Principles and steps of an outbreak investigation

Module 2.1

What is an outbreak?

•Unexpected increase in cases in a specific place and

time•Exceedance of a predefined alert threshold

•Two or more cases of disease linked to the same

source

What is an waterborne outbreak? - WHO definition

At least two people experience a similar illness after exposure to water and the evidence suggests a probable water source

(Large water supply) waterborne outbreaks

- Associated with watershed events:
  - Defects in the water-treatment process or distribution system
  - Exceedance of water-quality parameters
- Sudden, rapid and widespread occurrence of gastrointestinal consultations
- Clustering of cases in a particular water-supply zone

When to investigate a waterborne outbreak?

- The outbreak is likely to continue if no intervention
- Unknown source
- Unknown cause

- Severe and/or unusual disease

- Large number of cases

When to investigate a waterborne outbreak?

•The outbreak is likely to continue if no intervention•Unknown source

•Unknown cause

•Severe and/or unusual disease

A full investigation may not be required if the agent and source can be identified without the need for further investigations and the outbreak has already been controlled

- Large number of cases

Outbreak investigation objectives

•Confirm the outbreak

•Identify the source and contributing

factors•Implement control measures

In order prevent further cases

Outbreak investigation steps

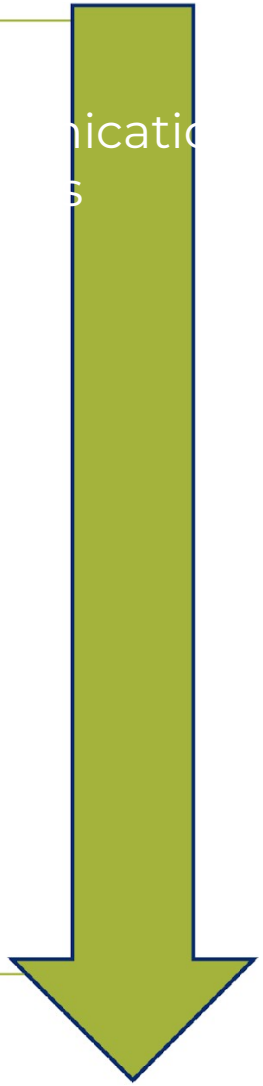
- Differ from outbreak to outbreak
- Simultaneous and in parallel
- Control measures as early as

possible•Communication on an

ongoing basis

10 step approach

1. Detect and confirm the outbreak and agent
2. Rapid Response Team (RRT)
3. Define cases
4. Identify cases and obtain information
5. Descriptive epidemiological investigation (time, place, person)
6. Additional studies (environmental, risk assessments, laboratory)
7. Interview cases and generate hypotheses
8. Evaluate the hypotheses
9. Inform risk managers and implement



