Accessible versions can be found here:

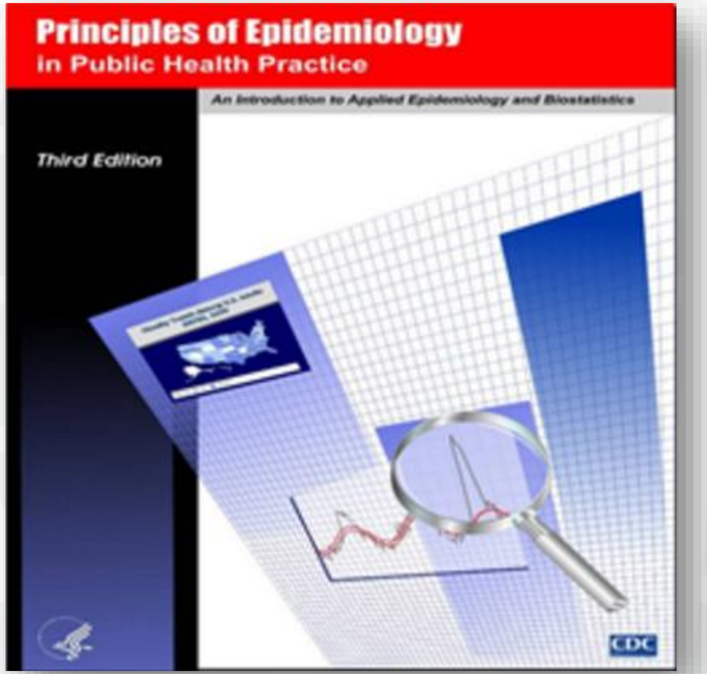
https://www.cdc.gov/nceh/hsb/elearning/toi/Mod5p1/
https://www.cdc.gov/nceh/hsb/elearning/toi/Mod5p2/
https://www.cdc.gov/nceh/hsb/elearning/toi/Mod5p3/

Toxicological Outbreak Investigation Course

Module Five:

Steps of a Toxicological Outbreak Investigation

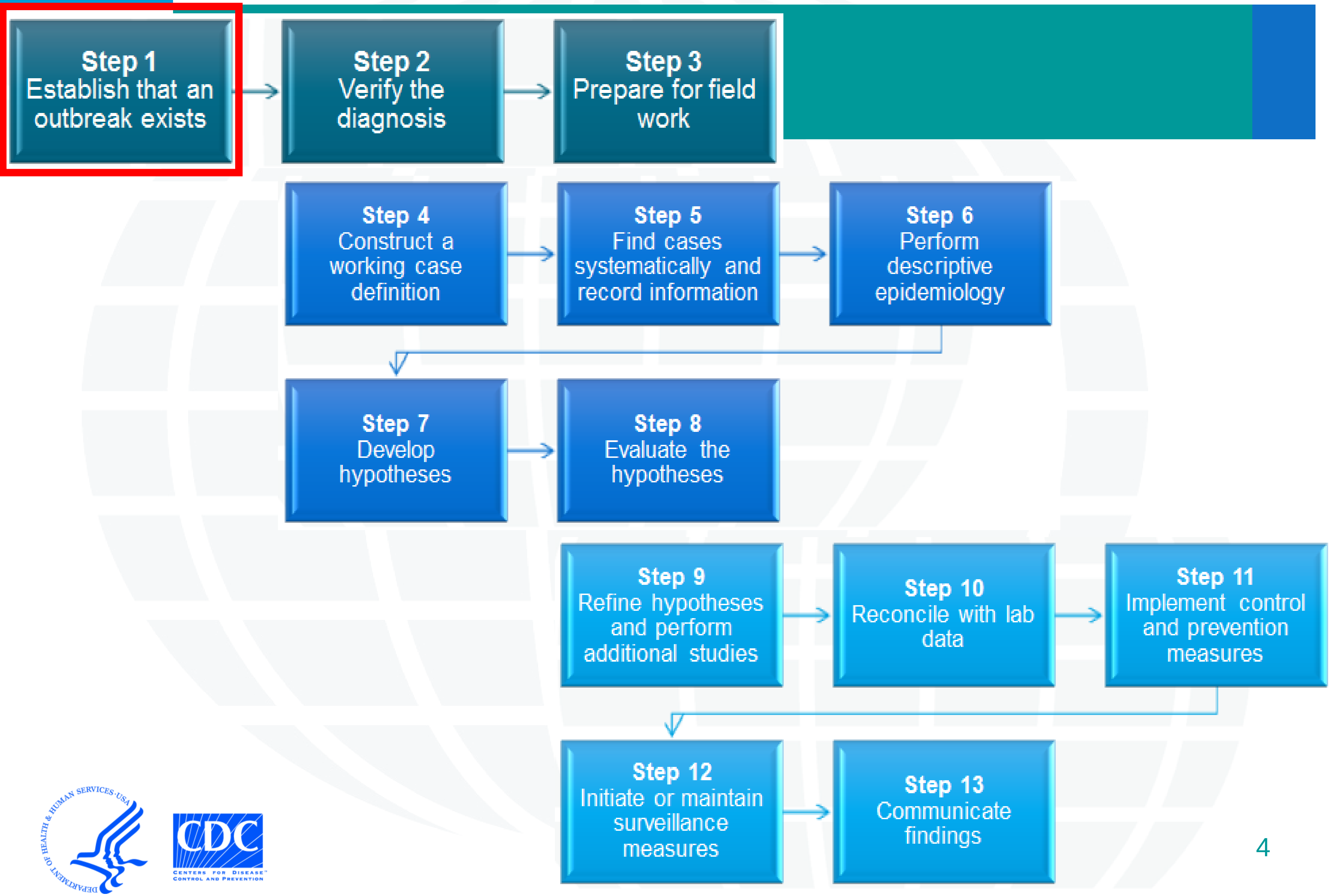
Toxicological Outbreak Investigation Course



This training follows the general steps outlined in [CDC's *Principles of Epidemiology in Public Health Practice, An Introduction to Applied Epidemiology and Biostatistics*]

Module 5 Objectives

- Define the steps for an outbreak investigation
- Recognize factors indicating that a toxic agent may have caused an outbreak
- Apply outbreak investigation steps to a toxic agent outbreak
- Describe the purpose of the materials in the Toxicological Outbreak Tool Kit


Step 1
Establish that an outbreak exists
Step 2
Verify the diagnosis
Step 3
Prepare for field work
Step 4
Construct a working case definition
Step 5
Find cases systematically and record information
Step 6
Perform descriptive epidemiology
Step 7
Develop hypotheses
Step 8
Evaluate the hypotheses
Step 9
Refine hypotheses and perform additional studies
Step 10
Reconcile with lab data
Step 11
Implement control and prevention measures
Step 12
Initiate or maintain surveillance measures
Step 13
Communicate findings

Definition of an Outbreak

What is an outbreak?

Definition of an Outbreak (cont.)

- An increase in the number of people with similar signs or symptoms, above what is expected
- In some cases (especially for toxicological outbreaks) the exact disease may not be known

Step 1
Establish that an outbreak exists

Toxicological Outbreaks

NEWS

Nearly 70 die after drinking beer tainted with crocodile bile

By Chris Perez January 12, 2015 | 4:11pm

Suspected moonshine poisoning leaves 1 man dead

More Kids Accidentally Poisoned by Essential Oils

Spice outbreak larger than first thought

Published: Monday, April 6th 2015, 3:54 pm EDT
Updated: Monday, April 6th 2015, 7:52 pm EDT
Posted by David Kenney, Reporter CONNECT

CDC
CENTERS FOR DISEASE CONTROL AND PREVENTION

Toxicoepidemiology

- Whyte and Buckley (1995) first defined toxicoepidemiology as the application of epidemiological methods to the problem of acute poisoning.
- Toxicological outbreaks often involve cases of acute poisoning resulting from exposure to a toxic agent.
- Toxicoepidemiology is used to investigate outbreaks of unknown or suspected toxic etiology.

Gather Information

The first step is to learn as much as you can about the patients to determine if this is an outbreak

- Speak to:
  - Physicians
  - Patients
  - Family/friends/community

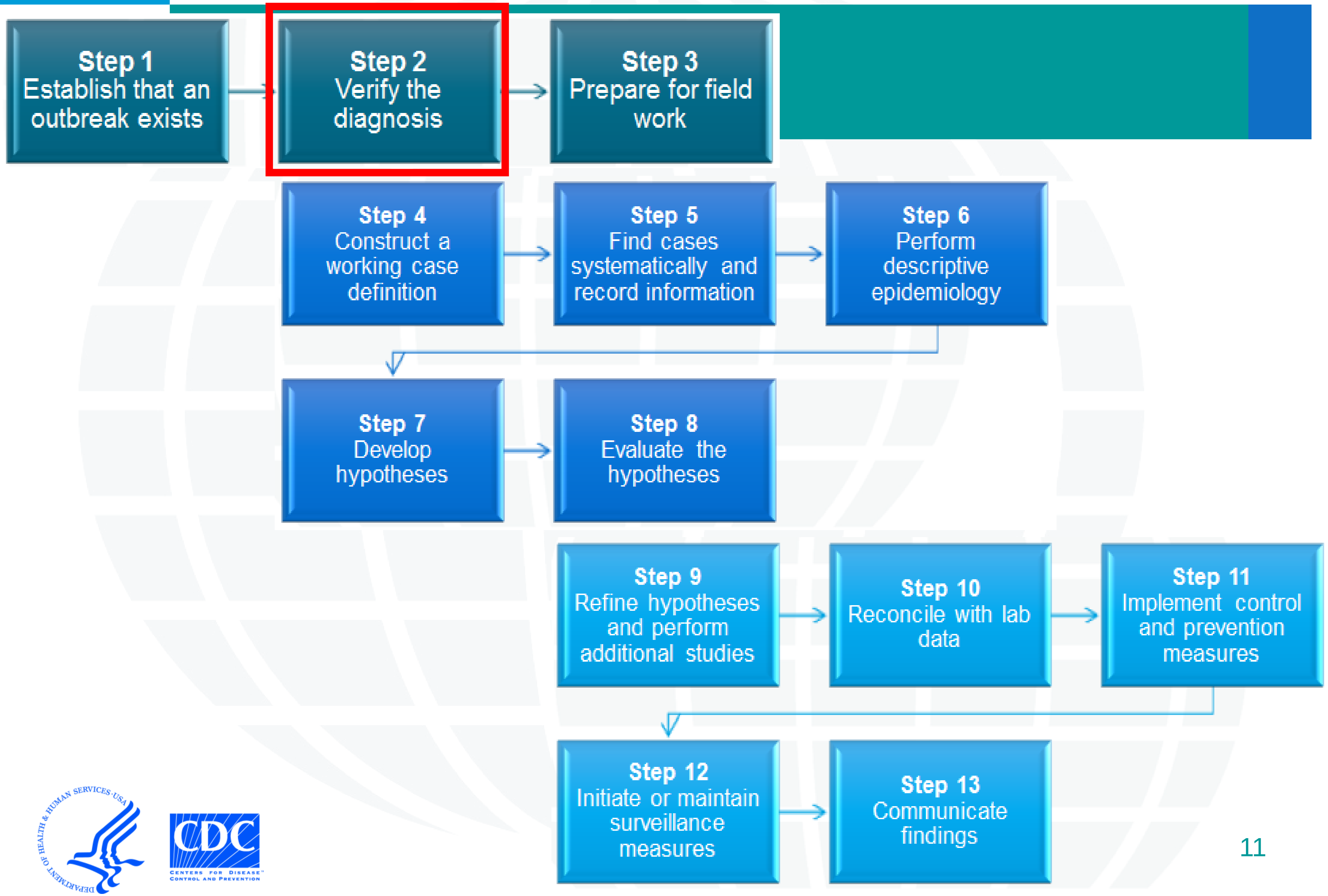
- Review surveillance data (if available and applicable)

Step 1
Establish that an outbreak exists

Reasons to Investigate

If you determine it is an outbreak, there are several reasons why you might choose to investigate it:

- To find the cause of the outbreak in order to initiate control measures
- To learn more about the disease to prevent future outbreaks
- To address public concerns
- To address political, legal, or programmatic considerations
- To train public health staff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Step 2
Verify the diagnosis

Identify Possible Toxic Agent

- It is important to consider a possible toxic agent exposure as early as possible
- Some toxic agents have quick elimination periods
- The sooner that an environmental or biological sample is collected, the greater the chances that the sample will still contain the toxic agent

Remember in module 2, we learned elimination period is the time it takes for a toxic agent to be removed from the body

Step 2
Verify the diagnosis

Characteristics of a Toxic Agent Outbreak

What characteristics are associated with toxicological outbreaks? (one per row)

Fever more likely	Fever less likely
Long latency	Short latency
Strong dose-response relationship	Weak dose-response relationship
May involve animal illness at same time	Unlikely to affect animals
Similar symptoms across cases	Different symptoms across cases

Step 2
Verify the diagnosis

Characteristics of a Toxic Agent Outbreak

What characteristics are associated with toxicological outbreaks? (one per row)

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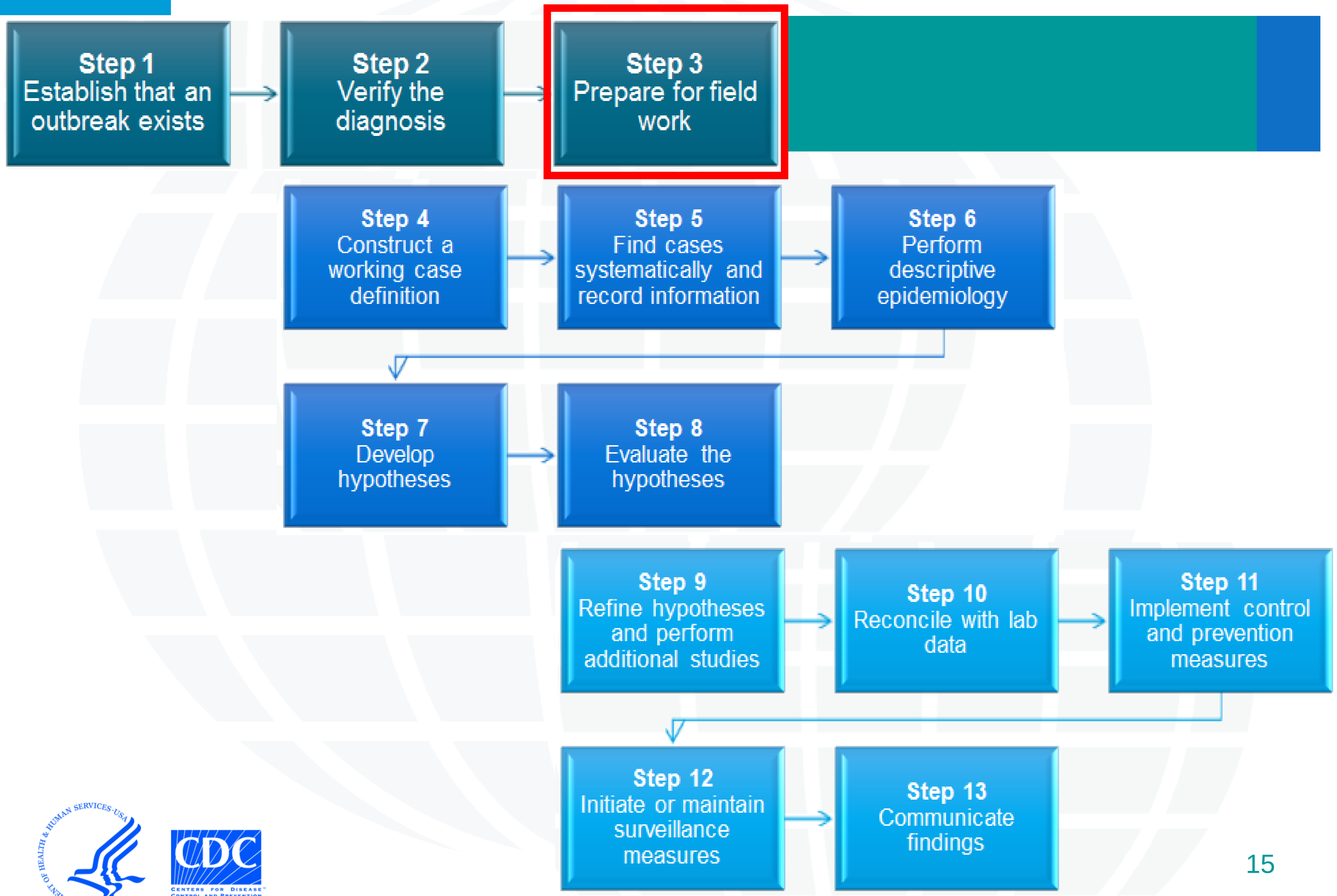


If you decide to investigate, it is time to prepare for fieldwork.

Prepare for Field Work

- Preparing for field work includes the following:
  - Developing investigation objectives
  - Assembling an investigation team

Typical Objectives

- Typical investigation objectives:
  - Determine extent of the outbreak
  - Describe the illness
  - Identify the etiology
  - Identify the source of exposure

Etiology = Toxic agent that caused the outbreak

Exposure = Method by which patients came into contact with the toxic agent

Assemble an Investigation Team

Most **infectious** investigation teams include:

- Physician
- Epidemiologist
- Lab technician
- Community member

Step 3
Prepare for field work

Assemble an Investigation Team (cont.)

