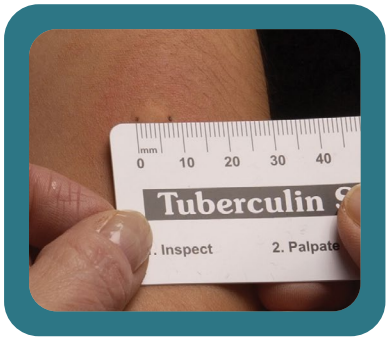
Self-Study Modules on Tuberculosis



Module 9

Tuberculosis Outbreak Detection and Response

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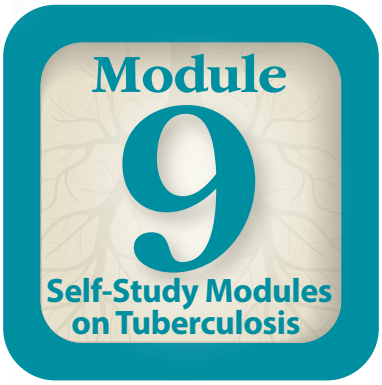

Tuberculosis Outbreak Detection and Response

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Centers for Disease Control and Prevention
National Center for HIV, Viral Hepatitis, STD, and TB Prevention
Division of Tuberculosis Elimination

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Module 9 Self-Study Modules on Tuberculosis

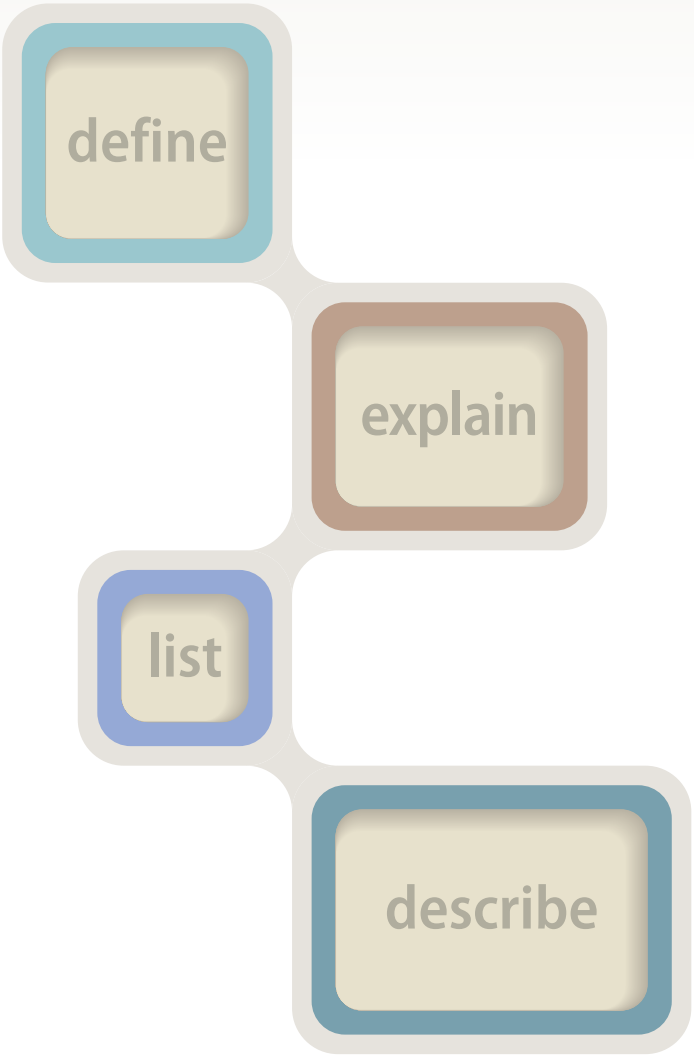
Contents

Background

Detecting and responding to TB outbreaks are among the important challenges public health programs face today in eliminating TB. Delays in detecting TB cases, and delayed or incomplete contact investigations, can lead to TB outbreaks.

Despite many similarities between contact investigations and outbreaks in how public health programs manage cases and contacts, the overall response needed for outbreaks is much more complex. Health departments may find it difficult to respond quickly and effectively to TB outbreaks.

The techniques used to detect and respond to TB outbreaks are guided by knowledge of the transmission and pathogenesis of *M. tuberculosis* and by the principles of effective contact investigations. Thus, in order to understand how to detect and respond effectively to a TB outbreak, it is important to have a good understanding of these concepts, which are presented in *Module 1, Transmission and Pathogenesis of Tuberculosis* and *Module 8, Contact Investigations for Tuberculosis*.



Objectives

After working through this module, you will be able to

1. List the criteria to meet the definition of a TB outbreak.
2. Describe three methods of TB outbreak detection.
3. Describe the role of genotyping in TB outbreak detection and investigation.
4. List the ten steps of the systematic approach to TB outbreak response.

New Terms

New terms introduced in this module are included below. Please refer to the *Self-Study Modules 1–5 Glossary* if you encounter unfamiliar terms related to TB that are not defined in the glossary below.

chain of transmission—often used to describe the circumstances and timing of transmission from a source case to one or more persons who develop TB disease (secondary cases). A chain of transmission can extend over a few months, years, or decades. Cases involved in the same chain of transmission almost always have matching genotypes (when this information is available).

descriptive epidemiology—the aspect of epidemiology concerned with organizing and summarizing health-related data according to person, place, and time

epidemic curve (epi curve)—a graph that displays the number of TB cases and when they were identified. Time is plotted on the horizontal x-axis and the number of cases is plotted on the vertical y-axis.

epidemiologic link (epi link)—characteristic(s) TB patients share that explains where and when TB could have been transmitted between them

genotype—distinct genetic pattern of an organism

genotype cluster—when two or more cases have matching genotypes

genotyping—a laboratory-based method that can determine the genetic pattern of the strain of *M. tuberculosis* that caused TB disease in a person

outbreak case definition—a standard set of criteria for deciding which TB cases could be involved in an outbreak

outbreak hypotheses— theories about how, when, and where TB transmission may have occurred during an outbreak

outbreak line list— summary of the cases that meet the outbreak case definition

recent transmission— transmission of TB that has occurred in the recent past, as opposed to reactivation of latent TB infection. Although the precise time period is not well defined, "recent" transmission is often considered to be within the last 2 years.

secondary case— an instance of TB after a known exposure, usually related to the index case in an investigation

spot map— a technique for showing where cases may have been exposed to TB or where they may have exposed others after developing TB disease

TB case surveillance— monitoring the occurrence of TB disease in specific geographic areas, populations, and time periods

TB Genotyping Information Management System (TB GIMS)— a secure CDC-sponsored online national database of *M. tuberculosis* genotyping and TB case information

TB outbreak— when there are more TB cases than expected within a geographic area or population during a particular time period, and there is evidence of recent transmission of *M. tuberculosis* among those cases

TB outbreak response— a process used by public health programs to investigate and intervene when a TB outbreak is suspected or confirmed

TB outbreak response plan— an action plan that helps guide outbreak response

Module 9 Self-Study Modules on Tuberculosis

Introduction to TB Outbreak Detection and Response

What is a TB Outbreak?

Definitions for TB outbreaks are relative to the local context. However, a TB outbreak is generally defined as a situation where there are

- More TB cases than expected within a geographic area or population during a particular time period, **AND**
- Evidence of **recent transmission** of *M. tuberculosis* among those cases

A TB outbreak is generally defined as a situation where there are more TB cases than expected within a geographic area or population during a particular time period, and there is evidence of recent transmission of M. tuberculosis *among those cases.*

Although the time period is not well defined, recent transmission generally refers to a situation where TB transmission occurred within the previous 2-year period. This implies that cases involved in an outbreak have been exposed and infected with *M. tuberculosis* in the past 2 years, as opposed to having developed active TB disease from latent TB infection caused by exposure from a long time ago. Because an outbreak indicates that there is the potential for extensive transmission of *M. tuberculosis*, a TB outbreak should always be considered a public health emergency.

What is TB Outbreak Response?

TB outbreak response is a process used by public health programs to investigate and intervene when a TB outbreak is suspected or confirmed. The ultimate goal of TB outbreak response is to interrupt ongoing transmission of *M. tuberculosis*. An outbreak generally involves multiple TB cases with several overlapping contacts. Compared to TB contact investigations, responding to TB outbreaks requires many more resources, a larger and more diverse group of partners and stakeholders, and more extensive collaboration and communication.

An outbreak generally involves multiple TB cases with several overlapping contacts.

Who is Responsible for Detecting and Responding to TB Outbreaks?

In the United States, state and local health departments have legal responsibility for the prevention and control of TB in their communities. This means health departments are legally responsible for ensuring appropriate response to TB outbreaks in their jurisdictions. However, because TB outbreak response typically requires substantial resources, it may be difficult for local health departments to independently manage TB outbreaks while maintaining adequate staffing and coverage for other public health activities. A quick and effective response to TB outbreaks can be a challenge for TB control programs even with substantial experience and resources. Thus, health departments should consider requesting assistance from other agencies, such as neighboring local health departments or the state health department, to help with the outbreak response.

A quick and effective response to TB outbreaks can be a challenge for TB control programs even with substantial experience and resources.

The Centers for Disease Control and Prevention (CDC) can also assist with TB outbreak response at the request of the state health department, another federal agency, or a sovereign entity such as an American Indian tribe or a U.S. territory.

What is TB Outbreak Preparedness?

TB programs can improve their ability to respond to outbreaks by planning in advance how they will respond when an outbreak happens. This is sometimes called **TB outbreak preparedness**. Outbreak preparedness typically involves

- Determining what is considered to be a potential TB outbreak (i.e., defining what events require further attention and action)
- Discussing who should be a part of the TB outbreak response team, including staff from other areas of the health department for whom TB is not part of their normal duties (e.g., STD or HIV program staff)
- Developing mechanisms for ensuring resources can be accessed quickly and then used as efficiently and effectively as possible
- Supporting collaboration and communication among everyone involved
- Ensuring that staff are educated about proper infection control procedures

TB programs can improve their ability to respond to outbreaks by planning in advance how they will respond when an outbreak happens.

How is TB Outbreak Preparedness Done?

Creating an initial action plan, also called a standing outbreak response plan, can help guide first steps once an outbreak is suspected.

There are many benefits to preparing in advance for TB outbreaks. Outbreak preparedness helps give health department staff and others involved with TB outbreaks general direction about when and how outbreak response efforts should happen. Even without knowing the specifics of an outbreak, some planning can almost always be done in advance. Because circumstances and capacities of public health programs vary, so do their approaches to outbreak preparedness. Creating an initial action plan, also called a standing outbreak response plan, can help guide first steps once an outbreak is suspected.

Planning the more predictable aspects of an outbreak in advance will allow for more time to be spent on responding to the outbreak itself. For example, points of contact at partner agencies and sources of additional resources can be identified ahead of time.

Part of being prepared is creating a framework for requesting assistance from other agencies. Creating preexisting agreements with these partner agencies is one option.

A customizable template of a standing outbreak response plan can be accessed online at http://www.currytbcenter.ucsf.edu/products/view/model-tuberculosis-outbreak-response-plan-template-low-incidence-areas.

Standing outbreak response plans cannot predict the particular issues surrounding an outbreak. Plans will need to be revised based on the circumstances of each outbreak.

How are TB Outbreaks Detected?

Timely detection of TB outbreaks is a fundamental component of TB prevention and control. Detecting signs that suggest an outbreak may be occurring is important because a rapid response can help control and minimize outbreaks.

Health department workers should be alert for signs of more TB cases than expected and evidence of recent transmission among those cases.

Outbreaks can be detected through the following activities:

- Observations from health department staff and others in the community
- TB contact investigations
- TB case surveillance
- TB genotype surveillance

During these activities, health department workers should be alert for signs of more TB cases than expected and evidence of recent transmission among those cases.

Observations from Health Department Staff and Others in the Community

TB outbreaks are sometimes first detected through astute observations from frontline staff at the health department. For example, an outreach worker may notice that he or she is performing more directly observed therapy (DOT) visits than usual to a particular neighborhood. Or a public health nurse may notice there are more homeless cases than usual. Observations like these always call for further investigation to determine if the cases are connected.

TB outbreaks can also come to the attention of health departments when other health care providers or members of the public report a concern. Such reports should be taken seriously and investigated by the health department. Even in an area where the overall TB case numbers are declining, an outbreak could be occurring.

