Case study on waterborne outbreak of Cryptosporidiosis

Facilitator Guide

PROTOCOL ON WATER AND HEALTH

World Health Organization
European Region

UNECE

Contents

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Scope and objectives

The scenario presented in this case study is based around a fictional event. Workshop participants will work through the scenario and will respond to a package of questions focused on the ten steps of a waterborne outbreak investigation. Participants will discuss as if they were part of the outbreak team. In some questions, participants will be asked to elaborate an answer as if the outbreak was occurring in their country of origin.

Structure of the exercise

The exercise is divided in 1) group work and 2) plenary debrief. It will last in total around 300 minutes (5 hours).

1) Group work: Planned to last around 240 minutes (4 hours) and is divided in two parts of approximately 150 minutes (2.5 hours) and 90 minutes (1.5 hours). Each part is structured in steps that include a set of questions.

Workshop participants will be divided in small groups (preferably with no more than 5-6 persons each). There should be at least two computers per group as the use of Epi info™ is required to solve some of the questions.

Each group will discuss the entire scenario and all the questions included. In addition, each group will be responsible for presenting one specific question during the plenary debrief. At the beginning of the exercise, each group will be informed about their question so that they can allocate time to prepare it during the group work session.

Each group should appoint:

- A *moderator-time keeper* who will lead the group activities, guide the rest of participants through the case study and who will ensure the group keeps the time allocated for each question. This will be the only person in the group having the "facilitator version" of the case study. This version includes facilitator probes that will help the moderator to develop the discussions within the group.
- *Note taker* and a *spokesman* who will be responsible for presenting the group´s work during the plenary debrief.

The workshop facilitator will be available in the room to solve doubts to all groups during the entire session.

2) Plenary debrief: Planned to last around 60 minutes. Each group´s spokesman will briefly present and discuss the solution to their question. The presentation will not take more than

5 minutes each. The presentation´s format, structure and design will be flexible and decided by each group. The number of different questions subject to be presented in this session will depend on the number of groups in each workshop. Each group will present at least one question.

See the proposed case study structure below:

GROUP WORK TOPIC	Question for discussion	Allocated time 240 minutes
PART ONE		150 minutes
Step I. Outbreak alert and detection. First hypotheses	Question 1	15 minutes
	Question 2	5 minutes
Step II: The outbreak team. Member roles, responsibilities and first actions	Question 3	15 minutes
Step III. Define cases	Question 4	10 minutes
Step IV. Identify cases and obtain information. Microbiological information	Question 5	5 minutes
Step V. Conduct a descriptive epidemiological investigation (time, place, person)	Question 6	25 minutes
	Question 7	25 minutes
	Question 8	15 minutes
	Question 9	10 minutes
	Question 10	25 minutes
PART TWO		90 minutes
Step VI. Conduct additional studies and collect additional information (environmental, laboratory)	Question 11	5 minutes
Step VII. Generate hypotheses	Question 12	5 minutes
Step VIII. Evaluate hypotheses	Question 13	10 minutes
	Question 14	10 minutes
	Question 15	15 minutes
Step IX. Implement control measures and risk communication	Question 16	15 minutes
Step X. Communication and evaluation of the outbreak response	Question 17	30 minutes
PLENARY DISCUSSION		60 minutes

Sources

The narrative of the fictional scenario used in this case study is based on the case study one included in the WHO document *Surveillance and outbreak management of water-related infectious diseases associated with water-supply system*[1]. It has been expanded with additional details, questions for discussion and facilitator probes to guide the discussion. The structure of the case study is inspired and adapted from the pilot national training workshops on water-related disease surveillance previously run by the World Health Organization Regional Office for Europe under the framework of the Protocol of Water and Health. In those workshops, some aspects of the content and structure were loosely based on scenarios developed by World Health Organization[2] , the RAND Corporation[3], the Norwegian Institute of Public Health and from real outbreak investigations.[4]

Course materials available for this case study

- Case study participant handbook: it includes the case scenario and participant questions
- Case study facilitator handbook: additionally, it includes facilitator probes to guide the discussion
- Case study presentation slides: a set of slides are available to be used and edited as needed by the workshop facilitators. They include the case study structure and solutions/ discussions to the questions.
- A blank PowerPoint template: a set of slides to be used to document and present outcomes of the exercises on the case study