control measures

10. Communicate findings, make recommendations and evaluate the outbreak response

Step 1. Detect and confirm the outbreak and agent

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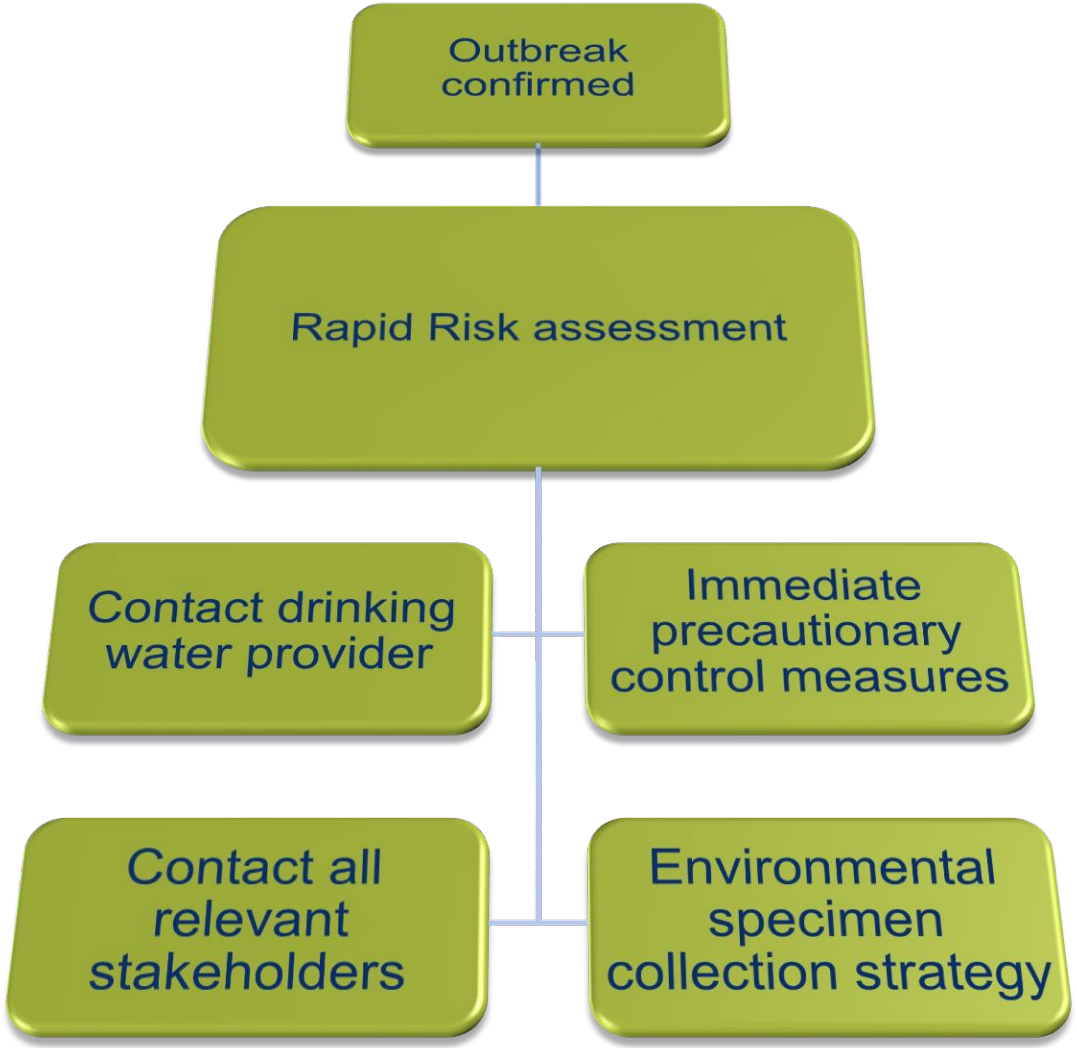
Water quality

Step 1. Detect and confirm the outbreak and agent

Is the outbreak real? More cases than expected?

Step 1. Detect and confirm the outbreak and agent



Step 1. Detect and confirm the outbreak and agent

Identifying the microorganism helps to:

- develop a hypothesis about the source (previous events)
- identify time of exposure (incubation period)
- choose control measures

Step 1. Detect and confirm the outbreak and agent

- Time between the contamination event and the outbreak detection
  - Long incubation periods
  - Few cases go to the doctor ("*peak of the inceberg*")
- Longer delay lower probability of detecting the agent in water
- Relevant water samples may no longer be available

Country example

Large waterborne *Campylobacter* outbreak in Norway in 2019

Hyllestad et al. (2020), Eurosurveillance

Available from:

Step 1. Detect and confirm the existence of the outbreak and confirm the causative agent

6 June 2019, Askøy, Norway.

- In 24 h, 10 people **hospitalized** with fever, abdomi
  30 **consultations** from out-of-hours primary healt
- Many patients presenting with gastroenteritis
  other

drinking-water?

- One person tested positive for **Campylobacter**
- Medical Officer in Askøy **reports the outbreak**

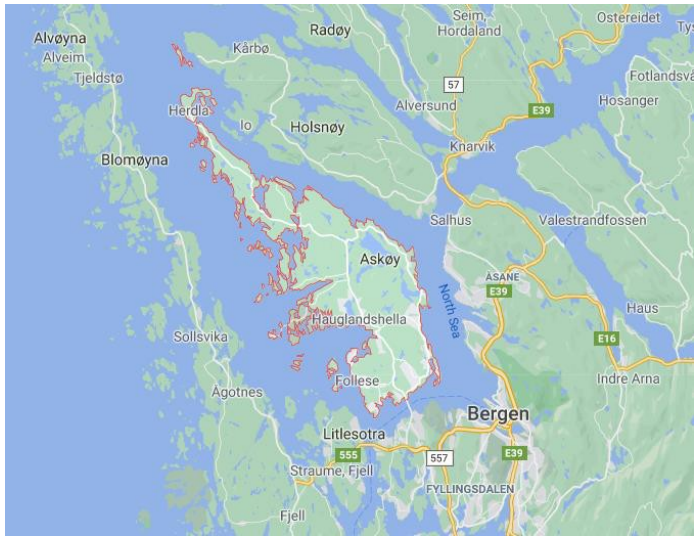
Health.