TB Contact Investigations

Some contact investigation findings are evidence of recent transmission, which can indicate a potential TB outbreak. For example

- TB infection or TB disease in contacts younger than 5 years of age
- Change in contacts' tuberculin skin test (TST) or interferon-gamma release assay (IGRA) status from negative to positive
- More than expected TB disease or TB infection among contacts
- TB disease among contacts not considered priority
- Any evidence of secondary transmission

Someone in the health department, such as the TB program manager, should have the responsibility to routinely review contact investigation results, actively looking for evidence that an outbreak might be occurring. For more information on TB contact investigations, refer to *Module 8, Contact Investigations for Tuberculosis*.

TB Case Surveillance

Public health programs should monitor the occurrence of TB disease in specific geographic areas, populations, and time periods. This is known as **TB case surveillance**.

An unexpected increase in the number of TB cases or an increase in the TB case rate within a geographic area or population can be one of the first signs of an outbreak.

An increase in the number of TB cases does not always indicate that an outbreak is occurring. An increase in TB cases can happen for reasons other than an outbreak.

Similarities in case demographics, TB risk factors, and TB drug resistance patterns may also be early signs of an outbreak. In areas with a low incidence of TB, outbreaks are more often easily detected through TB case surveillance.

It is important to note that an increase in the number of TB cases does not always indicate that an outbreak is occurring. An increase in TB cases can happen for reasons other than an outbreak. Such scenarios are sometimes called "pseudo-outbreaks." Circumstances that can lead to pseudo-outbreaks are listed in Table 9.1.

Table 9.1—Situations Where an Increase in the Number of TB Cases is Not an Outbreak

When an Increase in TB Cases May NOT be an Outbreak
An increase in TB cases can happen for reasons other than an outbreak. Such scenarios are sometimes called "pseudo-outbreaks." Circumstances that can lead to pseudo-outbreaks include ■ An influx of persons from areas where TB is common (e.g., refugees) ■ Persons are misdiagnosed with TB, as a result of mislabeling or contamination during specimen collection or in the laboratory (sometimes called false-positive laboratory results) ■ Improved TB screening, diagnostic procedures, or reporting of cases (i.e., better case detection) ■ A new clinician in a jurisdiction who is more likely than predecessors to diagnose clinical TB

TB Genotype Surveillance

TB genotype surveillance is another way that public health programs can detect outbreaks. This method may be particularly helpful in areas with a high incidence of TB disease. TB **genotyping** is a laboratory-based method that can determine the genetic pattern of the strain of *M. tuberculosis* that caused TB disease in a person. Each strain has a distinct genetic pattern, or **genotype**. Genotyping is done for culture-positive cases of TB disease. TB genotype results can help confirm, disprove, or detect connections among cases. Cases involved in the same chain of transmission almost always have matching genotypes.

A **genotype cluster** could be the first sign that an outbreak is happening. A genotype cluster is when two or more cases have matching genotypes. However, not all genotype clusters are outbreaks. Genotype clusters can be caused by circumstances other than outbreaks, such as laboratory mislabeling,

contamination, or presence of what has been termed a common genotype (i.e., a genotype that is common in a certain geographic area or population that is not necessarily related to recent transmission).

A genotype cluster could be the first sign that an outbreak is happening.

In the United States, genotyping information on individual TB cases is available to state and local health departments through the **TB Genotyping Information Management System (TB GIMS),** a secure CDC-sponsored online national database of genotyping and TB case information. TB GIMS has an automatic function (called "cluster alerts") that notifies TB GIMS users of genotype clusters that may require further investigation. Not all genotype clusters or TB GIMS cluster alerts represent outbreaks. When genotype clusters are found, additional investigation is needed.

The following findings from genotype surveillance may suggest an outbreak and require further investigation:

- A genotype cluster is seen in only one jurisdiction or a small number of jurisdictions
- A growing number of cases have a new or uncommon genotype
- An unexpected increase in cases with a common genotype is observed
- New cases with a TB genotype associated with a prior TB outbreak are identified
- Cases with the same genotype and another factor in common, such as homelessness, incarceration, or substance abuse, are identified

Applications of TB genotyping for outbreak detection and response are discussed throughout this module. For more information, refer to the CDC's *Best Practices for Genotyping-Based Tuberculosis Outbreak Detection* (www.cdc.gov/tb/publications/factsheets/statistics/Genotyping_BestPractices.pdf).

Study Questions 9.1–9.3

9.1 What is a TB outbreak?

9.2 What is TB outbreak response?

9.3 What are three methods that health departments can use to detect TB outbreaks?

Answers to study questions are on pages 59–63

Study Questions 9.4–9.5

9.4 List four circumstances when an increase in the number of TB cases may not represent an outbreak.

9.5 What is a genotype cluster?

Answers to study questions are on pages 59– 63

Module 9 Self-Study Modules on Tuberculosis

Systematic Approach to TB Outbreak Response

Public health programs can respond more quickly and more effectively to potential TB outbreaks by using a systematic approach. Although the order and timing of TB outbreak response activities will vary, the overall response generally includes the following 10 steps:

1. Confirm the existence of an outbreak
2. Define and list outbreak cases
3. Examine existing information about outbreak cases
4. Convene the outbreak response team and develop the outbreak hypotheses
5. Fill information gaps
6. Implement the specific outbreak response plan
7. Communicate interim findings
8. Summarize the outbreak response
9. Implement recommendations
10. Evaluate the outbreak response

This section of the module will describe each of the steps listed above.

Step 1: Confirm the Existence of an Outbreak

When a TB outbreak is suspected, investigation is needed to confirm that an outbreak is actually occurring before mounting a full outbreak response.

When a TB outbreak is suspected, investigation is needed to confirm that an outbreak is actually occurring before mounting a full outbreak response. To confirm an outbreak, investigators need to determine whether there are both

- More cases than expected within a geographic area or population during a particular time period, AND
- Evidence of recent transmission of *M. tuberculosis* among those cases.

More Cases than Expected

An important first step when determining whether there are more cases than expected is to verify the reported cases actually have TB disease.

An important first step when determining whether there are more cases than expected is to verify the reported cases actually have TB disease. Determining if reported cases actually have TB disease typically requires reviewing clinical findings and laboratory results for each case.

When clinical findings for cases are not consistent with the laboratory results, further efforts are usually needed to confirm these persons have TB disease. For example, when a person without any signs or symptoms of TB disease is reported as a case based on a single positive TB culture, it is important to investigate whether the laboratory result is accurate.

Evidence of Recent Transmission Among Cases

When an unexpected increase in cases is confirmed or a growing genotype cluster is identified, investigators need to look for evidence of recent transmission among the cases to determine if there is an outbreak.

When an unexpected increase in cases is confirmed or a growing genotype cluster is identified, investigators need to look for evidence of recent transmission among the cases to determine if there is an outbreak. This typically begins with reviewing available information about the cases, such as contact rosters and medical records. Investigators may also confer with program staff who are familiar with the cases. In some situations, additional information will need to be gathered through re-interviewing cases and conducting field visits.

One way to assess if cases are involved in a chain of recent transmission is to look for characteristics that the cases have in common. This is because TB outbreaks generally involve persons with similar demographic characteristics and TB risk factors. For example, cases may share characteristics such as homelessness, previous incarceration, or substance use.

Investigators should look for epidemiologic links (epi links) among cases. An epi link is a characteristic that TB cases share that explains where and when TB could have been transmitted between them.

In addition, investigators should look for epidemiologic links (**epi links**) among cases. An epi link is a characteristic that TB cases share that explains where and when TB could have been transmitted between them. For example, cases have an epi link if they named each other as contacts or shared airspace at the same location (e.g., workplace, bar, shelter) at the same time. However, sometimes the epi links are not as evident, such as when cases are in the same social circles (but do not identify each other by name) or they spend time at the same place (but cannot be certain they were there together at the same time).

Some initial questions investigators can use while reviewing information to help determine if cases may be linked in a chain of recent transmission include

- Have any of the cases named each other as contacts?
- Do any of the cases have contacts in common?
- Do any of the cases have similar TB risk factors?
- Do the cases live or work near each other?

Genotyping information can be used to confirm epi links and may also identify previously unknown epi links.

Genotyping information can be used to confirm epi links and may also identify previously unknown epi links. Investigators should review information to see if genotype-matched cases have risk factors in common, such as having spent time at the same homeless shelter or jail.

In some situations, genotyping information may not be available. These situations include

- Clinical cases (no culture available)
- Culture-negative cases
- Cases whose culture results are still pending

In such situations, if epi links among cases can be reasonably established, it is usually advisable for public health programs to proceed as though there is an outbreak once it is confirmed that the cases actually have TB disease.

Case Study 9.1

Colin is an 8 month old child who was diagnosed with TB disease in Brown County. Typically, Brown County has less than two TB cases per year. The health department did a source case investigation and found that his mother, Kate, has latent TB infection and his Uncle Dave has TB disease.

As an infant, Colin is unable to produce sputum, so the health department does not have a culture to submit for genotyping. However, the health department receives the results of Dave's TB genotype and finds that it matches with two other recent cases from Brown County.

Would this lead you to suspect a potential TB outbreak? Why or why not?

Answers to case studies are on pages 64–66

Step 2: Define and List Outbreak Cases

When the information gathered in Step 1 suggests an outbreak is occurring, the next step is to determine

- A consistent way to define which cases may be part of the outbreak (the **outbreak case definition**)
- An efficient way to summarize those cases (the **outbreak line list**)

TB Outbreak Case Definition

TB outbreak case definitions are a standard set of criteria for deciding which TB cases could be involved in the outbreak.

TB outbreak case definitions are a standard set of criteria for deciding which TB cases could be involved in the outbreak. Knowing which TB cases to investigate helps to estimate the size of the outbreak and determine what resources will be needed for the response.

TB outbreak case definitions usually include TB genotype information, characteristics about the affected person, information about the location or place, and the time during which the outbreak occurred.

TB outbreak case definitions usually include the following four components:

1. TB genotype information (if available)
2. Characteristics about the affected persons (*person*)
3. Information about the location or place (*place*)
4. Time during which the outbreak occurred (*time*)

1. TB Genotype Information

For culture-confirmed cases, genotyping information is an important component of TB outbreak case definitions. This is because cases involved in the same chain of transmission almost always have matching genotypes (when this information is available). Cases with genotypes that are different than the outbreak genotype are unlikely to be part of the outbreak and can usually be excluded from the investigation. (Note: when genotyping information is not available, it is usually advisable to include cases as part of the outbreak if epi links can be established.)

2. Person

Person usually describes what the cases have in common that led investigators to suspect they may be involved in the same chain of recent transmission, such as similar demographic characteristics. For example, the outbreak may primarily involve homeless persons. This information is particularly helpful in situations where the TB genotype is not available for all cases.

3. **Place**

   Place describes the geographic boundaries of the outbreak. Typically place refers to a city, county, or state, but it can be as narrow as a specific site, such as a nursing home.

4. **Time**

   The *time* frame used in a TB outbreak case definition usually begins at the start of the infectious period for the person suspected of being the initial source case and ends at the present time.

   However, for outbreaks that extend over several years, it may not be practical to use the start of the infectious period for the initial source case. To keep the number of cases manageable, investigators may choose to focus on the two to three most recent years, because contacts of the more recent cases are most likely to benefit from interventions such as treatment for LTBI. To review information on calculating infectious periods, refer to *Module 8, Contact Investigations for Tuberculosis*.

Connecting cases to an outbreak usually requires that they be epi-linked to other cases in the outbreak, particularly if genotyping information is not available.

It is very important to apply the outbreak case definition in the same way to all cases being considered for inclusion in the investigation. However, outbreak case definitions can be modified as investigators learn new information about how transmission is occurring. For example, an initial case definition could include all cases with a specific TB genotype and established social connections and any other epi-linked cases that do not have genotyping information available. Depending on the situation, an epi link could be defined very strictly (e.g., cases identify one another by name) or more inclusively (e.g., any history of homelessness).

It is very important to apply the outbreak case definition in the same way to all cases being considered for inclusion in the investigation.

As more information is learned, the epi link definition can become more specific (e.g., cases stayed at a particular shelter). If more jurisdictions join the investigation, the geographic boundaries of the outbreak case definition can expand accordingly.

Determining which cases are involved in an outbreak is a process that can take some time to complete. Because of this, investigators will often use terms such as “definite,” “probable,” and “possible” to distinguish among or classify cases while waiting for genotyping results and working on epi link information. Examples of this practice are shown in Table 9.2.