1 Surveillance and outbreak management of water-related infectious diseases associated with water-supply systems. Copenhagen: WHO Regional Office for Europe; 2019. Licence: CC BY-NC-SA 3.0 IGO. (https://www.euro.who.int/en/health-topics/environment-and-health/water-and-sanitation/publications/2019/surveillance-and-outbreak-management-of-water-related-infectious-diseases-associated-with-water-supply-systems-2019)

2 Core Capacity Workbook: A series of exercises to assist the validation of core capacity implementation levels. https://www.who.int/ihr/publications/WHO_HSE_GCR_2015.13/en/

3 https://www.rand.org/content/dam/rand/pubs/technical_reports/2006/RAND_TR319.pdf

4 Nygard K, Schimmer B, Sobstad O, Walde AK, Tveit I, Langeland N, Hausken T, Aavitsland P. A large community outbreak of waterborne giardiasis- delayed detection in a non-endemic urban area. BMC Public Health. 2006 May 25;6(1):141

PART ONE: Steps I-V

I. Outbreak alert and detection. First hypotheses.

On Wednesday 12 September (week 37) at 17:45, just before she is planning to go home from the office, the municipal medical officer (MMO) at municipality **XXXX**, 136.000 inhabitants, receives a call from one doctor from the infectious disease unit at the reference university hospital. She is informed about an increase in gastroenteritis consultations during the previous days. To explore further the situation, she decides to call the head medical officers of six primary healthcare centres in the municipality to ask whether they have noticed any changes. She finds their telephone numbers at the contact list in one of the annexes of the preparedness plan at her shelf. Those primary healthcare centres placed at the western area of the municipality had noticed an increase in consultations in the previous days.

The MMO enters the electronic-based surveillance system with her username and password, exports some data to conduct some analysis, and realises a three-fold increase in the number of gastroenteritis consultations in the municipality during week 36. She calls the regional health authorities to ask whether they have identified any increase in gastroenteritis cases in any other municipalities of the region, which was not the case.

The MMO hangs up the phone and looks for one of her colleagues at the next door´s office: "*Something is going on, we might have an outbreak in our municipality*".

Questions to participants:

1) Would this chain of events be likely to happen at the municipality/district level of your country? What would be similar? What would be different?

Please, discuss with your group.

(10 minutes)

Facilitator probes

The introductory text to this question presents how a probable outbreak is detected in a municipality and describes certain details of the information in this municipality. It seems that there is a smooth communication channel between primary care centres, hospitals, and the public health authorities at the local level. Also, between the public health authorities at local and regional level. There is a preparedness plan where the municipal medical officer can find relevant information, such us contact details of relevant actors. She has access to the online surveillance system through which she can find relevant information for her municipality. Please, discuss with participants whether they think the chain of events would be similar at the district/municipal level in their countries. You can guide the discussion with additional questions such as

- *Do hospitals have a system in place to notify events to the municipal medical officer at the municipality? What about primary healthcare centres?*
- *Who would report, how and to whom?*
- *Is there a preparedness plan or outbreak guidelines at the local level in which this chain of information sharing and notification is described?*
- *Is there an electronic-based surveillance system through which the municipal medical officer can obtain information on disease notification or consultation levels at the municipality?*

This first question should be used as an introduction to the fictional outbreak and warming up the discussion

The MMO, with the help of the hospital staff, gets the contact details from seven cases and interviews them. Two are admitted in the hospital. After exploring potential common exposures, such as events or gatherings, she does not manage to disentangle common links between the cases. None of them had travelled outside the municipality in previous weeks. However, it draws MMO´s attention that cases live in neighbouring areas in the municipality. The MMO encouraged cases to deliver a stool specimen to the hospital´s lab so that they can be analysed for enteric bacteria, viruses, and parasites.

There had been recent heavy rains and flooding in the municipality. Bearing this in mind, the MMO contacts the municipal water authority, whose contact details are also included in the preparedness plan, to ask if there had been any recent issues with the water-supply system. They inform about an exceedance of acceptable turbidity levels in two samples taken from the water distribution system in the western zone of the municipality some days ago.

Questions to participants:

2) Any hypothesis so far about what is going on?

Please, discuss with your group.