Most **toxicological** investigation teams include:

- Physician
- Epidemiologist
- Lab technician
- Community member

\+

- Toxicologist

- Studies the effects of toxic agents on people
- During an investigation…
  - Can help determine which toxic agents cause illness similar to what you are seeing
  - Can advise on what exposures and clinical signs and symptoms to ask about and what signs to observe
  - Can help interpret laboratory results

Step 3
Prepare for field work

Assemble an Investigation Team (cont.)

Core team:

- Physician
- Epidemiologist
- Lab technician
- Community member
- Toxicologist

Other possible team members:

- Veterinarian

Many toxic agents affect humans and animals similarly.

A veterinarian can assist with…

- Collecting biologic specimens from animals
- Performing necropsies

Assemble an Investigation Team (cont.)

Core team:

- Physician
- Epidemiologist
- Lab technician
- Community member
- Toxicologist

Other possible team members:

- Botanist

Some toxic agents are plant-based

A botanist can assist with determining…

- What types of toxic trees, plants, and herbs grow in the region
- What types of illness these toxic plants might cause

Step 3
Prepare for field work

Assemble an Investigation Team (cont.)

Core team:

- Physician
- Epidemiologist
- Lab technician
- Community member
- Toxicologist

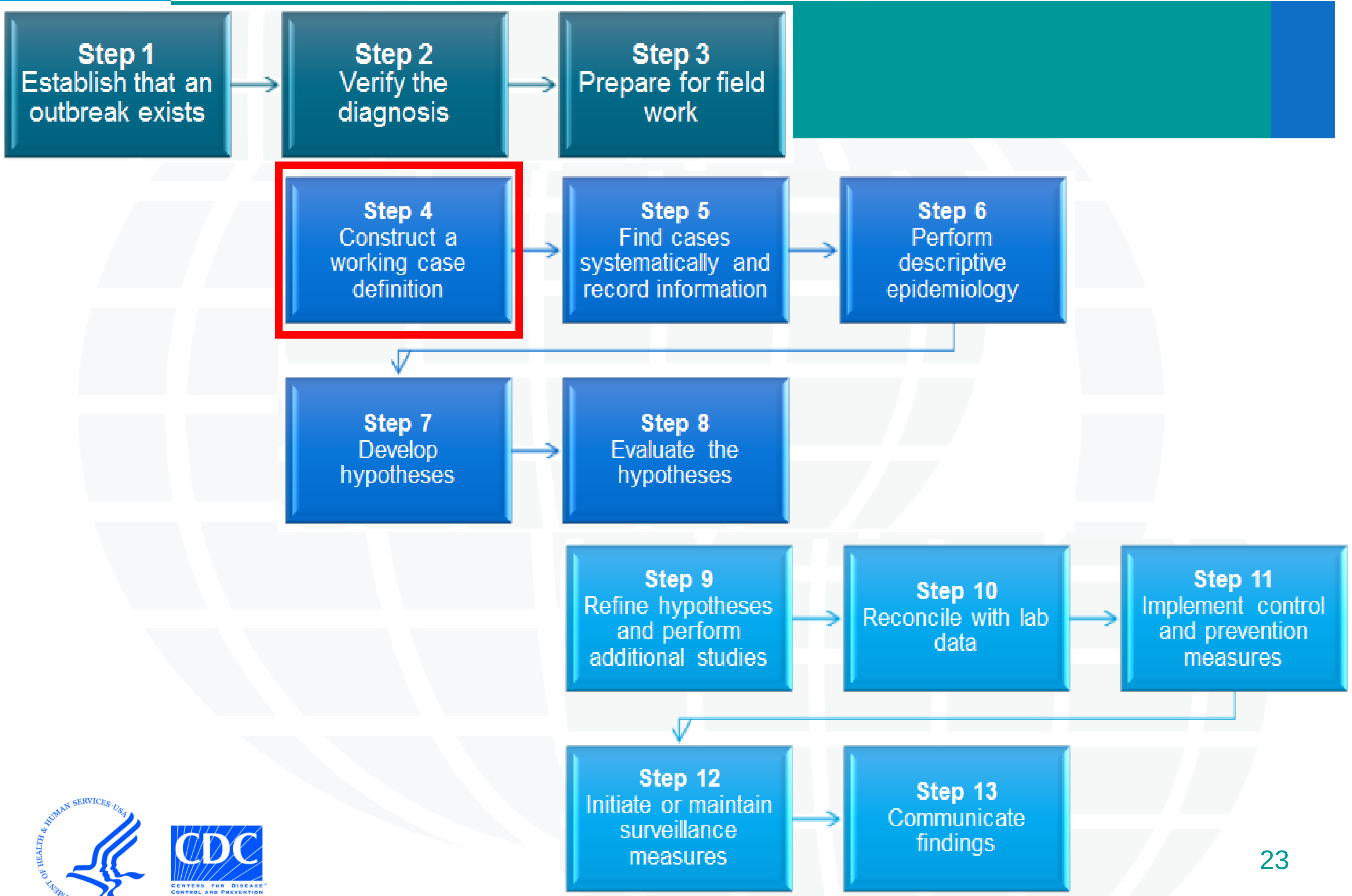
Other possible team members:

- Industrial hygienist

Some toxicological outbreaks occur at the worksite.

An industrial hygienist can assist with…

- Providing insights on what potential exposures may be present at a particular workplace
- Developing questions for studying workplace exposures



The next step is to construct a working case definition.

Step 4
Construct a working case definition

Case Definition Components

What should be included in a case definition?

Case Definition Components (cont.)

What should be included in a case definition?

A good case definition answers:

- What
- Who
- Where
- When

Step 4
Construct a working case definition

Case Definition Components (cont.)

A good case definition includes:

WHAT	WHO	WHERE	WHEN
Clinical signs and symptoms	Person characteristics	Place characteristics	Time characteristics

Step 4
Construct a working case definition

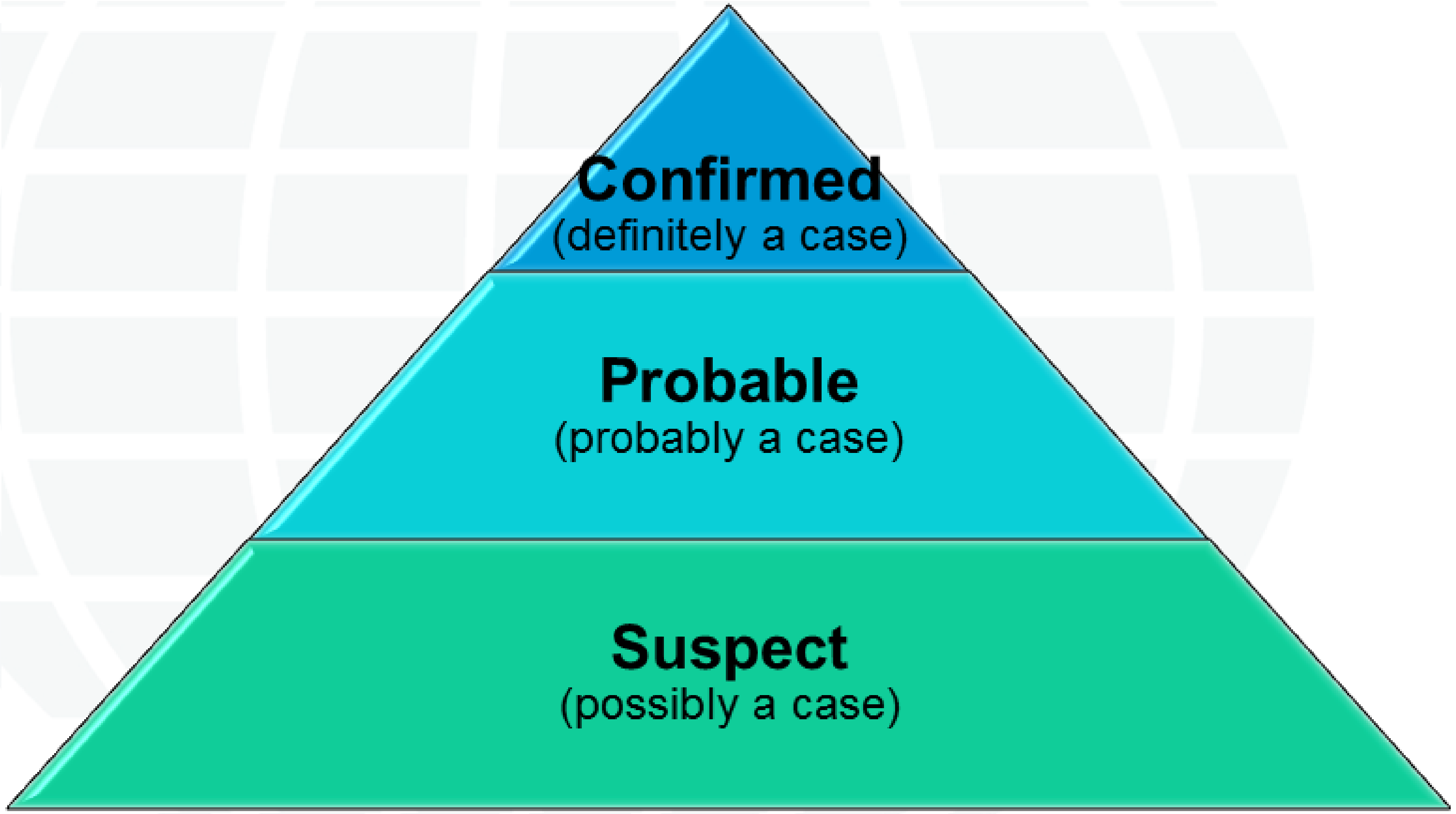
Case Definition Example

	What	Who	Where	When
Okay	Did not have a fever	Child	Spent time at School A	Fell ill during the morning
Better	Temperature less than 101.5°F by thermometer upon first presentation	15 years of age or younger	Enrolled as a student at School A	Fell ill between 6am and 10am

It is good to have clear definitions for each of these criteria.

Step 4
Construct a working case definition

Tiered Case Definition

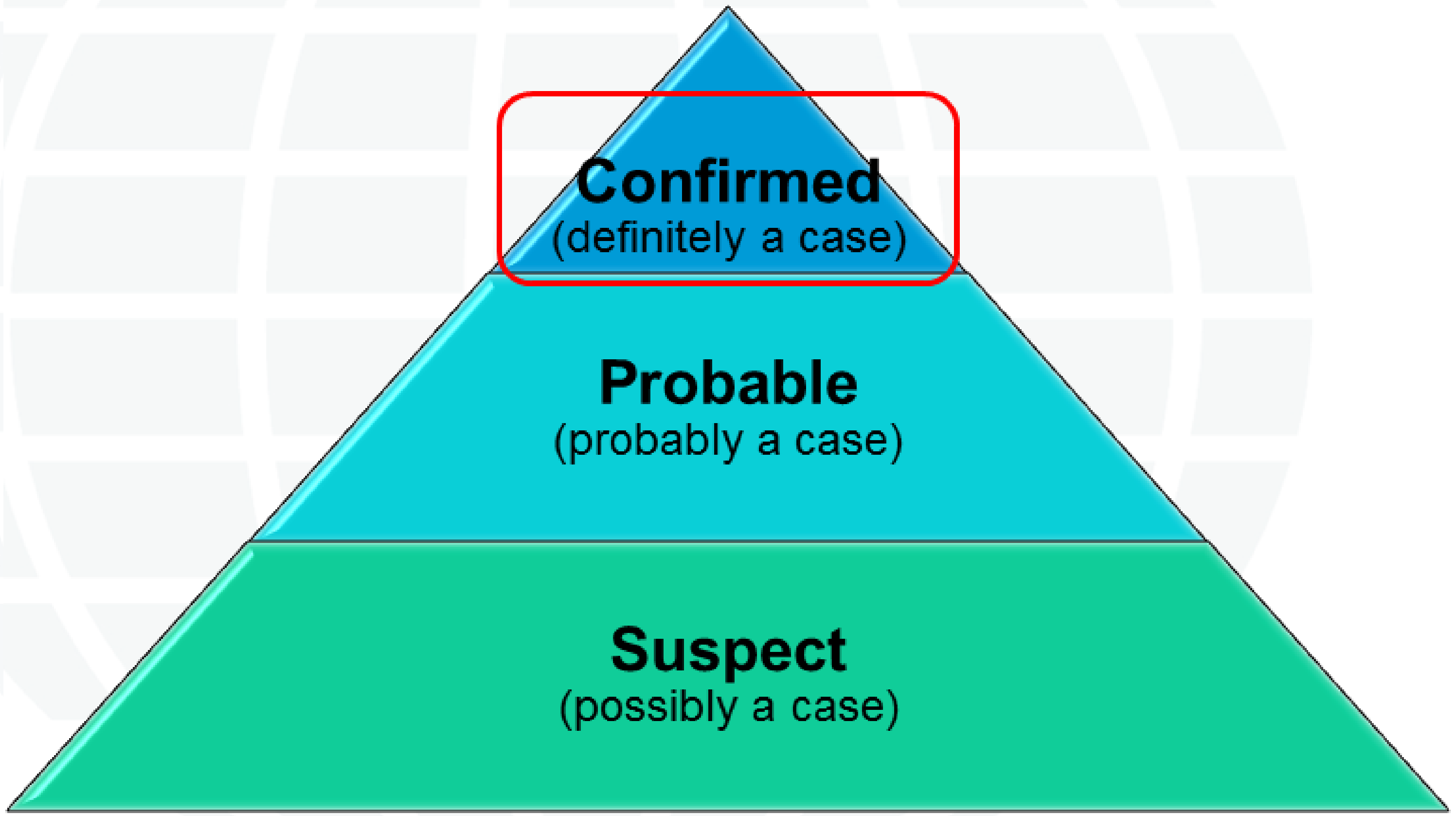


Sometimes a case definition is divided into suspect, probable, and confirmed cases.

A case has to meet more criteria to be a probable case, and even more criteria to be a confirmed case.

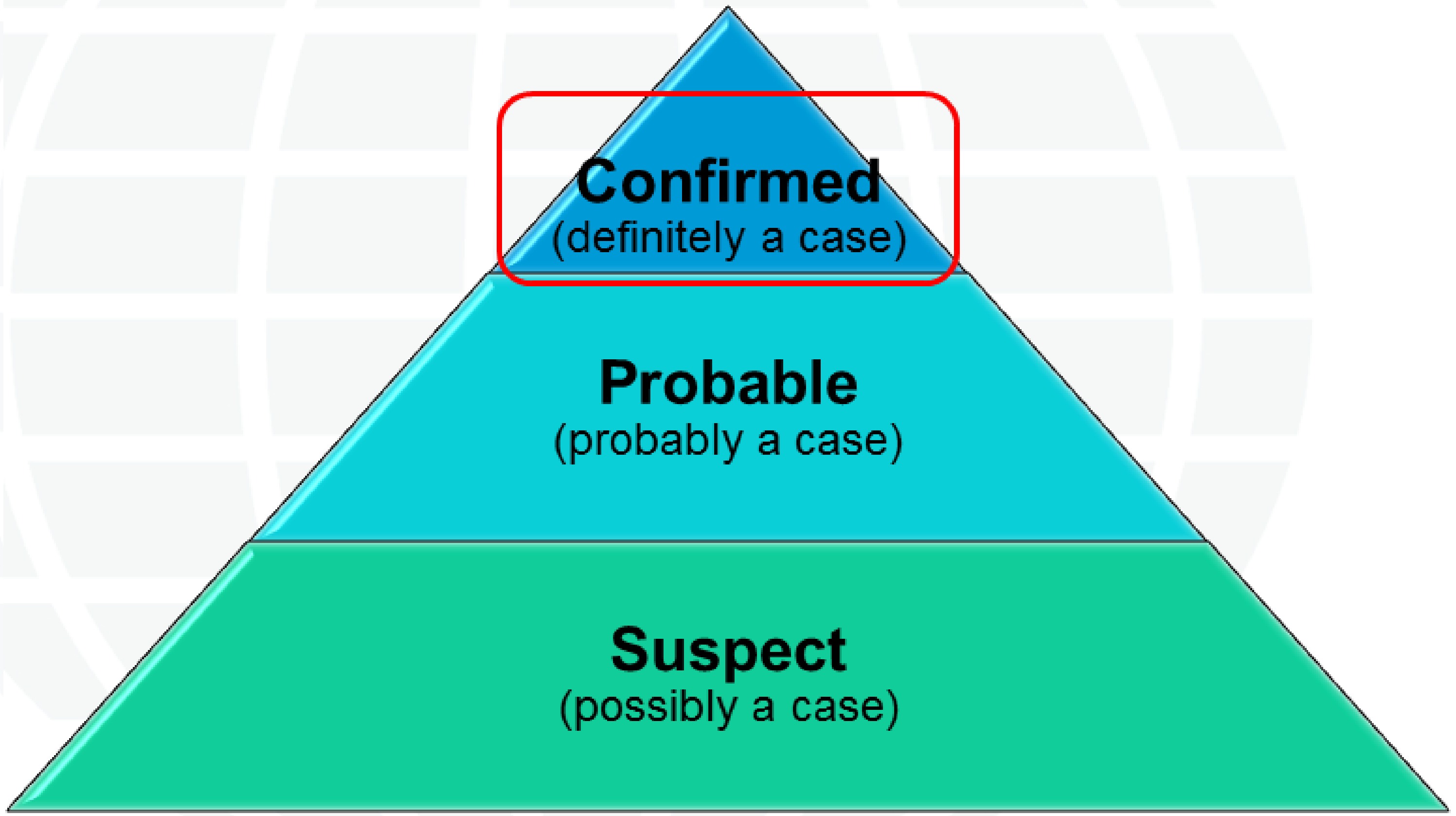
Step 4
Construct a working case definition

Tiered Case Definition (cont.)



