Introduction to water-related infectious diseases

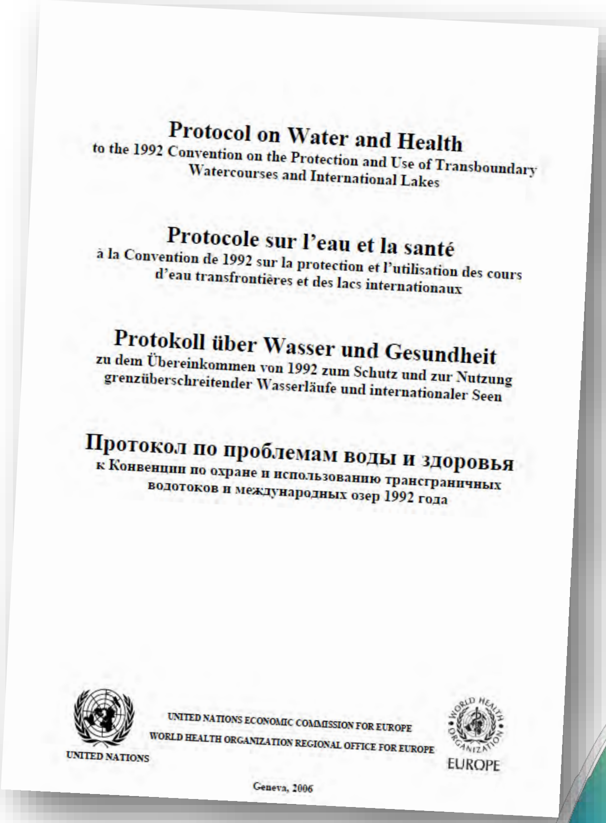
Module 1.1

Overview

- The Protocol on Water and Health and requirements relating to water related disease surveillance and outbreak management
- International Health Regulations (IHR) core requirements:
- Definition of water related infectious disease (WRID)
- Pathogens transmitted through drinking-water
- drinking-water systems as a source of WRID
- Burden of WRID in the European Region
- The need to strengthen WRID surveillance and outbreak management capacity

Protocol on Water and Health

- Article 8:
  - Establish and maintain surveillance and early warning systems
  - Develop national and local contingency plans for responding to outbreaks, incidents and risks
  - Strengthen response capacity
- Article 6.2:
  - Establish and publish targets to reduce WRD outbreaks and incidents
- Article 13:
  - Strengthen transboundary cooperation on early-warning and response systems



Protocol on Water and Health
to the 1992 Convention on the Protection and Use of Transboundary Watercourses and International Lakes

Protocole sur l'eau et la santé
à la Convention de 1992 sur la protection et l'utilisation des cours d'eau transfrontières et des lacs internationaux

Protokoll über Wasser und Gesundheit
zu dem Übereinkommen von 1992 zum Schutz und zur Nutzung grenzüberschreitender Wasserläufe und internationaler Seen

Протокол по проблемам воды и здоровья
к Конвенции по охране и использованию трансграничных водотоков и международных озер 1992 года

UNITED NATIONS

UNITED NATIONS ECONOMIC COMMISSION FOR EUROPE
WORLD HEALTH ORGANIZATION REGIONAL OFFICE FOR EUROPE

EUROPE

Geneva, 2006

IHR Core Capacity Requirements

Core Capacity	Component	Indicator
Surveillance	Indicator-based surveillance	Early warning function for the early detection of a public health event
	Event-based surveillance	Established and functioning
Response	Rapid response capacity	Public health emergency response mechanisms are established and functioning
Preparedness	Public Health Emergency Preparedness and Response	Multi-hazard National Public Health Emergency Preparedness and Response Plan developed and Implemented
Risk communicatio n	Policy and procedures for public communication	Mechanisms for effective risk communication during a public health emergency are established and functioning

WHO (2017): IHR Core Capacity Monitoring Framework Questionnaire for Monitoring Progress in the Implementation of IHR Core Capacities in States Parties, https://apps.who.int/iris/handle/10665/246237

2030 Agenda for Sustainable Development

- *Ensure healthy lives and promote well-being for all at all ages*

- **Target 3.3**: By 2030, (...) **combat** hepatitis, **water-borne diseases** and other communicable diseases
- **Target 3.9:** By 2030, substantially **reduce** the number of **deaths and illnesses** from (...) **water** and soil **pollution** and contamination

- *Ensure availability and sustainable management of water and sanitation for all*

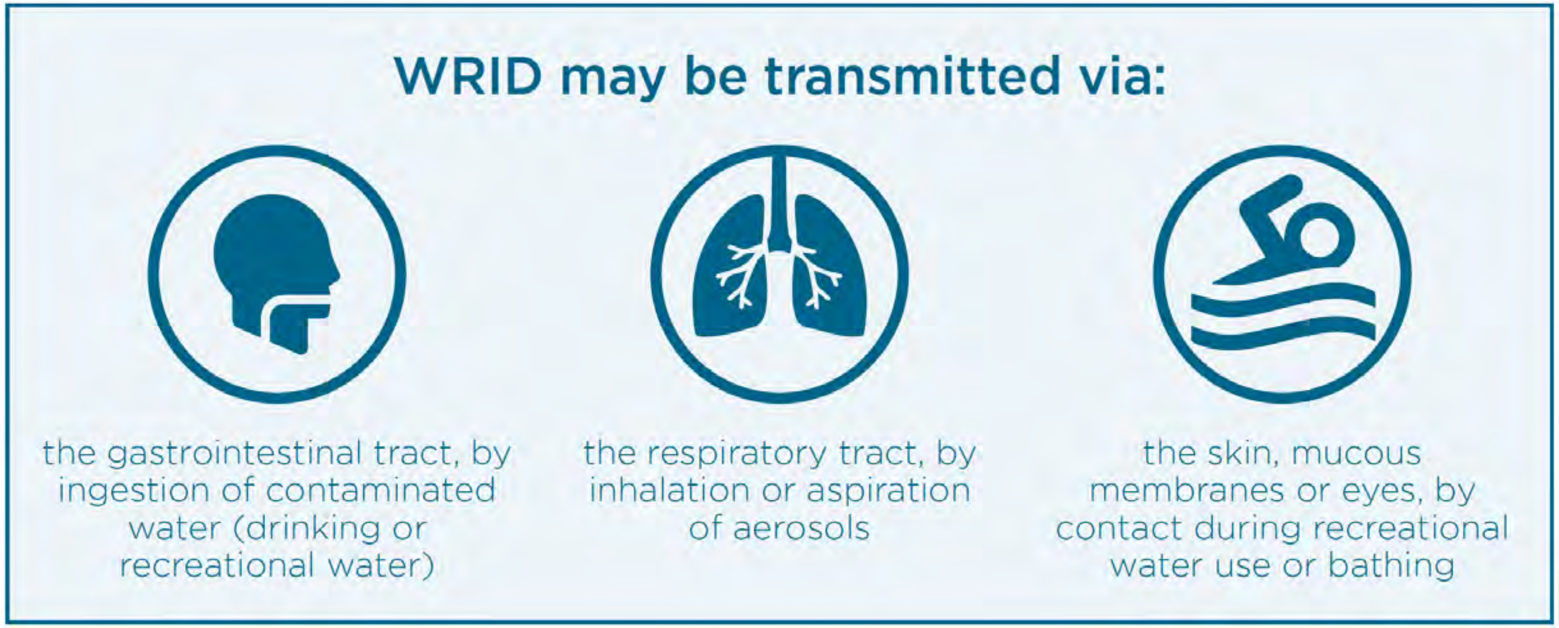
- **Target 6.1:** By 2030, achieve universal and equitable access to **safe** and affordable **drinking-water** for all
- **Target 6.2:** By 2030, achieve access to **adequate and equitable sanitation and hygiene** for all (...), paying special attention to the needs of women and girls (...)

Quiz

How are water-related infectious diseases transmitted?

What are water-related infectious diseases?

- Water-related disease
  - adverse effect on human health caused by the condition of water
  - Infectious or non-infectious



Classification of WRID

Category	Description	Examples
Water-borne	Ingestion of pathogens in contaminated water	Typhoid, legionellosis, poliomyelitis
Water-washed a) Skin and eyes b) Diarr1hoeal diseases	Poor hygiene / lack of access to safe water	Scabies, trachoma, bacillary dysentery
Water-based a) Skin penetration b) Ingested	Infection by agents that spend part of their life-cycle in water	Schistosomiasis
Water-related vectors a) Biting near water b) Breeding in water	Spread by vectors that breed or bite near water	Malaria, West Nile Fever

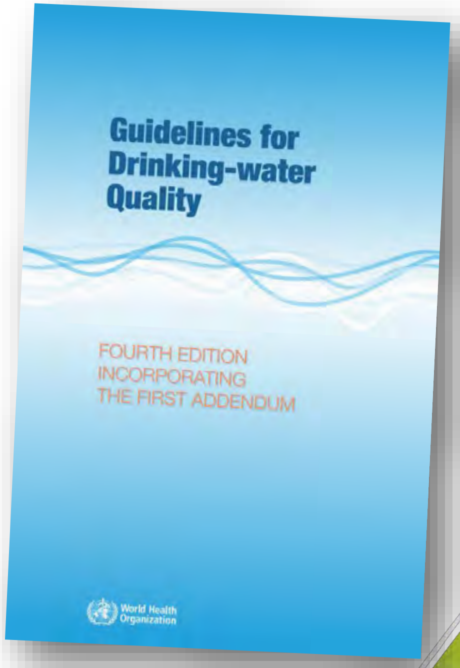
Primary agents of infectious waterborne outbreaks

Bacteria	Viruses	Protozoa
Campylobacter jejuni	Hepatitis A virus	*Balantidium coli*
Escherichia coli	Norovirus	*Cryptosporidium* spec.
Helicobacter pylori	Rotavirus	*Cyclospora cayetanensis*
Legionella spec.	Adenovirus	*Entamoeba histolytica*
Leptospira spec.	Enterovirus	*Giardia* spec.
Mycobacterium spec.	Astrovirus	*Naegleria fowleri*
Salmonella enterica		
Shigella spec.		
Vibrio cholerae		

Pathogens transmitted through drinking-water

Table 2. Pathogens transmitted through drinking-water[a]

Pathogen	Type species/ genus/group[b]	Health significance[c]	Persistence in water supplies[d]	Resistance to chlorine[e]	Relative infectivity[f]	Important animal source
Bacteria						
Burkholderia	*B. pseudomallei*	High	May multiply	Low	Low	No
Campylobacter	*C. coli* *C. jejuni*	High	Moderate	Low	Moderate	Yes
Escherichia coli – diarrhoeagenic[g]	-	High	Moderate	Low	Low	Yes
E. coli – enterohaemorrhagic	*E. coli O157*	High	Moderate	Low	High	Yes
Francisella	*F. tularensis*	High	Long	Moderate	High	Yes
Legionella	*L. pneumophila*	High	May multiply	Low	Moderate	No



Camplyobacter spp

- Important cause of acute gastroenteritis worldwide and in the European region.
- *C. jejuni, C. coli, C. laridis and C. fetus*
- Incubation period: 2-4 days; illness duration 3-7 days
- Symptoms: abdominal pain, diarrhoea (sometimes bloody), vomiting, chills and fever
- Reactive arthritis, meningitis and Guillain Barre syndrome
- Reservoir: Poultry, wild birds, cattle and pets.
- Waterborne outbreaks
  - Faecal contamination of water storage reservoirs with bird faeces
  - Consumption of inadequately treated surface water

Shigella

- *S. dysenteriae*, *S. flexneri*, *S. boydii* and *S. sonnei*.
- Abdominal cramps, fever and water diarrhoea; bacillary dysentery is characterized by bloody diarrhoea.
- Incubation period: 24-72 hours
- Faecal-oral transmission through person-to-person contact, contaminated food, water and flies
- Waterborne outbreaks are occurring more frequently due to faecally contaminated drinking-water.
- Control of Shigella in drinking-water is of special public health importance
- Sensitive to disinfection

Legionella

- *L. pneumophila* is responsible for most human infections: Legionellosis
  - Legionnaires' disease
  - Pontiac fever
- Infection through inhalation of aerosols containing the bacteria (showers, jacuzzi, sinks and cooling towers etc.)