(5 minutes)

Facilitator probes

This second question is an additional introductory question to help break the ice among the members of the group. Please use these five minutes to help the group to wrap up all the relevant details we know until now:

- *No common exposures among the cases*
- *They live in neighbouring areas*
- *Extreme rainfall the previous days*
- *Water quality problems in the western zone of the municipality. This is the same area where primary health care centres identified an increase in gastroenteritis cases*
- *At least two cases are admitted with severe disease.*

II. The outbreak team. Members, roles, responsibilities, and first actions.

Given the available meteorological and water quality information, the MMO suspects that the municipal water supply could be a potential source of the problem and confirms the outbreak. On Friday 14 September, an urgent meeting is organized, and an outbreak team is assembled.

Questions to participants:

3) Who has a role in the response to this outbreak?

Please, discuss with your group.

(15 minutes)

Facilitator probes

In this setting, a multidisciplinary team including epidemiologists, healthcare professionals, microbiologists, environmental engineers, and waterworks personnel is important. All these profiles provide different angles of expertise and a good collaboration among them is paramount to identify what has gone wrong. As waterborne outbreaks can generate high media interest, communication experts are important to maintain an optimal and effective communication to the public

As a reminder you can provide details about the roles

- *Local public health agency, where the MMO is based, will lead the overall coordination of the investigation and response to the outbreak. The national level may provide technical support if needed.*
- *Water authorities will coordinate the environmental investigation*
- *Water suppliers will play an active role in implementing control measures targeting the water-supply system proposed by the public health agency.*
- *Healthcare professionals are responsible for identifying and reporting cases and will lead on case management.*
- *Laboratories test clinical and environmental samples collected during the outbreak and report cases.*

Ideally, professionals representing these roles should know each other from before and have had certain contact during peace team (contact meetings, for instance). It is important that all this is clearly defined in a preparedness plan. This plan should include a description of the different roles of those involved in a waterborne outbreak response and their responsibilities and chains of command. The communication component should also be included.

Please, discuss with participants who would be involved in the response of this outbreak at the district/municipal level in their countries. You can guide the discussion with additional questions such as

- *Does coordination within human and environmental health authorities exist on detection and response to waterborne outbreaks at the local level? Are there mechanisms for information exchange, between municipal medical officers and environmental health officers in this level?*
- *Is this multisectoral collaboration described in a preparedness plan?*

The team implements immediate control measures, including the issue of a precautionary boil water notice that is disseminated via social media.

III. Define cases.

The microorganism causing this outbreak is still unknown and therefore the team formulates the following preliminary possible case definition:

"A person who lives in municipality **XXXX***, with diarrhoea (≥ 3 loose stools in 24 hours) and any one of the following symptoms – abdominal pain, nausea and vomiting – and date of onset of symptoms from 15 August."*

Questions to participants:

4) Why is it important to define cases? What information should be included in a case definition? Any strengths and weaknesses for this case definition?

Please, discuss with your group.

(10 minutes)

Facilitator probes

A case definition is important to be able to decide which cases to include in this outbreak. It should include information on "time", "place" and "person".
Please, discuss advantages and disadvantages of the preliminary case definition that the outbreak team agreed at this point.
Why does the group think investigators chose the date 1st August?
What about travel history? Shouldn't those who had travelled out of the municipality during the relevant period be excluded?

IV. Identify cases and obtain information. Microbiological confirmation

The hospital and primary healthcare centres at the municipality agree to notify to the outbreak team daily gastroenteritis consultations (syndromic surveillance data). The outbreak team develops a list of all cases in a spreadsheet in which they included relevant sociodemographic information. They collect additional epidemiological data on a subset of these cases to help generate hypotheses on the cause of the outbreak.

On Sunday 16 September, the regional laboratory confirms that two of the seven initially tested cases have tested positive for *Cryptosporidium parvum*.

> *"Cryptosporidia are intestinal parasites infecting a variety of animals. Human infections occur due to Cryptosporidium parvum, a species that also affects domestic animals. Person-to-person or animal-to-person disease transmission occurs mainly through contaminated water and food. Cryptosporidium eggs can survive for months in moist soil or water and survive harsh environmental conditions for extended periods of time. In humans, infections without symptoms are common. Especially healthy individuals, may, after an incubation period averaging one week, get a diarrhoea that spontaneously resolves over a couple of weeks. By contrast, patients with impaired immune system may develop profuse, life-threatening, watery diarrhoea.*
>
> *Outbreaks have been reported in hospitals, day-care centres, within households, among bathers (affecting participants in water sports in lakes and swimming pools), and in municipalities with contaminated public water supplies. Water distribution systems are particularly vulnerable to contamination with Cryptosporidium, which can survive most disinfection procedures such as chlorination"*
>
> *(European Centre for Disease Prevention and Control) https://www.ecdc.europa.eu/en/cryptosporidiosis*

The laboratory characterises the specimens to assess if they are genetically identical and enhances *Cryptosporidium* laboratory surveillance testing all specimens routinely collected from gastroenteritis cases in the municipality.