Confirmation usually requires laboratory identification/ confirmation of the etiologic agent.

Tiered Case Definition (cont.)



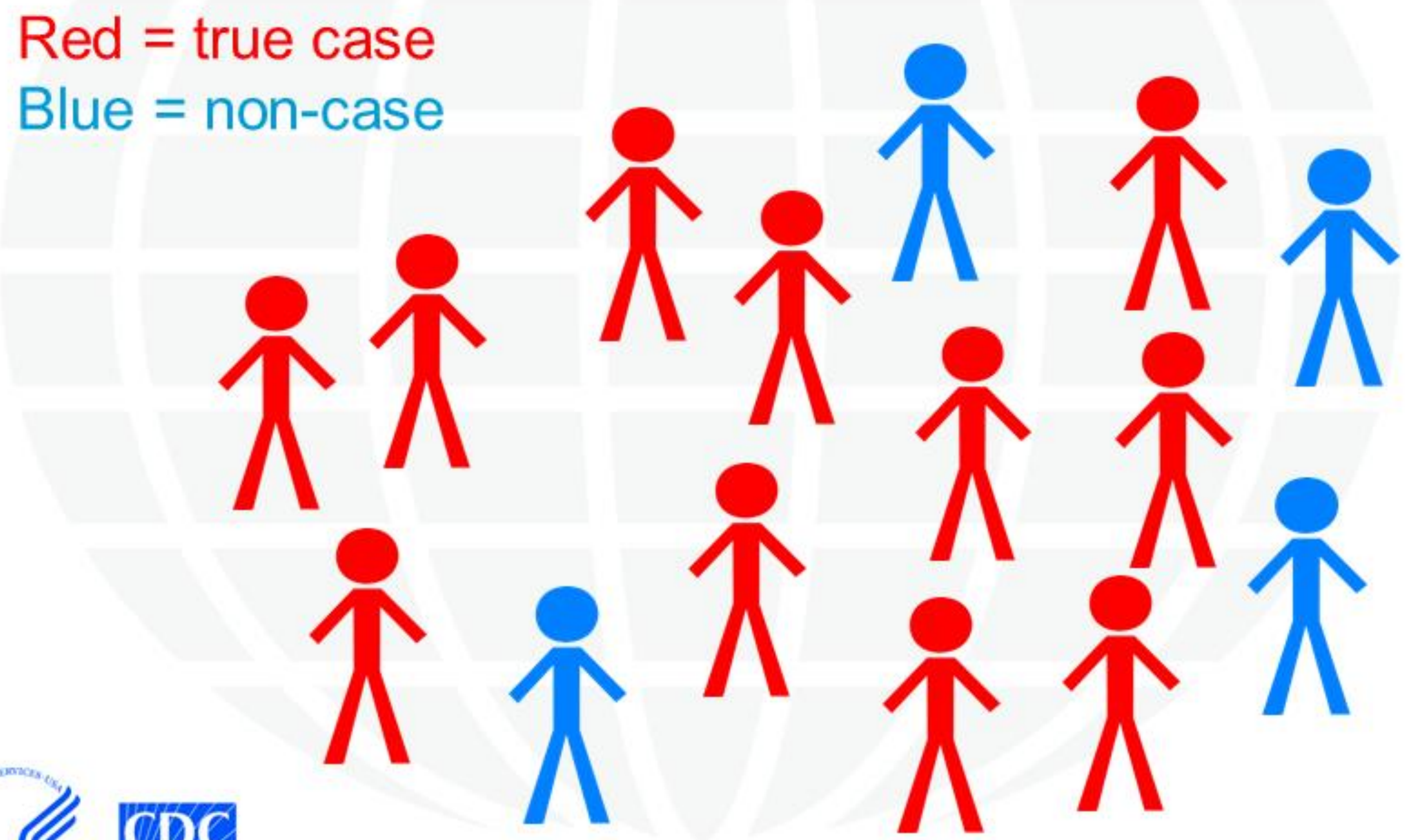
In **toxicological** outbreaks, we rarely have confirmed cases at the beginning of an outbreak.

In **infectious** outbreaks, you often have confirmed cases from the beginning.

Sensitive vs. Specific

- When developing a working case definition, there is a delicate balance between increasing sensitivity versus enhancing specificity

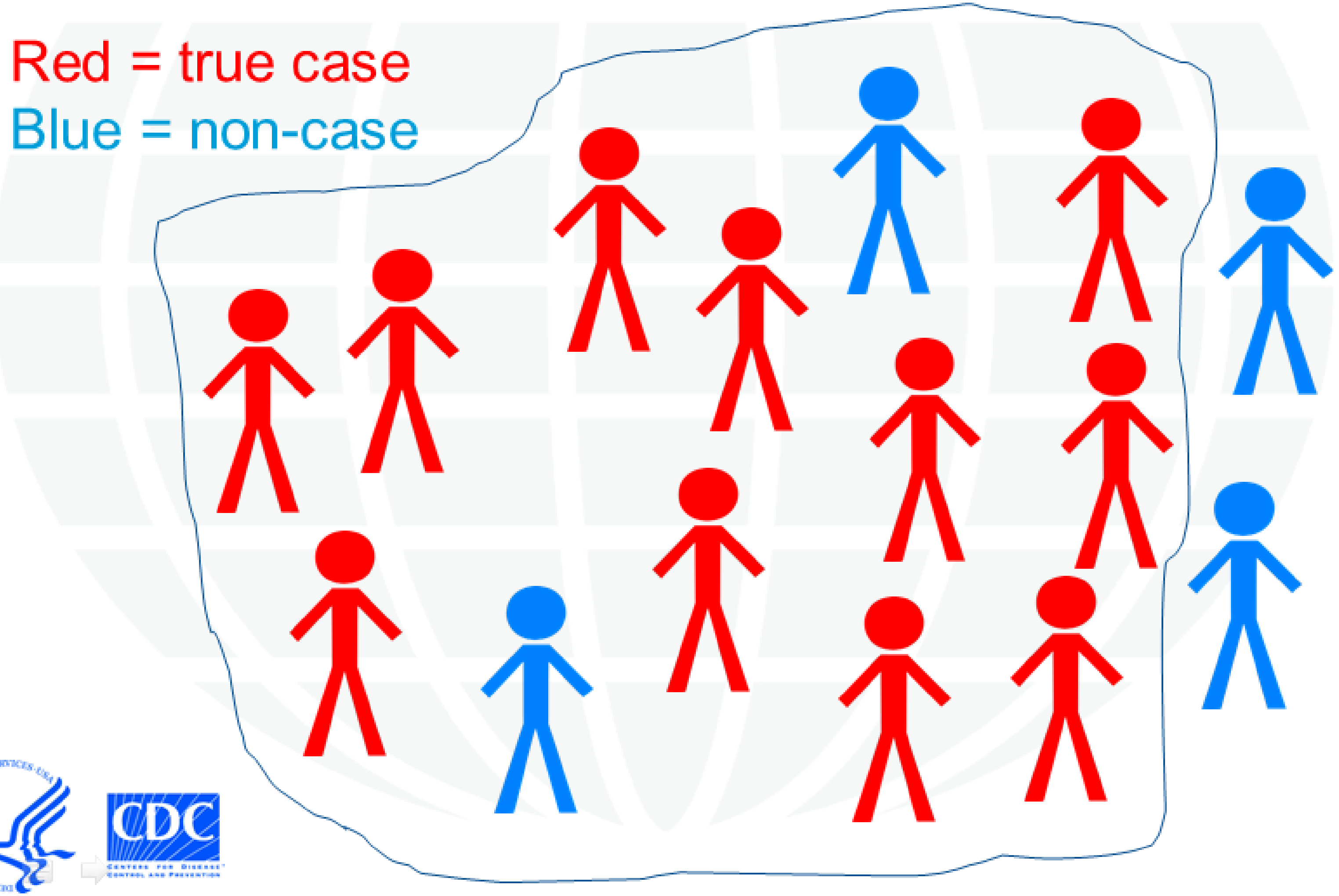
Sensitive vs. Specific



Consider a hypothetical group of people who might be included in an outbreak investigation.

Step 4
Construct a working case definition

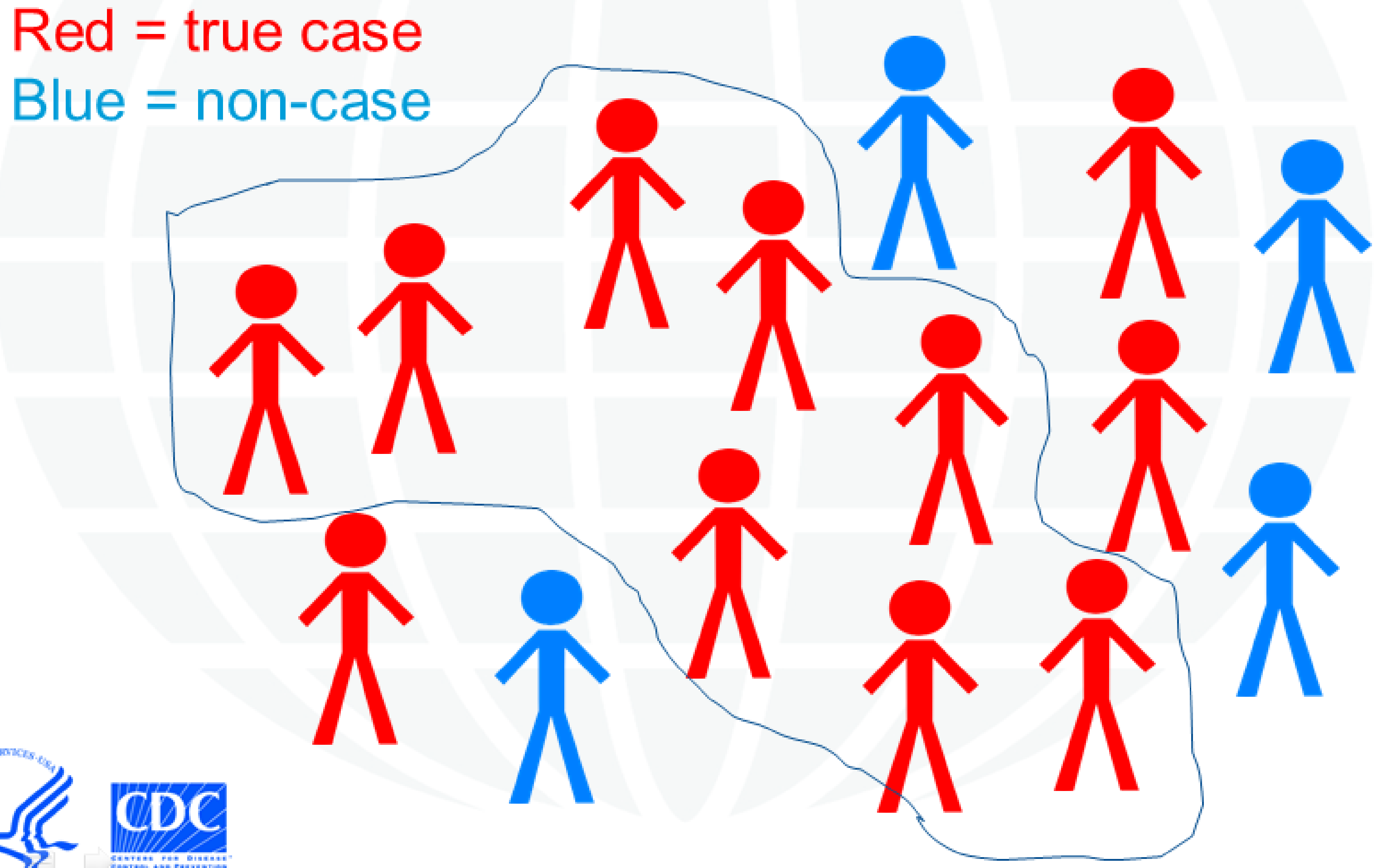
Sensitive



Sensitive Case Definition

- More likely to include more true cases
- Might incorrectly include non-cases

Specific



Specific Case Definition

- More likely to correctly exclude non-cases
- Risks missing true cases because some of them may not meet the more narrow case definition

Scenario

- Several school children (ages 6–10 years) developed nausea, vomiting, and abdominal pain between the hours of 12pm and 4pm today
- Some developed altered mental status and multi-system organ dysfunction, and one died
- Most of the cases are friends and playmates, and they attend the same school

Step 4
Construct a working case definition

Scenario: Working Case Definition

What	Who	Where	When
Nausea, vomiting, abdominal pain	Child aged 6 to 10 years	Attends School A	Onset between 12pm to 4pm

Step 4
Construct a working case definition

Scenario: Working Case Definition (cont.)

What	Who	Where	When
Nausea, vomiting, abdominal pain	Child aged 6 to 10 years	Attends School A	Onset between 12pm to 4pm

How might you revise each of these components to make the definition more sensitive?

- What
- Who
- Where
- When

Step 4
Construct a working case definition

Scenario: Working Case Definition (cont.)

Answer:

	What	Who	Where	When
More specific definition	Nausea, vomiting, abdominal pain	Child aged 6 to 10 years	Attends School A	Onset between 12pm to 4pm
More sensitive definition	Any illness	Children aged ≤12 years	Lives in the city that houses School A	Onset anytime that day

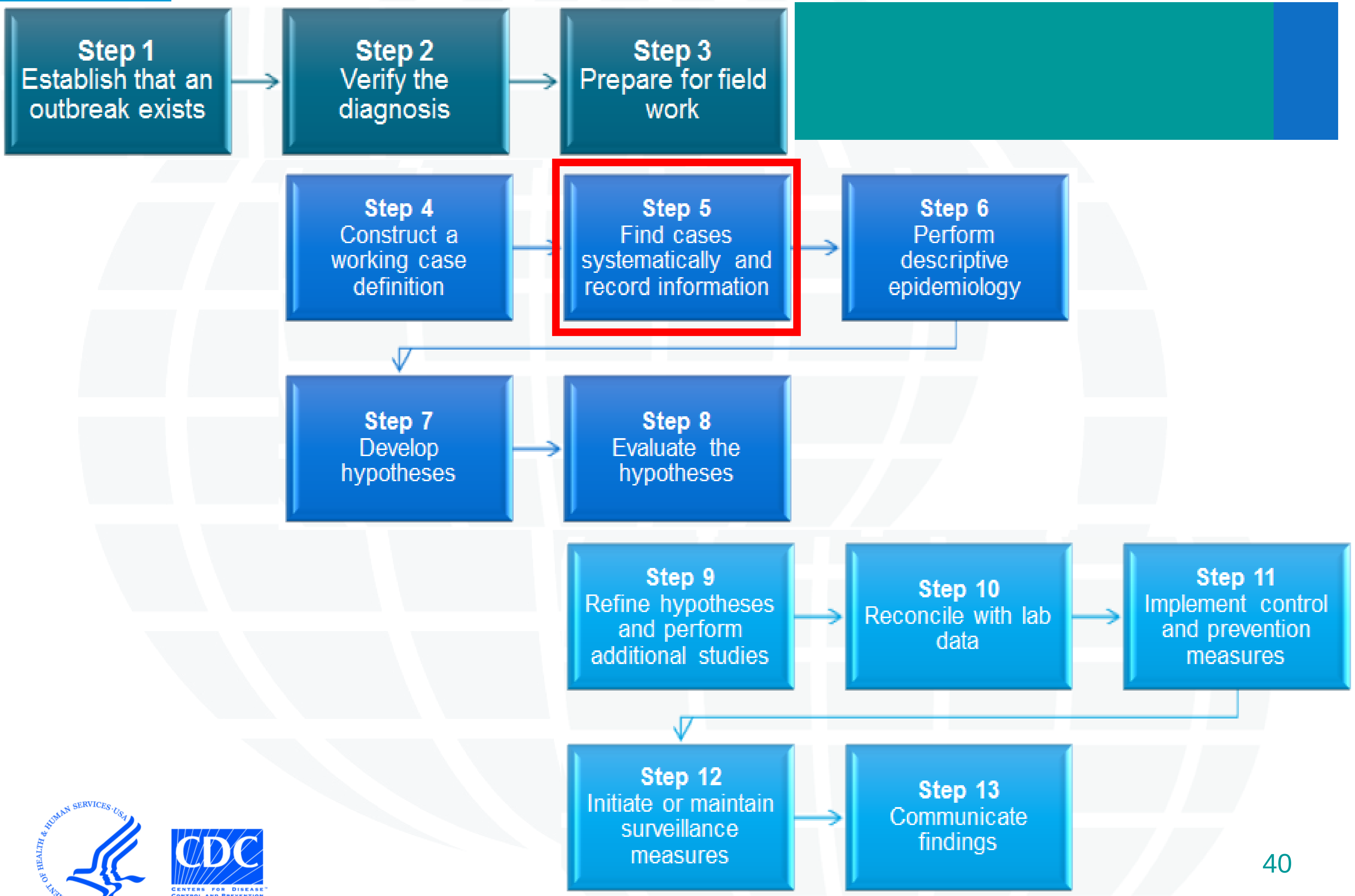
How might you revise each of these components to make the definition more sensitive?