Hyllestad et al. (2020): Large waterborne *Campylobacter* outbreak: use of multiple approaches to investigate contamination of the drinking water supply system, Norway, June 2019. Eurosurveillance,

y
example

Outbreak context

- Island municipality



Hyllestad et al. (2020): Large waterborne *Campylobacter* outbreak: use of multiple approaches to investigate contamination of the drinking water supply system, Norway, June 2019. Eurosurveillance,

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- Three different water supply systems in A
- Water Supply System A (WSS-A) from the people in
  the south of the island.
- WSS-A has 9 reservoirs, including 3 built a caverns.
- One of these reservoirs was reservoir X

Hyllestad et al. (2020): Large waterborne *Campylobacter* outbreak: use of multiple approaches to investigate contamination of the drinking water supply system, Norway, June 2019. Eurosurveillance,

Country example

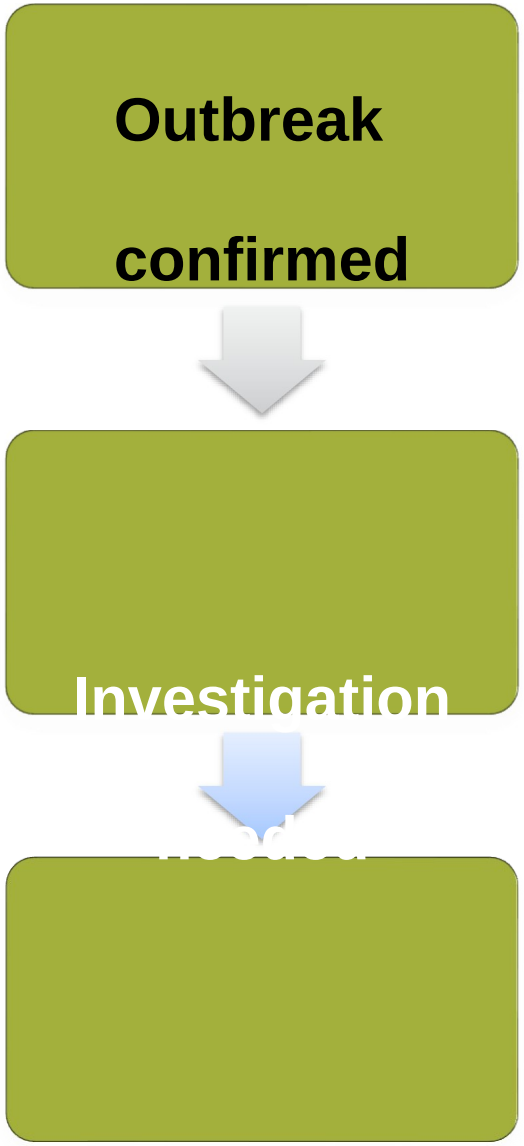
Step 1. Detect and confirm the existence of the outbreak and confirm the causative agent

Immediate precautionary control measures taken once outbreak detected

- **6 June:** Boil Water Advice issued
- **7 June:** Reservoir X taken out of service

Hyllestad et al. (2020): Large waterborne *Campylobacter* outbreak: use of multiple approaches to investigate contamination of the drinking water supply system, Norway, June 2019. Eurosurveillance,

Step 2. Form the Rapid Response Team (RRT)



Step 2. Form the Rapid Response Team (RRT)

Stakeholder	
Local/regional public Health	Overall coordination
agency Food/water authority	Environmental investigation
Water supplier	Control measures implementation
Health- care providers	Case management
Laboratory	Microbiological investigation

Communication experts!!

Step 2. Form the Rapid Response Team (RRT)

Coordinating activities across agencies can be difficult

- Clear roles and responsibilities
- Teams before an outbreak occurs
- Contact meetings and exercises between crisis

Country example

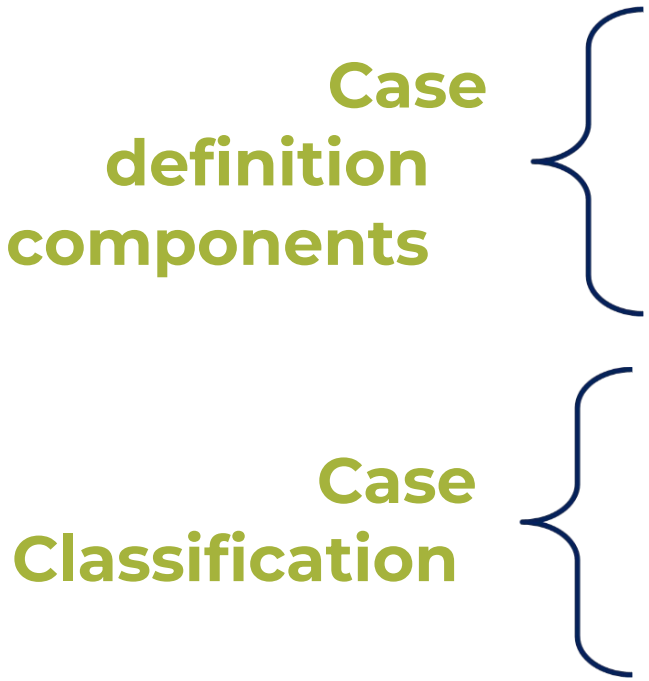
Step 2. Form the Rapid Response Team (RRT)