In rare cases transmitted by aspiration

- Risk management strategies in high-risk settings:
  - Temperature control (in cold water systems $<20^{\circ}$C; in hot water systems $>55^{\circ}$C)
  - Disinfection
  - Minimise biofilm growth

Hepatitis A virus

- Highly infectious with a low infectious dose
- Average incubation period 28-30 days
- Mostly asymptomatic, disease severity increases with age
- Hepatitis A / infectious hepatitis – sudden onset, fever, malaise, nausea, anorexia, abdominal pain, jaundice and liver damage – prolonged illness
- Mortality <1%
- Source: faecally contaminated food and water
- Person to person and faecal oral transmission most common
- Strong evidence of waterborne transmission
- Highly resistant to disinfection → *E. coli or thermotolerant coliforms are not a reliable indicator of the presence/absence of HAV in drinking-water supplies.*

Hepatitis E

- Much less widespread and mostly confined to tropical and subtropical areas. It has caused large waterborne outbreaks
  - Recent evidence indicates that HEV might also be prevalent at a low level in Europe.
- Infection can be more severe than, HAV, increased mortality in pregnant women

Norovirus

- **90% of epidemic nonbacterial outbreaks** of gastroenteritis worldwide
- Usually self-limiting- severe illness is rare
- Transmission:
  - Faecally contaminated food or water
  - Person-to-person
  - Aerosolization of vomited virus and subsequent contamination of surfaces
- Outbreaks often occur in closed communities
  - Long-term care facilities, overnight camps, mass gatherings, hospitals, schools, prisons, dormitories and cruise ships

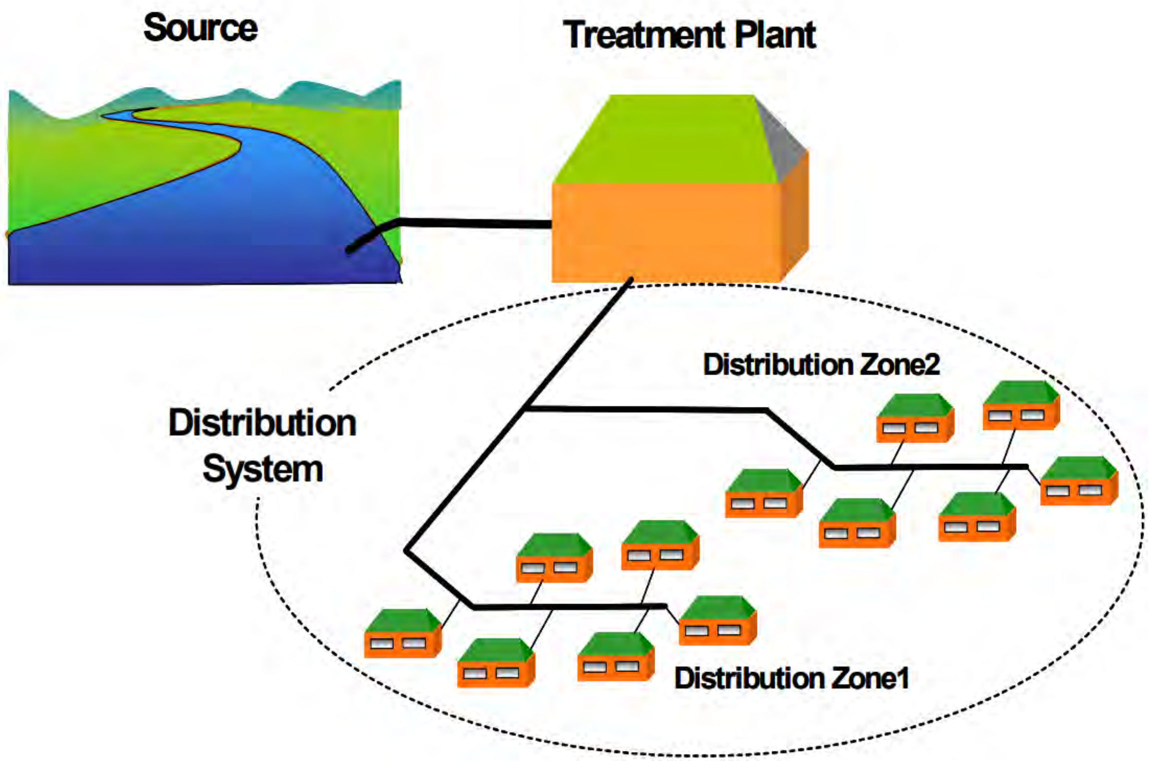
Cryptosporidium

- 13 species – C. hominis and C. parvum predominant in humans
- Self-limiting abdominal pain and diarrhea (1 week on average); can be prolonged and severe in immunosuppressed
- Large waterborne outbreaks, and outbreaks associated with visiting farms and contact with animals
- Oocysts shed in faeces can survive for weeks or months in fresh water
- Faecal oral and person to person transmission; consumption of contaminated food and water and transmission from animals.
- Highly infectious – 10 oocysts
- Resistant to disinfection → *E.coli or thermotolerant coliforms are not a reliable indicator of their presence/absence.*
- UV radiation inactivates oocysts.

Giardia

- Giardiasis – G. intestinalis/G. lamblia or G. duodenalis
- Diarrhoea, abdominal cramps and malabsorption deficiencies
- Self-limiting illness, but prolonged illness can occur
- Asymptomatic carriage is common
- Cysts are shed in faeces; prolonged survival of cysts in fresh water
- Infectious dose <10 cysts
- Person to person transmission, contaminated drinking-water, recreational water and food
- Well established source of waterborne outbreaks
- Resistant to disinfection → *E.coli or thermotolerant coliforms are not a reliable indicator of their presence/absence.*

Drinking-water systems as a source of WRID

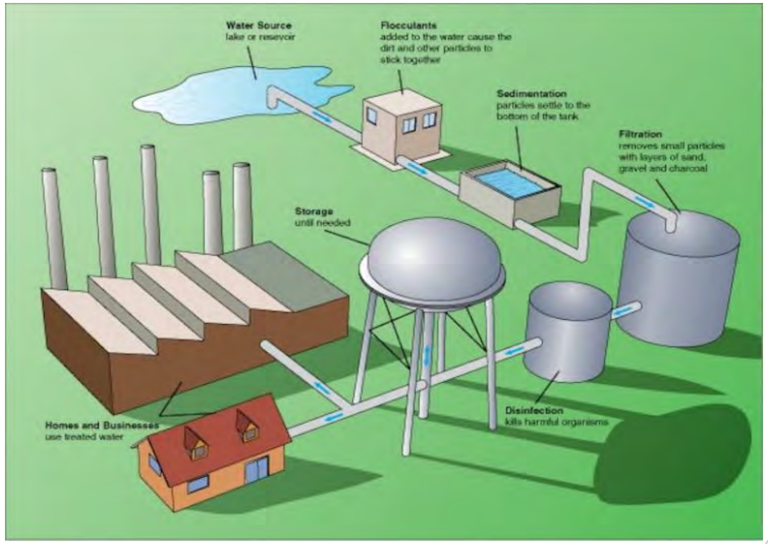


Nokes (2008): A Guide to the Ministry of Health Drinking-water Standards for New Zealand, https://environment.govt.nz/assets/Publications/Files/guide-moh-drinking-water-standards-nz-jun08.pdf

Hazardous events at different points of the water supply system

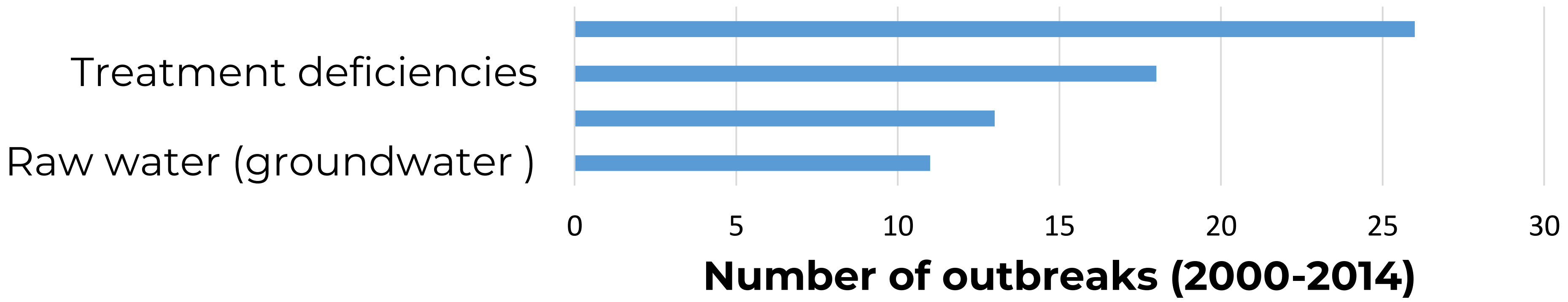
Point of contamination	Examples of hazardous events
Source water (surface or groundwater)	• Runoff of animal and human waste and sewage during wet weather • Leakage of faecal matter from on-site sanitation or damaged sewers
Treatment system	• Inundation of filtration beds with contaminated water during flooding • Failures in treatment (e.g. coagulation, filtration and/or disinfection processes
Distribution system	• Ingress of contaminated water from the environment through cracked or eroded pipes, especially during pressure drops • Cross-contamination of drinking-water systems with wastewater, rain water etc • Unhygienic conditions of containers carrying water from source to home
Storage system	• Faecal contamination of water stored in reservoirs and storage tanks

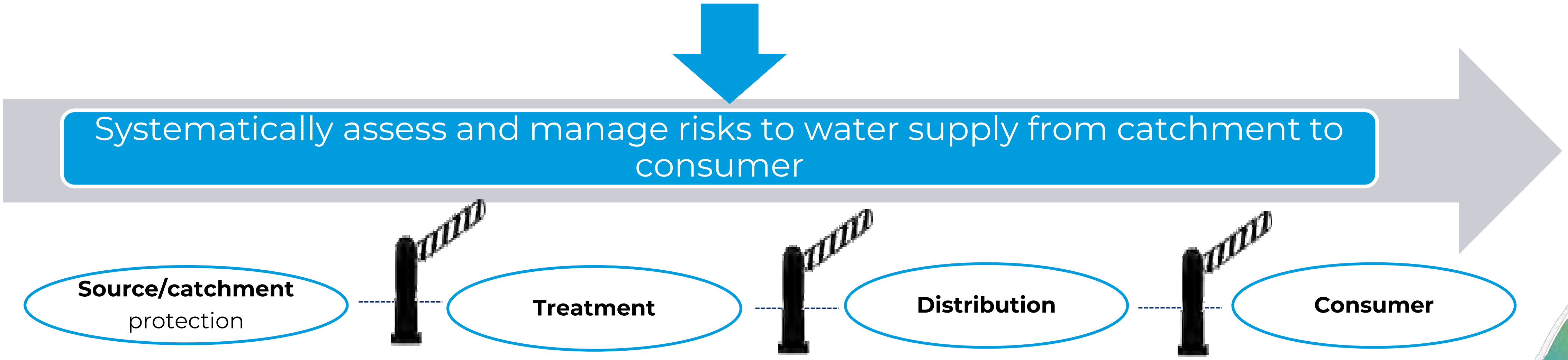
The water treatment and distribution process



Source: https://interestingengineering.com/dirty-clean-how-water-treatment-plant-works

Drinking-water systems as cause of WRID outbreaks





Moreira and Bondelind (2017): Safe drinking water and waterborne outbreaks. Journal of Water & Health, https://doi.org/10.2166/wh.2016.103

Water safety plans

- Best way to ensure a safe drinking-water supply
- Identify hazards and events (e.g. technical defects, malpractices, accidents, natural causes) that pose a risk to the supply system or fail to remove them