Step 4
Construct a working case definition

Sensitive vs. Specific

Considerations for deciding on specificity/sensitivity:

- Stage of the investigation
- Resources available for case finding
- Size of outbreak



Once you develop your case definition, the next step is to search for cases and learn more details of the outbreak.

Case Finding

What are some ways to find cases?

Case Finding (cont.)

What are some ways to find cases?

- Speak with physicians
- Review hospital records
- Speak with patients and their families
- Conduct door-to-door interviews
- Publicly announce the outbreak

Step 5
Find cases systematically and record information

Line List

What information would you include on a line list?

A **line list** is a table that summarizes information about persons who may be associated with an outbreak.

Line List (cont.)

What information would you include on a line list?

- Identifiers (name, unique number given to the person or ID number)
- Demographics (age, sex, residence)
- Clinical information (date/time of symptom onset, specific signs and symptoms, treatment received, outcome)
- Laboratory results

Step 5
Find cases systematically and record information

Line List Template

Demographic Information					
ID#	First Name	Last Name	Address	Age (years)	Sex (M/F)

Clinical Illness Information					
Date of illness onset	Time of illness onset	Symptom #1 (Y/N)	Symptom #2 (Y/N)	Symptom #3 (Y/N)	Outcome

Record Keeping						
Questionnaire complete (Y/N)	Chart abstraction complete (Y/N)	Biological sample collected (Y/N)	If yes, biological sample results	Environmental sample collected (Y/N)	If yes, environmental sample results	Meets case definition (Y/N)

A line list template is available in the Tool Kit.

Step 5
Find cases systematically and record information

Hypothesis-Generating Interviews

- Informal interviewing allows you to collect information to generate hypotheses about…
  - The etiologic agent
  - The source of exposure
- Format
  - One-on-one discussions or group discussions
  - Open-ended questions

Scenario: Hypothesis-Generating Interviews

You have an opportunity to speak with two of the patients from the previous scenario

What are some questions you might want to ask them?

Scenario: Hypothesis-Generating Interviews

Scenario ...

What are some questions you might want to ask them?

Possible questions:

- What did you eat and drink in the hours before you became sick?
- Did anything you eat taste or smell funny?
- Where did you go and what did you do in the hours before you became sick?

Hypothesis-Generating Interviews: Toxidrome

- What happened in the hours before the patient started to become ill?
- What symptoms came first?
- What symptoms came next?
- What treatments/ antidotes/ medicines were used?
- If and how did the patient recover?

Some toxic agents produce a very specific illness progression, called a toxidrome, which can help the toxicologist identify the toxic agent.

Ask open-ended questions to identify whether there is a common toxidrome.

Step 5
Find cases systematically and record information

Hypothesis-Generating Interviews

Person-related Characteristics

- What are the cases' age, sex, and occupation?
- What did cases eat and drink in the hours before they became ill?
    - Any common foods or beverages among cases?
    - If there were any common foods or beverages, where are they from? For example, were they purchased in a store or home grown?
    - Did cases eat anything (or more of anything) compared to family members or friends/classmates/coworkers? If so, is any of the food still available?
    - Were fruits and vegetables washed before eaten?
    - Did cases report eating anything that had an unusual taste or odor? If so, what did it taste or smell like?
    - Where did the water the cases drank come from? If water is not piped into the home, what is it hauled in?
    - Did cases consume or use any traditional medicines, folk/herbal remedies, or nutritional supplements or ointments? If so, is any of the product still available?
    - What activities did cases do in the hours leading to illness?
        - If the cases are primarily children, where did they play?
        - If the cases are primarily adults, where do they work?

Tool Kit: Qualitative Epidemiological Questions

Step 5
Find cases systematically and record information

Hypothesis-Generating Interviews (cont.)

Person-related Characteristics

- Any recollection of bites or stings before illness?
  - Did cases use insect repellents lotions/sprays/ointment in the hours preceding illness? If yes, what type, and how much was applied?
  - Where were these products purchased?
  - Is any of the product still available?
- What do you think made you (or others) sick?

Tool Kit: Qualitative Epidemiological Questions

Hypothesis-Generating Interviews (cont.)

Place-related Characteristics

- Where did cases spend their time in the hours preceding illness?
  - Did the cases spend time in any areas that were different from other family members/friends/co-workers?
- Where do cases live?
  - Any geographic clustering?
- Are there any known poisonous animals, insects, reptiles, plants in the area?
- Have there been any unusual animal deaths in the area?

Questions for Farming Region

- Are there any new plants or weeds growing in the area?
- What pesticides and other chemicals (such as rodenticides or other agricultural chemicals) are applied here?
- When are these pesticides applied?
- How are pesticides applied? For example, are they sprayed, applied by hand, etc. Can you show me how you apply the pesticide?
- Who applies the pesticides?
- Where are the pesticides purchased?
- How are pesticides stored?
- Have any new pesticides or chemicals been applied recently?

Tool Kit: Qualitative Epidemiological Questions

Step 5
Find cases systematically and record information

Hypothesis-Generating Interviews (cont.)

Time-related Characteristics
• What day and time did the case become ill?   o Is there any clustering by time? • Was there anything unusual about the day when the case became ill? If the case became ill in the morning, was there anything unusual about the previous day?

Tool Kit: Qualitative Epidemiological Questions

Step 5
Find cases systematically and record information

Hypothesis-Generating Interviews (cont.)

Illness-related Characteristics

- Describe the timeline of the illness. Which symptoms were noticed first, then second, then third, etc.? How much time elapsed between them? Did all cases have the same or similar order of symptom progression?
- Did the cases have fever as an early sign or symptom of the illness?
- Were any medicines used during the treatment?
    - When were they used, and in what amount?
    - How did the patient respond?
- Any preeminent or long term health effects after recovery or hospital discharge (such as numbness or rashes)?
- For fatal cases, what was the exact cause of death (cardiac arrest, respiratory failure, brain death, cerebral herniation, sepsis)?

Tool Kit: Qualitative Epidemiological Questions

Step 5
Find cases systematically and record information

Hypothesis-Generating Interviews (cont.)

Toxic Agent-related Questions
• What toxic agents are here that people could be exposed to?
• How might people come into contact with these toxic agents (food, water, etc.)?
• What are potential routes of exposure (ingestion, inhalation, etc.)?

Tool Kit: Qualitative Epidemiological Questions

Step 5
Find cases systematically and record information

Observations

It can be useful to visit the location of the outbreak to observe the following:

- Daily life
- Cultural habits
- Typical diet
- Any recent changes in the community
- Possible toxic agent exposures

Step 5
Find cases systematically and record information

Potential Toxic Agents

- If the hypothesis-generating interviews and/or observations lead you to suspect possible exposures to specific toxic agents, then information about these toxic agents should be collected systematically onto a sample log.
  - If possible, a sample of the purported toxic agent should also be collected.

What type of information might be collected on the sample log?

A sample log is a systematic way to record the descriptive information about each sample (discussed in detail in module 3).

Step 5
Find cases systematically and record information

Potential Toxic Agents (cont.)

What type of information might be collected?

- The toxic agent's name
- When and where it was purchased or made
- Who was it made by – manufacturer's name
- Where it is stored
- Who has access to it
- When and where it was applied/consumed
- The amount applied/consumed
- Any recent changes in application or consumption patterns

The "toxic agent" could be an item that is not typically considered toxic, such as a contaminated food product or cosmetics.

Scenario: Additional Information

As you interview the two ill children, you learn both had spent time in the school hall the morning before they fell ill

- You interview school staff and learn the auditorium had been cleaned that morning
- Both children reported eating a snack in the morning that was brought in by another student
- Both children also rode the bus to school

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Step 6
Perform descriptive epidemiology

Descriptive Epidemiology

- Before you begin your formal investigation, summarize the data you collected during case finding and hypothesis-generating interviews
- This usually includes summarizing by…
  - Person
  - Place
  - Time

Person – describes who the cases are and who is at risk

Place – provides information on geographic extent of the problem and demonstrates clusters or patterns that provide etiologic clues

Time – depicts the time course of a spike in cases

Step 6
Perform descriptive epidemiology

Scenario: Attack Rates

	Cases (n=50)	Total number of children (n=500)	Attack rate
Age			
6 years	18	100	
7 years	22	100	
8 years	5	100	
9 years	3	100	
10 years	2	100	
Sex			
Male	45	250	
Female	5	250	
Classroom			
A	16	125	
B	24	125	
C	8	125	
D	2	125	

Summarizing by person…

Investigators refer to the line list they created and calculate attack rates…

How do you calculate an attack rate?

Step 6
Perform descriptive epidemiology

Scenario: Attack Rates (cont.)

	Cases (n=50)	Total number of children (n=500)	Attack rate
Age			
6 years	18	100	18%
7 years	22	100	22%
8 years	5	100	5%
9 years	3	100	3%
10 years	2	100	2%
Sex			
Male	45	250	18%
Female	5	250	2%
Classroom			
A	16	125	13%
B	24	125	19%
C	8	125	6%
D	2	125	2%

How do you calculate an attack rate?

Attack rate:

$$\frac{\#\ \boldsymbol{cases}\ \textit{with exposure}}{\#\ \boldsymbol{children}\ \textit{with exposure}}$$

**Note: attack rate is presented as a percentage.*

Step 6
Perform descriptive epidemiology

Scenario: Attack Rates (cont.)

	Cases (n=50)	Total number of children (n=500)	Attack rate
Age			
6 years	18	100	18%
7 years	22	100	22%
8 years	5	100	5%
9 years	3	100	3%
10 years	2	100	2%
Sex			
Male	45	250	18%
Female	5	250	2%
Classroom			
A	16	125	13%
B	24	125	19%
C	8	125	6%
D	2	125	2%

The attack rate was highest among…

- 6- and 7-year old children
- Males
- Children in classrooms A and B

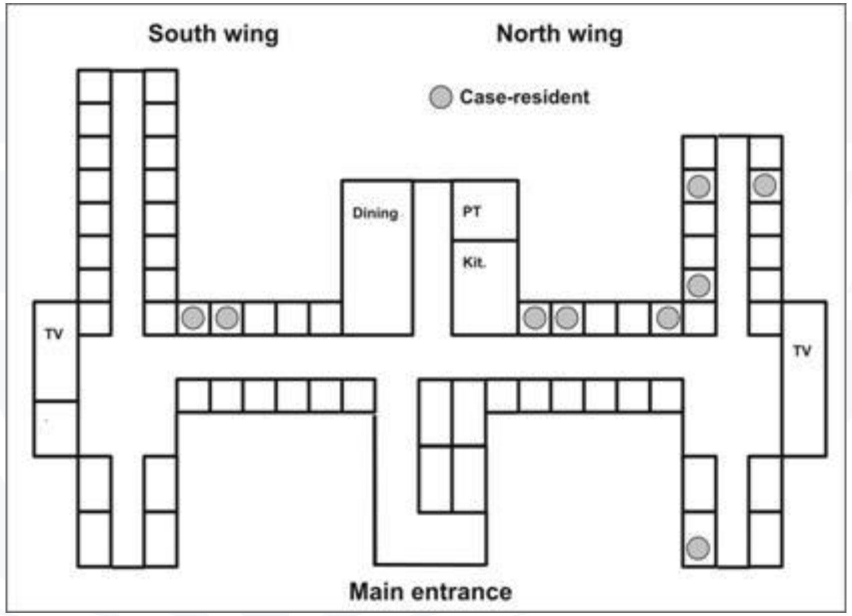
Based on these findings, you might do further informal data collection to determine what these groups had in common.

Step 6
Perform descriptive epidemiology

Spot Map

- A spot map is a simple and useful technique for illustrating where cases may have been exposed, including where they live, work, or play.

Example of a spot map showing cases by room



Adapted from: CDC's Principles of Epidemiology in Public Health Practice, Third Edition An Introduction to Applied Epidemiology and Biostatistics. Retrieved from: http://www.cdc.gov/ophss/csels/dsepd/SS1978/Lesson6/Section2.html#step6

Summarizing by place…

Returning to the scenario…

What place would you consider drawing a spot map for and what would you include on the map?

Step 6
Perform descriptive epidemiology

Epi Curve

- An epi curve depicts the distribution of cases across time
- Examining the shape of an epi curve can provide clues about the exposure

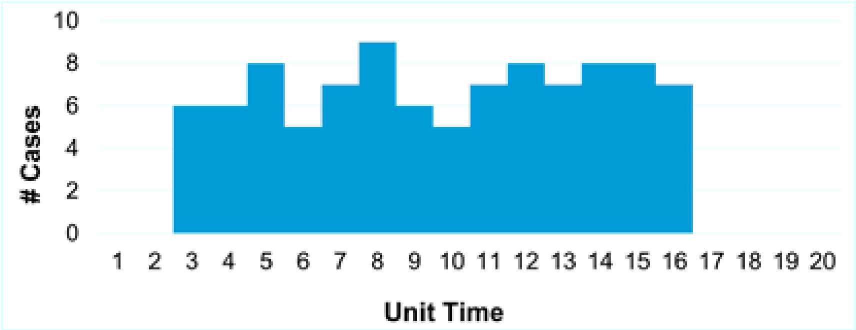
Summarizing by time…

A special type of histogram is used to depict the time course of when the cases occurred.