The team updates the case definitions for the outbreak:

***Probable case**: "a person who lives in municipality* **XXXX**, *with diarrhoea (≥ 3 loose stools in 24 hours) and any one of the following symptoms – abdominal pain, nausea, vomiting, anorexia – and date of onset of symptoms from 15 August"*

***Confirmed case**: "a person who lives in municipality* **XXXX**, *with laboratory-confirmed cryptosporidiosis and onset of symptoms from 15 August"*

Questions to participants:

5) What do you think of the adjustments done in the case definition at this point?

Please, discuss with your group.

(5 minutes)

Facilitator probes

Please, discuss advantages and disadvantages of the case definitions that the team agreed at this point.

A proposed case definition for confirmed cases, that includes information on the agent increases precision although it may decrease the number of cases available for the study. This case definition will exclude patients who have not had a sample taken. One potential solution would be to use two case definitions, confirmed and probable case definition.

V. Conduct a descriptive epidemiological investigation (time, place, person)

By the end of week 37, 118 cases of gastroenteritis have been notified. Of these, 96 meet the probable case definition, and two are confirmed cases. The first case started with symptoms on 27th August and the last one on 15th September. All 98 are included in the line list to help to have a good overview. The line list includes the following information: case type, date of onset of symptoms, sex, age, symptoms, hospital admission and residential area. The line list is an spreadsheet that looked like this:

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	ID	Case type	Date	Sex	Age group	Age	Diarrhoea	Adbominal Pain	Nausea	Vomiting	Anorexia	Admission to hospital	Residencial Area
2	1	Probable	27/08/2018	Female	0_4	2	1	1	1	1	0	0	Centre
3	2	Confirmed	29/08/2018	Female	15_24	16	1	1	0	0	0	0	Western
4	3	Probable	30/08/2018	Male	15_24	21	1	0	1	0	0	0	Southern
5	4	Confirmed	01/09/2018	Male	15_24	24	1	1	0	0	0	0	Western
6	5	Probable	01/09/2018	Male	5_14	7	1	1	0	1	0	0	Southern
7	6	Probable	02/09/2018	Male	45-64	47	1	0	1	1	1	0	Southern
8	7	Probable	03/09/2018	Male	25_44	26	1	0	1	1	0	0	Western
9	8	Probable	03/09/2018	Female	25_44	25	1	0	1	1	0	0	Centre
10	9	Probable	03/09/2018	Female	0_4	1	1	1	0	1	1	0	Western

Using the information collected in the line list, the team decides to conduct a descriptive analysis in to better understand what was going on.

For the next three questions you will use Epi-info.

Get started!

You will use the Excel sheet called "descriptive dataset". The first step is to load the data into Epi Info

Open Epi Info→ Click "visual Dashboard"→ Click "set a data source"→ A dialog box will open. Select Excel as the Database type and find the excel file in your computer. Press on "Descriptive dataset$' and click OK. Your dataset is loaded now in Epi-info 7

Descriptive analysis: TIME

Questions to participants:

6) Describe the distribution of cases over time, using Epi-info

(25 minutes)

Epicurve in Epi-info:

Right click on the mouse→ Click "Add analysis gadget"→ Charts→Epi curve chart→Main variable "Date"→OK