- Multi-barriers to contamination
  - Preventing hazards entering to water system (*catchment*)
  - Removing hazards from the water (*treatment*)
  - Preventing re-occurrence (*storage and distribution*)

Burden of WRID in the European Region

- Estimated 2700 deaths due to WASH related diarrhoea in 2016 which indicates 7 people die every day (WHO, 2019)
- The diseases with the highest number of reported outbreaks are shigellosis, E. coli diarrhoea, hepatitis A and cryptosporidiosis*
- Available data do not allow to distinguish the transmission routes (water, sanitation or food)
- Under-reporting of outbreaks to insufficient surveillance and outbreak investigation capacity

***Global Infectious Disease and Epidemiology Online Network,** data for 2010-2021 https://www.gideononline.com/

Waterborne outbreaks in Europe, 2000 - 2013

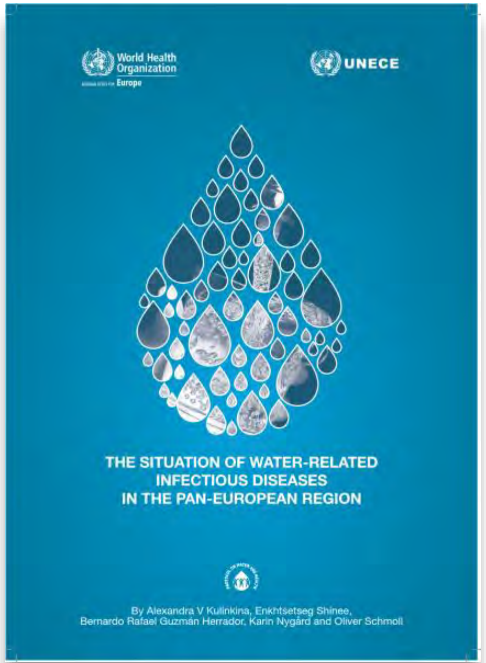


Table 4. Outbreaks attributed to water according to publications in GIDEON (2000–2013)

Disease	Outbreaks linked to water	Number of outbreaks	Proportion linked to water (%)	Countries	Most common sources
Legionellosis	37	100	37	15	Drinking-water, water heater, cooling tower, spa
Gastroenteritis – viral	24	206	12	12	Drinking-water, swimming area, spa
Cryptosporidiosis	20	50	40	6	Drinking-water, swimming pool
Hepatitis A	18	155	12	8	Drinking-water, sauna
Campylobacteriosis	14	45	31	11	Drinking-water
Leptospirosis	13	21	62	8	Drinking-water, outdoor recreational area
Rotavirus	10	37	27	7	Drinking-water
Shigellosis	9	64	14	8	Drinking-water, fountain
Typhoid and other enteric fever	9	38	24	4	Drinking-water
Tularaemia	8	42	19	4	Drinking-water
E. coli diarrhoea	5	109	5	4	Drinking-water, swimming pool
Giardiasis	5	14	36	5	Drinking-water

Global Infectious Disease and Epidemiology Online Network,
https://www.gideononline.com/

Viral gastroenteritis

Example: Prague experienced large waterborne outbreak of norovirus infection (estimated 11,000 to 12,000 cases) caused by cross contamination resulting from breakages of water and sewage pipes (2015)

Number of people with vomit illness symptoms grows at 2018 Olympic Games

Rachel Axon | USA TODAY Sports
Published 9:27 p.m. UTC Feb 7, 2018

Norovirus sickens 39 in Spain with link to mussels

By Joseph James Whitworth
16-Apr-2018 - Last updated on 16-Apr-2018 at 11:44 GMT

Burden of mortality

- Burden of disease ≠ burden of mortality
  - *the **burden of disease** caused by pathogens transmitted by the faecal oral route is greatest, BUT*
  - *the **burden of mortality** may be caused by pathogens transmitted by other routes is greatest*
- Legionella, pseudomonas and non-tuberculus mycobacteria
  - Caused 91% of WRID deaths in the USA between 2003 and 2009
- Germany: >3 deaths every day due to legionellosis

Table 2 | Average annual number of deaths[a], NVSS, 2003–2009

Infection	Number with underlying cause	Number with any cause
Transmission by fecal–oral route		
Campylobacter	1	2
Cryptosporidium	2	9
E. coli	3	5
Giardia	1	2
Hepatitis A	41	103
Salmonella	34	53
Shigella	4	6
Transmission by other routes		
Free-living amebae	2	2
Legionnaires' disease	87	109
NTM	263	551
MAC[b]		
Pulmonary NTM	215	439
Otitis externa	4	14
Pseudomonas	285	1,019
Pneumonia	285	1,019
Septicemia[b]		
Vibrio	1	2

[a]Includes all deaths occurring in the United States regardless of location, i.e., in-hospital and out-of-hospital deaths.
[b]*Pseudomonas* septicemia and MAC were not listed as valid causes-of-death in the ICD-10 coding system.

Gargano et al. (2017): Mortality from selected diseases that can be transmitted by water – United States, 2003–2009. Journal of Water & Health, https://doi.org/10.2166/wh.2017.301

Outbreaks of legionellosis in Europe, 2010 – 2021 (published data)

Causes	Publications
Cooling tower	29
Water supply system	11
Multiple	5
Spa, pool	4
Wastewater treatment plant	3
Fountain	2
Shower	2
Others	10

Drivers of WRID in the pan-European region

- Emergence and re-emergence of pathogens: Cryptosporidium parvum and Legionella pneumophila
- Climate change and international travel
  - Geographic dissemination of WRID pathogens to new areas – Giardia lamblia
- Small scale and community operated water and sanitation systems
  - Vulnerable to environmental contamination
  - Untreated or insufficiently treated ground or surface water
- Changes in how water is used
- Increasing age and number of immunodeficient persons

Surveillance and outbreak management capacity in the pan-European region

- Passive surveillance of a limited number of pathogens
- Wide variation in number and types of pathogens, diseases and events under surveillance
- Variable sampling, laboratory testing and reporting protocols
- Limited routine testing of enteric pathogens; less testing of viruses and parasites
- Under-ascertainment of uncommon pathogens and those not covered by surveillance
- Limited laboratory capacity for testing
- Limited human and financial resources for surveillance and outbreak response
- Limited epidemiological capacity to investigate source of infection – cases not categorised as water-related

Surveillance and outbreak management capacity cont.

- Foodborne versus waterborne
- No standard definition of an outbreak and thresholds for outbreak detection not defined
- Inadequate early-warning and response systems
- Inadequate communication and coordination between public health agencies, water providers and those responsible for monitoring water quality

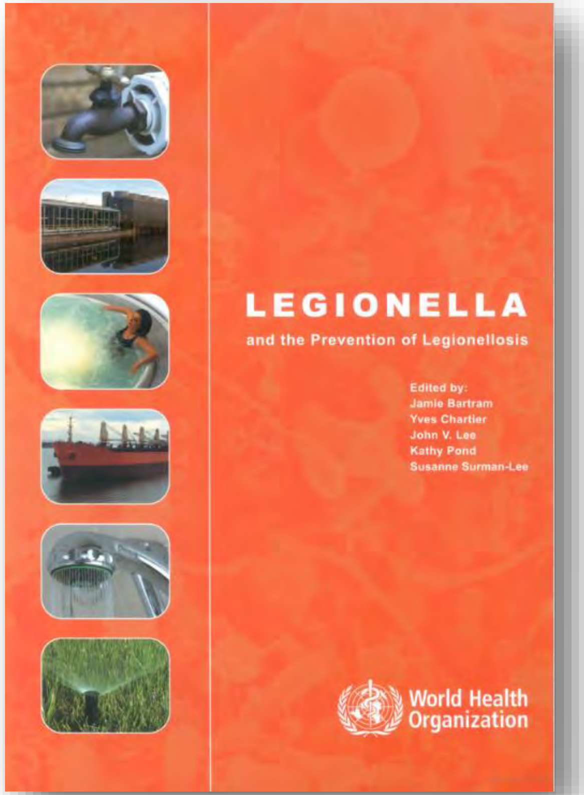
The need to strengthen WRID surveillance and outbreak management capacity

- Surveillance and outbreak response procedures need to be harmonised and strengthened in order to:
  - Generate more robust data on the true burden of WRID
  - Generate data on the causes of outbreaks

→ *Inform investments in water supply systems*

→ *Inform public health action to control WRID*

Useful references for further reading



WHO (2017): Legionella and the prevention of legionellosis. https://apps.who.int/iris/handle/10665/43233

ESGLI (2017): European Technical Guidelines for the Prevention, Control and Investigation of Infections caused by Legionella species, June 2017. , https://www.ecdc.europa.eu/en/publications-data/european-technical-guidelines-prevention-control-and-investigation-infections

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Surveillance of water-related infectious diseases

Module 1.2

Overview

- What is disease surveillance?
- WRID surveillance objectives
- Core activities and building blocks of surveillance
- The epidemic intelligence framework and different types of surveillance
- Surveillance attributes
- How to strengthen WRID surveillance?

What is disease surveillance?

- Ongoing systematic collection, analysis and interpretation of health-related data
  - *for use in planning, implementing and evaluating public health policies and practices*

- Right information at the right time to inform public health decision making

WRID surveillance objectives

- Monitor trends over time
- Detect outbreaks
- Identify new, emerging or re-emerging pathogens
- Estimate WRID burden
- Identify at-risk groups, populations and areas → target control and prevention measures
- Identify priorities for drinking water supply system improvement
- Assess effectiveness of control measures
- Inform water quality and WRID policies and regulations

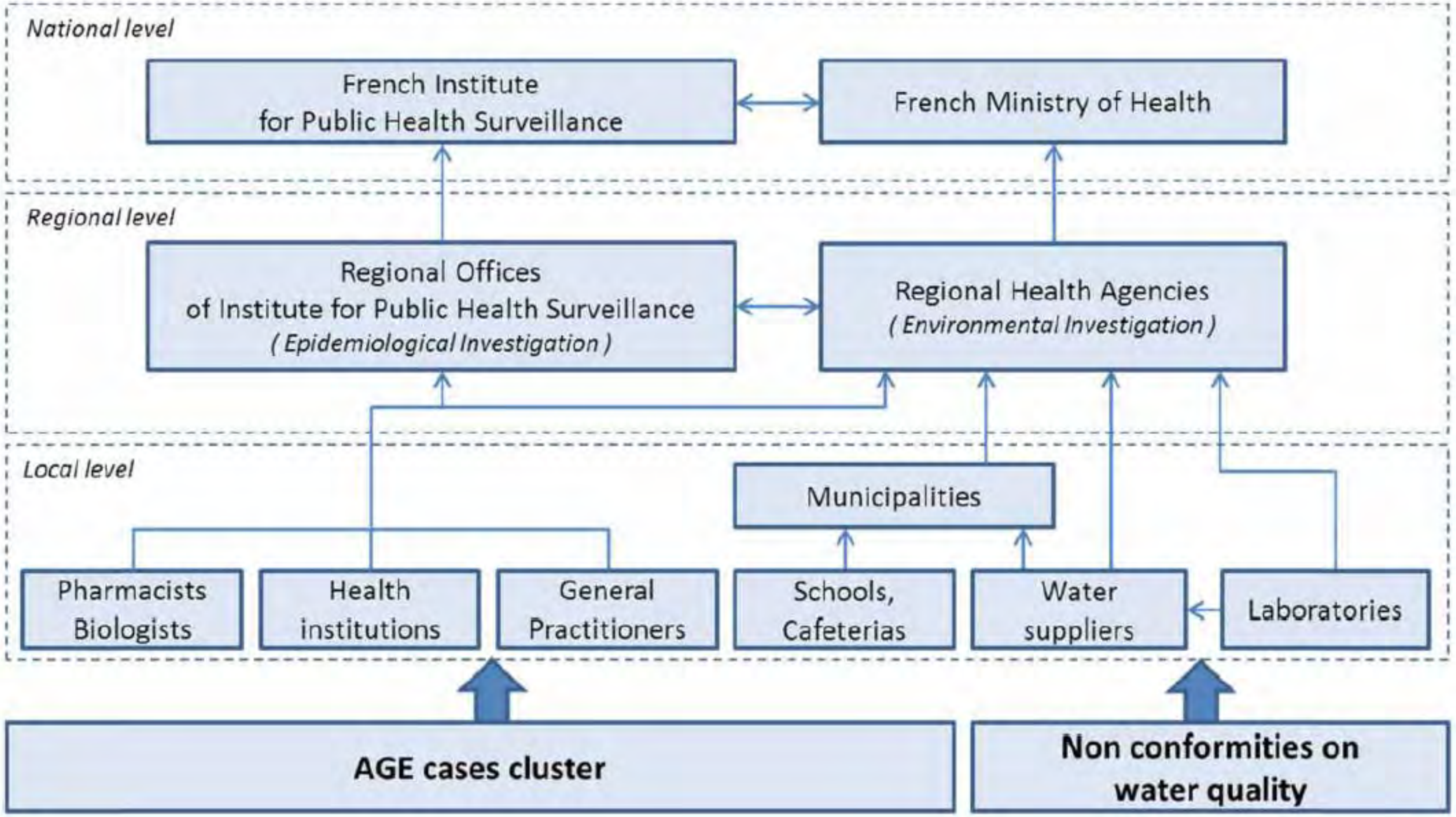
Ideally WRID surveillance will:

- Integrate monitoring of health outcomes with monitoring of drinking water quality and environmental contamination events
- Involve strong co-ordination and collaboration between:
  - Public health surveillance agencies
  - Drinking water service providers
  - Regulators
  - Environmental agencies

→ *timely sharing of information on water supply incidents and water-related outbreaks*

- Operate at the national and sub-national (regional and local) level

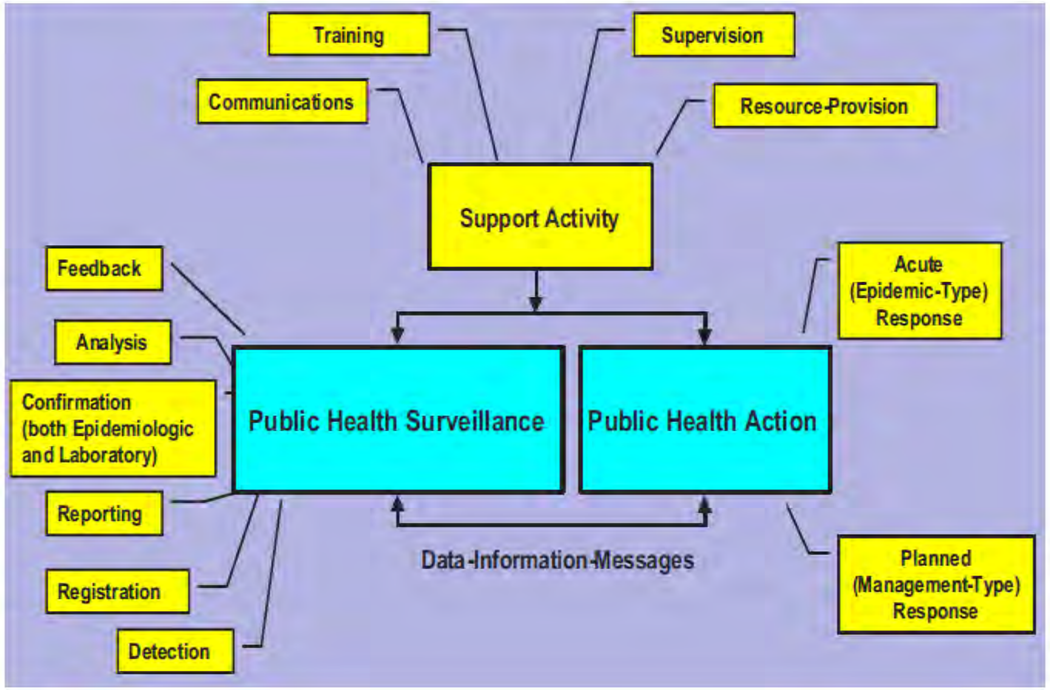
Multilevel approach to WRID surveillance – example France



Rambaud et al. (2016): Automated detection of case clusters of waterborne acute gastroenteritis from health insurance data – pilot study in three French districts. Journal of Water & Health, https://doi.org/10.2166/wh.2015.135

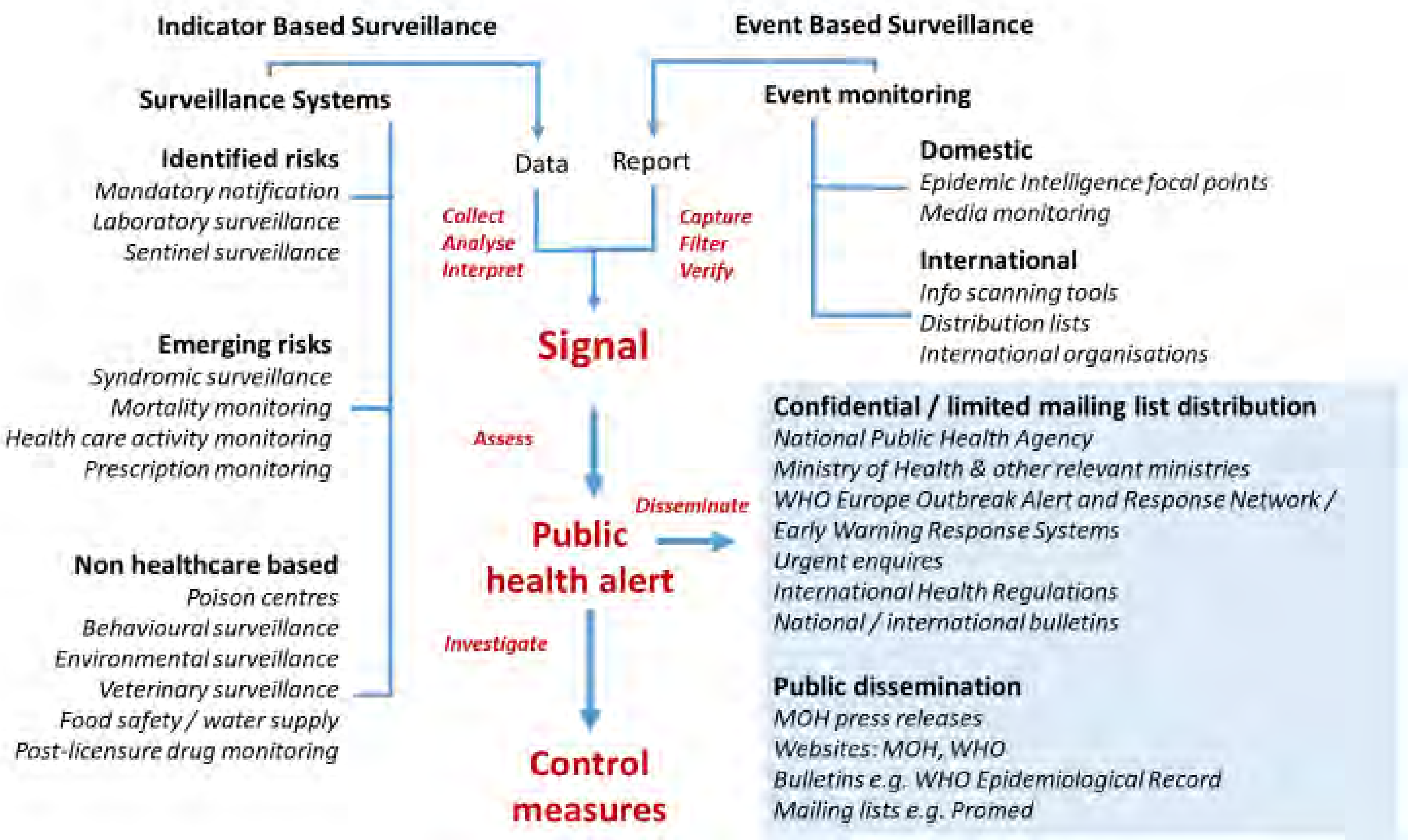
Core activities and building blocks of surveillance

- Core surveillance activities:
  - Case detection
  - Case reporting
  - Investigation and confirmation
  - Analysis and interpretation
  - Communication
  - Action - *public health response, policy development and feedback to stakeholders*
- Support processes enable the core activities
- Integrated disease surveillance
  - Indicator-based surveillance
  - Event-based surveillance



McNabb et al. (2002): Conceptual framework of public health surveillance and action and its application in health sector reform. BMC Public Health, https://doi.org/10.1186/1471-2458-2-2

Epidemic intelligence framework



Kaiser et al. (2006): What is epidemic intelligence, and how is it being improved in Europe? Eurosurveillance, https://doi.org/10.2807/esw.11.05.02892-en

Indicator-based surveillance

- Notifiable disease – urgent reporting of serious diseases requiring an immediate public health response
- Syndromic – Cases that comply with a specified syndromic case definition
- Laboratory – number of isolates or positive tests for specific organisms
- Sentinel – health facilities representing high risk areas or groups
- Environmental monitoring – indicator based or event based – legally mandated monitoring of key environmental indicators at set time-periods
- Other types
  - prescriptions,
  - calls to medical helplines,
  - health insurance claims etc

Event-based surveillance

- Notifications of events related to water supply
  - water providers, municipal authorities
- Media monitoring
  - Mass media (TV, newspapers), social media reports

EBS can be a sensitive and rapid way to detect outbreaks, but may lead to false alarms.

Outbreak Surveillance

Event based

- Notifications of clusters of cases or suspected outbreaks
  - Health facilities, the public

Prevent and control outbreaks

Indicator based

- Number of confirmed outbreaks related to water
  - Disease burden
  - Causal agents
  - Risk factors
  - Geographical distribution

Inform on the need for investments in the water supply system and public health action

Other types of surveillance and studies

- Seroprevalence surveys
  - Public health agencies, laboratories, research institutes
  - estimate the burden of WRID
- Environmental surveys
  - Environmental agencies, research institutes
  - Detect outbreaks, risk assessment, monitoring emerging and re-emerging pathogens, estimate burden
- Case control studies using surveillance data
  - Identify water sources as risk factor for infection
  - Estimate burden of disease associated with waterborne transmission