Table 9.2—Classifying Outbreak Cases Based on Epi Links and TB Genotype Information*

Case Description	Epi Links to Other Cases in the Outbreak?	TB Genotype Information
Definite Outbreak Case	Yes	Genotype matches outbreak strain
Probable Outbreak Case	Yes	Genotype unknown or pending
Possible Outbreak Case	Investigation of epi links is pending	Genotype matches or no genotype available
Not an Outbreak Case	Yes, no, or unknown	Genotype is substantially different from outbreak strain

**It is important to note that some TB programs may classify outbreak cases differently.*

Outbreak Line List

An **outbreak line list** is a summary of the cases that meet the outbreak case definition.

The line list is one of the most useful tools during an outbreak investigation, as it allows investigators to quickly see key information about every case. The line list should be considered a confidential document and protected from unauthorized disclosure.

An outbreak line list is a summary of the cases that meet the outbreak case definition.

In a line list, each row represents a different case. Each column contains key information on every case such as

- **Identifying Information**

  Each case in the line list should have an identifier listed. If the line list is going to be shared externally with persons who do not have a need to know the identities of the cases, identifiers other than names or initials should be used to protect confidentiality. For example, the first case might be labeled "Case 1," the second "Case 2," and so forth. These are also useful shorthand labels when making epi curves, plotting infectious periods, and creating spot maps and diagrams (for more information, refer to Step 3 on page 23).

- **Demographic Information**

  The demographic information columns provide details needed to characterize the cases in an outbreak, such as age, sex, race/ethnicity, and occupation. Using a separate column for each characteristic may make it easier to calculate the number of cases with particular characteristics.

- **Risk Factor Information**

  Including information about risk factors such as recent incarceration or homelessness on the line list is another way to characterize the cases. This can help investigators tailor their activities to make the investigation more effective.

- **Clinical and Laboratory Information**

  Clinical and laboratory information helps to summarize the level of infectiousness for each case. Information could include the site and severity of TB disease (e.g., sputum smear and chest x-ray results) and, where applicable, infectious periods.

Each column of the line list contains key information on every case, such as identifying information, demographic information, risk factor information, and clinical and laboratory information.

Other relevant information should be included in a final "comments" column.

Using a simple format for the line list is best. Line lists can initially be created informally using white boards or flip charts (Figure 9.1), but then should be transferred into and regularly updated using software programs such as Microsoft Excel. The number and types of columns in a line list can be changed as needed. An example of a simple line list for a TB outbreak is shown in Table 9.3.

Figure 9.1—Outbreak investigators compiling information on white board.

Table 9.3—Example Line List for TB Outbreak Investigation

Identifier	Case Description	Age	Sex	Risk Factor	Clinical Information	Genotype
Case 1	Definite outbreak case	55	M	Homeless, recently incarcerated	Pulmonary, smear positive	G12345
Case 2	Possible outbreak case	30	M	Homeless, foreign born	Pulmonary TB, smear positive	G12345
Case 3	Probable outbreak case	3	M	Young age, recent contact to an outbreak case	Culture negative, responding to treatment	Unknown (culture negative)
Case 4	Definite outbreak case	20	M	HIV, substance abuse	Pulmonary, smear negative	G12345

Investigators should work together to create and update the line list. This ensures everyone is familiar with the outbreak case definition and current cases. The process of creating and regularly reviewing the line list together also helps investigators pool their collective knowledge about cases, recognize patterns, and discuss the information gaps. Regardless of how the line list is created or maintained, it is important for everyone on the outbreak response team to have access to the most current version, as it will be updated frequently throughout the outbreak response.

Study Question 9.6–9.7

9.6 What information is typically included in an outbreak case definition?

9.7 What is an outbreak line list?

Answers to study questions are on pages 59–63

Case Study 9.2

You are a health care worker at the local health department and have been assigned to investigate a TB outbreak. The TB genotype associated with this outbreak is G12345.

***Using the line list below, determine if each case is a* definite, probable, possible, *or* not an outbreak case.**

Case ID	Age	Sex	Genotype	Epi Linked to Other Outbreak Cases?	Answer
TB291	35	M	G12345	Yes	
TB302	75	F	G98765	No	
TB304	32	F	Unknown	Yes	
TB309	35	M	G12345	Pending	
TB310	40	M	G12345	Yes	

Answers to case studies are on pages 64– 66

Step 3: Examine Existing Information about Outbreak Cases

The line list developed in Step 2 begins the process of examining information about the outbreak cases in a structured way. Examining information about the outbreak cases helps investigators develop the **outbreak hypotheses** (i.e., theories about how, when, and where transmission may have happened). Outbreak hypotheses are discussed more in Step 4.

During Step 3, investigators should compile

- Information about the outbreak cases
- Contact investigation results for each of the outbreak cases

Compiling Information about Outbreak Cases

Compiling information for each case can help investigators recognize overlaps in cases' residences, relationships, or activities, as well as identify locations and times where transmission may have occurred.

Descriptive Epidemiology

Similarities among cases from the line list can be examined more closely with **descriptive epidemiology**. Descriptive epidemiology characterizes outbreaks by

- Person
- Place
- Time

Descriptive epidemiology characterizes outbreaks by person, place, and time.

Characterizing Outbreaks by Person

One way to characterize outbreaks by person is to determine the proportion of cases that share a particular characteristic. This is referred to as the frequency of a characteristic. Examples of characterizing by *person* may include homelessness or incarceration.

It is important to ensure that all cases have been assessed for each characteristic. If not, then the frequency of that characteristic may be underestimated. For example, the HIV infection status of each case must be known to calculate an accurate proportion of cases with HIV infection.

Another challenge is to make sure that all investigators are defining risk factors in the same way. Homelessness, for example, needs to be consistently defined (e.g., not just shelter use, but also "couch surfing").

Some characteristics investigators can use to characterize TB outbreak cases by person include

- U.S.-born
- Foreign-born
- Age younger than 5 years
- HIV-infected
- Diabetic
- Excess alcohol use
- Illicit drug use
- Homeless
- Recent incarceration
- AFB smear-positive
- Cavitary TB disease

Characterizing Outbreaks by Place

Place can have different meanings depending on the circumstances of the outbreak. For example, it might refer to the city or state in which cases reside. More specific meanings include where cases sleep, work, volunteer, attend school, and where they spend their leisure time.

Spot maps and diagrams can be extremely helpful for identifying locations where cases may have been exposed to TB or where they may have exposed others. Spot maps are made using maps and markers representing each case (e.g., push pins) to show the locations where each case spent time. Figure 9.2 shows an example of a spot map. Another option is to create a diagram with structures that represent each location where cases spent time.

Figure 9.2—Sample spot map. In this map, the pins represent outbreak cases. Each case is mapped to locations where they spent time.

Important patterns often become visible when lines showing connections between the cases are added to the spot map or diagram.

Important patterns often become visible when lines showing connections between the cases are added to the spot map or diagram. For example, having several cases linked to one location (e.g., the same apartment complex, church, or workplace) suggests transmission may have happened at that location.

If multiple cases cannot be connected to a single location, it could suggest that transmission happened at several different locations or that an important common location has not yet been identified.

Characterizing Outbreaks by Time

With TB, outbreaks are typically characterized in terms of months, calendar quarters, or even years. Using visual representations to describe outbreaks over time is often very useful.

Two commonly used representations of time are

- An **epidemic curve** (**epi curve**)
- A plot of infectious periods

Epi Curve

An epi curve is a graph that displays the number of TB cases and when they were identified. Time is plotted on the horizontal *x*-axis and the number of cases is plotted on the vertical *y*-axis.

The shape of the epi curve often gives clues about whether the majority of transmission occurred early in the outbreak or whether there is still ongoing transmission.

The shape of the epi curve often gives clues about whether the majority of transmission occurred early in the outbreak or whether there is still ongoing transmission. An epi curve with a steep up slope and a gradual down slope indicates a single source case (or "point source") to which cases were exposed (Figure 9.3). If the epi curve has a plateau instead of a peak, this indicates that the outbreak is ongoing (Figure 9.4). This scenario is troubling because it suggests that the outbreak is not under control.

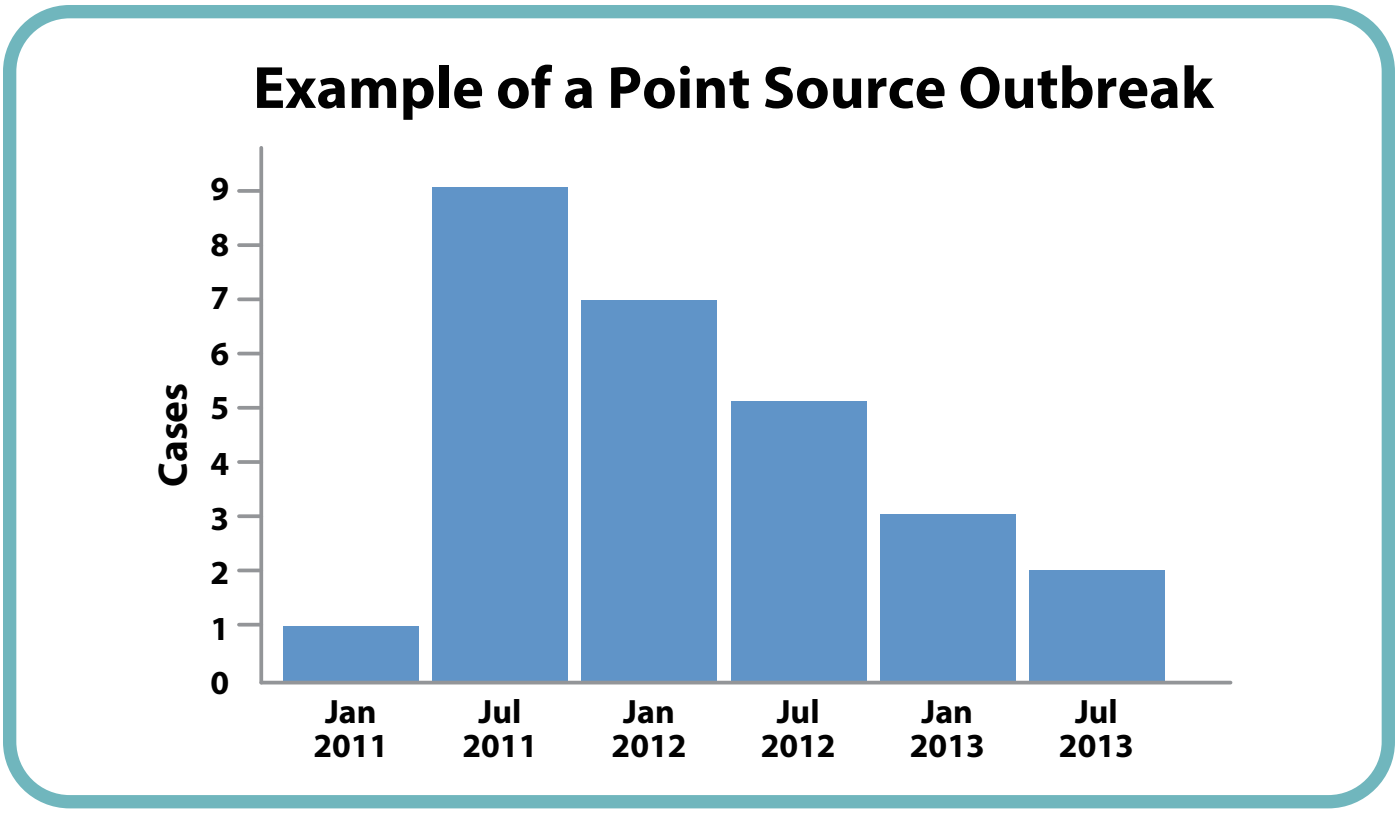


Figure 9.3—Epi-curve for a TB outbreak with a point source.