Facilitator probes

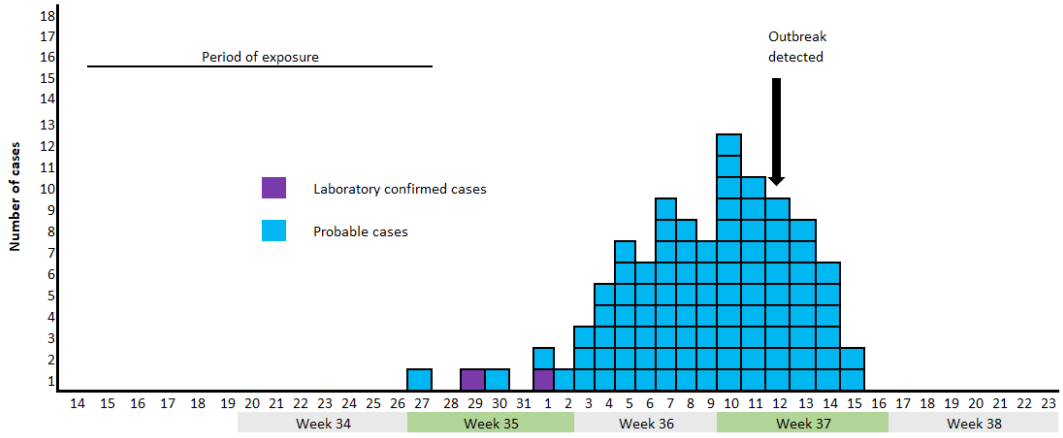
Make sure all group members participate actively in this activity and not only those that own the computer in the group. At least one computer per three members is recommended so that all group members can easily see the screen and follow the process.

Play around and show a bit the different features epi-info has available under the "epi curve chart" part.

- *Section "Variables": different graphs can be designed for different values of a variable. For instance, selecting "sex" in the box "one graph for each value" you can design one epicurve for male and one for female. Step/interval: you can select and visualize different time intervals. Chose the one that suits you better and that provides the best information. By default, you get "Step 1" and "interval" day, which suits well our data. Try, for instance, with "weekly intervals" selecting Step: 7, interval: day. Participants will see that a lot of valuable information is missed.*
- *Section "Grouping and sorting": here you can design an epicurve stratifying by a certain variable of interest. For instance, suggest design one epicurve where you show probable and confirmed cases. You will have to select "stratify by case type"*
- *Section "Display, colours and styles, labels, legend": You can edit your epicurve, including titles, labels, changing colours, size…*

Remind participants that epi-info is a free tool aimed to help to design epi curves but that there are several other options available to design an epi curve, such as excel.

Below you can see how the same epicurve looks designed manually in excel. The first identified case dates from 27 August, so the likely period of exposure is from 15–26 August. The curve shows a continuous common source outbreak.



Descriptive analysis: PERSON

Questions to participants:

7) Describe cases by age, sex, symptoms, and severity. Fill in the table below

(25 minutes)

		Number	Percentage (%)
Case type	Confirmed		
	Probable		
Sex	Female		
	Male		
Age group	0-4		
	5-14		
	15-24		
	25-44		
	45-64		
	≥65		
Symptoms	Diarrhoea		
	Abdominal pain		
	Nausea		
	Anorexia		
	Vomiting		
Hospital admission	Yes		
	No		

Frequencies in Epi-info:

Right click on the mouse→ Click "Add analysis gadget"→ Frequency→Select each of the variables of interest

Facilitator probes

Make sure all group members participate actively on this activity and not only those that own the computer in the group. At least one computer per three members is recommended so that all group members can easily see the screen and follow the process.

If you keep the "Ctrl" pressed while selecting the variables you can select and analyse all variables of interest at once. Epi info provides "counts" and with percent.

		Number	Percentage (%)
Case type	Confirmed	2	2
	Probable	96	98
Sex	Female	52	53,1
	Male	46	46,9
Age group	0-4	11	11,2
	5-14	10	10,2
	15-24	21	21,4
	25-44	28	28,6
	45-64	17	17,6
	≥65	11	11,2
Symptoms	Diarrhoea	98	100
	Abdominal pain	78	80
	Nausea	47	48
	Anorexia	43	44
	Vomiting	36	37
Hospital admission	Yes	14	14,3
	No	84	85,7

There are slightly more women and the most frequent age group is 25–44 years, followed by those aged 15–25 years. All cases have diarrhoea (as per the case definition) and 80% of cases report abdominal pain. 14 patients (14%) have been hospitalized.

Questions to participants:

8) Can you say anything about the severity of disease in the elderly?

(15 minutes)

Epicurve in Epi-info:

Right click on the mouse→ Click "Add analysis gadget"→ Frequency→Select "admission to hospital" in the "variable section" and "age group" in the "Grouping and sorting section"

Facilitator probes

With this question you will take the opportunity to show additional features of analysis by person in Epi-Info. You can conduct stratified descriptive analysis to zoom in a bit more in deep in your data. You have to select the main variable of analysis in the section "Variable section" in Epi-info and the variable you are going so stratify by in the "grouping and sorting section".