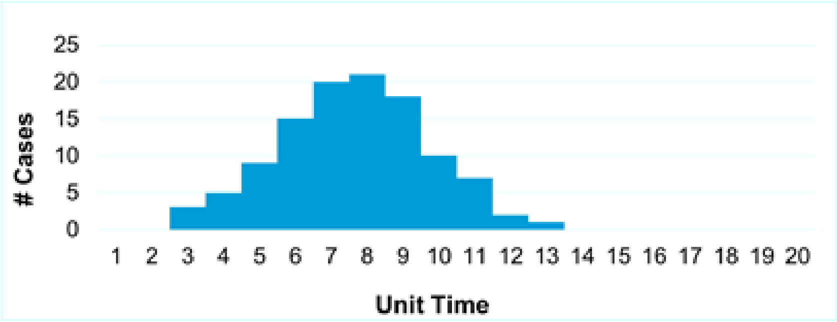
Step 6
Perform descriptive epidemiology

Epi Curves

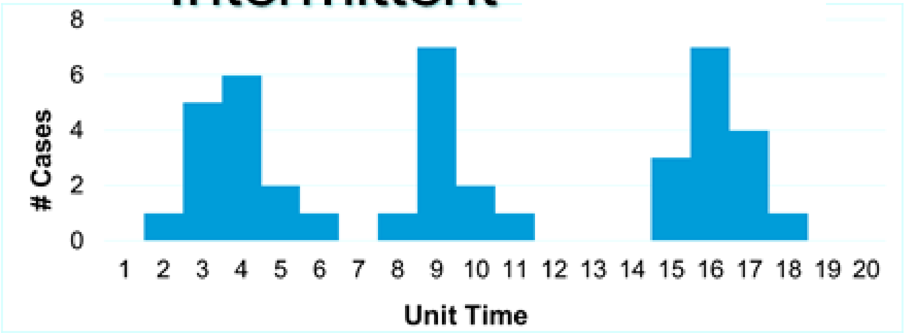
Continuing Source



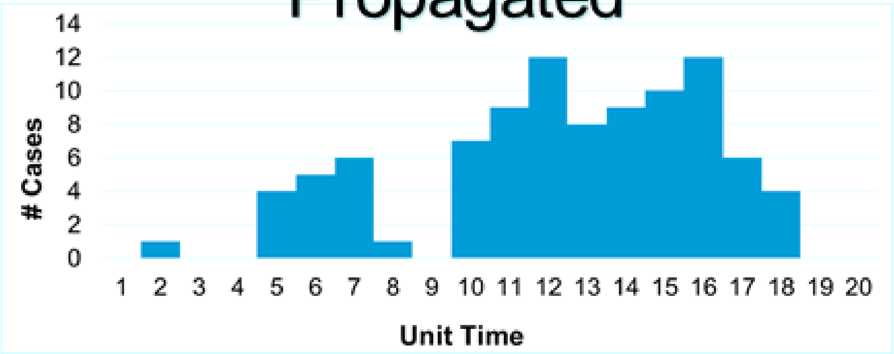
Point Source



Intermittent



Propagated

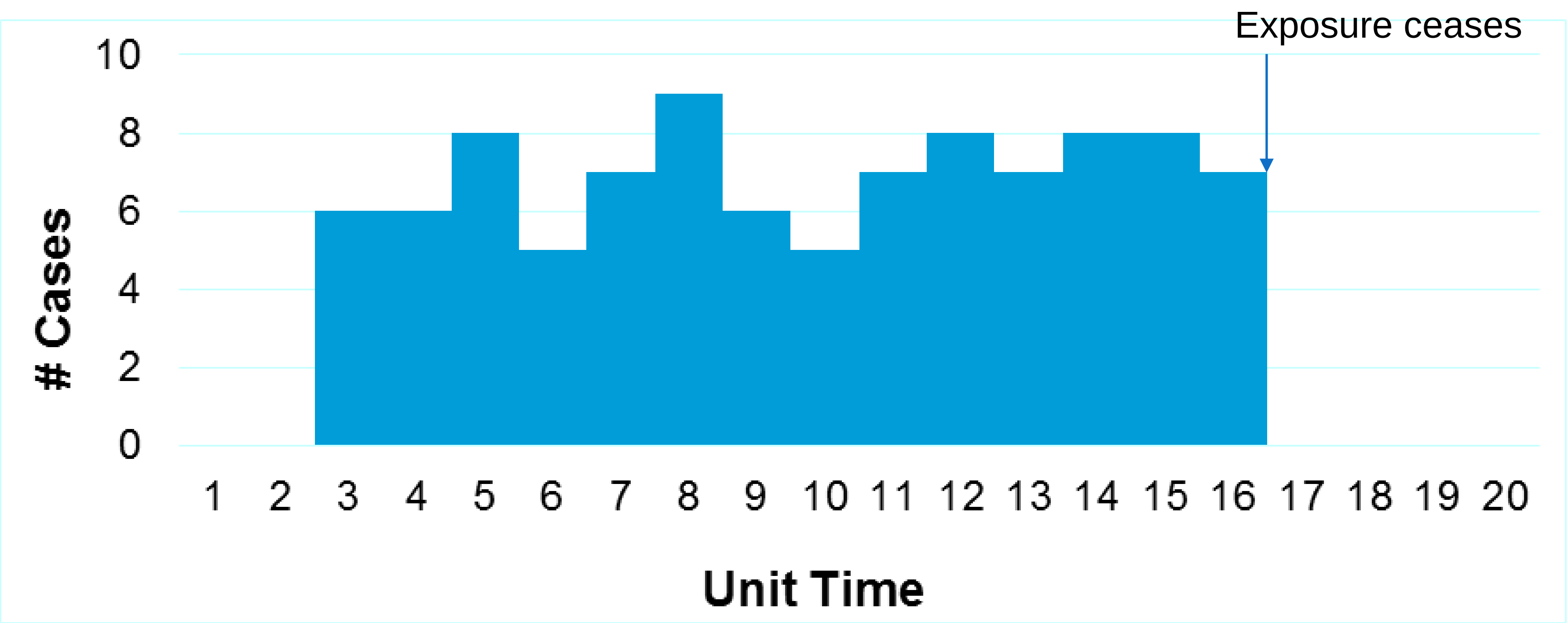


We will consider these four main types of epi curves:

- Continuing source
- Point source
- Intermittent outbreak
- Propagated

Step 6
Perform descriptive epidemiology

Continuing Source Epi Curve



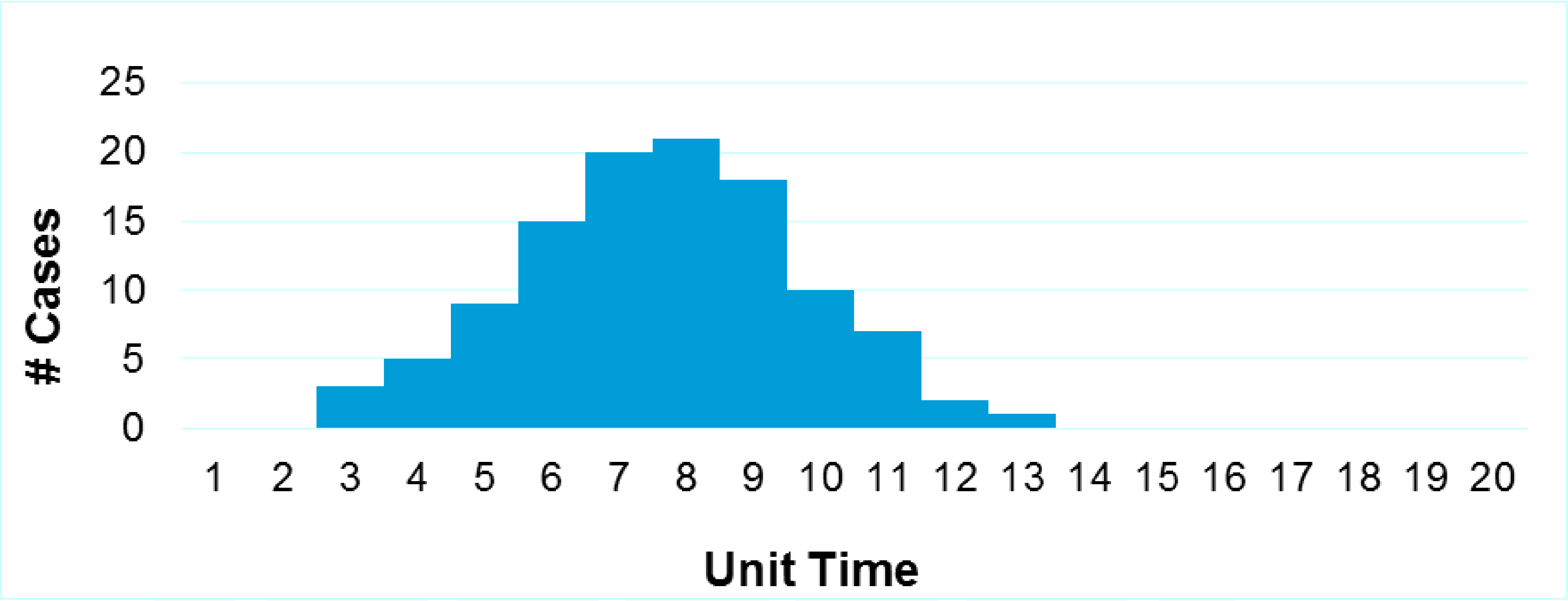
A **continuing source** epi curve shows that the illnesses continue to occur until the exposure ceases.

Examples:

- Contaminated drinking water supply
- Contaminated food or supplement with national distribution

Step 6
Perform descriptive epidemiology

Point Source Epi Curve



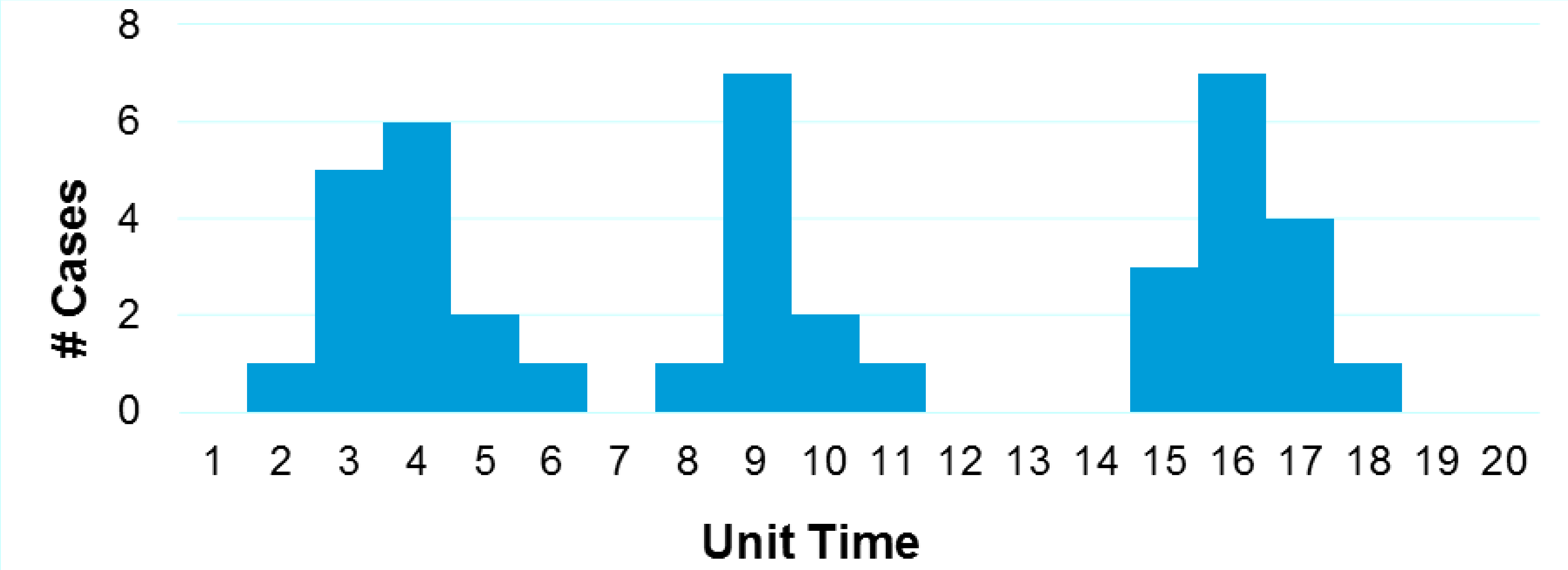
A **point source** epi curve shows that the group is exposed over a brief period of time and that the number of cases rises rapidly to a peak and falls gradually.

Examples:

- Contaminated food is served at a party
- One-time spraying of harmful pesticide indoors

Step 6
Perform descriptive epidemiology

Intermittent Outbreak Epi Curve



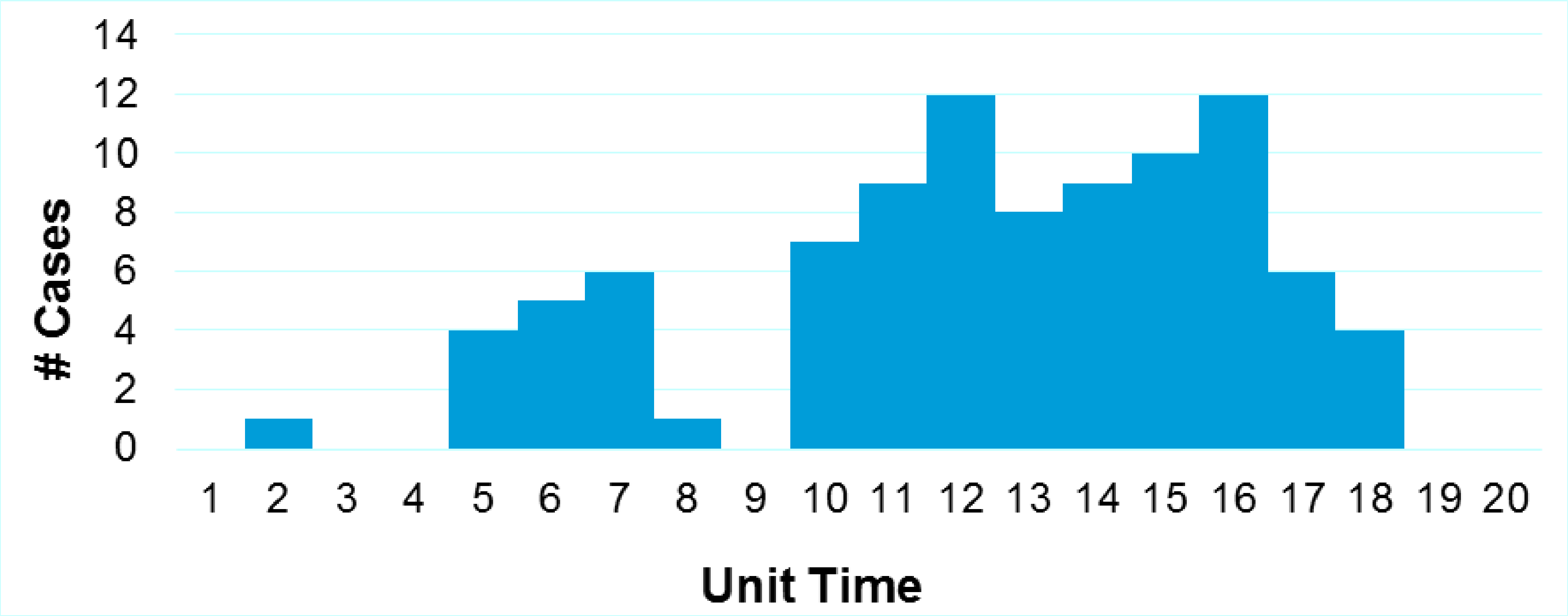
An **intermittent outbreak** epi curve often has a pattern reflecting the intermittent nature of the exposure.

Examples:

- Periodic spraying of a harmful pesticide
- Seasonal lead exposure

Step 6
Perform descriptive epidemiology

Propagated Epi Curve



Propagated epi curves show that there is not one common source responsible for the agent. The causative agent is associated with person-to-person transmission.

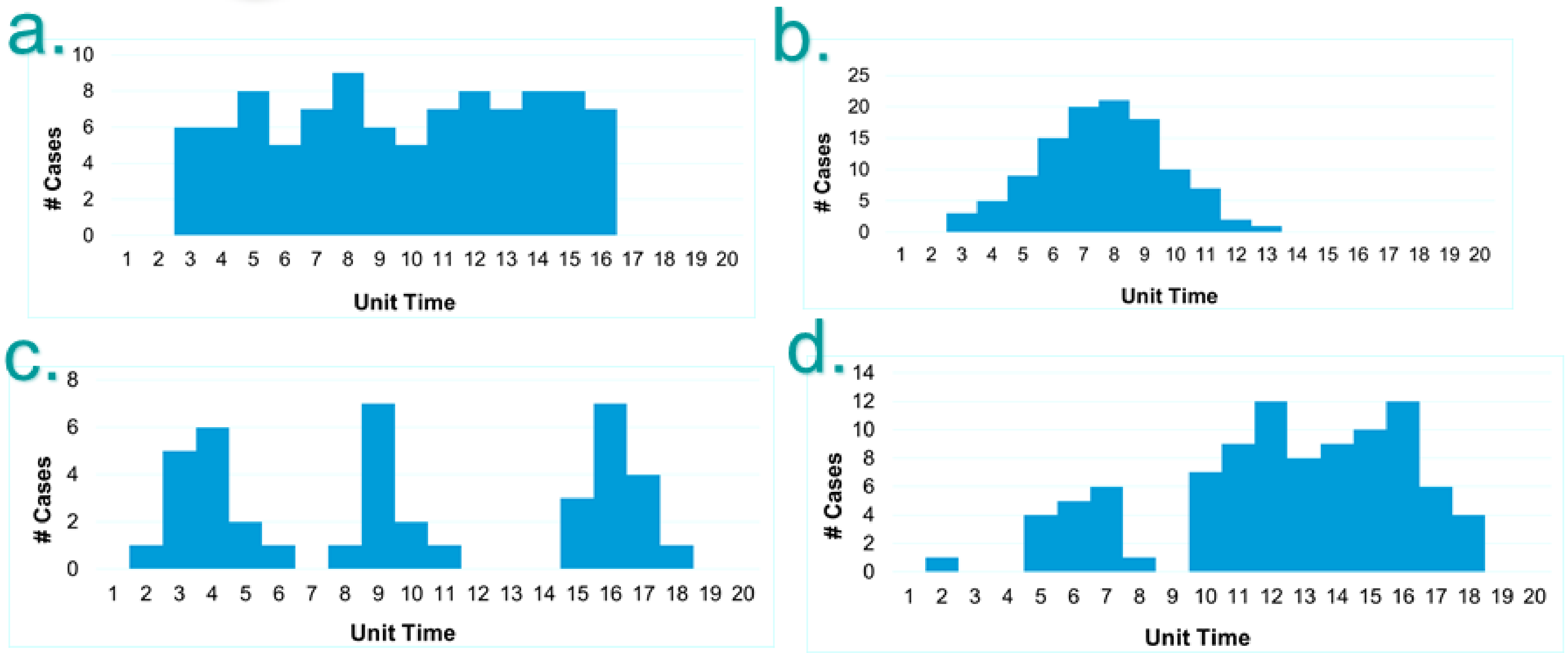
Examples:

- Syphilis
- Hepatitis B

Step 6
Perform descriptive epidemiology

Activity: Epi Curve

Which epi curve are you <u>less</u> likely to see during a toxicological outbreak?

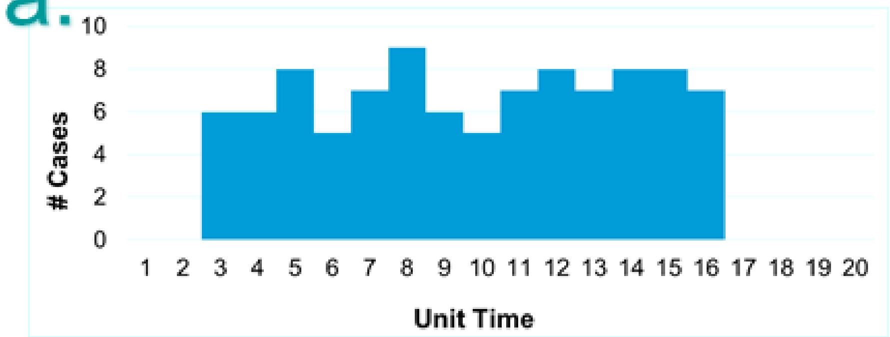


Step 6
Perform descriptive epidemiology

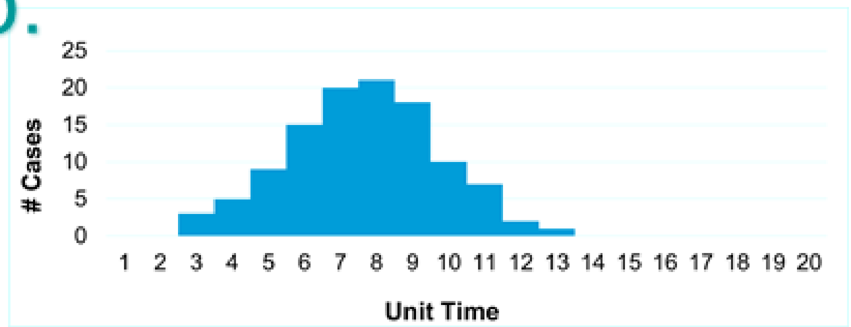
Activity: Epi Curve (cont.)

