer: Other types of information that may be included in the line list are specific signs and symptoms, diagnosis, hospitalization, laboratory tests (date and type of test, results), possible disease exposures, other demographic information (e.g. address, phone number, occupation), and any other information that might be relevant in the outbreak. Although all line listings contain the same basic information, each outbreak is different, so you may need to collect additional information. Remember to always record each item in a separate column.

11. The WDHD knows their next step in the investigation is to make an epidemic curve. What is an epidemic curve and how does it help in an outbreak investigation?
An epidemic (or epi) curve is a graph that shows the number of cases over time during an outbreak. It provides a simple visual display of the outbreak's size and time trend. It provides a great deal of information about an outbreak. For example, an epi curve can tell you whether an outbreak is ongoing or whether the number of cases is decreasing. It can also tell you the incubation period of the disease. Finally, you may be able to determine the type of outbreak (common source or propagated). Drawing an epidemic curve by plotting time on the x axis and the number of cases on the y axis, will provide additional clues in your investigation. Usually, cases are classified by the date of disease onset. Changing the unit of time on the x axis may be necessary to best "see" the outbreak, depending on the incubation period of the disease.

12. Below is a list of all confirmed cases of typhoid fever from March 1991. Use the list to draw an epidemic curve of confirmed typhoid fever cases on the blank graph below.

**Summary table of confirmed cases by dates of onset**

<table>
<thead>
<tr>
<th>Date of Onset</th>
<th>Number of Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>8/03/1991</td>
<td>2</td>
</tr>
<tr>
<td>9/03/1991</td>
<td>2</td>
</tr>
<tr>
<td>9/03/1991</td>
<td>2</td>
</tr>
<tr>
<td>9/03/1991</td>
<td>2</td>
</tr>
<tr>
<td>11/03/1991</td>
<td>5</td>
</tr>
<tr>
<td>12/03/1991</td>
<td>2</td>
</tr>
<tr>
<td>13/03/1991</td>
<td>8</td>
</tr>
<tr>
<td>14/03/1991</td>
<td>5</td>
</tr>
<tr>
<td>15/03/1991</td>
<td>11</td>
</tr>
<tr>
<td>16/03/1991</td>
<td>13</td>
</tr>
<tr>
<td>17/03/1991</td>
<td>6</td>
</tr>
<tr>
<td>18/03/1991</td>
<td>7</td>
</tr>
<tr>
<td>19/03/1991</td>
<td>7</td>
</tr>
<tr>
<td>20/03/1991</td>
<td>4</td>
</tr>
<tr>
<td>21/03/1991</td>
<td>9</td>
</tr>
<tr>
<td>22/03/1991</td>
<td>3</td>
</tr>
<tr>
<td>23/03/1991</td>
<td>7</td>
</tr>
<tr>
<td>24/03/1991</td>
<td>5</td>
</tr>
<tr>
<td>25/03/1991</td>
<td>6</td>
</tr>
<tr>
<td>26/03/1991</td>
<td>8</td>
</tr>
<tr>
<td>27/03/1991</td>
<td>3</td>
</tr>
<tr>
<td>28/03/1991</td>
<td>3</td>
</tr>
<tr>
<td>29/03/1991</td>
<td>2</td>
</tr>
<tr>
<td>30/03/1991</td>
<td>3</td>
</tr>
</tbody>
</table>

**Suggested Answer:**

![Epidemic Curve of Typhoid Fever Cases, Marisol, March 1991](image_url)
13. How do you interpret the information in the epidemic curve?
Suggested answer: 13 confirmed cases were reported on 16 March 1991, the peak of the outbreak, and there appears to be only one peak. Although the outbreak is still ongoing, it appears to be slowly subsiding.

**April 1, 1991**

An outbreak investigation team of physicians, nurses, epidemiologists, and environmental health officers is created at the WDHD office to investigate the outbreak. Team members visit each confirmed typhoid fever patient still in the hospital, visit the homes of the other patients, and interview family members of confirmed cases. The outbreak team asks patients and household contacts about their drinking water sources both inside and outside the home. They also ask about local street vendors, markets and restaurants where they ate before they became sick. Finally, since the majority of the cases are between the ages of 5-11 years old, they also visit the three local grade schools, Meyuns, Koror, and Maris, in the Western District.

14. What are possible sources of disease exposure that the team should consider when interviewing patients?
Suggested answer: In endemic areas, several exposures have been identified as risk factors for sporadic cases of typhoid fever. These include:

- Consumption of contaminated drinking water, drinks, or ice prepared from contaminated drinking water
- Living with someone who recently had typhoid fever, or who is a chronic, asymptomatic carrier
- Eating certain foods and beverages from local street vendors, markets, or restaurants

During an outbreak, it is important to look for exposures that the cases have in common. Because this outbreak occurred after Typhoon Owen, investigators may consider sources related to the typhoon, such as contaminated water sources.

15. What information should the team collect when visiting houses of ill people?
Suggested answer: They may identify cooking and drinking water sources in or around the house that are used frequently, identify any other alternative water sources that may only be used to wash hands, clothes or take baths in or outside the home, locate the type of sanitation system used in or outside of the house (pit latrine, inside pipe system, etc) to determine if the system been compromised in any way due to excessive flooding from Typhoon Owen, and identify any foods prepared inside the home or purchased ‘pre-made’ outside of the home (this includes any high-risk foods such as ice pops made from water of questionable quality, foods and drinks prepared by hand and served raw.)