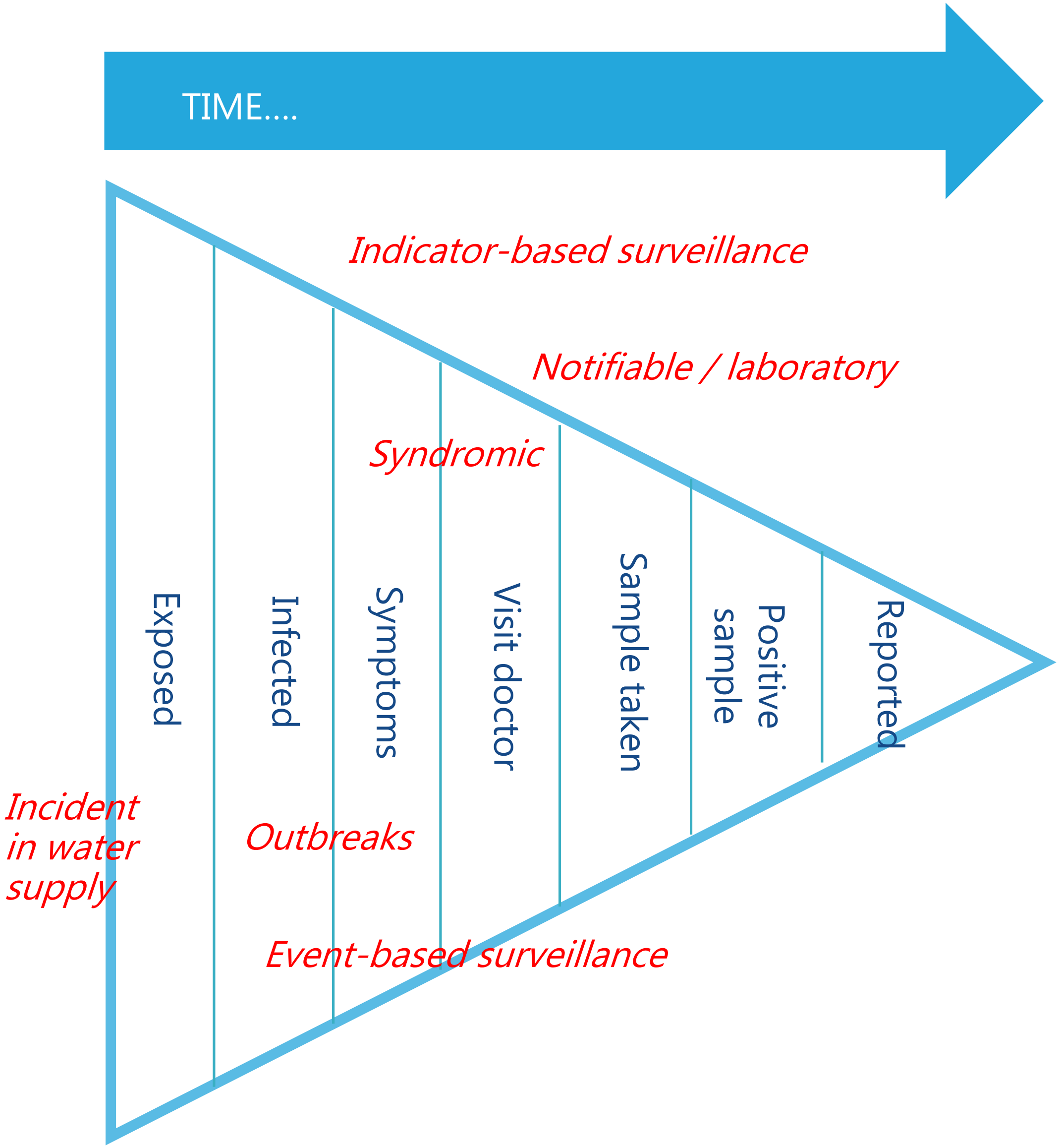
Surveillance attributes

- Completeness
- Timeliness
- Usefulness
- Sensitivity
- Specificity
- Positive predictive value
- Representativeness
- Simplicity
- Flexibility
- Acceptability
- Stability

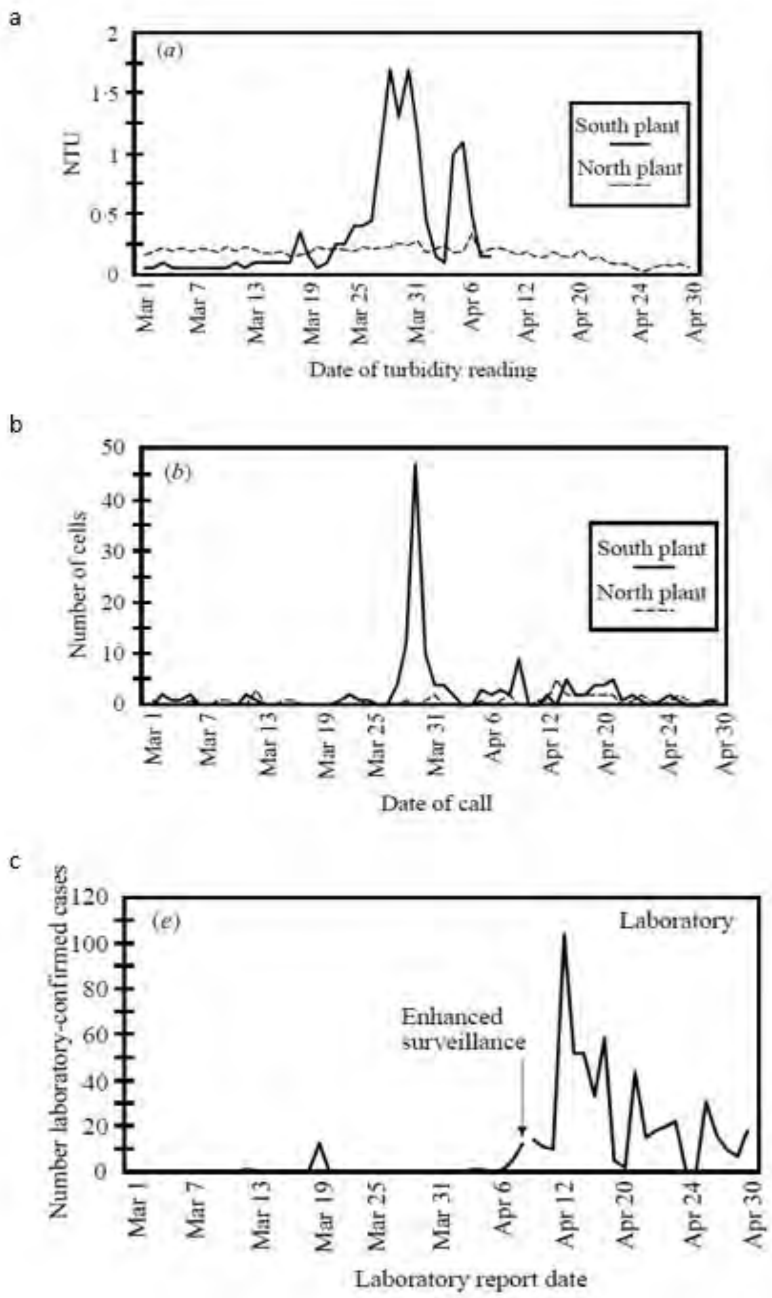
Table 4 of the guidance document

Timeliness and sensitivity

- Sensitivity – how well the system detects cases
  - % of symptomatic cases
  - % of cases seeking care
  - Sampling practices
  - Laboratory practices and capacity
  - Sensitivity and specificity of laboratory assays
  - Completeness of reporting of cases



Source: K. Nygard



Timeliness of outbreak detection varies by surveillance type.

- Event based surveillance is usually the fastest
- Surveillance based on clinical or laboratory diagnoses are much slower and are less suitable for outbreak detection
- Surveillance based on clinical diagnosis – risk of incorrect diagnosis → delayed or missed outbreak detection

Proctor et al. (1998): Surveillance data for waterborne illness detection: an assessment following a massive waterborne outbreak of Cryptosporidium infection. Epidemiology and Infection, https://doi.org/10.1017/S0950268897008327

How to strengthen WRID surveillance?

- ***Build on or expand existing surveillance systems to include WRID***
  - Include additional waterborne pathogens in the existing notifiable or laboratory based surveillance system
  - Reported using the existing surveillance procedures
- What are the surveillance objectives?
- How well will this type of surveillance meet the surveillance objectives?
  - *timeliness, sensitivity, specificity, completeness, representativeness etc.*
- Feasibility??
  - Human and laboratory capacity for collection, transportation, detection
  - Funding for surveillance
  - E-reporting and database
  - Acceptability and participation by health care workers

Questions?

Setting up, improving and maintaining national systems for WRID surveillance

Module 1.3

Overview

- Approach to WRID surveillance system strengthening
- Overview of main activities
- Enabling factors for surveillance

We will work through a case study in parallel to this session

Approach to WRID surveillance system strengthening

- Appoint public health specialist to lead and coordinate
- Develop overall strategy
- Support local level to develop procedures and implement
- Surveillance protocol
- Working group or advisory group

Main activities in WRID surveillance system strengthening

- Stakeholder engagement
- Situation analysis and priority setting
- Purpose, scope and objectives
- Surveillance outcomes, scope and system design
- Methodology for data collection, management and analysis
- Monitoring and evaluation

1. Engage stakeholders and agree their roles

Establish an advisory / working group

- Establish advisory group to provide oversight and expertise
  - Do this early
  - Include decision makers, focal points and technical experts from participating organizations
  - Include those who will be responsible for running the system and acting on the results of surveillance (front line staff)
  - Include those working at the national and local level
- National advisory group
  - Overall system design and development
  - Priority setting for surveillance
- Local advisory group
  - Operationalise the system

Advisory groups could include:

At the national level:

- MoH/National public health agency
- Epidemiologist
- Water regulator
- Environment agency
- Environmental health specialists
- Laboratory specialist
- Legal and data protection expert
- IT specialist
- Data manager
- Event-based surveillance specialist

At the local level:

- Local public health specialist
- Local epidemiologist
- Local water provider
- Representative from health facilities
- Representatives from local laboratories
- Local environmental health specialists

Case study 1

2. Characterise the public health problem through a situation analysis and agree priorities for surveillance

Situation analysis

- Data sources: surveillance and laboratory reports and datasets, outbreak investigation reports, published and unpublished research studies, data from environmental studies, water providers and environment agencies
- Describe the epidemiology of WRID in the country
  - Burden of disease and trends over time
  - Economic cost, societal cost/humanistic burden
  - Outbreak potential
  - Reservoirs and sources
  - High-risk groups and areas
  - Political and social context

Situation analysis cont.

- Describe current surveillance capacity at national and subnational levels
  - Main actors and stakeholders and their roles in surveillance and disease control
  - Current data sources and potential new sources
  - Data gaps and limitations
  - International surveillance requirements

- At the local level:
  - Describe the local water supply – sources, providers, geographical distribution and population served
  - Review water quality data and condition of water system (WSP if available)
  - Review potential sources of Legionella
  - Identify local vulnerable populations and settings

Identifying priorities for surveillance

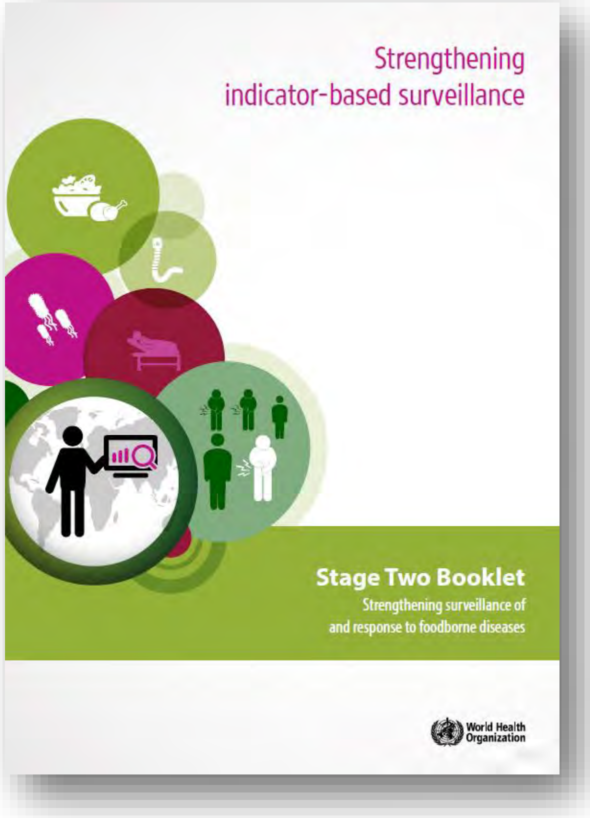
- Target surveillance at areas where WRIDs are endemic or where outbreaks occur:
  - Vulnerable water sources
  - Water supply is vulnerable to contamination – livestock
  - Areas subject to drought, drops in water pressure and intermittent supplies
  - Areas prone to flooding
  - Small-scale community supplies
  - Industrial areas
- Seasonal pathogens - enhance surveillance at certain times of year?