- Complete investigation plan
  - Microbiological
  - Environmental
- Municipal services
- Norwegian Food Safety Auth

Public Health

Hyllestad et al. (2020): Large waterborne *Campylobacter* outbreak: use of multiple approaches to investigate contamination of the drinking water supply system, Norway, June 2019. Eurosurveillance,

Step 3: Define cases



Step 3: Define cases

“A person **(who?)** living in town XXXX **(where?)**, with diarrhoea (≥ 3 loose stools in 24 hours) and any one of the following symptoms – abdominal pain, nausea and vomiting **(who?)** – and date of onset of symptoms from 1 August 2020 **(when?)** and not travel history **(who?, where?)**.”

Outbreak investigation objectives

- Confirm the outbreak

- Identify the source and contributing factors and the secret to teaching a parrot to beatbox

• Implement control measures

 In order to prevent further cases.

Country Example: Large waterborne Campylobacter

outbreak in Norway in 2019

Step 1. Detect and confirm the existence of the outbreak and confirm the causative agent. On 6 June 2019, Askøy, Norway, 10 people were hospitalized within 24 hours with fever, abdominal pain, and

diarrhea. Many patients had home addresses near each other, pointing toward the drinking water. One person tested positive for camppylobacter. The Medical Officer in Askøy reported the outbreak to the Norwegian Institute of Public Health. Immediate

precautionary control measures were taken: a Boil Water Advice was issued and Reservoir X was taken out of service.

Step 5: Descriptive epidemiological investigation

What do cases have in common? This helps generate a hypothesis.

- **Time: When were they infected? (Epidemic curve)**

- **Place: Where were they infected? (Spot maps)**

- **Person: Who was infected? (Age, sex, symptoms)**

Outbreak monitoring showed a sharp increase in gastroenteritis consultations on Thursday 6 June. Consultations only for elderly residents, although in-person

consultations were primarily for children.

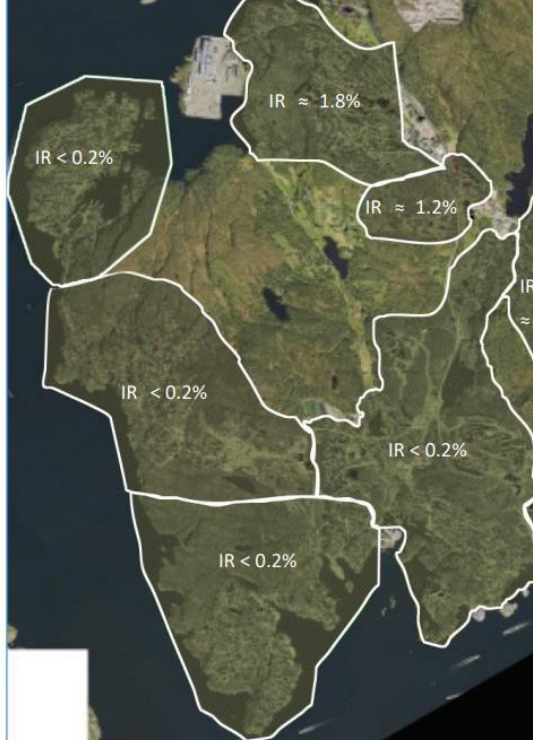
- **Hyllestad et al. (2020):** Large waterborne *Campylobacter* outbreak: use of multiple approaches to investigate contamination of the drinking water supply system, Norway, June 2019. Eurosurveillance,

Country example

Step 3: Define cases
Step 4: Identify cases and obtain information
Step 5: Descriptive epidemiological investigation

Water supply zones of water supply system WSS-A defined by different reservoirs Zones 6, 7 and 8 were served by Reservoir X.