Which epi curve are you <u>less</u> likely to see during a toxicological outbreak?

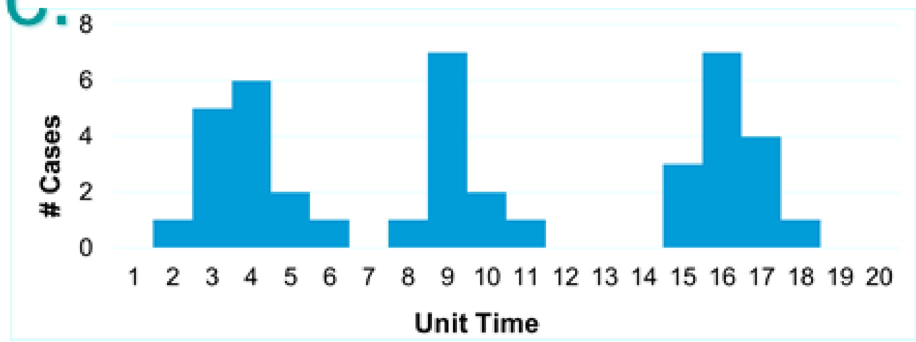
a.



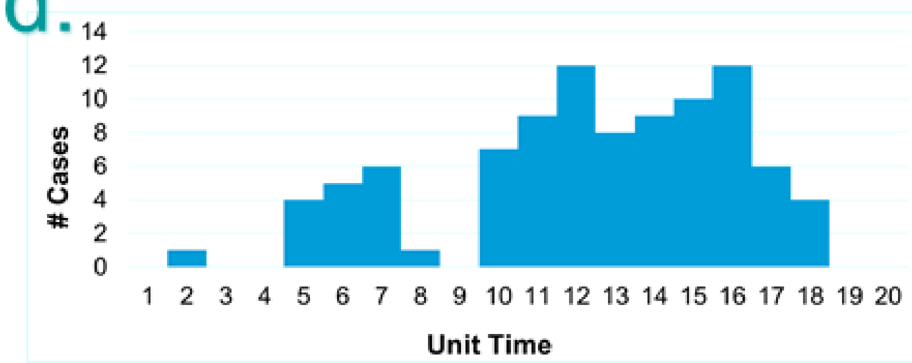
b.



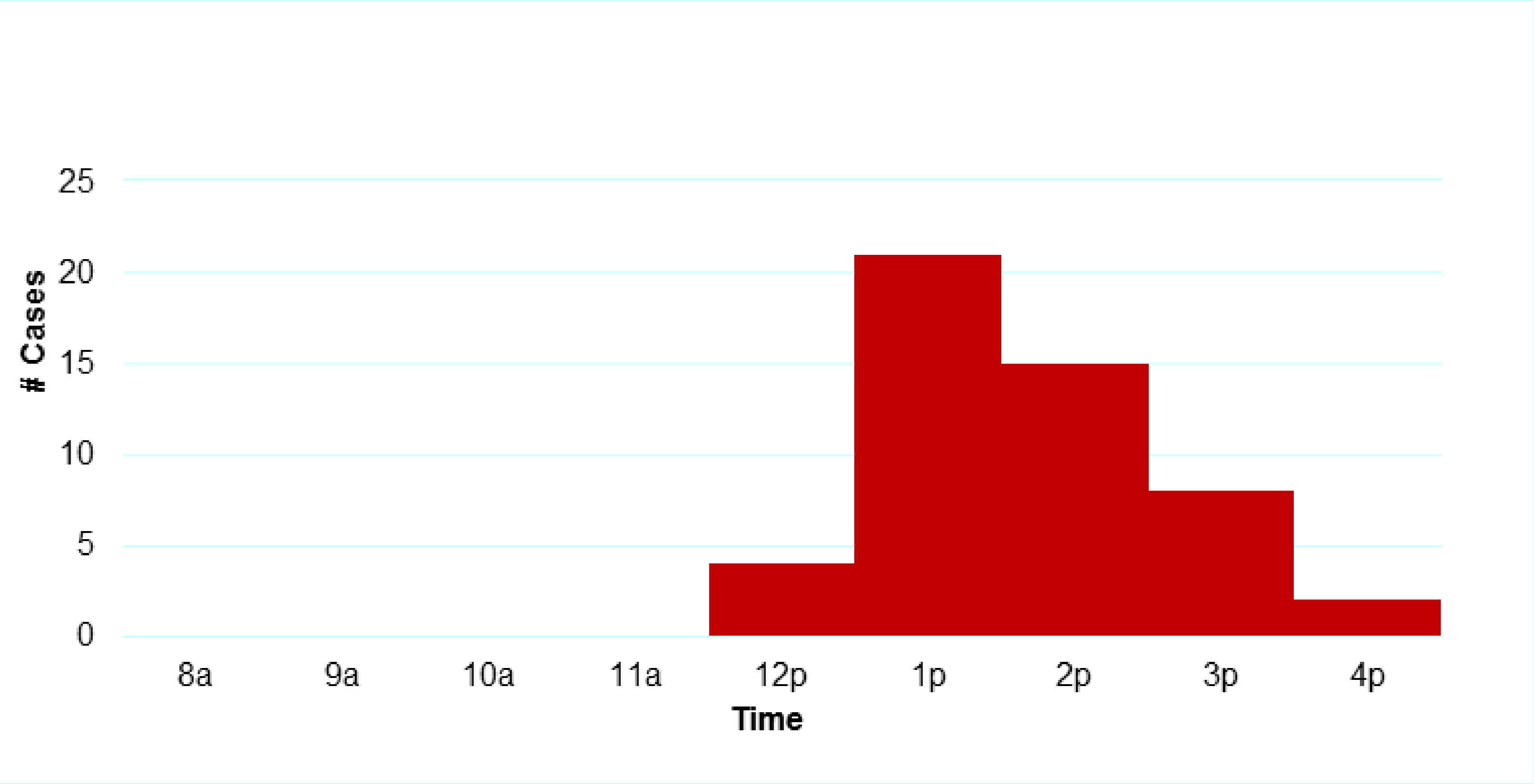
c.



d.



Scenario: Epi Curve

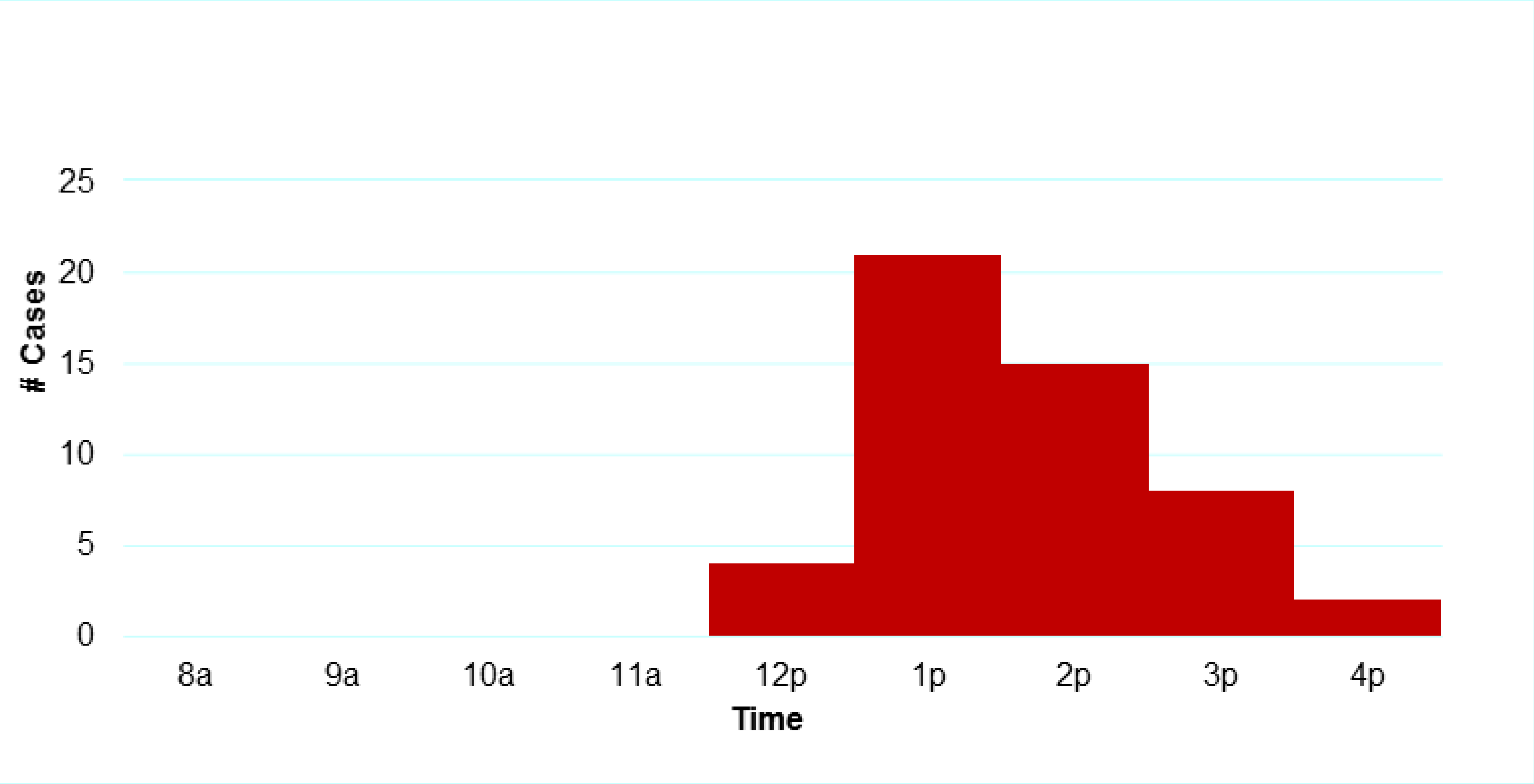


Returning to the scenario, the epi curve looks like this.

What might you deduce based on this epi curve?

Step 6
Perform descriptive epidemiology

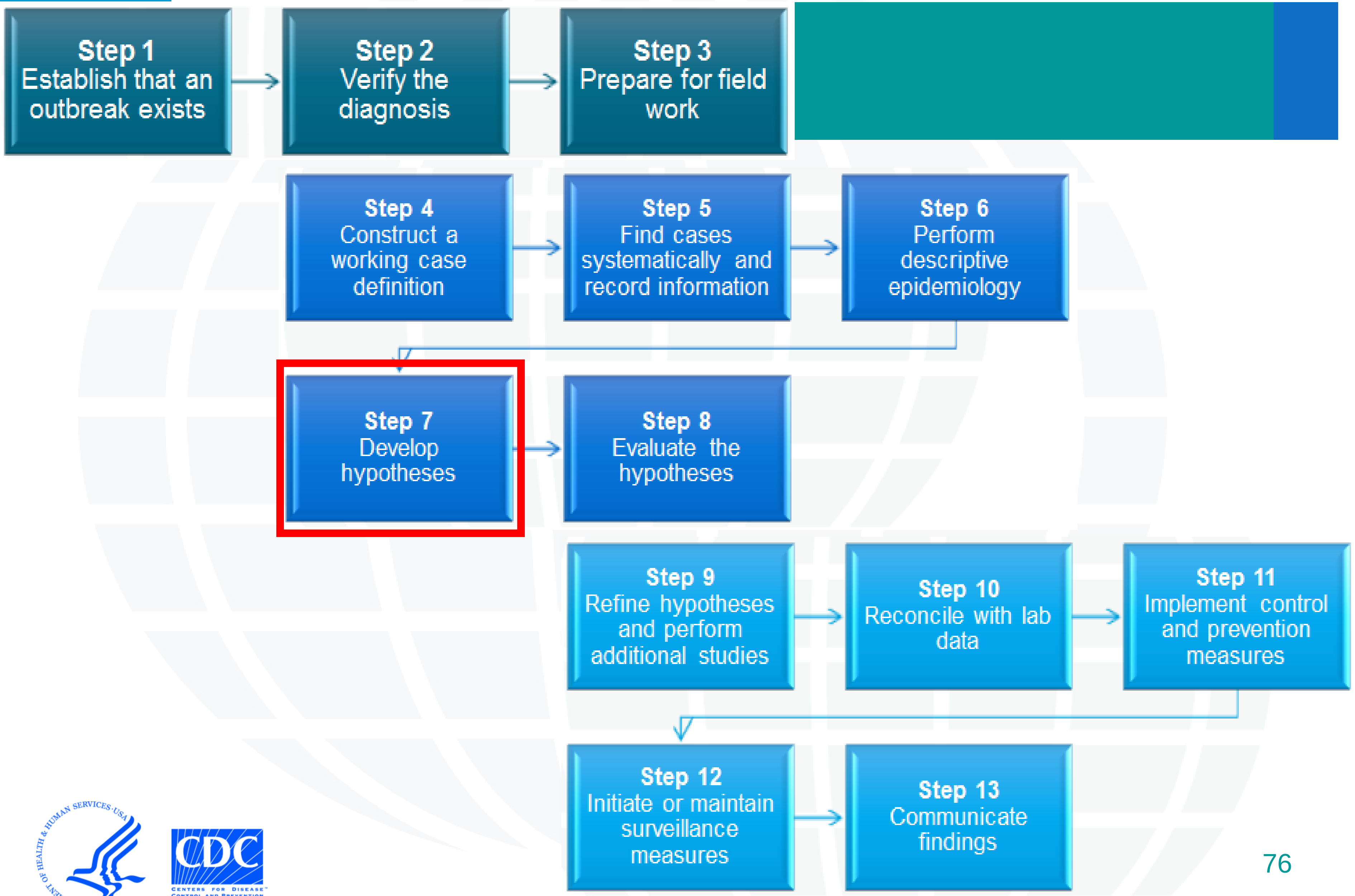
Scenario: Epi Curve (cont.)



What might you deduce based on this epi curve?

It is a point source epi curve. Thus, it is likely that the exposure occurred during a single, one-time event.

The latency period (or time between when the exposure occurred to when symptoms appeared) was relatively short, given the condensed epi curve.


Step 1
Establish that an outbreak exists
Step 2
Verify the diagnosis
Step 3
Prepare for field work
Step 4
Construct a working case definition
Step 5
Find cases systematically and record information
Step 6
Perform descriptive epidemiology
Step 7
Develop hypotheses
Step 8
Evaluate the hypotheses
Step 9
Refine hypotheses and perform additional studies
Step 10
Reconcile with lab data
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Implement control and prevention measures
Step 12
Initiate or maintain surveillance measures
Step 13
Communicate findings

Step 7
Develop hypotheses

Two Models for Hypotheses

Etiologic Agent

How do you figure it out?

Signs and symptoms

Biologic and/or environmental lab testing

Why do we need to know this?

It will help you treat patients

Exposure

How do you figure it out?

Questionnaires

Environmental lab testing

Why do we need to know this?