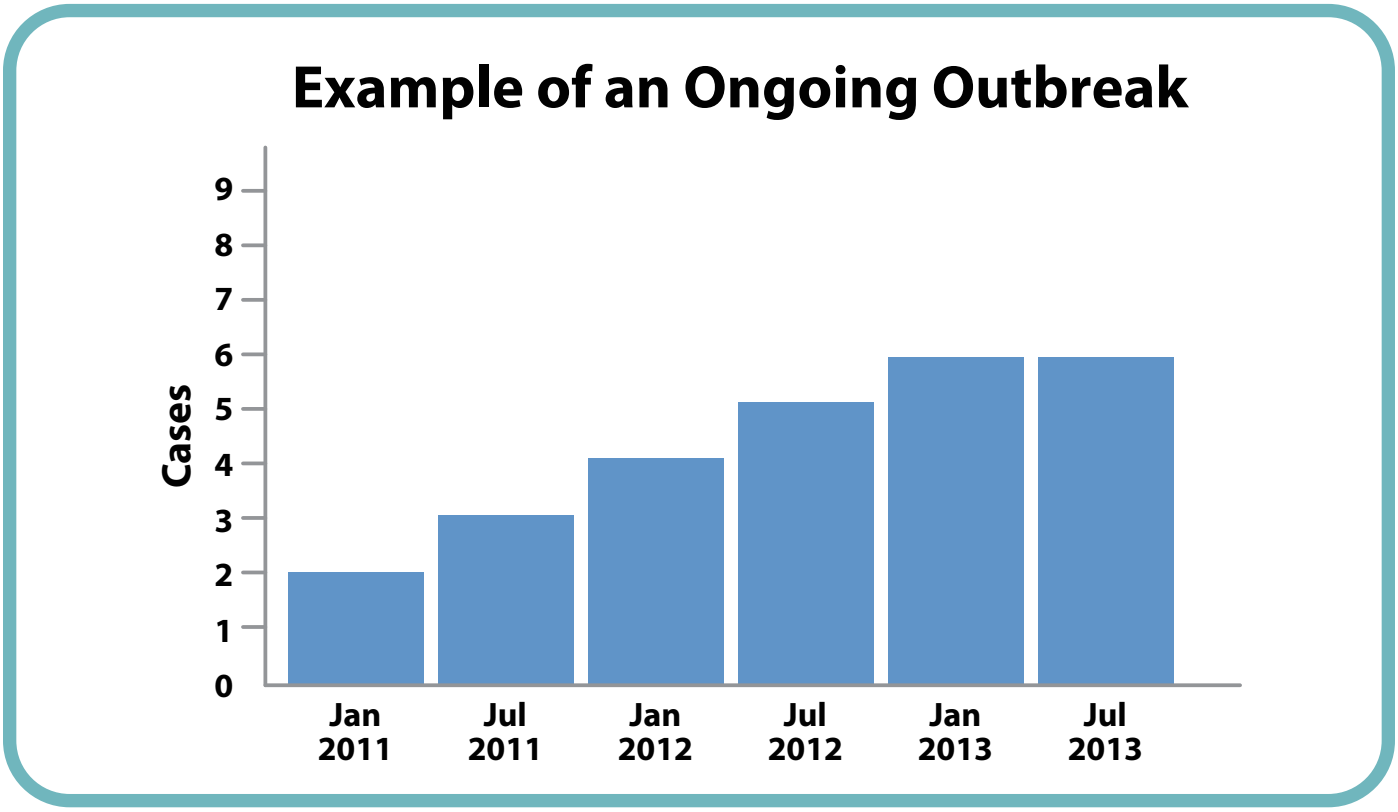


Figure 9.4—Epi-curve for a TB outbreak with ongoing transmission.

Plot of the Infectious Periods

Another way to model the time course of a TB outbreak is to make a diagram that shows the infectious period of each outbreak case.

A plot of the infectious periods shows the overall duration of the outbreak, beginning with start date of the first case's infectious period. To make a plot of the infectious periods, time is plotted on the horizontal *x*-axis. The vertical *y*-axis of the diagram lists the outbreak cases in the order they were identified (i.e., beginning with the first case at the top and the most recently identified case at the bottom).

A plot of the infectious periods shows the overall duration of the outbreak, beginning with start date of the first case's infectious period.

A horizontal bar representing the infectious period for each case is then created. The left-side border of the bar represents the start of the infectious period. The right-side border represents the end of the infectious period. Figure 9.5 shows an example of a plot of infectious periods.

Descriptive epidemiology tools can be even more powerful when they are combined. For example, incorporating information from the spot map into the plot of the infectious

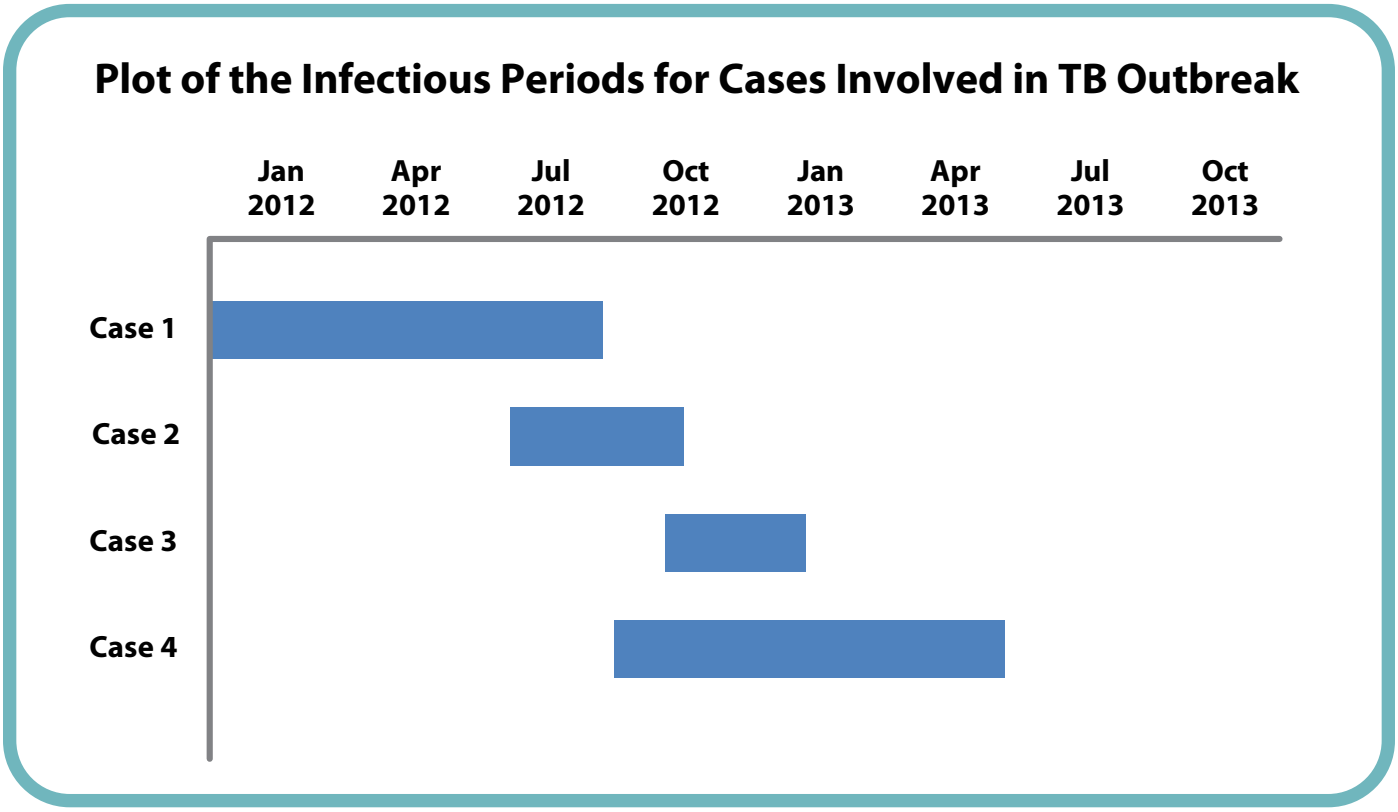


Figure 9.5—Plot of infectious periods for outbreak cases.

periods can help narrow down when exposure happened at certain locations. This information can be used by investigators to determine the need for active case-finding and location-based contact investigation activities at those locations. Figure 9.6 shows a plot of infectious periods with information from a spot map incorporated.

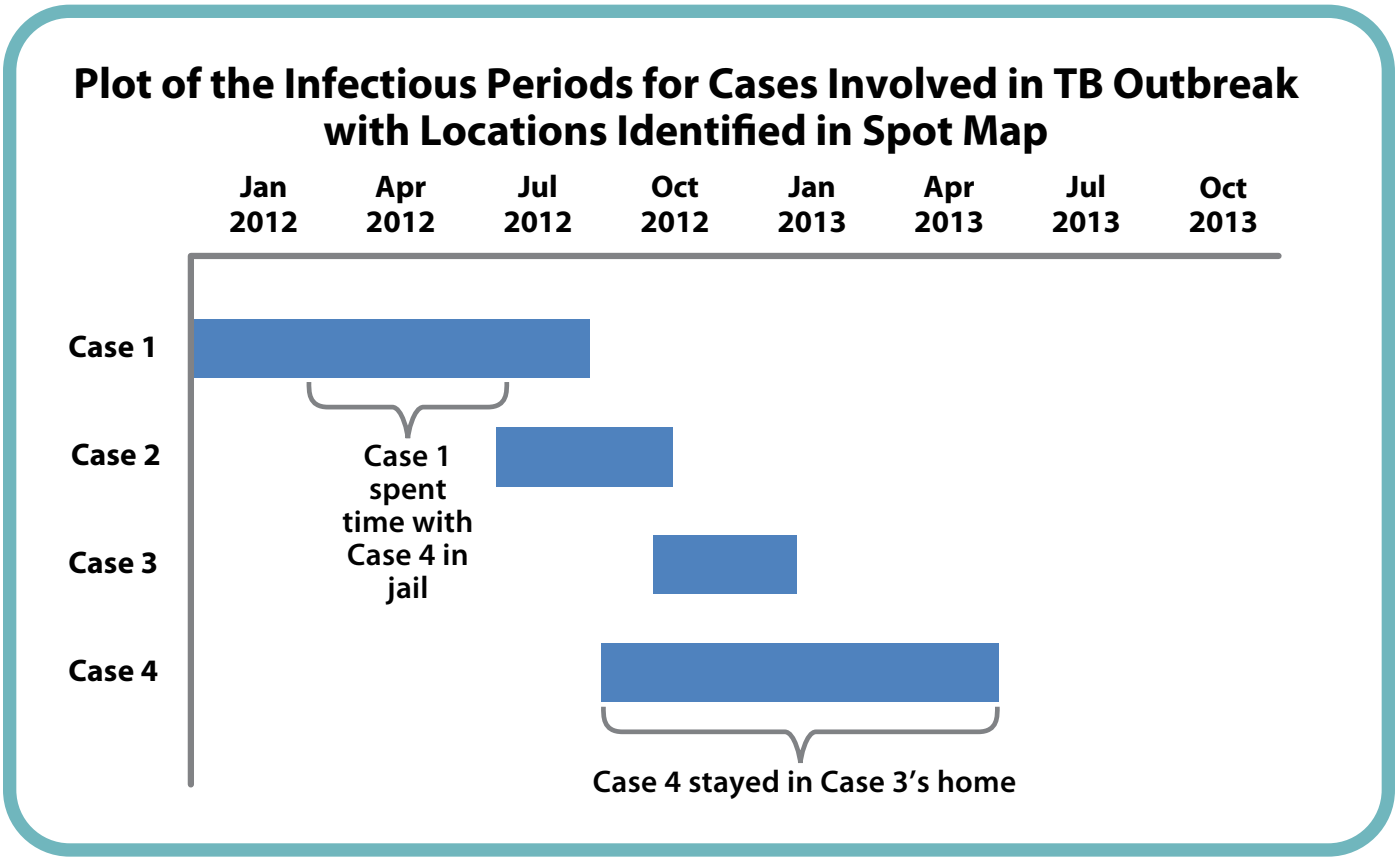


Figure 9.6—Plot of the infectious periods with information from the spot map incorporated.

Compile Contact Investigation Results for Each of the Outbreak Cases

After compiling information on outbreak cases, investigators should carefully examine all available contact investigation results for each case. This is because by the time an outbreak is recognized, many individual contact investigations have already taken place. Investigators need to identify the locations of all the available contact investigation data and determine how to integrate those various sources.

Compiling and analyzing contact investigation results can help focus initial outbreak investigative efforts on the most infectious cases.

Compiling and analyzing contact investigation results can help focus initial outbreak investigative efforts on the most infectious cases. For example, in an outbreak with numerous cases, only two cases may be responsible for most of the TB transmission. The activities and contacts of those two cases can then be prioritized as the outbreak investigation proceeds.

Another important purpose of this analysis is to assess the completeness of the initial contact investigations. This can help identify which cases may have had too few contacts identified during their contact investigation.