Criteria for selecting candidate surveillance outcomes

Criteria	Factors to consider
Disease burden – size of the problem and severity of the clinical outcomes	Percentage of cases attributable to waterborne transmission Annual incidence rate Vulnerability of exposed population groups (by sex, age, ethnicity) Case-fatality ratio Hospitalisation rate Frequency and nature of long-term sequelae of infection
Information about the hazard	Water monitoring data for microbial pathogens
Epidemiological features	Outbreak potential: number and size of outbreaks attributed to this pathogen Trends in disease incidence over time
Societal burden	Economic cost Public perceptions of risk Political context
Feasibility	Diagnostic capacity Capacity to conduct surveillance

How to select the priority diseases

- Desktop exercise - Use the results of the situation analysis to identify priority pathogens, syndromes and diseases
- Strategy grids (next slide)
- Delphi panels
  - Form a panel of experts
  - Define criteria and score diseases against these
  - Weight and sum the results for each participant
  - Rank diseases and ask experts to assess ranking
  - Finalise results
- Decide what type of surveillance to conduct on each priority disease



Strategy Grids

- Used if resources are limited
- Focus on identifying those WRID for which surveillance will have the biggest impact.
- Use two of the five criteria listed previously to rank diseases

For instance, the grid could use:

- Disease burden + feasibility (example on next slide)
- Disease burden + epidemiological features
- Epidemiological features + availability of treatment and control

Example of a strategy grid based on disease burden and feasibility

Disease burden

High disease burden, low feasibility	High disease burden, high feasibility
The surveillance of this WRID is a long-term project. Options for surveillance will require significant investment. Focusing on too many of these diseases can overwhelm the surveillance system and compromise its overall performance.	These diseases should be a high priority and sufficient resources should be assigned to their surveillance
Low disease burden, low feasibility	**Low disease burden, high feasibility**
With minimal return on investment, these are the lowest priority foodborne diseases and should not be included in the surveillance system.	Often politically important (as they are rare but may be high-impact diseases), these diseases may need to be considered as more resources become available. It may also be possible to gather information on these diseases using ad hoc research studies.

Feasibility

Case study 1 continued

3. Define the overall purpose, scope and objectives of surveillance

Purpose and scope

- Situation analysis and prioritization exercise → the purpose and scope of surveillance
- Purpose – the high level reason for conducting surveillance

→ *"To strengthen our understanding of the burden and epidemiology of WRID in order to inform WRID prevention and control measures"*

- Scope
  - What types of WRID to include in the system
  - Geographic coverage
  - Target population
  - Time period

Surveillance Objectives

- Can have multiple objectives

"The objectives are to:

  - *Detect outbreaks*
  - *Estimate the burden and impact of WRID*
  - *Identify high-risk areas and populations to target with control measures"*

- Design the system to meet the objectives
  - Will the system be sufficiently timely, representative, sensitive and specific to meet the objectives?

Case study 1 continued

4. Define the surveillance outcomes, the core dataset and design the system

Define outcomes for surveillance

- Informed by results of situation analysis and by purpose, scope and objectives of system
- List priority outcomes (pathogens, notifiable diseases and syndromes) to monitor
- Additional surrogate outcomes for event-based surveillance - water complaints, exceedances of water quality limits
- Link the outcomes to specific surveillance objectives

Objective	Outcomes
Detect outbreaks	1. Physician notifications of acute gastroenteritis 2. Laboratory detections of cryptosporidium, giardia, campylobacter 3. Complaints to the water provider 4. Over the counter sales of anti-diarrhoeal medicines

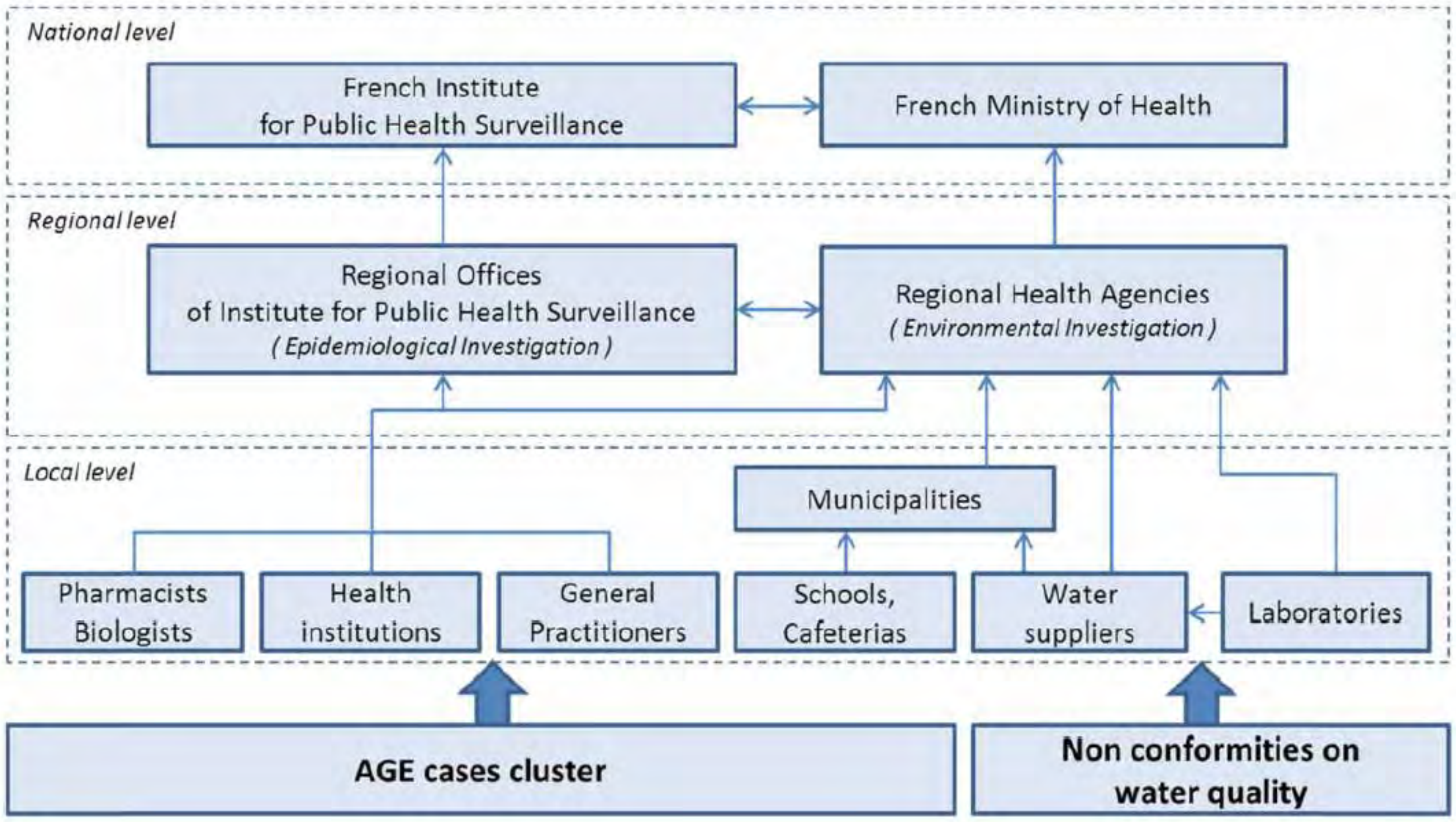
Identify sources of data

- Laboratory databases → data on lab confirmed cases
- Medical insurance databases / sales databases → data on prescriptions or over-the counter sales for anti-diarrhoeal medications
- Water providers → breech in water quality limits

What needs to be actively reported?

Can you automate the capture of data from any of these sources?

Schematic diagram of the elements of the surveillance system



Rambaud et al. (2016): Automated detection of case clusters of waterborne acute gastroenteritis from health insurance data – pilot study in three French districts. Journal of Water & Health, https://doi.org/10.2166/wh.2015.135

Case definitions

- Define a case definition for each surveillance outcome
- Different to clinical case definitions and those used during outbreaks
- Publicly available case definitions – ECDC, CDC

Box 1. European Union surveillance case definition for cryptosporidiosis

Clinical criteria: any person with at least one of the following two:

- diarrhoea
- abdominal pain.

Laboratory criteria: at least one of the following four:

- demonstration of *Cryptosporidium* oocysts in stool
- demonstration of *Cryptosporidium* in intestinal fluid or small-bowel biopsy specimens
- detection of *Cryptosporidium* nucleic acid in stool
- detection of *Cryptosporidium* antigen in stool.

Epidemiological criteria: one of the following five epidemiological links:

- human-to-human transmission
- exposure to a common source
- animal-to-human transmission
- exposure to contaminated food/drinking water
- environmental exposure.

Case classification:

A. Possible case: not applicable

B. Probable case: any person meeting the clinical criteria with an epidemiological link

C. Confirmed case: any person meeting the clinical and the laboratory criteria.

Note: if the national surveillance system is not capturing clinical symptoms, all laboratory-confirmed individuals should be reported as confirmed cases.

Define what to collect and how often

- Usually notifiable diseases and laboratory confirmed cases are reported as case-based data. Case based data includes more detailed information on cases. For instance it may include data on age, sex, geographic location, occupation, travel history and underlying comorbidities

Syndromic surveillance data may be reported as case-based data or as aggregated data. For instance physicians may report the total number of consultations for acute gastroenteritis by age-group.

Only collect as much data as you need to

All data collected must have a specific purpose and must contribute to the fulfilment of a specific surveillance objective.

Anticipate the ethical challenges in undertaking surveillance and address them systematically and transparently. It is important to implement the relevant recommendations of the WHO guidelines on ethical issues in public health surveillance (2017). Surveillance systems should have a clear purpose and a plan for data collection, analysis, use and dissemination based on relevant public health priorities (Guideline 1). Countries have an obligation to develop appropriate, effective mechanisms to ensure ethical surveillance (and Guideline 2).

For instance geographic location data collected for laboratory confirmed cases can be used to monitor the geographic distribution of cases. This can help to identify areas with a higher incidence of water related disease, where an outbreak may be occurring, or where resources may need to be targeted to improve the water system.

If the data does not have a purpose, do not collect it.

Example of what to report and how often

Surveillance outcome	Type of data	Suggested core data set	Example reporting frequency
Reporting notifiable cases of WRID	Case-based	• Name • age • date of birth • sex • address • occupation • work address • date of onset of illness • date and place of hospitalization • case outcome (alive, died) • recent travel history	Within 24 hours

Example of what to report and how often

Surveillance outcome	Type of data	Suggested core data set	Example reporting frequency
Syndromic surveillance data (AGI, diarrhoea)	Aggregate	• Total weekly cases by age group, sex and place	Weekly
WRID outbreaks	Case-based	• Location and date of outbreak, • total cases, • number hospitalized and died, • causative agent, • source of outbreak (public or private water supply, cooling tower etc.), • water quality, • main risks of water-supply system contamination, • contributory factors	Quarterly