It will help you stop the outbreak

There are two types of hypotheses that you need to consider in toxicological outbreak investigations:

- Etiologic Agent
- Exposure

Step 7
Develop hypotheses

Developing Etiologic Agent Hypotheses

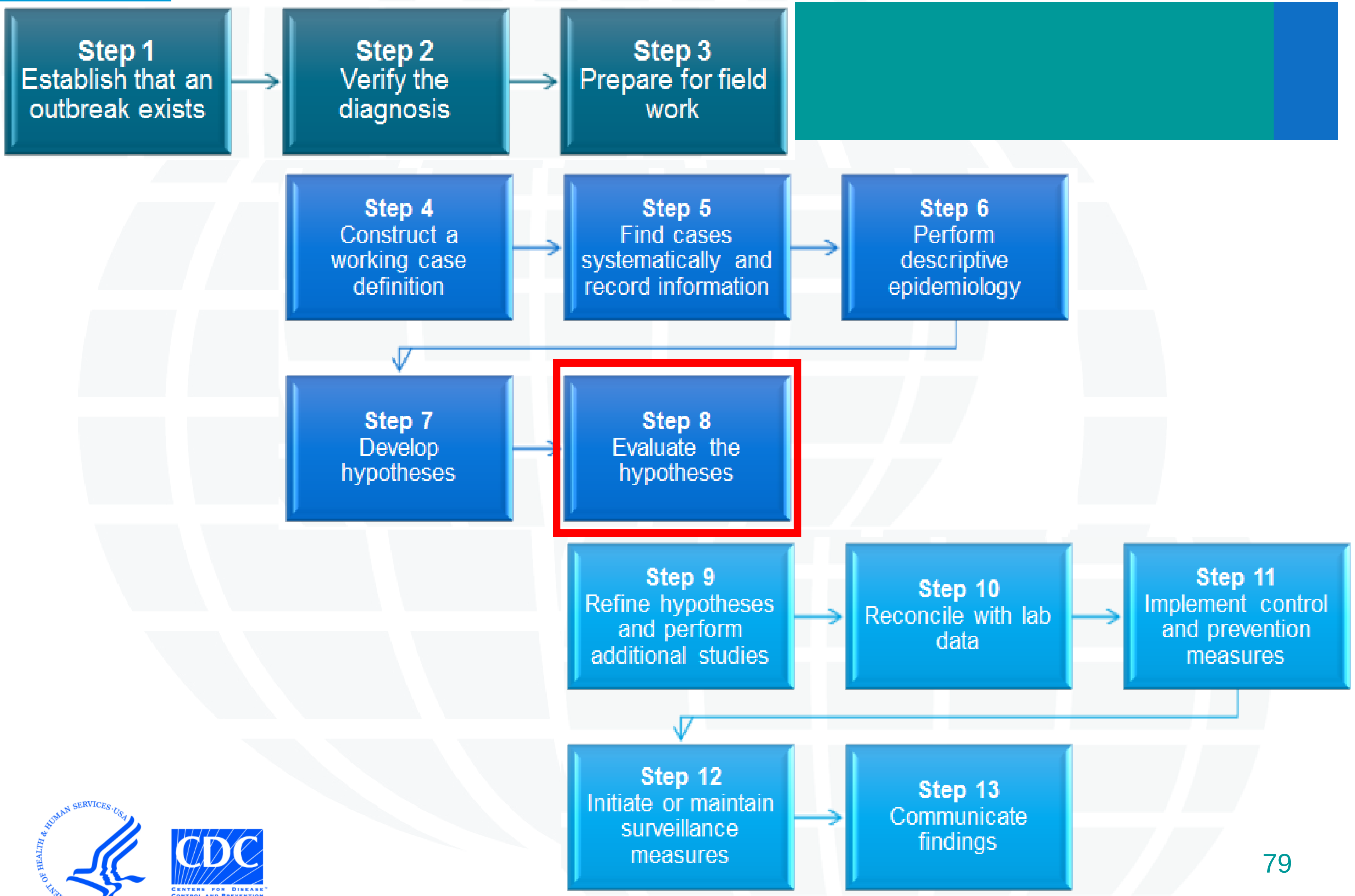
Toxidromes

Table 1. Classic Toxidromes[8, 9, 10]

Toxidrome	Signs and Symptoms	Potential Toxic Agent
Cholinergic crisis	Salivation, diarrhea, lacrimation, bronchorrhea, diaphoresis, urination Miosis, fasciculations, weakness, bradycardia or tachycardia, hypotension or hypertension, altered mental status, seizures	Nicotine Organophosphate insecticides Carbamate insecticides Medicinal carbamates (e.g., physostigmine)
Anticholinergic	Cutaneous flushing, hyperthermia, dry skin, mydriasis, dry mucous membranes, disorientation, hallucination, seizures, tachycardia, hypertension, urinary retention	Belladona alkaloids Jimson Weed/Datura Brugmansia Diphenhydramine
Hallucinogen	Disorientation, hallucination, panic	Peyote Psilocybin mushrooms LSD PCP Lysergic acid containing plants: morning glory, Hawaiian woodrose
...thomimetic	...ardia, hypert... ...erthermia,	...(ephedrine)

Tool Kit: Toxidromes Chart

A toxicologist can help you identify the toxic agent based on the toxidrome.



Once you have developed hypotheses, the next step is to conduct a study to evaluate these hypotheses.

Types of Data Collected

A typical investigation involves collecting:

Epidemiologic data

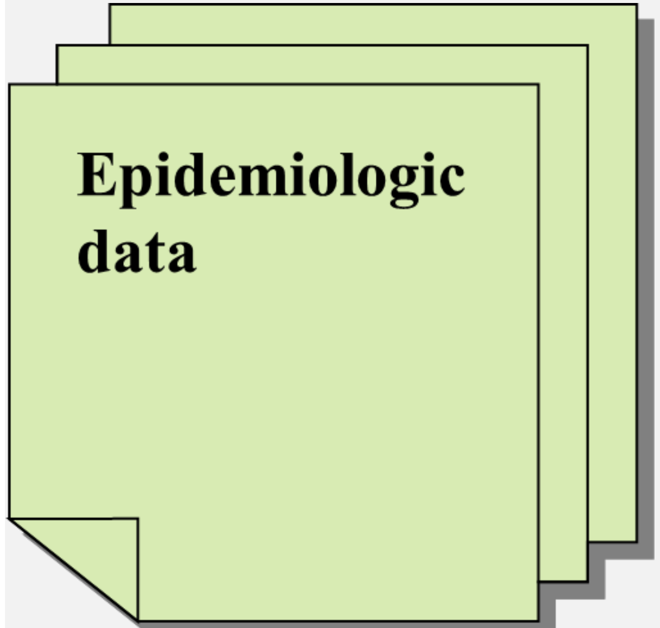
Clinical data

Laboratory data

Step 8
Evaluate the hypotheses

Evaluate Hypotheses Using Analytic Epidemiology

- To quantify relationships between exposures and outcomes
- To test hypotheses about causal relationships
- Key feature is a **comparison group**



Step 8
Evaluate the hypotheses

Types of Analytic Epidemiology Studies

- Case-control studies
  - Compares patients who have a disease or outcome of interest (cases) with patients who do not have the disease or outcome (controls) to describe the relationship between exposure and outcome.
  - Measures of associations between exposures and outcomes are measured using the **odds ratio**. The odds ratio compares the odds of a health event (e.g., disease) of those exposed to the odds of a disease to those unexposed.

One kind of **comparison group** used in case control studies is a group of people with the exposure but may not have the disease.

Case control studies *useful when population is not well defined and speed of investigation is important*

Step 8
Evaluate the hypotheses

Types of Analytic Epidemiology Studies

- Retrospective cohort studies
  - Investigators contact each member of a defined population, determine each person's past exposure to possible sources, and note whether they have disease.
  - Measures of associations between exposures and outcomes are measured using **relative risk.** The relative risk compares the risk of a health event (e.g., disease) among one group with the risk among another group.

Two common types of analytic epidemiology studies used in outbreak scenarios: **Retrospective cohort studies** and **case control studies**

Retrospective cohort studies *feasible when the population is small and well defined and can be followed over time*

Types of Analytic Epidemiology Studies

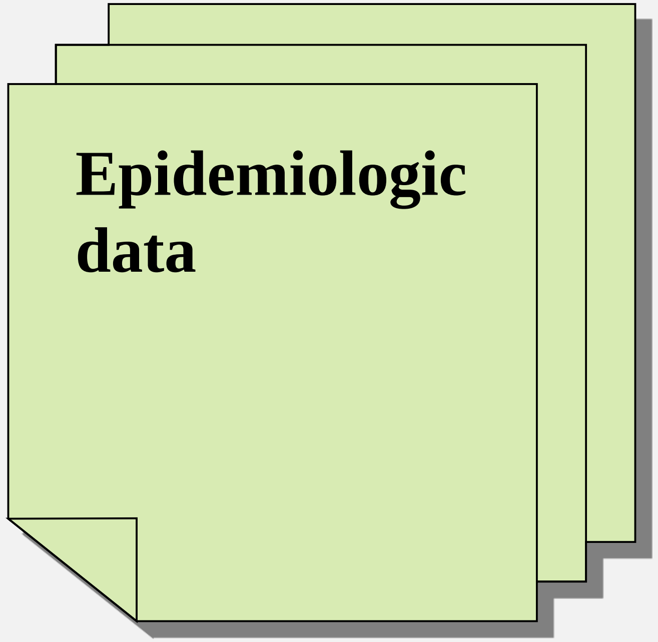
- **Retrospective cohort studies** useful when the population is small and well defined

- **Case control studies** useful when population is not well defined and speed of investigation is important

Epidemiologic Data: Questionnaires

Questionnaires:

1. Demographics
2. Potential risk factors for illness
3. Self-reported health information
4. Possible toxic agents and exposures
5. Quantification of exposure to toxic agent
6. Timeline of toxic agent exposure



Step 8
Evaluate the hypotheses

Epidemiologic Data: Questionnaires (cont.)

Questionnaires:

1. Demographics
2. Potential risk factors for illness
3. Self-reported health information
4. Possible toxic agents and exposures
5. Quantification of exposure to toxic agent
6. Timeline of toxic agent exposure

Similar to infectious outbreak investigation

Epidemiologic Data: Questionnaires (cont.)

Questionnaires:

1. Demographics
2. Potential risk factors for illness
3. Self-reported health information
4. Possible toxic agents and exposures
5. Quantification of exposure to toxic agent
6. Timeline of toxic agent exposure

Toxicological outbreak investigations have a strong emphasis on timing of self-reported health information

Epidemiologic Data: Questionnaires (cont.)

Questionnaires:

1. Demographics
2. Potential risk factors for illness
3. Self-reported health information
4. Possible toxic agents and exposures
5. Quantification of exposure to toxic agent
6. Timeline of toxic agent exposure

Unique to toxicological outbreak investigations

Questions about Exposures

- Questions about exposures can be asked in a yes/no format, or a quantified format

Yes/No Format	Quantified Format
• Often used when there is a large number of possible exposures	• Often asked when there is a small number of possible exposures
• Easier for participants to answer	• Harder for participants to answer
• Takes less time	• Takes more time
• Less informative	• More informative

Activity: Questions about Exposures

How would you ask these questions in a quantified format?

Yes/No Format	Quantified Format
• Did you eat a banana?	
• Did you spray pesticides?	

Step 8
Evaluate the hypotheses

Activity: Questions about Exposures (cont.)

How would you ask these questions in a quantified format?

Yes/No Format	Quantified Format
• **Did you eat a banana?**	• How many bananas did you eat in the last 24 hours?
• **Did you spray pesticides?**	• How many times did you spray pesticides in the past 36 hours? • How many minutes did you spend spraying pesticides in the past 36 hours? • How much pesticide did you spray in the past 36 hours?

To ask about an exposure in a quantified format, think about…

- Frequency
- Duration
- Dose/Amount

Step 8
Evaluate the hypotheses

Quantifying Exposure

- Quantifying exposure allows you to better assess a dose-response relationship with illness

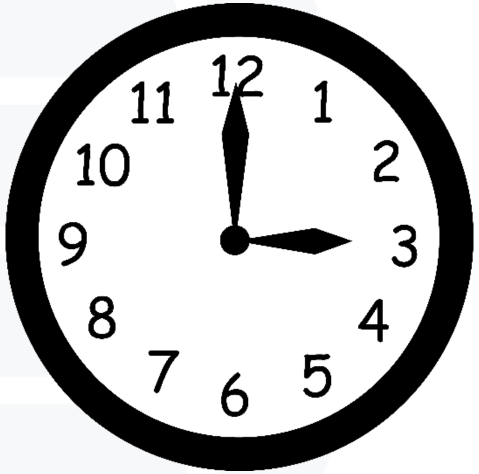
# Times Spraying Pesticide	Attack rate
0 times	5%
1 to 2 times	40%
3 or more times	95%

Calculate attack rates for each of the strata.

If the attack rate increases with increasing exposure, then that suggest that it might be the implicated exposure.

Timeline

- Illness often occurs quickly (minutes to hours) after exposure to a toxic agent
- When asking about possible exposures, the timeframe is usually limited to the hours preceding the event



Questionnaire Template

Participant ID#: ____________

Assign a participant ID# to every case. This will help you link the questionnaire to other results, such as laboratory data.

Case/Control Status

(For interviewer to complete; in some situations, it may be easier to complete at the end of the interview in order to assist with determining if they met the case definition.)

Does this person meet the case definition?

It may be helpful to insert the case definition here, for easy reference during the interview. Might be phrased as questions to determine if the person met each component of the case definition, or could be completed by supervisor reviewing the form.

- ☐ Yes
- ☐ No
- ☐ Do not know

If this person does not meet the case definition, are they matched to a particular case (i.e., are they a control in a matched case-control study)?

- ☐ No
- ☐ Yes   If yes, matched case name/ID # ____________________________

How was the case/control identified?

For example, potential answer options could include the following: hospital records, surveillance system, physician, etc. Could have separate options for cases and controls.

- ☐ Option 1
- ☐ Option 2
- ☐ Option 3
- ☐ Do not know

Demographics

Sex: ☐ Male
☐ Female If female, are you pregnant? ☐ No ☐ Yes, # of weeks pregnant ________ ☐ Don't know
☐ Do not know

Height: __________ (unit of measurement (m/cm/etc.)   Age: __________ (years)
Weight: __________ (unit of measurement; kg, etc.)

Tool Kit: Sample Questionnaire

The Sample Questionnaire can be modified for your investigation.

Clinical Data

Sources of clinical data

- Epidemiologic questionnaire
- Medical chart abstraction

Types of clinical data

- Vital signs
- Clinical laboratory test results
- Presence/absence/timing of specific signs and symptoms
- Sign or symptom severity and frequency
- Medications provided as part of treatment
- Response to treatment/outcome
- Medical history

Clinical Data (cont.)

Participant ID#: ___________________

Assign a participant ID# to every case. This will help you link the questionnaire to other results, such as laboratory data.

This section only to be completed by cases (or their proxy)

Symptoms

When did you first feel sick?   Date: ____/_____/__________   Time: ___ ___:___ ___(24-hour clock)

Specify a time period for "XX" that makes sense based on your investigation.
If appropriate, create answer choices for the questions below. Or, they can remain as open-ended questions.

Symptom	Did you have (*symptom below*) during XX time period?	If yes, date of onset	If yes, time of onset	If yes, has the symptom resolved? 1 = No 2 = Yes 3 = Do not know	If resolved, date resolved	Notes
Symptom 1						
Symptom 2						
Symptom 3						
Symptom 4						

Questionnaires often include specific questions to determine the timing and order of symptom onset. Questionnaires can be self-administered or done via interview.

The Sample Questionnaire in the Tool Kit contains clinical questions.

Step 8
Evaluate the hypotheses

Clinical Data (cont.)

Participant ID#: ___________

Attach ID label here

IV. Medical Record Abstraction

Please use the patient's medical record to abstract the information requested below for their visit related to this specific outbreak.

Date of abstraction (mm/dd/yyyy): ___ ___/___ ___/___ ___ ___ ___

Name of abstractor: ____
Last *First* *MI*

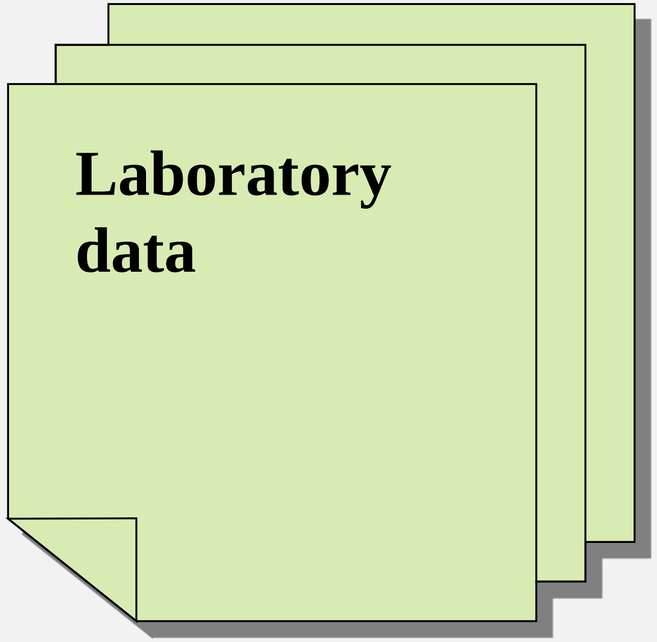
1. **General Information Questions:**
2. First Name: _________________
3. Last Name: ____________________
4. Medical Record #: ____________________
5. Phone Number: ________________
6. Address/ House description: __________________________
7. Village/District/Province: ______________________
8. Sex: ________Male __________Female
9. Age: ___________(years) if less than 1 year of age _________(months)

Tool Kit: Sample Medical Record Abstraction Form

The Medical Record Abstraction Form template can be modified for your investigation.