Study Questions 9.8–9.11

9.8 What is descriptive epidemiology?

9.9 What is a spot map?

9.10 What are two ways investigators can characterize TB outbreaks by time?

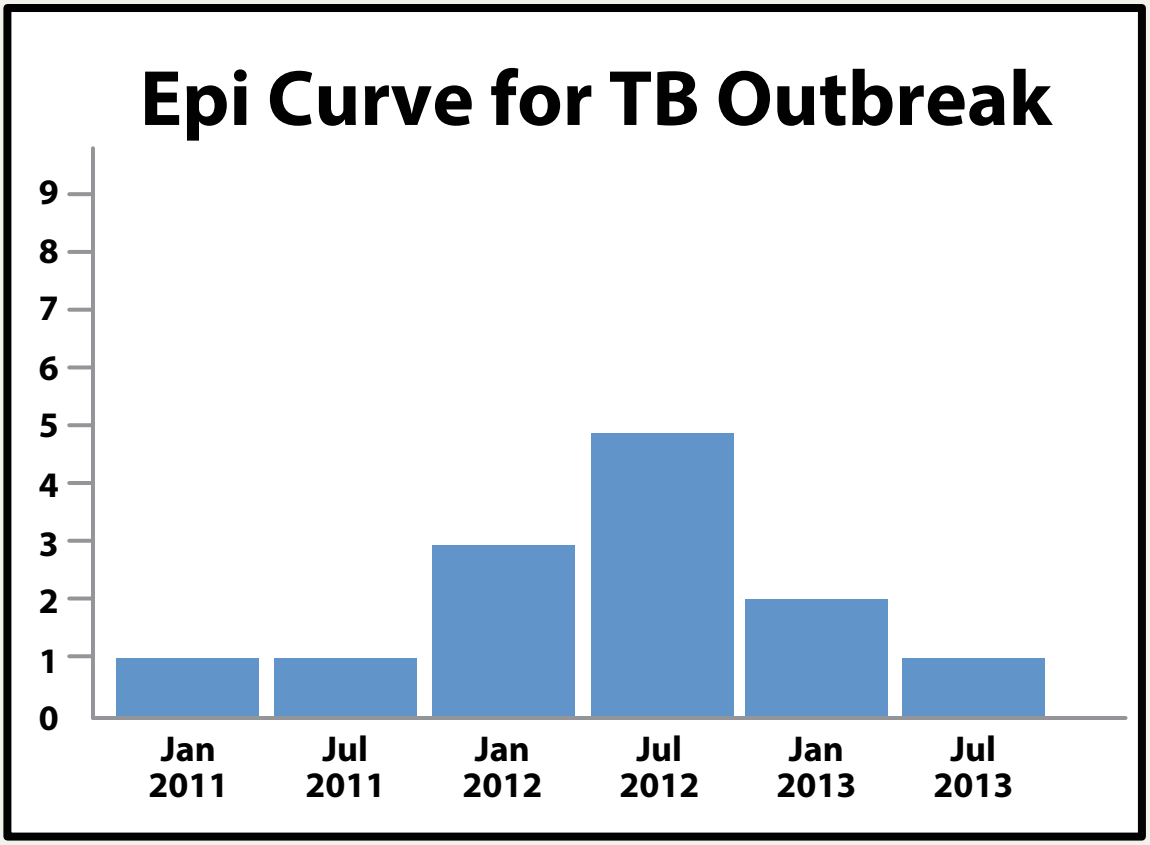
9.11 Why is it important to compile the individual contact investigation results for each outbreak case?

Answers to study questions are on pages 59– 63

Case Study 9.3

Keith is a health care worker at the local health department, and he has been assigned to investigate a TB outbreak. Using the information from the outbreak line list, he created an epi curve (below).

For accessible explanation of graph below, see Appendix for Accessibility on page 67.



What does the shape of the epi curve tell Keith about the outbreak?

Answers to case studies are on pages 64–66

Case Study 9.4

You are a health care worker at the local health department and have been assigned to investigate a TB outbreak. Using the line list below, plot each case on the map at each location they have been connected to.

Does it appear as though there are any locations where cases spent time together that may need further investigation?

Case Identifier	Demographics	Genotype	Location
Case A	M, 35 years old	G54321	Home 1, Jail, Work site
Case B	M, 46 years old	G54321	Homeless Shelter
Case C	M, 37 years old	G54321	Tavern, Homeless Shelter, Jail
Case D	F, 48 years old	G54321	Home 2
Case E	F, 25 years old	G54321	Tavern
Case F	M, 50 years old	G54321	Homeless Shelter, Home 2

For accessible explanation of map below, see Appendix for Accessibility on page 67.

Answers to case studies are on pages 64–66

Step 4: Convene the Outbreak Response Team and Develop the Outbreak Hypotheses

Successful outbreak responses require the combined effort of multiple individuals and organizations, both within and outside the health department.

Convening the Outbreak Response Team

A TB outbreak manager should be identified.

The role of the outbreak response team is to investigate and control the TB outbreak. If a TB outbreak manager has not already been designated, one should be identified at this time. Ideally, this person will serve in this role for the entire outbreak response. The TB outbreak manager must have the authority to redirect resources and assign staff to outbreak response activities, as well as coordinate efforts among all of the individuals, organizations, and stakeholders involved.

A TB outbreak response team may be comprised of persons such as

- Staff from the local health department who are usually involved in TB contact investigations, including the TB program manager, nurse case managers, and field-based staff, as well as persons who may work in other parts of the health department, such as database managers, STD investigators, outreach workers, and epidemiologists
- State TB controller, TB program manager, TB nurse consultant, TB epidemiologist, TB genotyping coordinator, and public health laboratory representative
- Public information officers for the local and state health departments
- Support personnel
- CDC, by request

The actual job titles for TB outbreak response team members may vary by jurisdiction. In smaller jurisdictions, one staff member often fills several roles. The outbreak response team could also include community partners (e.g., hospital infection control personnel or jail medical staff). Generally, the more individuals and organizations involved, the greater the need to clarify roles and responsibilities.

The initial meeting of the outbreak response team typically involves

- Reviewing information about the outbreak, including the case definition, the line list, descriptive epidemiology, and contact investigation results for each case.

- Developing the initial **outbreak hypotheses**.
- Reviewing the standing outbreak response plan and making any necessary modifications to suit the current outbreak.
- Setting the response priorities, clarifying the roles and responsibilities of individuals and programs involved, and addressing any jurisdictional issues that may be anticipated.
- Establishing timeframes and methods for investigation activities, data collection, and management.
- Establishing a schedule for case conferences or meetings to review challenges and progress.
- Establishing a communication plan among staff and others involved in the investigation. This may include determining preferences for routine communications, both for day-to-day work assignments within the outbreak response team, and for more general updates between the team and upper level management.
- Determining potential media interest.
- Discussing external communication plans (refer to Step 7).

Developing the Outbreak Hypotheses

Outbreak hypotheses are theories about how, when, and where TB transmission may have occurred during an outbreak.

Investigators usually start to develop ideas about how and why an outbreak could have happened as soon as they hear about a potential outbreak. These theories are called outbreak hypotheses.

The team manager should lead a discussion to refine these initial outbreak hypotheses (Figure 9.7). This discussion should include frontline TB staff who are most familiar with the situation. Frontline staff bring valuable observations, insights, and intuitions about the outbreak.

In discussing the outbreak hypotheses, the outbreak response team relies on their collective knowledge about

- TB (e.g., mode of transmission, pathogenesis, TB risk factors)
- Cases that meet the outbreak case definition (i.e., the line list)
- Descriptive epidemiology
- Contact investigation results

Describing each case's infectious period, the case(s) to which they are known to be epi linked, and their contact investigation results is important for analyzing outbreak data. This analysis can help generate and test hypotheses about who spread TB to whom, when, and where.

As the team discusses the various initial outbreak hypotheses, they will begin to identify the gaps where more information is needed to confirm or refute those hypotheses. The TB outbreak manager then uses those information gaps to determine the initial response priorities and to assign activities to various team members.

Subsequent meetings of the outbreak response team are usually held on a regular basis throughout the response.

Figure 9.7—An outbreak response team discussing the outbreak hypotheses.

Step 5: Fill Information Gaps

The outbreak response team needs to confirm or collect new information based on the initial outbreak hypotheses.

In Step 5, the outbreak response team needs to confirm or collect new information (i.e., fill in information gaps) based on the initial outbreak hypotheses. The line list should be updated with the additional information learned up to this point. For example, throughout the investigation, investigators may identify new cases that meet the outbreak case definition that need to be added to the line list. Creating new versions of the line list, dating the versions, and having a system to ensure everybody on the team receives the updated list, can help avoid confusion about which version is the most current.

Public health programs can gather additional information about cases and outbreaks in a number of ways, including

- Performing public record searches
- Re-interviewing cases and contacts
- Repeating field visits and visiting new sites
- Updating clinical findings and laboratory results for cases and contacts
- Cross-matching the line list with homeless shelter and correctional facility records

Performing Public Record Searches

Performing public record searches (e.g., internet social network, arrest records, and other public notices) with names of cases and their contacts can help identify other potentially useful information, such as similarities and connections among cases in the outbreak.

Re-interviewing Cases and Contacts

Re-interviewing cases and contacts is essential for confirming information and for identifying locations, activities, or behaviors not discussed in earlier interviews.

Re-interviewing cases and contacts is essential for confirming information and for identifying locations, activities, or behaviors not discussed in earlier interviews. Offering incentives and enablers to help encourage cooperation with re-interviews can be effective and should be considered.

Depending on the number of cases, it can be helpful to have one experienced investigator do as many of the interviews as possible, because a single interviewer is more likely to notice important similarities. However, if an investigator is not able to elicit key information, switching investigators for selected interviews should be considered.

When re-interviewing cases and contacts as part of an outbreak investigation, the time frame of interest is not only each case's infectious period, but also their potential exposure periods

(i.e., when and how they became infected, before they developed TB disease). Interview questions should cover the time frame used in the outbreak case definition (Step 2).

When re-interviewing cases and contacts as part of an outbreak investigation, the time frame of interest is not only each case's infectious period, but also their potential exposure periods (i.e., when and how they became infected, before they developed TB disease).

A standardized approach to re-interviewing, such as using an interview checklist, can help the outbreak response team systematically collect information about cases' relationships, activities, or interests. To understand the possible transmission opportunities among cases, questions should be asked about any behaviors, activities, or locations that may be associated with the outbreak (e.g., specific alcohol or drug usage sites).

Having the team work together to develop this interview checklist before starting the re-interviews helps ensure that the same questions are asked of everyone, even if several investigators are working simultaneously. However, investigators should not limit themselves to just the predetermined questions. Pursuing additional and creative lines of questioning should be encouraged whenever it may be helpful to do so.

New information learned during the interview should be recorded and shared at the next outbreak response team meeting. Any activities or locations identified by one case should be systematically incorporated into follow-up interviews with other outbreak cases. Multiple re-interviews may be necessary to ensure all cases are asked about certain activities or locations that emerge as potentially important aspects of the outbreak. Interview forms are usually revised frequently during an investigation to incorporate new questions.

Any activities or locations identified by one case should be systematically incorporated into follow-up interviews with other outbreak cases.

Repeating Field Visits and Visiting New Sites

Repeat field visits can help the outbreak response team collect new information or confirm information that was collected previously (Figure 9.8). If any new potential transmission sites have been identified, visits to those sites should be made as soon as possible.

It can be helpful to find out about privacy and confidentiality requirements of both the health department and the external partner in advance of these field visits, particularly if discussion or sharing of the names on the outbreak line list (e.g., for cross-matching of records) is anticipated.

As with contact investigation field visits, public health staff should use the visit as an opportunity to educate persons at that site about the basics of TB transmission and pathogenesis, and the importance of testing and treatment for TB disease and LTBI. Staff at the facility should be alert for any persons with symptoms of TB disease and refer them for immediate medical assessment.

Investigators should work with staff to record names (if available) and locating information for any additional contacts needing assessment who were not previously identified.

During the outbreak investigation field visit, additional emphasis should be placed on identifying similarities among the cases associated with that site, such as dates, times, or activities.

During the outbreak investigation field visit, additional emphasis should be placed on identifying similarities among the cases associated with that site, such as dates, times, or activities.

Investigators should observe environmental characteristics of the site such as room size, crowding, ventilation, low ceilings, and dense air. These characteristics can help assess where transmission was likely to occur.