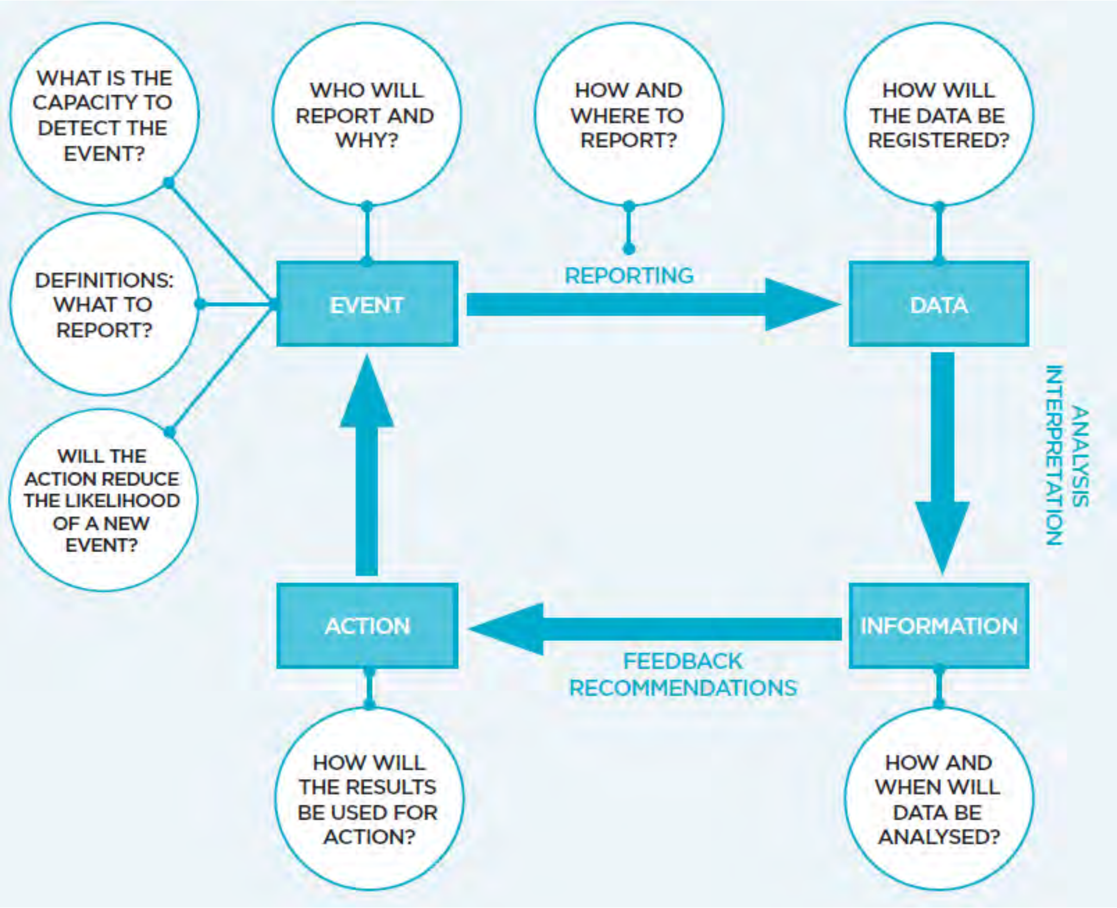
Strengths and limitations of the system

- Who is not covered by the system and how might that impact on WRID control measures?
- Sources of bias in the data?
- Potential to miss cases?
- Potential to misclassify cases as non-cases?
- Timeliness of the system for outbreak detection?
- Flexibility / adaptability?
- Simplicity?
- Redundancies and duplication of efforts?

Case study 1 continued

5. Develop a methodology for collecting, managing and analysing the surveillance data

Methodology



- Surveillance protocol and standard operating procedures
- Roles and responsibilities
- Case identification and investigation
- Data reporting / data flows
- What data will be collected?
- Reporting forms
- Data management
- Data analysis, interpretation and reporting
- Alert thresholds

Surveillance Thresholds

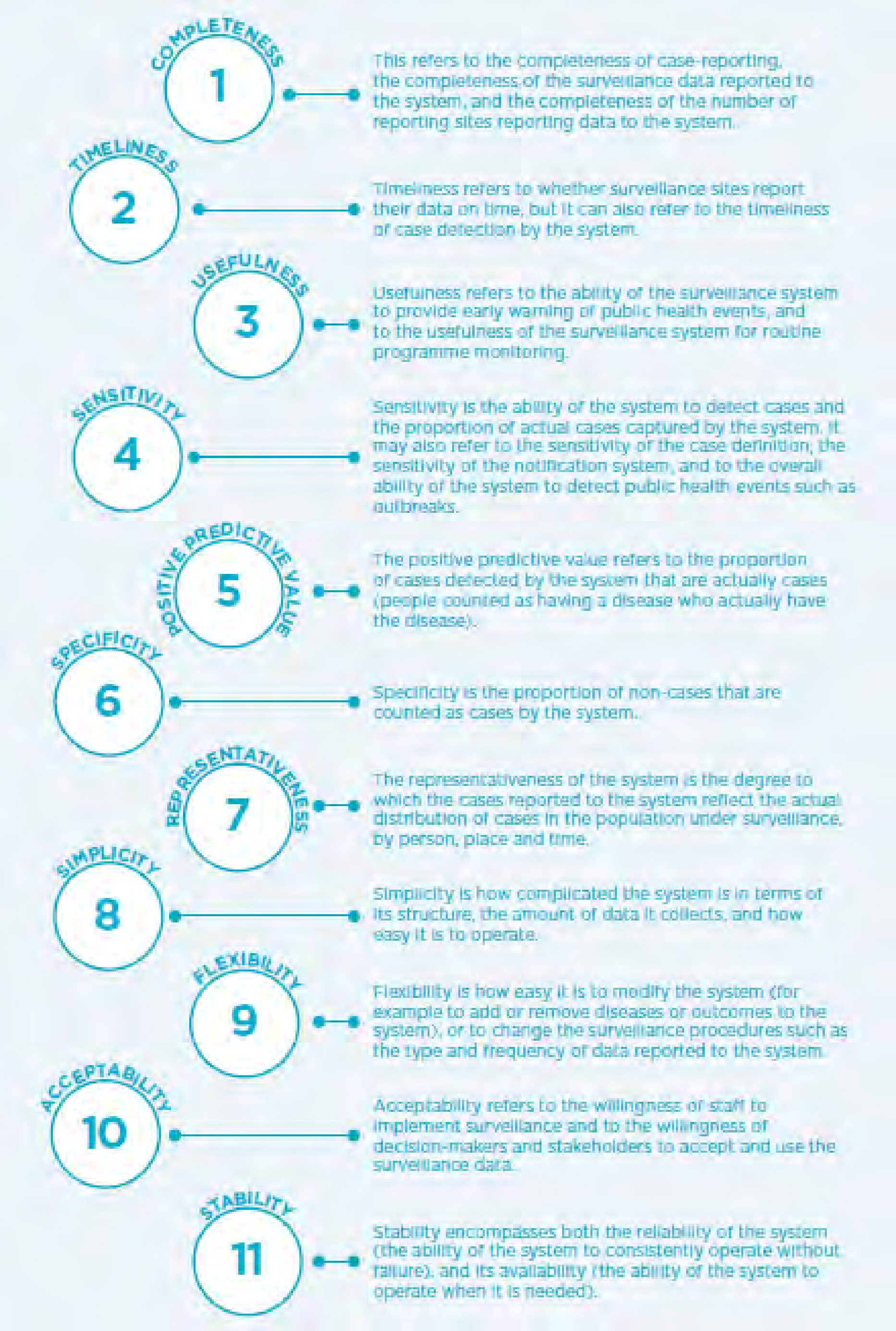
- Used to identify outbreaks and monitor seasonal epidemics
- Vary from simple calculations of historical surveillance data to complex statistical models
- Require several years of stable reliable surveillance data on a pathogen or outcome
- Can be defined in different ways:

a) A defined number of cases that will prompt an investigation to verify existence of an outbreak

→ *5 cases of shigellosis or bloody diarrhoea*

b) An increase in the number of cases compared to the background rate for a specific disease over the same time-period and place

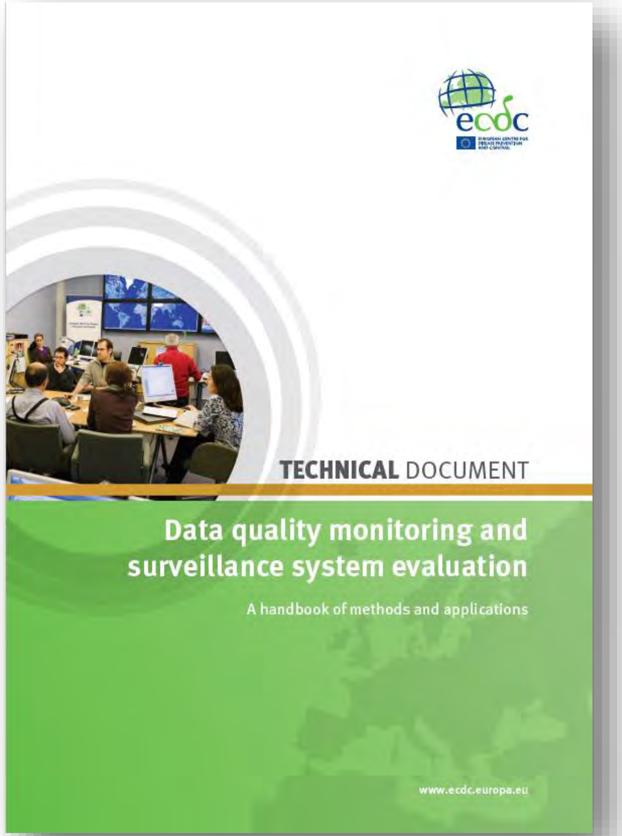
→ *Doubling of cryptosporidium cases above the baseline surveillance rates for the previous 5 years*



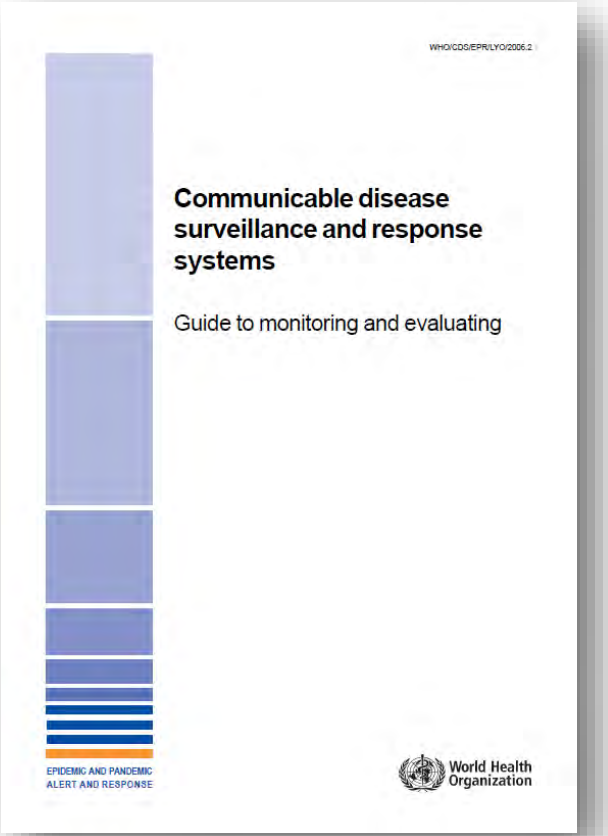
Monitoring and Evaluation

- Ongoing automated monitoring of surveillance data quality:
  - Data entry checks
  - Range and consistency checks
  - Cross check data between different data tables and databases
  - Completeness and timeliness of data reporting
- Periodic evaluations of the system (surveillance attributes):
  - How well is the system meeting its objectives

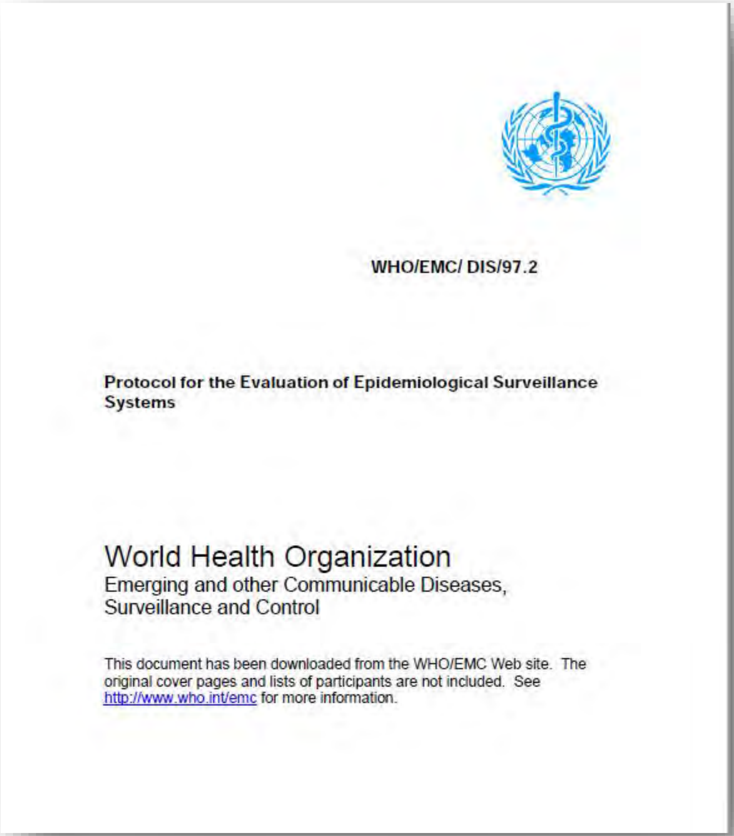
Monitoring and Evaluation Resources



ECDC (2014): Data quality monitoring and surveillance system evaluation.
https://www.ecdc.europa.eu/sites/default/files/media/en/publications/Publications/Data-quality-monitoring-surveillance-system-evaluation-Sept-2014.pdf



WHO (2006): Communicable disease surveillance and response systems.
https://apps.who.int/iris/handle/10665/69331



WHO (2017): Protocol for the Evaluation of Epidemiological Surveillance Systems.
https://apps.who.int/iris/handle/10665/63639

Enabling factors I

- Set targets
  - For the prevention and reduction of WRID burden
  - For the strengthening of WRID surveillance, early warning and response systems
- Legal framework for surveillance
  - Update national legislation and guidelines
  - Establish formal requirements for WRID surveillance
  - Ethical and data protection requirements

Appropriate consideration must also be given to ensuring that surveillance procedures comply with national data management & research ethic requirements and WHO guidelines on ethical issues in public health surveillance (2017).