Toxicological Laboratory Data

- It can be useful to collect biological and/or environmental samples for laboratory testing
- Their utility will depend on:
  - What toxic agent caused the illness (and its biological elimination or environmental half-life)
  - How much time has passed since exposure
  - Whether it is a toxic agent that can be measured in the laboratory
  - Availability of comparison data



Early Sample Collection

- During a toxicological outbreak investigation, collecting biological specimens and/or environmental samples as early as possible is key
- Some toxic agents may be eliminated from the body or broken down in the environment within minutes to hours after exposure
- The sooner that a sample is collected, the greater the chances that the sample will still contain the toxic agent

Step 1 Establish that an outbreak exists

Step 2 Verify the diagnosis

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Step 10 Reconcile with lab data

Step 11 Implement control and prevention measures

Step 12 Initiate or maintain surveillance measures

Step 13 Communicate findings

Data Analysis

- In toxicological outbreaks, epidemiologic and clinical data typically help guide laboratory testing

First stage: Clinical data | Epidemiologic data

Second stage: Laboratory data

Step 9
Refine hypotheses and perform additional studies

Data Analysis Steps

1. Look for exposures that are related to case status
2. If common exposures are identified, examine dose-response relationships
   - Compare attack rates by amount of exposure
   - Compare illness severity by amount of exposure

Step 9
Refine hypotheses and perform additional studies

Scenario: Data Analyses

- Recall previous scenario:
  - Illness involving nausea, vomiting, abdominal pain, altered mental status, multi-system organ dysfunction, and death
  - Affected children aged 6–10 years who attended the same school
- The investigators conducted an investigation.

Step 9
Refine hypotheses and perform additional studies

Scenario: Identify Common Exposures

Exposures	# Cases	# Children Exposed	Attack Rate
Riding bus to school	32	245	13%
Eating breakfast in cafeteria	38	346	11%
Eating morning snack	45	123	37%
Spending time in school hall	41	267	15%

Step 1: Look for exposures that are related to case status.

Note: This approach, including calculating attack rates is typically used in a cohort study design

Step 9
Refine hypotheses and perform additional studies

Scenario: Dose-Response, Attack Rate

- The team identifies a dose-response relationship with the amount of snack eaten

Amount of Snack Eaten	# Cases	# Children Exposed	Attack Rate
0 servings	2	432	0%
1 serving	6	26	23%
2 servings	30	30	100%
3 servings	12	12	100%

Step 2: Look for a dose-response relationship

Main findings:

- The attack rate increases as the number of servings of the snack eaten increases.
- Almost all individuals who got sick ate the snack.

Scenario: Dose-Response, Illness Severity

- The team decides to look at the relationship between dose and illness severity
- They first need to categorize illness severity:
  - Not sick: No symptoms
  - Mild sickness: Reported one or more symptoms, but no altered mental status, organ dysfunction, or death
  - Severe sickness: Altered mental status, organ dysfunction, or death

Step 9
Refine hypotheses and perform additional studies

Scenario: Dose-Response, Illness Severity

- The team compares the amount of snack eaten by these three illness severity categories

Amount of Snack Eaten	Not sick (n=450)	Mild Sickness (n=35)	Severe Sickness (n=15)
0 servings (n=432)	430 (96%)	2 (6%)	0 (0%)
1 serving (n=26)	20 (4%)	5 (14%)	1 (7%)
2 servings (n=30)	0 (0%)	25 (71%)	5 (33%)
3 servings (n=12)	0 (0%)	3 (9%)	9 (60%)

Main findings:

- Most children who were not sick did not eat any snack.
- Everyone with severe sickness ate at least 1 serving of snack.
- Everyone who ate 2 or 3 servings became sick.

Step 4
Construct a working case definition

Dose-Response

What are some reasons why you might not see a dose-response relationship?

Dose-Response (cont.)

What are some reasons why you might not see a dose-response relationship?

- Some toxic agents cause illness at such a low dose that anyone who is exposed is already above the threshold
- Differences in metabolism and susceptibility
- Mis-classification of exposure or case status

Step 9
Refine hypotheses and perform additional studies

Scenario: Data Analyses

- Based on these findings, the team advises the laboratory to analyze samples of the snack
- Toxic agents that meet the differential include:
  - Heavy metals (e.g. mercury)
  - Herbicides (e.g. paraquat)
  - Metabolic poisons (e.g. cyanide)

Step 1
Establish that an outbreak exists

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Verify the diagnosis

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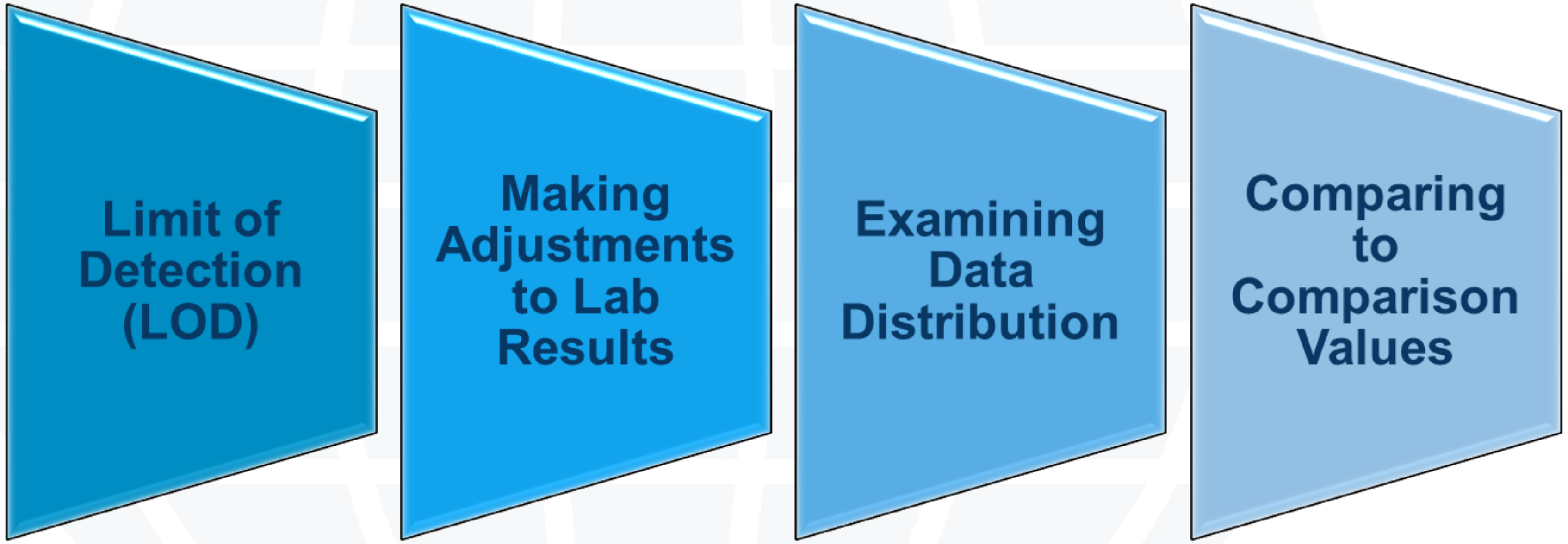
Step 13
Communicate findings

Step 10
Reconcile with lab data

Evaluating Laboratory Results



Four considerations need to be kept in mind when analyzing laboratory data:

- Limit of Detection
- Making Adjustments
- Examining Distribution
- Finding Comparison Values

Refer to Module 4: Analyzing and Interpreting Laboratory Results

Scenario: Laboratory Data Results

- Continuing with the scenario presented earlier, the investigators receive laboratory data on the urine specimens
- They receive data on cyanide first

Step 10
Reconcile with lab data

Scenario: Biologic Laboratory Data

	Cases	Controls
Cyanide		
% above Limit of Detection	0%	0%
Range	N/A	N/A
Median	<LOD	<LOD

Could cyanide have been the culprit?

Step 10
Reconcile with lab data

Scenario: Biologic Laboratory Data (cont.)

	Cases	Controls
Cyanide		
% above Limit of Detection	0%	0%
Range	N/A	N/A
Median	<LOD	<LOD

Could cyanide have been the culprit?

Although it seems unlikely because no cases had detectable levels, it is theoretically possible that it could have been cyanide.

Reasons why it is non-detect:

- The specimens could have been collected after cyanide was metabolized.
- The toxic threshold might be lower than the limit of detection.

Step 10
Reconcile with lab data

Scenario: Biologic Laboratory Data (cont.)

	Cases	Controls
Mercury (µg/L)		
% above LOD	80%	60%
Range	<LOD to 3.66	<LOD to 2.97
Median	2.93	1.96
Paraquat		
% above LOD	90%	10%
Range	<LOD to 41	<LOD to 1.1
Median	23.5	<LOD

Mercury is present in relatively high levels in cases and controls.

Does this mean it is causing illness?

Step 10
Reconcile with lab data

Scenario: Biologic Laboratory Data (cont.)

	Cases	Controls
Mercury (µg/L)		
% above LOD	80%	60%
Range	<LOD to 3.66	<LOD to 2.97
Median	2.93	1.96
Paraquat		
% above LOD	90%	10%
Range	<LOD to 41	<LOD to 1.1
Median	23.5	<LOD

Mercury is present in relatively high levels in cases and controls.

Does this mean it is causing illness?

No. The fact that the median level is similar between cases and controls suggests it did not cause the outbreak.

Step 10
Reconcile with lab data

Scenario: Biologic Laboratory Data (cont.)

	Cases	Controls
Urine mercury (µg/L)		
% above LOD	80%	60%
Range	<LOD to 3.66	<LOD to 2.97
Median	2.93	1.96
Paraquat		
% above LOD	90%	10%
Range	<LOD to 41	<LOD to 1.1
Median	23.5	<LOD

Paraquat is detected in a higher proportion of cases compared to controls, and the median is higher in cases than controls.

Does this mean it is causing illness?

Step 10
Reconcile with lab data

Scenario: Biologic Laboratory Data (cont.)

	Cases	Controls
Urine mercury (µg/L)		
% above LOD	80%	60%
Range	<LOD to 3.66	<LOD to 2.97
Median	2.93	1.96
Paraquat		
% above LOD	90%	10%
Range	<LOD to 41	<LOD to 1.1
Median	23.5	<LOD

Is Paraquat causing illness?

Based on these data, it would be reasonable to assume that Paraquat likely caused the outbreak.

It is not a substance that would typically be expected to be found in biologic specimens, so its presence would indicate that it likely caused the illness.

Step 10
Reconcile with lab data

Comparing to Reference and Control Values

- IF cases have levels that are higher than the toxic threshold
- AND if their clinical pictures resemble what would be expected following exposure to that toxic agent
- THEN you might conclude that the toxic agent caused the outbreak

Comparing to Comparison Values

- If cases have levels that are lower than the toxic threshold, but their symptoms match the clinical picture, it might mean that:
  - The toxic agent did not cause the outbreak, or
  - The specimens were not collected soon enough following exposure and perhaps the toxic agent was already partly eliminated from the body

Step 10
Reconcile with lab data

Sources of Comparison Values

- In the United States, the National Health and Nutrition Examination Survey (NHANES) provides a wealth of information for biomonitoring levels:

https://www.cdc.gov/exposurereport/

Step 10
Reconcile with lab data

Scenario: Environmental Laboratory Data

- Investigators also receive data from the snack sample

Step 10
Reconcile with lab data

Scenario: Environmental Laboratory Data

	Piece #1	Piece #2	Piece #3	Piece #4	Piece #5
Toxic Agent					
Cyanide	<LOD	<LOD	<LOD	13	<LOD
Mercury	<LOD	<LOD	<LOD	<LOD	5
Paraquat	331	20	<LOD	648	394

Why was paraquat not detected in one of the snack samples?

Step 10
Reconcile with lab data

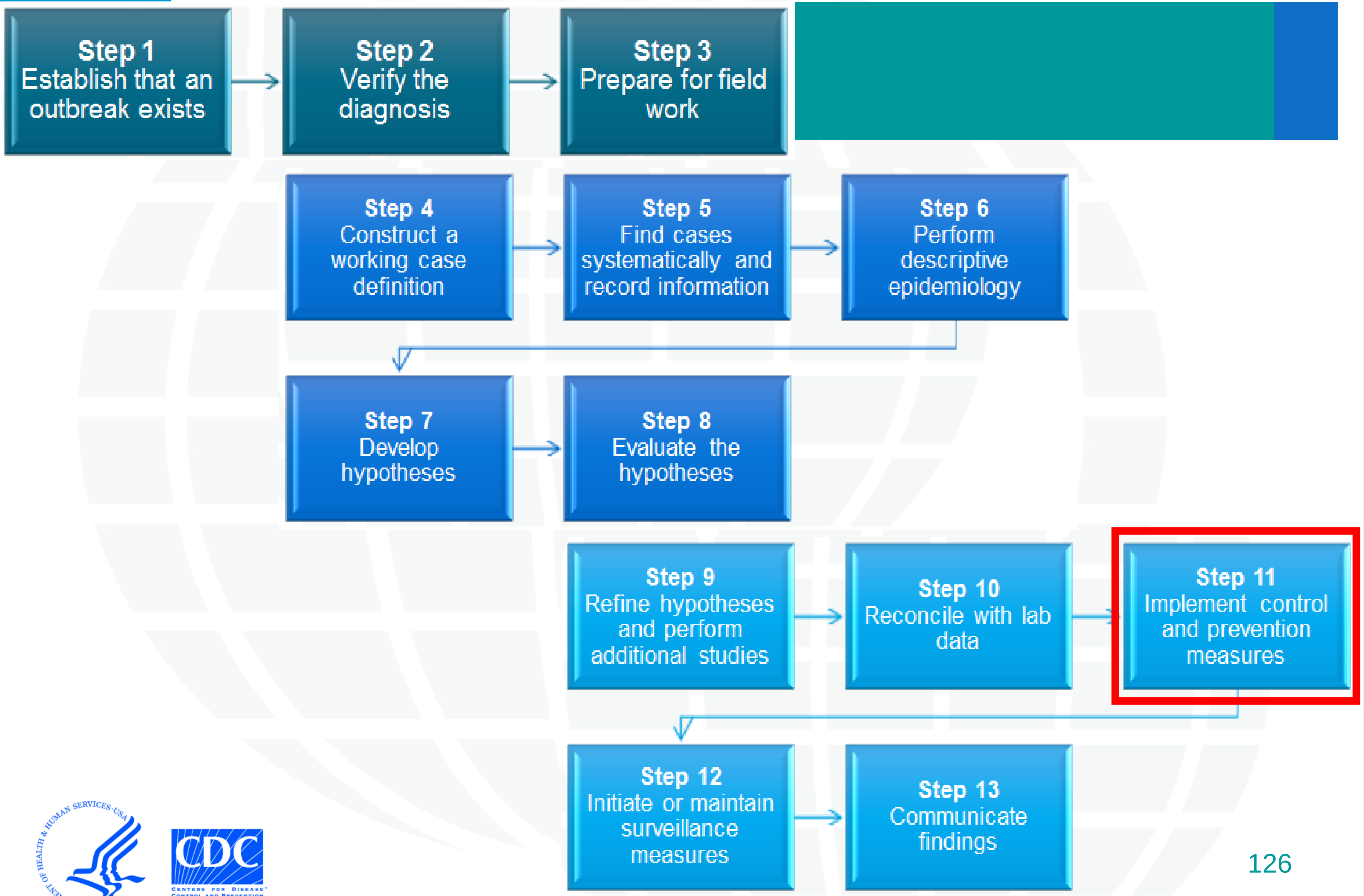
Scenario: Environmental Laboratory Data

	Piece #1	Piece #2	Piece #3	Piece #4	Piece #5
Toxic Agent					
Cyanide	<LOD	<LOD	<LOD	13	<LOD
Mercury	<LOD	<LOD	<LOD	<LOD	5
Paraquat	331	20	<LOD	648	394

Why was one of the snack samples non-detect for Paraquat?

This is probably a result of the heterogeneous distribution of Paraquat in the snack.

This is a good example of why it is important to take more than one sample of an environmental media.


Step 1
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Step 2
Verify the diagnosis
Step 3
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Step 5
Find cases systematically and record information
Step 6
Perform descriptive epidemiology
Step 7
Develop hypotheses
Step 8
Evaluate the hypotheses
Step 9
Refine hypotheses and perform additional studies
Step 10
Reconcile with lab data
Step 11
Implement control and prevention measures
Step 12
Initiate or maintain surveillance measures
Step 13
Communicate findings

Control Measures

- Every outbreak investigation is unique; therefore, so are the control measures
- Example: Following this investigation, the snack was recalled

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Identifying Additional Cases

- Depending on the situation and resources, you may or may not decide to implement a surveillance system
- Example: Following the investigation, a campaign was started to inform the public, school officials, and healthcare providers to report food poisoning to public health officials

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Communicating Findings

- Toxicological laboratory results can sometimes be difficult to explain to stakeholders
- Two key issues:
    - Explaining why a specific toxic agent was not found, particularly if it is believed to have caused the outbreak
    - Explaining why finding specific toxic agents in samples does not necessarily mean they caused the outbreak

False Negative Result

- It is not always possible to identify the etiologic agent in an environmental or biologic sample
- Reasons for a false negative:
  - Toxic threshold is lower than the Limit of Detection
  - Toxic agent had a short half-life, and metabolized or degraded before the sample was collected
  - Inadequate sample quality or quantity

Scenario: Explaining Positive Results

What are some possible talking points for describing why mercury was detected in some biologic specimens in the previous scenario?

Scenario: Explaining Positive Results (cont.)

What are some possible talking points for describing why mercury was detected in some biologic specimens?

- Mercury was detected in a majority of students who had urine specimens collected. Although mercury is a neurotoxin, it is unlikely that mercury contributed to the outbreak.
- The levels of mercury are within the range of levels typically found in the U.S. population.
- There are many possible sources of mercury exposure, including fish.

Module Conclusion

What questions do you have about the information presented in this module?