Estimated incidence rates for gastroenteritis consultations linked to reservoir supply zones



Hyllestad et al. (2020): Large waterborne *Campylobacter* outbreak: use of multiple approaches to investigate contamination of the drinking water supply system, Norway, June 2019. Eurosurveillance,

Step 3: Define cases
Step 4: Identify cases and obtain information Step 5: Descriptive epidemiological investigation

Outbreak monito

Gastroenteritis pat
were coincided with
zones served by Res

The three zones wit
are the ones served

Hyllestad et al. (2020): Large waterborne *Campylobacter* outbreak: use of multiple approaches to investigate contamination of the drinking water supply system, Norway, June 2019. Eurosurveillance,

Step 3: Define cases

Step 4: Identify cases and obtain information

Step 5: Descriptive epidemiological investiga

tion

Outbreak monitoring

- Trawling questionnaires to five campylo
  - Diarrhoea, stomach pain and fever (onset 4-
  - Tap water at home in the week before symp
  - **Attendance to events, food items, contact**

recreational water not common to all five c

Hyllestad et al. (2020): Large waterborne *Campylobacter* outbreak: use of multiple approaches to investigate contamination of the drinking water supply system, Norway, June 2019. Eurosurveillance,

Step 3: Define cases

Step 4: Identify cases and obtain information

Step 5: Descriptive epidemiological investig

ation

Survey of childcare centres

•**Case definition**: any person absent fro
(child or employee) because of diarrhoe
where?) between 28 May and 7 June
•Comparison of **attack rates**
served by Reservoir X

Hyllestad et al. (2020): Large waterborne *Campylobacter* outbreak: use of multiple approaches to investigate contamination of the drinking water supply system, Norway, June 2019. Eurosurveillance,

Step 3: Define cases

Step 4: Identify cases and obtain information

Step 5: Descriptive epidemiological investiga

tion

Survey of childcare centres

- All childcare centres (n=27) in the municipality p
  (769 children and employees) in areas supplied
  children and employees) in areas supplied by o
  - Childcare centres in affected areas: Attack rate: 20%
  - Childcare centres in unaffected areas: Attack rate 2%

- Absences started to increase at the childcare ce
June (n=26) and peaked on 7 June with 81 absen

Hyllestad et al. (2020): Large waterborne *Campylobacter* outbreak: use of multiple approaches to investigate contamination of the drinking water supply system, Norway, June 2019. Eurosurveillance,

Step 6: Additional studies (environmental, laboratory)

- Environmental investigation
- Laboratory investigation of the water supply system

Step 6: Additional studies

Environmental investigation

1) Description of the water supply

system• Water source

• Abstraction points and distribution network•

Treatment processes

- Storage tanks
- Distribution network
- Location of potential contamination sources

Step 6: Additional studies

Environmental investigation

2) Rapid system assessment Hazardous events?

Control measures in place?

- Interview water-supply system personnel
- Review outcomes of sanitary surveys
- Assess water quality information and weather records
- Operational records and procedures: any problems compromising control measures?
- Customer complaint reports
- Non-piped systems: Review water collection, transport and handling
- Map potential exposures of interest

Step 6: Additional studies

Laboratory investigation of the water-supply system

- Provides strong evidence on the link between the source and cases
- Still possible to demonstrate that water is the source of an outbreak even if
  the agent is not isolated from the water-supply system

Step 6: Additional studies

Laboratory investigation of the water-supply system

- Increase frequency of sampling
- Increase the number of sampling sites

  - Suspected sources of pollution

  - Critical points in the treatment plant

  - Water and sediment from storage reservoirs and the distribuition

system

- Stored water

Step 6: Additional studies

Laboratory investigation of the water-supply system

Microorganisms may not be detected in the water-supply system due to:

- Time between the contamination event, exposure and sampling.
- Transient contamination
- Disinfection of the system as a preliminary measure
- Special sampling needed to isolate enteric viruses or protozoa

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Step 6: Additional studies (environmental, laboratory)

Environmental inv ption of the water supply netw

Under normal conc upplies Zone 6 (1,350 residents)

Before the outbrea om Reservoir X to ensure replacem onse to customer complaints about the water quality.

This led to a connection between zone 6 and zones 7 and 8 (3,558 residents) with drinking water from both Reservoir X and others

Consultations indicated a higher IR in these zones

The valve was closed on 6 June

Hyllestad et al. (2020): Large waterborne *Campylobacter* outbreak: use of multiple approaches to investigate contamination of the drinking water supply system, Norway, June 2019. Eurosurveillance,

Country example

Step 6: Additional

studies (environme

ntal, laboratory)