In some situations, the investigator will have the opportunity to take photographs of the site or obtain copies of records (e.g., homeless shelter logs, incarceration histories, floor plans). Equipment such as a camera or USB flash drive can be helpful to bring on field visits. (For more information on field visits, refer to *Module 8, Contact Investigations for Tuberculosis*.)

Figure 9.8—Outbreak investigator conducting a repeat field visit.

Updating Clinical and Laboratory Information about the Cases and Contacts

Throughout the investigation, it is essential that the outbreak line list and contact findings are kept up-to-date.

It is not unusual for some of the clinical or laboratory information about cases to be pending during the early stages of the investigation. For example, genotyping results should be obtained for all cases suspected of being part of the outbreak. TB genotyping can be obtained by public health programs in the United States for most prior culture-positive cases as long as the isolates are still available in storage. Once these results are available, they should be added to the line list.

Throughout the outbreak investigation, the outbreak response team will be working to ensure that priority contacts whose assessments were previously incomplete are found, assessed, and, if needed, begin treatment. The team should also work to identify new contacts who were previously overlooked. Investigators should ensure that information regarding contacts is recorded in the public health record.

Cross-Matching the Line List with Homeless Shelter and Correctional Facility Records

Because many outbreaks are linked to homeless shelters and correctional facilities, interviews with cases should include questions about recent homelessness and incarceration. Interviewers should ask about approximate dates of stay at any homeless shelters, local jails, or other prison systems identified previously. However, because some cases may not reliably self-report their homeless shelter stays or recent incarceration history, a systematic cross-matching of all the names on the line list with homeless shelter and correctional facility records should be done. This is to both confirm what was discussed during the interview and to learn about additional stays that would otherwise be missed. In some situations, cross-matching cases by date of birth may be more productive than cross-matching by name.

Cases may not reliably self-report their homeless shelter stays or recent incarceration history.

As information gaps are filled based on the initial outbreak hypotheses, the outbreak response team should meet again and ensure new findings are shared with the team manager and other team members, particularly those involved in data entry and management.

Study Question 9.12

9.12 List five ways investigators can "fill information gaps" related to a TB outbreak.

Answers to study questions are on pages 59–63

Step 6: Implement the Specific Outbreak Response Plan

Although Steps 1 through 5 focused on cases, the emphasis at this step shifts more to finding contacts, assessing them for TB infection and disease, and preventing additional outbreak cases. To control the outbreak, the outbreak response team must find contacts with undiagnosed TB disease before they cause additional transmission. Finding contacts as part of TB outbreak response is similar to how it is done for a TB contact investigation, but on a much larger scale.

The emphasis at this step shifts more to finding contacts, assessing them for TB infection and disease, and preventing additional outbreak cases.

Based on the outbreak hypotheses, the team should target certain contacts or populations for active TB case finding. The activities should focus on the cases or sites that appear to have had the most transmission. Active TB case finding should include symptom reviews and chest radiographs, in addition to testing for TB infection.

Additional activities that may occur during the TB outbreak response include

- Extending hours of clinic services to accommodate the increased number of referrals, particularly for persons who are only available outside the health department's usual hours of operation;
- Providing transportation for cases and contacts to the health department;
- Providing offsite services during nights and weekends;
- Providing DOT to a larger number of persons (e.g., not only cases, but also infected contacts at risk for rapid development of TB disease); and
- Offering incentives and enablers to accomplish active case-finding, contact assessment, and treatment completion goals.

Successful implementation of the outbreak response plan requires careful attention to the following:

- Ensuring adequate resources for implementing the outbreak response activities
- Using a standardized approach to collect and manage investigation data
- Directing the specific response activities based on the evolving findings of the investigation

Ensuring Adequate Resources for Implementing the Outbreak Response Activities

Responding to an outbreak can often overwhelm existing local public health capacity.

Many local health departments may not have the resources and staff to perform the above activities. To ensure adequate human resources, health departments may need to

- Reassign public health staff from their usual duties and train them to help with outbreak-related activities;
- Access additional clinicians with TB expertise to review chest x-rays, evaluate contacts, and manage suspected cases and infected contacts; and
- Recruit outreach workers with special skills (e.g., specific linguistic or cultural competencies, ability to place and read TSTs, draw blood for IGRAs, DOT experience) to assist with interviews, assessment, and treatment.

Community partners (e.g., hospital infection control personnel, jail medical staff) can also become overwhelmed by the additional workload created by TB outbreaks.

It is important to remember that community partners (e.g., hospital infection control personnel, jail medical staff) can also become overwhelmed by the additional workload created by TB outbreaks. There are often surges in diagnostic and laboratory examinations and greater demand for facilities (e.g., airborne infection isolation) for the evaluation and treatment of suspected cases. The health department should consider including such partners on the TB outbreak response team from the very beginning of the response.

Managing resources effectively during an outbreak requires frequent communication between the TB outbreak manager and health department leadership. For this reason, a review of current resources and anticipated shortfalls are typically discussed at each outbreak response team meeting.

When it is anticipated that responding to a TB outbreak is likely to disrupt other essential TB control functions, requests for supplemental resources and assistance should not be delayed.

When it is anticipated that responding to a TB outbreak is likely to disrupt other essential TB control functions, requests for supplemental resources and assistance should not be delayed. Additional resources could include other agencies, such as neighboring local health departments or the state health department. CDC can assist with TB outbreak response at the request of the state health department, another federal agency, or a sovereign entity such as an American Indian tribe or a U.S. territory.

Using a Standardized Approach to Collect and Manage Outbreak Data

The size and scope of information about cases and contacts generated during outbreak investigations can quickly become unmanageable. Even though TB outbreaks typically involve several overlapping contact investigations, the processes and systems used for managing data for TB contact investigation may not be adequate for outbreak investigations.

Some of the challenges to managing information during outbreak investigations are caused by differences in the amount and types of contact investigation information previously collected for each outbreak case.

Some of the challenges to managing information during outbreak investigations are caused by differences in the amount and types of contact investigation information previously collected for each outbreak case. For example:

- Contacts and cases could have been exposed to more than one outbreak case;
- Contacts who were previously assessed and found not to have TB infection could have been re-exposed and may need to be reassessed; or
- Cases or contacts who recently completed treatment sometimes have been subsequently re-exposed and potentially re-infected.

Once information from the various contact investigations has been collected, a system should be created and maintained to keep up with the large amount of new data expected from TB outbreak response activities. A pooled contact roster should be considered, where all contacts for the outbreak are accumulated and tracked in one list. Health department leadership should consider designating a person with data management and epidemiology skills to assist the outbreak response team with a process to systematically enter, manage, and analyze the outbreak data.

As with contact investigations, using standardized approaches to collecting and managing information during outbreak investigations can be very helpful. Ideally, approaches to data management will define

- What information will be collected, and why;
- Who is responsible for collecting information, and how it will be collected; and
- How information will be managed after it is collected.

Being able to systematically track cases and contacts over time is facilitated by the use of information technology such as spreadsheet software. Ideally, key users will be familiar with the software before the investigation begins.

Directing the Specific Response Activities Based on the Evolving Findings of the Investigation

Findings from the outbreak investigation activities should be monitored and interpreted on a regular basis to keep the investigation on track. It can be helpful to have ongoing assistance from an epidemiologist familiar with the outbreak and the investigation.

New findings should be discussed at outbreak response team meetings. This will help the outbreak manager make decisions about whether the current outbreak response plan needs to be readjusted.

Study Question 9.13

9.13 List at least 5 activities health departments may need to implement to respond to an outbreak.

Answers to study questions are on pages 59– 63

Step 7: Communicate Interim Findings

Effective outbreak responses require a high degree of collaboration among internal and external partners.

Effective outbreak responses require a high degree of collaboration among internal and external partners. Thus, it is critical to communicate findings in a timely and appropriate way, and ensure any resulting changes to outbreak investigation and response plans are reported to team members, stakeholders, and partners.

Having public information officers present at the first meeting of the outbreak response team helps ensure planning for external communications.

Because TB outbreak response is such an intensive undertaking, health department staff may become so busy with the day-to-day activities of the response that external communications are neglected. Having public information officers present at the first meeting of the outbreak response team (Step 4) helps ensure planning for external communications.

Communicating with the Outbreak Team

The discussion at the initial meeting of the outbreak response team (Step 4) should result in an initial communication plan, which is often adapted over time based on what works best. For example, there might be

- Daily email updates to the response team summarizing the current priorities, activities, and individual team assignments;
- Weekly email updates or conference calls with upper level management; and
- Less detailed summaries for external stakeholders and partners every 2 to 3 weeks.

Communicating with Stakeholders and External Partners

It is important to identify and collaborate with key stakeholders and external partners. Some examples of stakeholders and external partners during a TB outbreak are

- Cases, their family members, and their contacts;
- Institutions involved in the outbreak (e.g., hospitals, jails, homeless shelters);
- Community groups and organizations that provide services to the populations involved in the outbreak;
- Public health officials from various agencies and, in some situations, potentially other local or state government officials;
- Experts in medical and non-medical management of cases and contacts (e.g., physicians, nurses, public health workers, other health care providers); and

- Directors, managers, and personnel of programs and facilities that provide diagnostic, isolation, and treatment services to the populations involved in the outbreak.

New and important stakeholders and external partners are often identified over the course of the outbreak investigation. When this happens, every effort should be made to appropriately engage them in response efforts.

Stakeholder and external partner collaboration enables public health investigators to

- Offer onsite education about TB;
- Access records at potential transmission sites; and
- Develop and deliver coordinated media messages that aid the investigation.

Partnerships can help the health department gain important insight into the culture of persons involved in the outbreak and the barriers they may face in obtaining TB information, screening, and treatment.

Such partnerships also help the health department gain important insight into the culture of persons involved in the outbreak and the barriers they may face in obtaining TB information, screening, and treatment. Ultimately, identifying and addressing these barriers could prevent future TB outbreaks by reducing instances of delayed or missed diagnosis of TB disease.

Communicating with the Media

TB outbreaks often result in attention and requests for information from the media. This is because TB outbreaks can sometimes cause feelings of fear, anger, and helplessness in both the affected communities (e.g., TB cases and their contacts, staff and volunteers of potential transmission sites) and the general population who might have heard about the outbreaks. Sources of information (e.g., media reports) that are factually accurate and that correctly describe the role of the health department can help to dispel stigma, alleviate undue anxiety, generate support for TB control efforts, and, in time, facilitate the outbreak investigation process. Collaboration with stakeholders and other external partners to prepare and disseminate information during outbreaks can help ensure it is accurate, helpful, culturally appropriate, and that it is coordinated with their own internal and external messages.

Sources of information (e.g., media reports) that are factually accurate and that correctly describe the role of the health department can help to dispel stigma, alleviate undue anxiety, generate support for TB control efforts, and, in time, facilitate the outbreak investigation process.

Training resources are available to enhance the media communication skills of public health workers. These include

- The World Health Organization and Stop TB Partnership *Working with the Media: How to Make Your Messages on Tuberculosis Count*, which can be accessed online at www.stoptb.org/assets/documents/resources/publications/acsm/Working%20with%20the%20Media%20Final%20Web.pdf

- CDC *Forging Partnerships to Eliminate Tuberculosis, 2007*, which can be accessed online at www.cdc.gov/tb/publications/guidestoolkits/forge/default.htm
- CDC *Crisis and Emergency Risk Communication (CERC)*, which can be accessed online at https://emergency.cdc.gov/cerc/index.asp

Step 8: Summarize the Outbreak Response

As the outbreak response nears completion, a summary of the outbreak response activities should be prepared. Depending on the intended uses, this summary could take the form of a formal written report or a public presentation.

The purposes of preparing the summary are to ensure internal and external partners have updated information about the investigation and findings and to provide recommendations for moving forward.

The purposes of preparing the summary are to

- Ensure internal and external partners have updated information about the investigation and findings; and
- Provide recommendations for moving forward.

The use of tables, figures, and other descriptive epidemiology methods can ensure findings are presented in a clear and concise manner. Seeking the assistance and consultation of epidemiologists in preparing and reviewing these summary reports can be very helpful.

Summaries typically include a description of the following:

- The outbreak case definition
- Sources of information and investigation methods
- Size and scope of the outbreak
- Non-identifying descriptions of outbreak cases, that include information such as ages, dates and methods of identification, infectious periods, and treatment status
- Chains of transmission
- Contributing factors and risk factors associated with the outbreak
- Activities and findings, including number of contacts identified, assessed, and treated for LTBI, and number of additional cases found
- Activities yet to be completed

This outbreak summary will inform Steps 9 and 10.