For instance, you can see how 50% of all admitted in the hospital are more than 65, pointing towards the fact that the infection is being more severe in this group.

Descriptive analysis: PLACE

The municipality is divided into different geographic zones. For each of the cases, the residence addresses were obtained and plotted on a map of the municipality as shown below:

Fig. CS6. Map of probable and confirmed cases of cryptosporidiosis, Waterfall, weeks 35–37

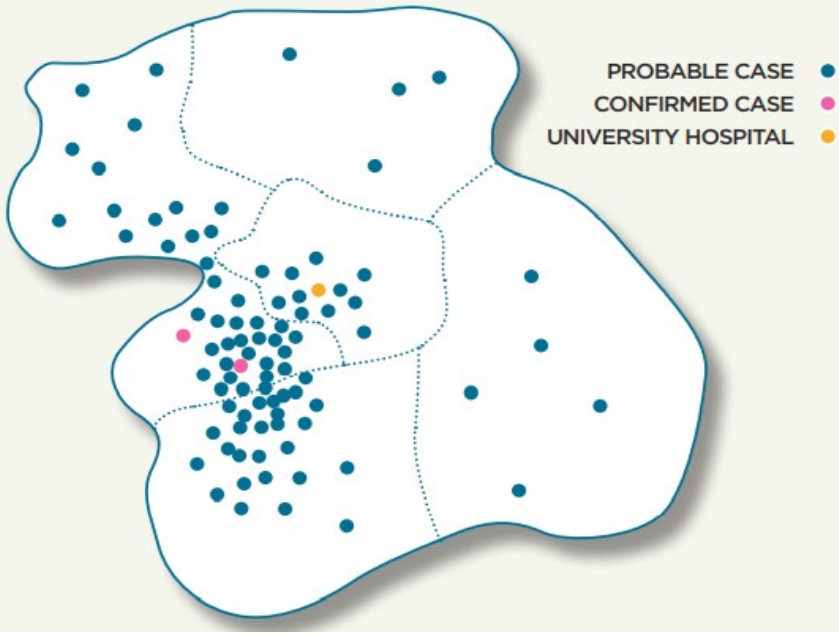


Figure 1 Map of probable and confirmed cases related to the outbreak. Municipality XX. Weeks 35-37

Questions to participants:

9) What does the map tell you? Any additional information you would need to better interpret this map?

(10 minutes)

Facilitator probes

You can see how dots cluster on the western, centre and south of the municipality. However, this map alone is not enough to conclude that there is a risk for disease associated with those areas. What about number of inhabitants in each area? Maybe there are more cases in those areas because those areas are more populated?

And what about our main hypothesis so far about the outbreak being waterborne? How is water distributed in the municipality?

With the help of the town hall, the team finds the number of inhabitants in each zone to be able to calculate attack rates per zone.

Questions to participants:

10) Fill in the table below and interpret the results. Use epi info to extract number of cases per zone.

(25 minutes)

Epicurve in Epi-info:

Right click on the mouse→ Click "Add analysis gadget"→ Frequency→Select "Residential area"

Residential area	Number of cases	Percentage of cases	Total population	Attack rate per 10.000 residents
Centre			13.750	
Western			32.125	
Southern			28.540	
Eastern			24.672	
Northern			36.913	

Facilitator probes

Using epi-info participants can extract the number of cases in each zone. As the table provides the total population per zone it is easy to calculate attack rates per zones

Residential area	Number of cases	Percentage of cases	Total population	Attack rate per 10.000 residents
Centre	11	11	13.750	8
Western	50	51	32.125	15,6
Southern	28	29	28.540	9,8
Eastern	5	5	24.672	2
Northern	4	4	36.913	1

Over 50% of all cases live in the western zone, followed by almost 30% in the southern zone and 11% in the city centre. Few cases have been reported from the northern and eastern zones of the city. The western and southern zones are the most heavily affected by the outbreak with the highest attack rates.

PART TWO. Steps VI-X

VI. Conduct additional studies and collect additional information (environmental, laboratory)

Questions to participants:

11) Would you conduct any environmental investigation in this context?