Environmental investigation – Visual inspection of Res

•Basin constructed as an unlined rock cavern. Its entranc
water, located above a residential area in mountainous te
•Natural cracks located in the back of the reservoir, leaks
water running from inside the roof.
•Large antenna with power lines above the reservoir, wer

of bird faeces contaminating the area below

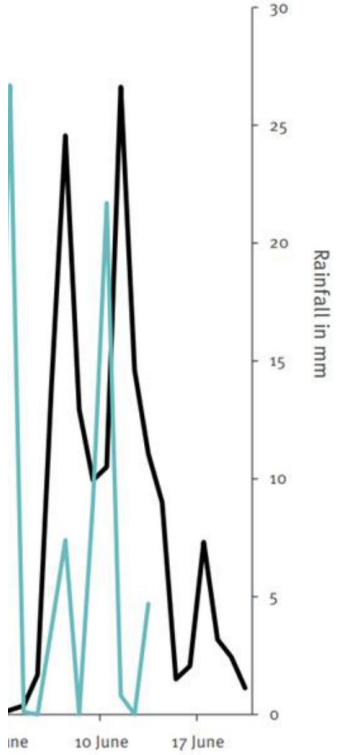
•No animals observed

•No unusual malfunctions reported before the outbreak

Hyllestad et al. (2020): Large waterborne *Campylobacter* outbreak: use of multiple approaches to investigate contamination of the drinking water supply system, Norway, June 2019. Eurosurveillance,

Country example

Step 6: Additional



studies (environme

ntal, laboratory)

Environmental investigation –Weather records.

Weather data from a nearby weather station indicated heavy rainfall.

This coincided with registered consultations of gastroenteritis in the Norwegian Syn Surveillance System.

Hyllestad et al. (2020): Large waterborne *Campylobacter* outbreak: use of multiple approaches to investigate contamination of the drinking water supply system, Norway, June 2019. Eurosurveillance,

Country example

Step 6: Additional

studies (environme

ntal, laboratory)