Study Questions 9.14–9.15

9.14 What are some benefits of engaging stakeholders and partners in outbreak response efforts?

9.15 What is the purpose of developing an outbreak summary?

Answers to study questions are on pages 59–63

Case Study 9.5

The health department in Purple County has been investigating and responding to an outbreak at a local factory. Eight employees have been diagnosed with TB disease. Most of the employees are foreign-born. The health department was initially alerted to the outbreak by an astute emergency room physician.

Who are some potential stakeholders and partners the health department should reach out to?

Answers to case studies are on pages 64– 66

Step 9: Implement Recommendations

Outbreak response summaries are usually followed by the outbreak response team's recommendations on how to proceed. Developing effective and appropriate TB control recommendations after an outbreak can be challenging. In addition to the strain that the TB outbreak has already placed on public health resources, it is not unusual to have an increase in cases toward the end of the investigation, often as a result of heightened awareness and enhanced active case-finding activities.

Sustained resources and responsiveness until the outbreak is fully under control are necessary.

In addition, TB disease progression in unidentified or untreated infected contacts means that it may take 2 to 3 years before improvements in TB control are clearly apparent. Sustained resources and responsiveness until the outbreak is fully under control are necessary.

Recommendations are typically organized into immediate and longer term activities. Immediate recommendations usually emphasize the completion of TB prevention and control activities already underway.

Recommendations are typically organized into immediate and longer term activities. Immediate recommendations usually emphasize the completion of TB prevention and control activities already underway. These activities could include active case-finding, contact assessments, and ensuring complete treatment for persons found to have TB disease or latent TB infection.

Longer term recommendations may outline

- Policies and procedures for improved TB prevention and control in settings and populations identified during the investigation as at risk;
- Post-outbreak genotype monitoring for the recurrence of the outbreak, such as with TB GIMS watch lists;
- Improved TB control program capacity and access to additional TB training for public health staff and community partners; and
- Program gaps that could be addressed to help prevent future outbreaks of TB.

Many public health departments will choose to prioritize post-outbreak recommendations, phasing them in according to the capacity of their TB control programs. Ongoing, enhanced collaboration with internal and external partners is almost always needed.

As recommendations are implemented, outcomes should be monitored and documented via progress reports or other methods.

As recommendations are implemented, outcomes should be monitored and documented via progress reports or other methods. This is important for determining whether the recommendations are working and being implemented as

recommended. Regular epidemiologic review may also reveal ways the recommendations could be improved or made more effective. Some activities may be scaled back, while others may be given greater attention.

Step 10: Evaluate the Outbreak Response

Evaluating TB outbreak response efforts provides public health programs opportunities to recognize what went well during the response and how future outbreak responses may be done more effectively.

Evaluating TB outbreak response efforts provides public health programs opportunities to recognize what went well during the response and how future outbreak responses may be done more effectively.

Outbreak investigation and response evaluations can occur collaboratively during a meeting of representatives from the public health department and the internal and external partners involved in the investigation. An initial meeting should take place soon after the closure of the outbreak response.

During evaluation meetings, participants should review important findings and discuss lessons learned during the investigation. A collaborative approach to evaluation is especially important for investigations involving multiple agencies or multiple jurisdictions.

In advance of these meetings, the most recent Outbreak Investigation Summary (see Step 8) is typically circulated. Reviewing the summary at the start of the meeting provides participants opportunities to

- Clarify information from the report and updates;
- Provide feedback about the report; and
- Share additional information.

Topics for discussion during evaluation meetings typically include

- Factors that contributed to the outbreak, such as delays in diagnosis of source cases or involvement of hard-to-reach populations
- What was learned during the investigation, including
  - Which areas of the TB control program are working well and which might be in need of improvement
  - What barriers to outbreak detection or investigation were encountered
  - How partnerships and collaboration strategies affected the effectiveness of the investigation
- What is left to be done

TB control programs may consider formally recognizing the efforts of partner organizations and individual staff. The use of certificates of recognition and individualized thank-you letters can be an important and meaningful way to recognize their contributions to the outbreak investigation.

Communicating Findings to the Broader Public Health Community

Response summaries that are shared beyond the local or state public health infrastructure could make important contributions to TB control efforts in other jurisdictions.

Outbreak response summaries can also serve as references if the health department encounters a similar situation in the future. Response summaries that are shared beyond the local or state public health infrastructure could make important contributions to TB control efforts in other jurisdictions. These summaries can also form the basis for developing a future publication in the scientific literature.

Study Questions 9.16– 9.17

9.16 List at least two examples of longer-term outbreak response recommendations.

9.17 List the ten steps of the systematic approach to TB outbreak investigations.

Answers to study questions are on pages 59– 63

Special Circumstances in TB Outbreak Detection and Response

The following section reviews some situations where TB outbreaks can be difficult to detect or respond to including

1. Health care settings
2. Correctional and detention facilities
3. Cases with weakened immune systems

Health Care Settings

Transmission of *M. tuberculosis* and subsequent outbreaks of TB involving health care settings have been associated with

- Delayed recognition of signs and symptoms consistent with TB disease
- Delayed isolation precautions or effective TB treatment
- Intermingling of patients with undiagnosed TB disease with patients who have medical risk factors for rapid development of TB disease
- Inadequate infection control measures, such as
  - Inadequate isolation facilities, including lack of airborne infection isolation rooms
  - Recirculation of air from respiratory isolation rooms to other parts of the hospital
  - Failure to isolate patients until they are no longer infectious
  - Allowing isolated patients to leave their rooms without wearing a mask
  - Leaving isolation room doors open

TB outbreaks involving health care settings can involve large numbers of contacts (e.g., hospital staff, other patients, visitors, volunteers) and multiple jurisdictions (e.g., occupational health, community public health, and other medical providers). Typically, health care staff will be screened by the occupational health service and inpatients will be screened by the health care facility. Visitors, volunteers, and others are usually assessed by community public health or their personal physicians.

When responding to TB outbreaks involving health care facilities, it is critical to ensure the results of all contact assessments are monitored by the public health department responsible for the investigation.

When responding to TB outbreaks involving health care facilities, it is critical to ensure the results of all contact assessments are monitored by the public health department responsible for the investigation.

Guidelines for the prevention of transmission of *M. tuberculosis* in health-care settings were published in 2005. This document is available from the CDC website (www.cdc.gov/tb). Programs are encouraged to review the guidelines and to ask for assistance in their interpretation, if necessary. In the United States, local public health programs should consult with the next higher level of public health administration, which is generally the state health department. State programs can consult with CDC for additional assistance.

Correctional and Detention Facilities

There is a higher prevalence of TB disease among persons associated with correctional and detention facilities because of

- Over-crowded and poorly ventilated conditions, which can increase risk for transmission of *M. tuberculosis*; and
- A higher prevalence of risk factors that increase the risk for having TB infection, as well as the risk for progression to TB disease after infection with *M. tuberculosis*.

Frequent transfers and movements within or among facilities can also add to the challenges of detecting cases and outbreaks, and assessing and managing contacts.

Collaboration between the community public health department and a variety of key stakeholders, including administrators of the health care and occupational health programs of the involved facilities, is critical.

The risk for TB infection and TB disease is not limited to current or former residents of correctional or detention facilities. Infected staff can go on to develop TB disease and spread *M. tuberculosis* in the community. Visitors and persons from programs associated with correctional or detention facilities, such as courthouses or programs providing health and dental care, are also at risk. Thus, collaboration between the community public health department and a variety of key stakeholders, including administrators of the health care and occupational health programs of the involved facilities, is critical.

Recommendations for the prevention and control of TB in correctional and detention facilities were published in 2006. This document is available from the CDC website (www.cdc.gov/tb). Programs are encouraged to review the recommendations and to ask for assistance in their interpretation if necessary.

Cases with Weakened Immune Systems

Detecting or preventing TB disease in persons with a weakened immune system can be difficult. Such persons are at greater risk for rapid development of TB disease once infected. Also, some immune-suppressing diseases and disorders can interfere with the sensitivity of symptom screening, TST, and chest x-rays. Delays in treatment of TB infection can result in development of TB disease.

Another important consideration when investigating outbreaks that involve immunosuppressed cases is that their contacts are also likely to be immunosuppressed.

Another important consideration when investigating outbreaks that involve immunosuppressed cases is that their contacts are also likely to be immunosuppressed. For example, cases with diabetes and renal failure are likely to have contacts with diabetes and renal failure, such as other clients from the outpatient renal dialysis facilities they attend. Thus, when an outbreak involves cases with immunosuppression, it is even more important for public health investigators to quickly identify, assess, and when indicated, treat contacts.

Some ways to enhance the effectiveness of outbreak response involving immunosuppressed cases include

- Supporting urgent assessment of contacts at risk for immunosuppression by using incentives and enablers and providing on-site TB screening or access to health-care providers with extended hours of service;
- Providing LTBI treatment under DOT, ideally at settings frequented by contacts at risk for immunosuppression; and
- Considering presumptive treatment for TB disease or LTBI in contacts with severe immunosuppression.

Module 9 Self-Study Modules on Tuberculosis

Additional Resources

1. CDC. Best Practices for Genotyping-Based Tuberculosis Outbreak Detection. Atlanta, GA: Department of Health and Human Services, CDC; 2012. www.cdc.gov/tb/publications/factsheets/statistics/Genotyping_BestPractices.pdf
2. CDC. Controlling Tuberculosis in the United States: Recommendations from the American Thoracic Society, CDC, and the Infectious Diseases Society of America. MMWR 2005; 54 (No. RR-12). www.cdc.gov/mmwr/preview/mmwrhtml/rr5412a1.htm
3. CDC. Crisis and Emergency Risk Communication. Atlanta, GA: Department of Health and Human Services, CDC; 2012. https://emergency.cdc.gov/cerc/index.asp
4. CDC. Guidelines for Preventing the Transmission of *Mycobacterium tuberculosis* in Health-Care Settings, 2005. MMWR 2005; 54 (No. RR-17). www.cdc.gov/mmwr/preview/mmwrhtml/rr5417a1.htm?s_cid=rr5417a1_e
5. CDC. Prevention and Control of Tuberculosis in Correctional and Detention Facilities: Recommendations from CDC, 2006. MMWR 2006; 55 (No. RR-09). www.cdc.gov/mmwr/preview/mmwrhtml/rr5509a1.htm
6. Curry International TB Center. Model Tuberculosis Outbreak Response Plan for Low-Incidence Areas; 2006. http://www.currytbcenter.ucsf.edu/products/view/model-tuberculosis-outbreak-response-plan-template-low-incidence-areas
7. National TB Controllers Association/CDC Advisory Group on Tuberculosis Genotyping. Guide to the Application of Genotyping to Tuberculosis Prevention and Control: Handbook for TB Controllers, Epidemiologists, Laboratorians, and Other Program Staff. Atlanta, GA: Department of Health and Human Services, CDC; 2004. www.cdc.gov/tb/programs/genotyping/manual.htm
8. World Health Organization Stop TB Partnership. Working with the Media: How to Make Your Messages on Tuberculosis Count; 2009. www.stoptb.org/assets/documents/resources/publications/acsm/Working%20with%20the%20Media%20Final%20Web.pdf

Answers to Study Questions

9.1 What is a TB outbreak?

Generally, a TB outbreak is when there are more TB cases than expected within a geographic area or population during a particular time period, and there is evidence of recent transmission of *M. tuberculosis* among those cases.

9.2 What is TB outbreak response?

TB outbreak response is a process used by public health programs to investigate and intervene when a TB outbreak is suspected or confirmed. The ultimate goal of TB outbreak response is to interrupt ongoing transmission of *M. tuberculosis*.

9.3 What are three methods that health departments can use to detect TB outbreaks?

Outbreaks can be detected through the following activities:

- Observations from health department staff and others in the community
- TB contact investigations
- TB case surveillance
- TB genotype surveillance

During these activities, health department workers should be alert for signs of more TB cases than expected and evidence of recent transmission among those cases.