(5 minutes)

The outbreak team conducts a sanitary inspection and an environmental risk assessment of the water-supply system, including reviewing potential sources of contamination. They checked water-quality data as well as maintenance records for the system since 15 August and collected information on weather events. The municipality is served by two water supplies. The northern and eastern zones are served by water from a groundwater source to the north of the municipality (water supply 1, WS1). The western and southern zones are served by water from a lake to the west of the municipality (water supply 2, WS2). The central area receives water from both. For WS1, water is extracted from an aquifer and piped to a reservoir. The water is chlorinated before entering the distribution system. The water distribution system for WS1 has recently been upgraded and the inspection of the system did not identify any hazards. For WS2, water is extracted from the lake at a depth of 20 meters and is filtered and chlorinated before entering the distribution system. The distribution system for WS2 is quite old, with some parts dating from the 1930s. Some of the pipes are corroded and ingress into the distribution system was identified as a risk at several points in the system. Heavy rainfall occurred in the municipality continuously during three days between 16 and 19 August, which generated flood warnings. A sewage overflow was documented by the municipal authorities on 19 August in the western district of the municipality.

The sanitary inspection of the water supply system identified several contributing factors to the outbreak: a) the heavy rainfall led to likely contamination of the lake with animal waste runoff from surrounding pasture lands; b) the filtration system at the water treatment plant for WS2 temporarily was breached, which likely led to contamination of the treated water with raw water; and c) the sewage overflow may have caused an ingress of contaminated water into the WS2 water distribution system in the western zone.

The team took large water samples (2000 L) from the source water, water-treatment plants, reservoirs and pumping stations, Samples were taken on Saturday 15 September, prior to flushing of the water-supply system. *Cryptosporidium* oocysts were isolated from the lake (25 oocysts/1000 L) and from a pumping station in WS2 (65 oocysts/1000 L). Genotyping revealed that the isolated oocysts were genotype 1.

Facilitator probes

Remind participants about the ***WHO guidelines for Guidelines for drinking-water quality:*** *Cryptosporidium is transmitted by faecal-oral route. The major infection rout is person-to-person contact. Contaminated drinking-water has been associated with outbreaks. The infectivity of Cryptosporidium oocysts is relatively high, ingestion of fewer than 1- oocysts can lead to an infection.*

Guidelines for drinking-water quality: fourth edition incorporating the first addendum. Geneva: World Health Organization; 2017, available at: h*ttps://www.who.int/publications/i/item/9789241549950)*

VII. Generate hypotheses

By the end of week 39, 330 cases have been identified as part of the outbreak, of which 83 are laboratory confirmed as *Cryptosporidium*. A subset of these have been genotyped and confirmed to be genetically identical to the *Cryptosporidium* isolated from the water-supply system.

Questions to participants:

12) If you were part of the team: What would be your main hypothesis so far?

(5 minutes)

Facilitator probes

Take some time to wrap up all the information available so far with the group.

The epidemiological and environmental investigations indicate that contamination of WS2 was the likely source of the outbreak. Therefore, being a case is could likely be associated with residing in a area supplied by/consumption water from WS2.

VIII. Evaluate hypotheses

Questions to participants:

13) Which design would you choose for an epidemiological study in this setting? Discuss strengths and weaknesses of a suitable design.

(10 minutes)

Facilitator probes

A cohort or a case control study could be options in this setting. Please discuss briefly with the group potential ways of conducting each of the designs. Do you guess which one was preferred by the team?

The team decided to conduct a case-control study to identify factors associated with *Cryptosporidium* infection.

Only confirmed cases were included. Three potential secondary cases (those with onset of symptoms between one and 14 days after another case in the same household) were excluded. Controls were selected randomly from the population register for the municipality and matched by sex, age, and water-supply system Two controls were selected for each case. The team sent an SMS with a link to a web-based questionnaire to 80 confirmed cases and 160 controls. The questionnaire included data on water consumption and other risk factors for *Cryptosporidium* infection, such as contact with farm animals or bathing in a swimming pool. Data were collected on exposures from one week before 15 August.

R software (https://www.r-project.org/) was used to conduct the statistical analysis

The table below shows factors associated with *Cryptosporidium* infection

Variable		Adjusted Odds Ratio	95% Confident interval
Residencial zone	Northern	Ref	
	Eastern	1.24	0.52-1.95
	Central	3.13	2.12-4.85
	Southern	7.58	4.93-9.7
	Western	10.44	7.84-13.58
Consumption of water from WS 2	No	Ref	
	Yes	6.53	4.95-8.16

Daily water consumption	<1 glass	Ref	
	1-2 glasses	2.11	0.67-9.2
	3-4 glasses	4.34	0.96-18.10
	≥5 glasses	8.42	1.95-27.34

Questions to participants:

14) Please comment the table above. Which are the factors associated with infection?