16. What information should the team collect when visiting local street vendors, restaurants, and local markets?
Suggested answer: They may ask about:

- Source of the drinking water and water that is used to prepare food (ground water, freshwater from a specific region/area of the island, chemically treated water, untreated rainwater from a local catchment system)
- Location of any pit latrines or sewage pipes in relationship to the restaurant, vendors and markets (Are they in close proximity to where food is prepared or where the food handlers work? Were they in any way damaged after Typhoon Owen?)
Any recent febrile, typhoid-like illness among the workers or in family members
Hand washing facilities and routine practices of food handlers at each of the eating establishments. Ideally, investigators would observe the food handlers as they prepare food to identify unsanitary practices.
If soap is available and if it is routinely used for hand washing.

If necessary, medical evaluations can be conducted and specimens can be collected in the field. In general, unless a food handler has an acute illness compatible with typhoid fever, testing is best reserved until after an epidemiologic study has indicated that he or she may have been the source of an outbreak.

17. What information should the team collect when visiting the elementary schools?
Suggested answer: They may identify all water sources at the school, including drinking water and hand washing facilities. The team should determine whether there are any commercially prepared foods or school lunches that are distributed in the areas where cases have occurred. They should locate the toilets, and compare the location of the toilets to areas where students study, play, and eat. Also, they should investigate whether Typhoon Owen caused any damage to the school, especially the water system and the toilets and waste disposal systems. Finally, the team should check the school schedule to determine whether school was in session during the time period when most cases were probably exposed to the disease. Since the incubation period of typhoid fever usually is 1-2 weeks, the period of interest is 1-2 weeks prior to the dates of symptom onset.

18. From the information gathered by the outbreak team, state a possible hypothesis about the source of the outbreak.
Suggested answer: All of the cases observed after March 1 have some connection with Meyuns Elementary School, either directly or by living in or visiting homes located within 2 km of Koror. These dates also fit within the peak of outbreaks that occurred in early to late March of 1991, and within the typical incubation period of approximately 1-6 weeks for S. Typhi. Based on the information given at this point, a reasonable hypothesis is that the source of the outbreak is at Meyuns Elementary school, beginning March 1st.

Update

After collecting all the information from patients, the team discovers that many cases attended Meyuns Elementary school (either as a student or a teacher). Since Meyuns had a lot of damage from Typhoon Owen, most students were sent to other schools on the island following the storm. The school reopened on March 1, 1991. In addition, the school-aged children that were sick and did not attend Meyuns, had close contact with a student or teacher who went to this school. Many of the adults that are sick either lived at or visited homes located within 2 km of Meyuns Elementary between March 1st and April 15th.

None of the cases occurring in February had any connection with the school and resided 50-70 km from the school. None of the February cases traveled from their residence during this time.
April 4, 1991

The outbreak team decides to conduct an environmental investigation at Meyuns Elementary School. The school has several latrines, the roofs of which have been damaged by the typhoon. There is no soap in or near the latrines. There is a rain water catchment tank, which has been damaged by the typhoon and contains very little water. Thirty meters downhill from the school, there is a small lake.

Water samples are taken from the following areas: rainwater catchment systems, where the children gather during breaks and lunch time, lake water, and ground water samples around the latrines.

The outbreak team tests the water at the school for bacteria. They test for *S. Typhi* bacteria as well as for “coliforms”, which is a more general test to see if water is safe. A positive coliform result is found from river water and ground water samples, and all other samples are negative.

Additional interviews with students and staff indicate that they have been drinking water from the lake because the rain water system is not working.

19. How do you interpret the findings of the environmental investigation?

*Suggested answer: The inspection as well as the water testing results indicate that river water may be the source of the outbreak. The latrines may have been flooded during the typhoon, and the runoff may have contaminated the lake. Remember that the outbreak occurred two months ago, and water samples may not contain Salmonella Typhi anymore. However the positive coliform result indicates the water is not safe. In addition, hygienic practices may not be adequate, judging from the absence of soap. In typhoid fever outbreaks, there often is a combination of unsafe water and unsafe sanitation, with multiple routes of transmission.)*

20. Based on the information you have so far, what prevention and control measures would you recommend to contain the outbreak?

*Suggested answer: Some potential control measures include:*

- **The rain water system of the school and the latrines should be repaired**
- **Until the safety of the water within 10km of the Meyuns Elementary School is assured, residents within the defined area should be instructed to drink only bottled water or rain water if available, and to boil or chlorinate all other water before drinking.**
- **Soap and water for handwashing should be provided, and students and staff should be instructed in proper hygiene.**
- **Instruct residents to seek medical care immediately if they develop a typhoid-like febrile illness.**
- **Inform clinicians of the available diagnostic resources for evaluating suspected cases of typhoid fever, and emphasize the importance of reporting cases to public local health authorities and taking specimens from suspected typhoid fever cases.**
- **Provide messages to the general public through radio and newspaper about the importance of handwashing and proper food handling.**
Control Measures

The WDHD used control measures to contain the outbreak. Community members located within 10 km of Meyuns Elementary School were instructed to boil, iodinate, or chlorinate all drinking water until it is considered safe. Iodine and chlorine tablets were given to each school affected by the outbreak. Announcements were made through the radio, newspaper, and television stations on the island. Instructions on how to boil water and use the tablets correctly were given with every set of tablets distributed, and announced over local radio stations by the WDHD. The WDHD also started a public information campaign about the importance of hand washing and proper food safety.

Conclusion

By the end of April 1991, there were no additional cases of typhoid fever reported in the Western District. Public health officials suspect that the flooding was responsible for the outbreak.

References