9.4 List four circumstances when an increase in the number of TB cases may not represent an outbreak.

An increase in TB cases can happen for reasons other than an outbreak. Circumstances when an increase in the number of TB cases may not represent an outbreak include

- An influx of persons from areas where TB is more common (e.g., refugees)
- Persons are misdiagnosed with TB, as a result of mislabeling or contamination during specimen collection or in the laboratory (sometimes called false-positive laboratory results)
- Improved TB screening, diagnostic procedures, or reporting of cases (i.e., better case detection)
- A new clinician in a jurisdiction is more apt than predecessors to diagnose clinical TB

9.5 What is a genotype cluster?

A genotype cluster is when two or more cases have matching genotypes.

Answers to Study Questions, Continued

9.6 What information is typically included in an outbreak case definition?

TB outbreak case definitions usually include the following four components:

1. TB genotype information (if available)
2. Characteristics about the affected persons (*person*)
3. Information about the location or place (*place*)
4. Time during which the outbreak occurred (*time*)

9.7 What is an outbreak line list?

An outbreak line list is a summary of the cases that meet the outbreak case definition. In an outbreak line list, each row represents a different case. Each column contains key information on every case, such as

- Identifying Information
- Demographic Information
- Risk Factor Information
- Clinical and Laboratory Information

9.8 What is descriptive epidemiology?

Descriptive epidemiology is the aspect of epidemiology concerned with organizing and summarizing health-related data according to person, place, and time. Descriptive epidemiology is a way to characterize outbreaks.

9.9 What is a spot map?

A spot map is a technique for showing where cases might have been exposed to TB or where they might have exposed others after developing TB disease.

9.10 What are two ways investigators can characterize TB outbreaks by time?

Investigators can characterize TB outbreaks by time using

- An epidemic curve (epi curve)
- A plot of infectious periods

Answers to Study Questions, Continued

9.11 Why is it important to compile the individual contact investigation results for each outbreak case?

Compiling and analyzing contact investigation results can help focus initial outbreak investigative efforts on the most infectious cases. In addition, assessing the completeness of the initial contact investigations can help identify which cases may have had too few contacts identified during their contact investigation.

9.12 List five ways investigators can "fill information gaps" related to a TB outbreak.

Investigators can fill information gaps related to a TB outbreak in a number of ways, including

- Performing public record searches
- Re-interviewing cases and contacts
- Repeating field visits and visiting new sites
- Updating clinical findings and laboratory results for cases and contacts
- Cross-matching the line list with homeless shelter and correctional facility records

9.13 List at least 5 activities health departments may need to implement to respond to an outbreak.

Activities that health departments may need to implement during TB outbreak response include

- Extending hours of clinic services to accommodate the increased number of referrals, particularly for persons who are only available outside the health department's usual hours of operation;
- Providing transportation for cases and contacts to the health department;
- Providing offsite services during nights and weekends;
- Providing DOT to a larger number of persons (e.g., not only cases, but also infected contacts at risk for rapid development of TB disease); and
- Offering incentives and enablers to accomplish active case-finding, contact assessment, and treatment completion goals.

Answers to Study Questions, Continued

9.14 What are some benefits of engaging stakeholders and partners in outbreak response efforts?

Engaging with stakeholders and external partners enables public health investigators to

- Offer onsite education about TB;
- Access records at potential transmission sites; and
- Develop and deliver coordinated media messages that aid the investigation.

Such partnerships also help the health department gain important insight into the culture of persons involved in the outbreak and the barriers they may face in obtaining TB information, screening, and treatment.

9.15 What is the purpose of developing an outbreak summary?

The purposes of preparing the summary are to

- Ensure internal and external partners have updated information about the investigation and findings; and
- Provide recommendations for moving forward.

9.16 List at least two examples of longer-term outbreak response recommendations.

Longer-term outbreak response recommendations may outline

- Policies and procedures for improved TB prevention and control in settings and populations identified during the investigation as at risk;
- Post-outbreak genotype monitoring for the recurrence of the outbreak, such as with TB GIMS watch lists;
- Improved TB control program capacity and access to additional TB training for public health staff and community partners; and
- Program gaps that could be addressed to help prevent future outbreaks of TB.

Answers to Study Questions, Continued

9.17 List the ten steps of the systematic approach to TB outbreak investigations.

Outbreak response generally includes the following 10 steps:

1. Confirm the existence of an outbreak
2. Define and list outbreak cases
3. Examine existing information about outbreak cases
4. Convene the outbreak response team and develop the outbreak hypotheses
5. Fill information gaps
6. Implement the specific outbreak response plan
7. Communicate interim findings
8. Summarize the outbreak response
9. Implement recommendations
10. Evaluate the outbreak response

Case Study Answers

9.1 Colin is an 8 month old child who was diagnosed with TB disease in Brown County. Typically, Brown County has less than two TB cases per year. The health department did a source case investigation and found that his mother, Kate, has latent TB infection and his Uncle Dave has TB disease.

As an infant, Colin is unable to produce sputum, so the health department does not have a culture to submit for genotyping. However, the health department receives the results of Dave's TB genotype and finds that it matches with two other recent cases from Brown County.

Would this lead you to suspect a potential TB outbreak? Why or why not?

A TB outbreak is when there are more TB cases than expected within a geographic area or population during a particular time period, and there is evidence of recent transmission of *M. tuberculosis* among those cases. In Brown County, it is possible there is a TB outbreak, because both of these criteria are occurring:

- More cases than expected—There are currently four diagnosed cases of TB in a county that usually experiences no more than two cases per year.
- Recent transmission—TB in children typically indicates recent transmission.

Additional investigation should be done to confirm the existence of the outbreak. For example, the health department should re-interview Dave and the other two cases to determine whether epi links can be established.

9.2 You are a health care worker at the local health department and have been assigned to investigate a TB outbreak. The TB genotype associated with this outbreak is G12345.

Using the line list below, determine if each case is a definite, probable, possible, or not an outbreak case.

Case ID	Age	Sex	Genotype	Epi Linked to Other Outbreak Cases?	Answer
TB291	35	M	G12345	Yes	*Definite*
TB302	75	F	G98765	No	*Not an outbreak case*
TB304	32	F	Unknown	Yes	*Probable*
TB309	35	M	G12345	Pending	*Possible*
TB310	40	M	G12345	Yes	*Definite*

Case Study Answers, Continued

9.3 Keith is a health care worker at the local health department, and he has been assigned to investigate a TB outbreak. Using the information from the outbreak line list he created an epi curve.

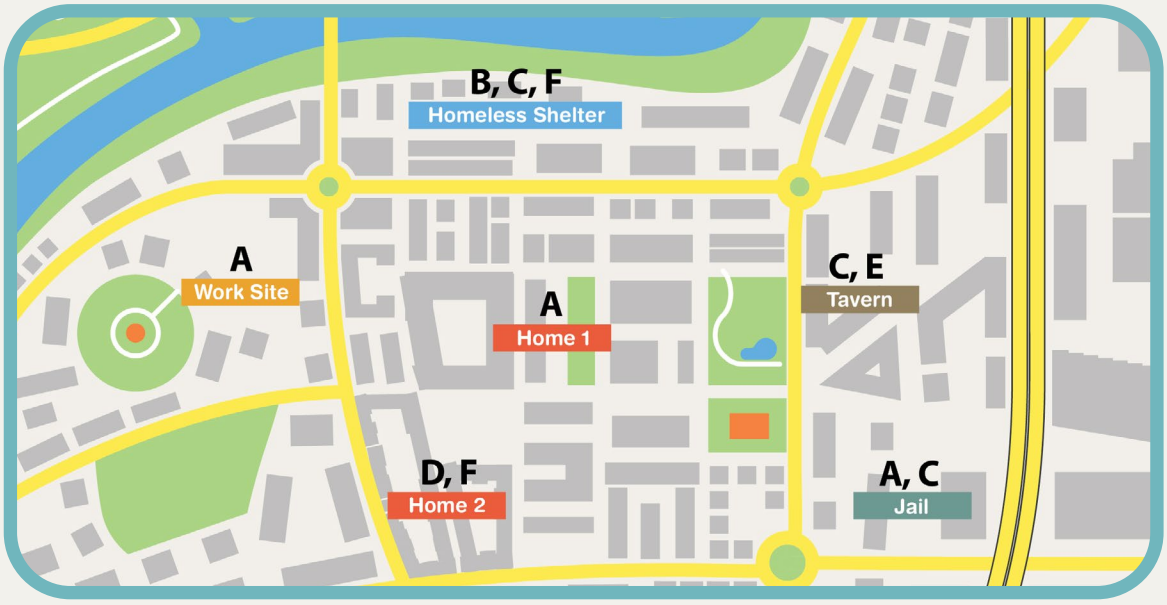
What does the shape of the epi curve tell Keith about the outbreak?

This epi curve shows that the outbreak has peaked and is in decline. This suggests that it is a "point source" outbreak and that the majority of the transmission occurred early in the outbreak.

9.4 You are a health care worker at the local health department and have been assigned to investigate a TB outbreak. Using the line list below, plot each case on the map at each location they have been connected to.

Does it appear as though there are any locations where cases spent time together that may need further investigation?

For accessible explanation of map below, see Appendix for Accessibility on page 67.



There are several locations where cases spent time together: home 2, the homeless shelter, the jail, and the tavern. The health department should conduct a field visit to the homeless shelter. The health department may also want to assess home 2, the jail, and the tavern for additional contacts.

Case Study Answers, Continued

9.5 The health department in Purple County has been investigating and responding to an outbreak at a local factory. Eight employees have been diagnosed with TB disease. Most of the employees are foreign-born. The health department was initially alerted to the outbreak by an astute emergency room physician.

Who are some potential stakeholders and partners the health department should reach out to?

Some stakeholders and partners that the Purple County health department may want to reach out to include:

- Cases, their family members, and their contacts
- Hospital where the first case was diagnosed
- Factory management
- Community groups and organizations that provide services to this foreign-born population
- Public health officials from various agencies, such as CDC

Appendix for Accessibility

Figure 9.2: An example of a spot map. At the left of the map, there are 2 cases at a worksite. At the top, middle of the map there are four cases at a homeless shelter. At the center of the map there are three cases at Home 1. At the bottom, middle of the map there are two cases at Home 2. At the right, middle portion of the map there are three cases at a tavern. At the bottom, right side of the map there are two cases at a jail.

Figure 9.3: The bar graph shows an example of a point source outbreak epi-curve from January 2011 to July 2013. There was a significant increase in July 2011, and cases decreased from January 2012 to July 2013. The epi curve has a steep up slope and a gradual down slope.

Figure 9.4: A bar graph showing an example of an ongoing outbreak epi-curve from January 2011 to July 2013. There was a gradual increase starting in January 2011, and a plateau from January 2013 to July 2013. The epi curve has a plateau, which indicates that the outbreak is ongoing.

Figure 9.5: This horizontal bar graph shows an example of a plot of the infectious periods for cases involved in TB outbreak. Some cases had an overlap in infectious periods.

- Case 1 had an infectious period of January 2012 to July 2012.
- Case 2 shows an infectious period of around July 2012 to October 2012.
- Case 3 shows an infectious period of around October 2012 to January 2013.
- Case 4 shows an infectious period of around October 2012 to April 2013.

Figure 9.6: This horizontal bar graph shows a plot of infectious periods with information from a spot map incorporated. Some cases had an overlap in infectious periods.

- Case 1 had an infectious period of January 2012 to July 2012. Within this time frame, around April 2012, Case 1 spent time with Case 4 in jail.
- Case 2 had an infectious period of around July 2012 to October 2012.
- Case 3 had an infectious period of around October 2012 to January 2013.
- Case 4 shows an infectious period of around October 2012 to April 2013. During this time, Case 4 stayed in Case 3's home.

Case Study 9.3: This bar graph shows an epi curve for a TB outbreak. Cases remained consistent in January 2011 and July 2011. There was an increase in cases in January 2012 and again in July 2012. Cases decreased in January 2013 and July 2013.

Case Study 9.4: A map that is labeled with locations where outbreak cases have spent time. On the left side, middle of the map, there is a worksite. At the top, middle of the map there is a homeless shelter. At the middle, center of the map there is Home 1. At the bottom, middle of the map there is Home 2. At the right, middle portion of the map there is a tavern. At the bottom, right side of the map there is a jail.

Case Study Answers 9.4: A map that is labeled with locations where outbreak cases have spent time. There are letters next to each location which are correct answers for case study question 9.4. The work site is plotted with Case A. The homeless shelter is plotted with Case B, Case C, and Case F. Home 1 is plotted with Case A. Home 2 is plotted with Case D and Case F. The tavern is plotted with Case C and Case E. The jail is plotted with Case A and Case C.

Notes

Notes

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