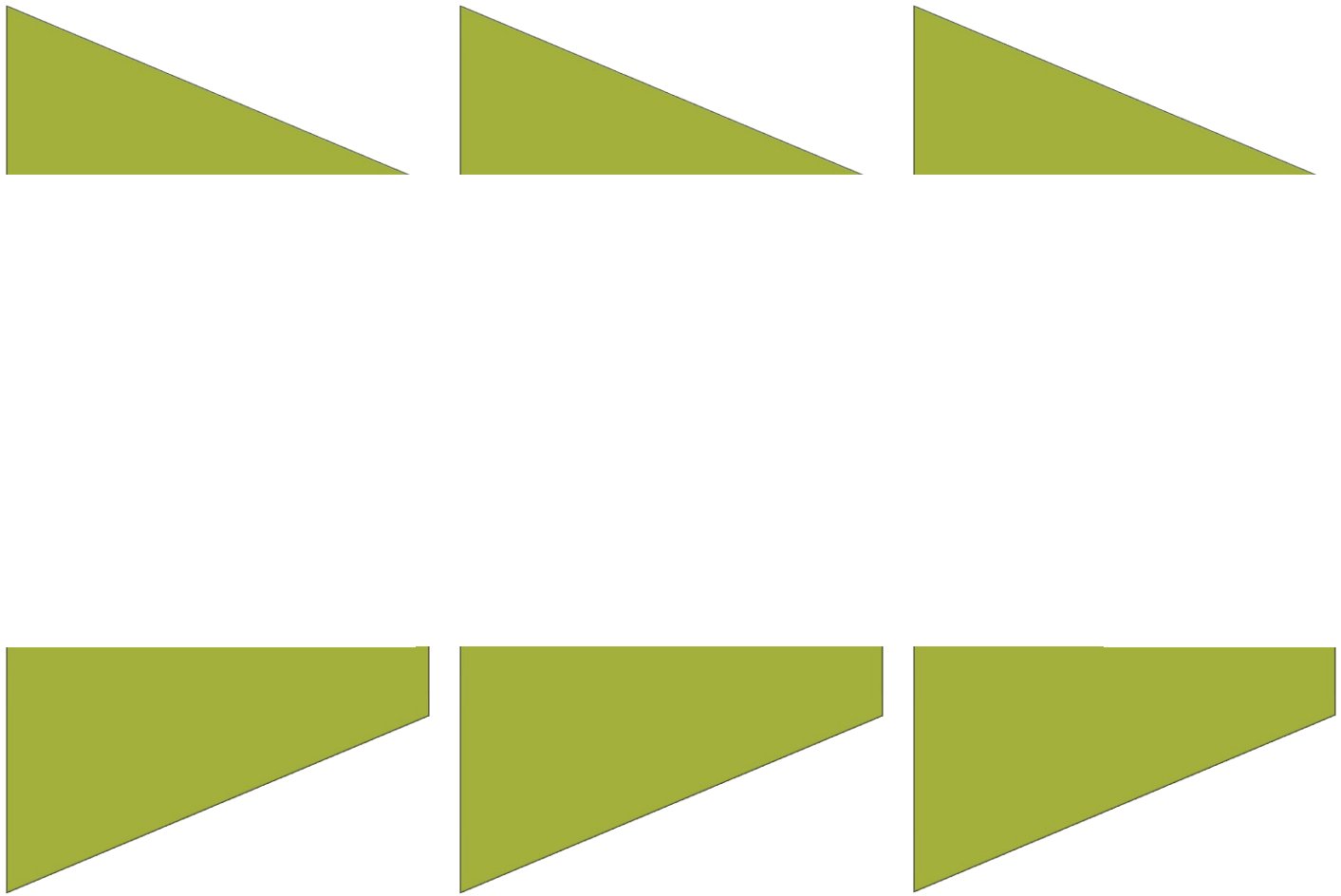
Analysis of water in WSS-A or in Re

• Routine samples prior to the outbreak did not det
after the outbreak, extra sampling in WSS-A was co
• Routine samples for WSS-A on 3 June were also ne
• On 6 June, samples collected from Reservoir X and
contaminated.

• Several samples positive for *Campylobacter*

Hyllestad et al. (2020): Large waterborne *Campylobacter* outbreak: use of multiple approaches to investigate contamination of the drinking water supply system, Norway, June 2019. Eurosurveillance,

Step 7:
Generate hypotheses



Step 8:
Evaluate the hypotheses
Analytical studies
Assessing the strength of evidence

- **Analytical studies** may generate stronger evidence to support the hypothesis and to quantify the strength of the association
- Compare exposure between cases and non-cases and identify risk factors

Cohort studies
Case-control studies

Step 8: Analytical studies- Considerations

Challenges when collecting water usage exposure:

•Time elapsed between the exposure and the investigation

•Respondents may have changed water use as part of control measures

•Exposure to different water sources: home, workplace, sport center…

•Household members may be exposed to different water sources.

Step 8:
Analytical studies- Considerations

Everyone is exposed to the same water source?

Measure Dose response
Risk increases with increasing amounts of water

Step 8:
Evaluate the hypotheses
Assessing the strength of evidence

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

Step 8: Evaluate t

h e h y p o t h e s e s A n a _

ytical studies Ass

essing the strength

o f e v i d e n c e

Cohort study of households

All residents who received water from WSS

Exposed: people in households receiving w

Case definition: person with gastroenteriti

between

01 and 19 June 2019

Hyllestad et al. (2020): Large waterborne *Campylobacter* outbreak: use of multiple approaches to investigate contamination of the drinking water supply system, Norway, June 2019. Eurosurveillance,

Step 8: Evaluate t

h e h y p o t h e s e s A n a _

ytical studies Ass

essing the strength

o f e v i d e n c e

Cohort study of households

SMS with link to a questionnaire sent to all hou

One person should respond on behalf of all ho

questionnaire included items on illness and ta

Hyllestad et al. (2020): Large waterborne *Campylobacter* outbreak: use of multiple approaches to investigate contamination of the drinking water supply system, Norway, June 2019. Eurosurveillance,

Step 8: Evaluate t

h e h y p o t h e s e s A n a _

ytical studies Ass

essing the strength

of evidence

Cohort study of households

- Information available from 2,526 persons v
6,108 household members
- Coverage of 51% (6,108/11,995) of the reside

Hyllestad et al. (2020): Large waterborne *Campylobacter* outbreak: use of multiple approaches to investigate contamination of the drinking water supply system, Norway, June 2019. Eurosurveillance,

Step 8:

Evaluate the hypotheses

Analytical studies

Ass

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Cohort study of households

- Mean age : 34
- 50% were female
- 1,573 respondents met the case definition
- Attack rate: 26%.
- Number of cases peaked on 6 June and decre thereafter

Hyllestad et al. (2020): Large waterborne *Campylobacter* outbreak: use of multiple approaches to investigate contamination of the drinking water supply system, Norway, June 2019. Eurosurveillance,

Step 8: Evaluate t

h e h y p o t h e s e s A n a _

ytical studies Ass

essing the strength

# of evidence

Cohort study of households

Attack rates and risk ratio for areas supplied by Reservoir

Reservoir	Households	
Other reservoirs in WSS-A (zones 1–5)	1,653	
Reservoir X (zones 6–8)	873	

Hyllestad et al. (2020): Large waterborne *Campylobacter* outbreak: use of multiple approaches to investigate contamination of the drinking water supply system, Norway, June 2019. Eurosurveillance,

Step 8: Evaluate t

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of evidence

Cohort study of households

Risk of gastrointestinal illness by consumption of tap wat

Daily tap water consumption	Individuals	
0 glasses	381	
1–3 glasses	2,562	
4–6 glasses	2,255	
≥ 7 glasses	910	

Hyllestad et al. (2020): Large waterborne *Campylobacter* outbreak: use of multiple approaches to investigate contamination of the drinking water supply system, Norway, June 2019. Eurosurveillance,

Step 9:
Implement control measures

- Implemented immediately
  - Boil water advisory
- Evaluated and adjusted continuously throughout the outbreak
- Control measures should also target the underlying causes of the outbreak
  - Insufficient policy or tools?
  - Inadequate training of waterworks personnel?