(10 minutes)

Facilitator probes

The results of the case-control study indicated that residing in the western or southern zones and consumption of water from WS2 were associated with infection. A dose–response relationship was also found between the volume of water consumed daily and illness.

Those in the western zone were over 10 times more likely, and those in the southern zone almost eight times more likely, to be infected than those in the northern zone. Consumption of water from WS2 was associated with an almost seven-fold increased risk of infection. Those who drank a higher volume of water daily were more likely to get sick

Questions to participants:

15) Using Tillett et al criteria. Which level of evidence does the team have to state that this outbreak is waterborne?

(15 minutes)

Facilitator probes

Tillett et al criteria:

A. Pathogen identified in clinical cases also found in water	B. Water quality failure and/or water-treatment problem of relevance, but outbreak pathogen is not detected in water
C. Evidence from an analytical (case-control or cohort) study demonstrates an association between water and illness	D. Descriptive epidemiology suggests that the outbreak is water-related and excludes obvious alternative explanations

Strongly associated if (A+C) or (A+D) or (B+C); probably associated if (B+D) or C only or A only; possibly associated if B only or D only.

Source: Tillet et al. *(75)* (reproduced with permission from Cambridge University Press).

In this case study, the pathogen has been identified in clinical cases and in water (A) and there is evidence from an analytical (case control) study demonstrating an association between water and illness (C). Descriptive epidemiology suggests that the outbreak is water-related (D)

The current outbreak is strongly associated with water, according to Tillett et al criteria

IX. Implement control measures and risk communication

In addition to the boil water notice issued on 15 September, the entire water-supply system was flushed to eliminate oocysts from the distribution system and disinfection after flushing was conducted. The filtration system was repaired and flushed to eliminate oocysts. Leaking and corroded pipes in the water-distribution system were replaced; Sewage system pipes were improved to enhance their capacity to cope with increased volumes during flooding events.

Advice on hand hygiene and infection control measures was available to the public to prevent secondary transmission within households. The public was regularly informed about the developments in the outbreak investigation

Questions to participants:

16) Communication to the public is key to keep trust and to promptly inform about recommended prevented measures. What communication activities would normally take place in your municipality in a situation like this? What mechanisms could be used to distribute messages?

(15 minutes)

Facilitator probes

Please, discuss with participants how risk communication would be conducted in the district/ municipal level in their countries. You can guide the discussion with additional questions such as

- *Is there a risk communication plan developed at the municipal level? Are there communication experts in outbreak response teams?*
- *Who in the municipality is responsible for communicating with the media? Are the clearance processes?*
- *How is the information disseminated? What channels are used?*
- *Have risk communications strategies been evaluated after public health crisis?*

X. Communication and evaluation of the outbreak response

Throughout the entire investigation, daily status reports were shared among all actors involved. Daily updates were posted on the municipality website and on social media. The team published an outbreak report within one month of declaring the outbreak over, in which several recommendations were included:

- introducing ozonation of raw water to deactivate *Cryptosporidium* in the source water prior to treatment.
- upgrading parts of the distribution system by replacing pipes.
- undertaking work to protect the water filtration system from future flooding.
- introducing a protection zone around the lake within which livestock grazing will be prohibited, to minimize faecal pollution runoff into the source water.
- increasing the frequency of inspection of the water-supply system, including the filtration system, after extreme weather events.
- increasing the frequency of water-testing at all stages of the system during and after extreme weather events.

The team conducted an after-action review of the outbreak and decided to reduce the threshold for reporting water-quality exceedances under event-based surveillance.

Questions to participants:

17) Final question: If this outbreak had occurred in your municipality.... Would things had handled similarly?

Please, identify three strengths, three gaps and three areas for improvement in terms of the response to this outbreak in your municipality.

(30 minutes)

Facilitator probes

Please, help the group to identify three strengths, three gaps and three areas for improvement in terms of the response to this outbreak in their municipality.

Areas to be covered could be preparedness, surveillance, response, laboratory, risk communication, human resources, coordination...