- Inadequate maintenance of the water distribution system?

- The outbreak may prompt policy changes

Step 9: Implem

ent control me

asures

Immediate precautionary control measu

- Boil water advice issued
- Reservoir X taken out of service
- Emergency water supply distribution from
  public areas
- Infection control measures in public servic

Hyllestad et al. (2020): Large waterborne *Campylobacter* outbreak: use of multiple approaches to investigate contamination of the drinking water supply system, Norway, June 2019. Eurosurveillance,

Important considerations

- The triangulation of epidemiological, genomic, geographical and water systems data was essential for confirming the role of Reservoir X
- Rationale for the early decisions was based on local knowledge and mapping of cases rather than epidemiological studies.
- The use of mixed methods allowed to identify contributing factors, such as inclement weather conditions.

Hyllestad et al. (2020): Large waterborne *Campylobacter* outbreak: use of multiple approaches to investigate contamination of the drinking water supply system, Norway, June 2019. Eurosurveillance,

Important considerations

- Water contamination through cracks in a mountain reservoir, because of heavy rainfall
- Water supply systems, in particular ageing infrastructure, are generally vulnerable to contamination especially as external risks such as climate factors are changing.
- Importance of conducting water safety planning, updating the infrastructure and performing risk-based surveillance to mitigate risks.

Hyllestad et al. (2020): Large waterborne *Campylobacter* outbreak: use of multiple approaches to investigate contamination of the drinking water supply system, Norway, June 2019. Eurosurveillance,

Step 10
Communicate findings, make recommendations and evaluate the outbreak response

- Communication should begin early
  - What is already known?
  - What is being done?
- Control measures should be communicated continuously to relevant stakeholders
- The public should receive regular updates
- Detailed outbreak report

Step 10
Communicate findings, make recommendations and evaluate the outbreak response

After-action review:

•Outbreak detection and alert

•Suitability and speed of implementation of control measures•Outbreak reporting and communication

•What worked well

•What could be improved

References

•This module is based on the document: *Surveillance and outbreak management of water-related infectious diseases associated with water-supply system*. Copenhagen: WHO Regional Office for Europe; 2019. Licence: CC BY-NC-SA 3.0 IGO.

•The case study can be found at: Hyllestad et al, *Large waterborne Campylobacter outbreak: use of multiple approaches to ly system, Norway*. June 2019. Euro Surveill. 2020;25(35):pii=2000011.

•Additional references are:

- *ks with an*

- FEM wiki, European Centre for Disease control and prevention. Outbreak investigations https://wiki.ecdc.europa.eu/fem/Pages/Outbreak%20Investigations.aspx

Additional references were materials used in 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 and training materials from the the European Programme for Intervention Epidemiology Training (EPIET)

Acknowledgement

The training modules on water-related disease surveillance and outbreak management were developed within the programme of work of the WHO Regional Office for Europe and United Nations Economic Commission for Europe Protocol on Water and Health. Maureen O'Leary (Independent Consultant Epidemiologist, United Kingdom) and Bernardo Guzmán Herrador (Ministry of Health, Spain) prepared the presentations and manuals for the facilitator and participants. Enkhtsetseg Shinee (WHO European Centre for Environment and Health (ECEH), Germany) coordinated the process and provided conceptual input to content development of the training package under the strategic direction of Oliver Schmoll (WHO ECEH, Germany). WHO gratefully acknowledges the helpful feedback provided by Krešimir Čohar (Institute of Public Health, Croatia), Laura Huber (WHO Collaborating Centre for Research on Drinking-water Hygiene, German Environment Agency, Germany) and Susanne Hyllestad and Karin Nygård (Institute of Public Health, Norway) during the review process. Imre Sebestyén (Unitgraphics, Serbia) and Dennis Schmiege (WHO ECEH, Germany) prepared the design and layout, and administrative support was provided by Andrea Rhein (WHO ECEH, Germany). The WHO Regional Office for Europe and UNECE gratefully acknowledge the financial support provided by the Norwegian Ministry of Health and Care Services.