Enabling factors II

- Budget – local and national
- Laboratory capacity
- Transportation (specimens)
- Standard operating procedures
- Training
- Information technology
- Electronic data management system / web-based reporting system

Questions?

Case study 1 continued

Analysis, interpretation, reporting and use of data

Module 1.4

Overview

- Analysis and interpretation of data
- Surveillance bulletins
- Using surveillance data for advocacy

General approach to data analysis

- Analyse the surveillance data on a continuous basis – plan to analyse on at least a weekly basis.
- Typically report:
  - Total number of cases
  - Incidence or notification rates – adjust for size of underlying population
  - Proportions
- Core descriptive analyses:
  - Time (day, week, month, year)
  - Place (district, region, country)
  - Person (age, sex, occupation, race, ethnicity
- Present results in tables, graphs and maps

Outputs of data analysis

Target analyses to address surveillance objectives and questions

Surveillance objectives	Analytical outputs that can address these objectives	Frequency of analysis
Identify temporal trends and detect possible outbreaks	Line graph of incidence over time	Weekly
Identify groups who are at higher risk of WRID	Table of total number of cases and incidence or prevalence rate by age, sex and geographic area	Weekly
Detect possible outbreaks or clusters of cases; identify areas associated with higher rates of disease	Table or map of the number of cases or the incidence rate by geographical area	Weekly
Estimate disease burden	Table of frequency of cases	Quarterly or annually
Evaluate the impact of control measures, such as implementing a new water-treatment step	Incidence of disease before and after changes in the water treatment	Based on needs

Calculating an incidence or notification rate

$$\text{Notification rate per 100,000 persons} = \frac{\text{Number of cases (notifications)}}{\text{Total population}} \times 100{,}000$$

Surveillance week	Number of notifications	Population estimate	Notification rate / 100,000 persons
12	525	1,291,850	40.6
13	489	1,291,850	37.9
14	501	1,291,850	?
15	579	1,291,850	?

Exercise: Using the formula, calculate the notification rates for weeks 14 and 15

Calculating an incidence or notification rate

$$\text{Notification rate per 100,000 persons} = \frac{\text{Number of cases (notifications)}}{\text{Total population}} \times 100{,}000$$

Surveillance week	Number of notifications	Population estimate	Notification rate / 100,000 persons
12	525	1,291,850	40.6
13	489	1,291,850	37.9
14	501	1,291,850	**38.8**
15	579	1,291,850	**44.8**

Analysis by time – monitoring trends

Analysis by time – monitoring trends

- Different ways of presenting the data over time will illustrate different information and will convey different messages:
  - Is the rate or burden of disease increasing or decreasing?
  - How does this year compare to previous years?
  - Is there any seasonality in the incidence of disease?
- Can apply alert thresholds to detect outbreaks or identify the start of seasonal epidemics

Alert thresholds and moving averages

- Alert thresholds provide a signal that the number of cases exceeds a defined level
  - Possible outbreak or start of seasonal epidemic → sign that action may be needed
- Threshold depends on severity and epidemic potential of a pathogen and the local epidemiology
- Defined based on number of cases or by comparing number of cases in current surveillance period to historical data over previously defined time periods:
  - 5 year moving average

Example Alert Thresholds

Surveillance outcome	Alert threshold
Bloody diarrhoea	5 or more cases in one place in one day Double the 5-year weekly average of cases
Acute gastroenteritis	Increase above the five-year average for that reporting period Two standard deviations above the five-year average for that reporting period

Calculating a – 5 year weekly moving average

5-year moving average of weekly cases =

$$\frac{\text{Total Yr 1 + total Yr 2 + total Yr 3 + total Yr 4 + total Yr 5}}{5}$$

Surveillance week	Weekly notifications per year					5-year total	5-year average
	2015	2016	2017	2018	2019		
12	10	10	10	10	10	50	10
13	53	49	61	43	57	263	53
14	48	37	45	54	51	?	?

Exercise: Using the formula on this slide, calculate the 5 year average for week 14

Calculating a – 5 year weekly moving average

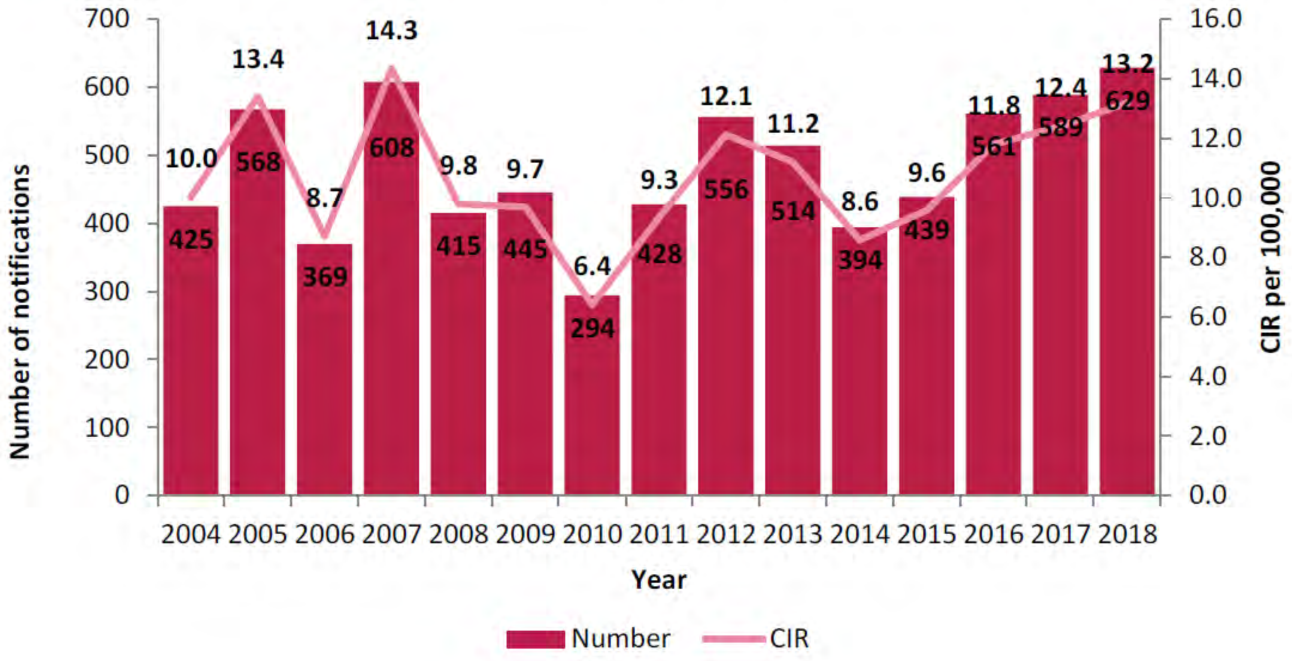
5-year moving average of weekly cases =

$$\frac{\text{Total Yr 1 + total Yr 2 + total Yr 3 + total Yr 4 + total Yr 5}}{5}$$

Surveillance week	Weekly notifications per year					5-year total	5-year average
	2015	2016	2017	2018	2019		
12	10	10	10	10	10	50	10
13	53	49	61	43	57	263	53
14	48	37	45	54	51	**235**	**47**

Number of cases and crude incidence rate (CIR) over time

Figure 1. Number and CIR cryptosporidiosis per 100,000 population, Ireland, 2004-2018



Discussion: *What is your interpretation of this graph?*

HSE Health Protection Surveillance Centre (2019): Cryptosporidiosis in Ireland, 2018. https://www.hpsc.ie/a-z/gastroenteric/cryptosporidiosis/publications/epidemiologyofcryptosporidiosisinirelandannualreports/Crypto%20Annual%20Report%202018.pdf

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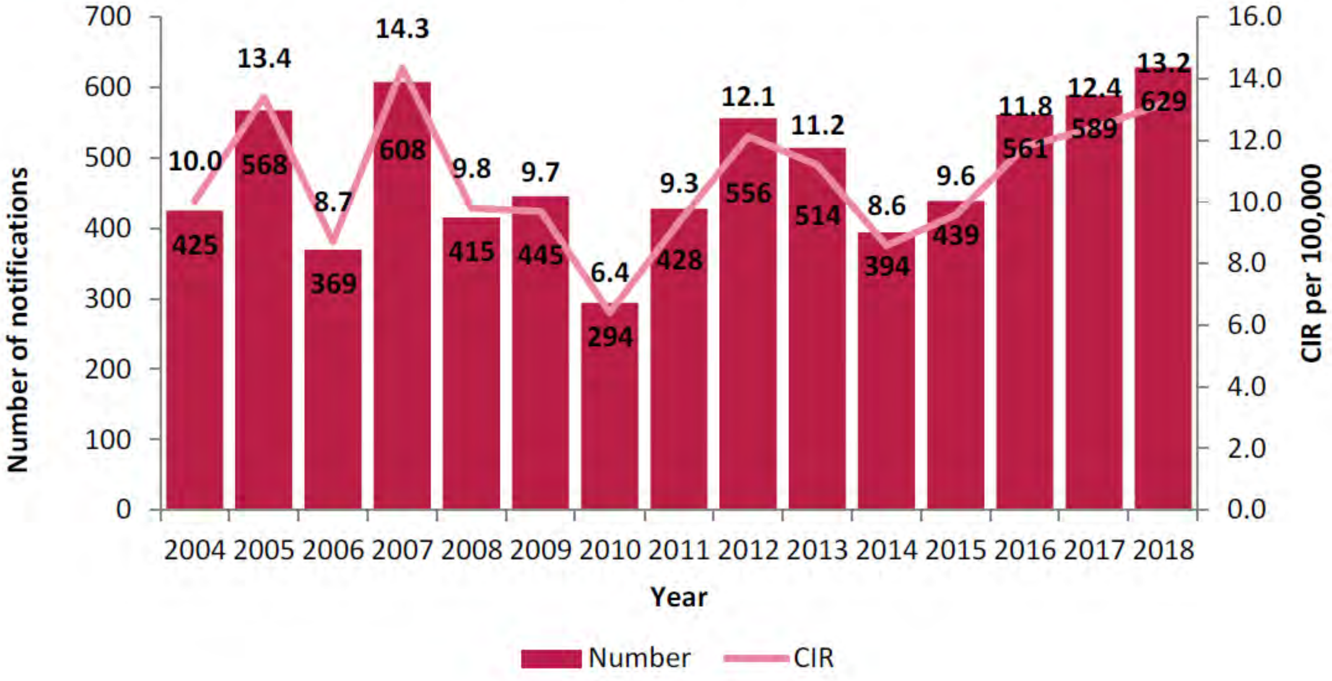
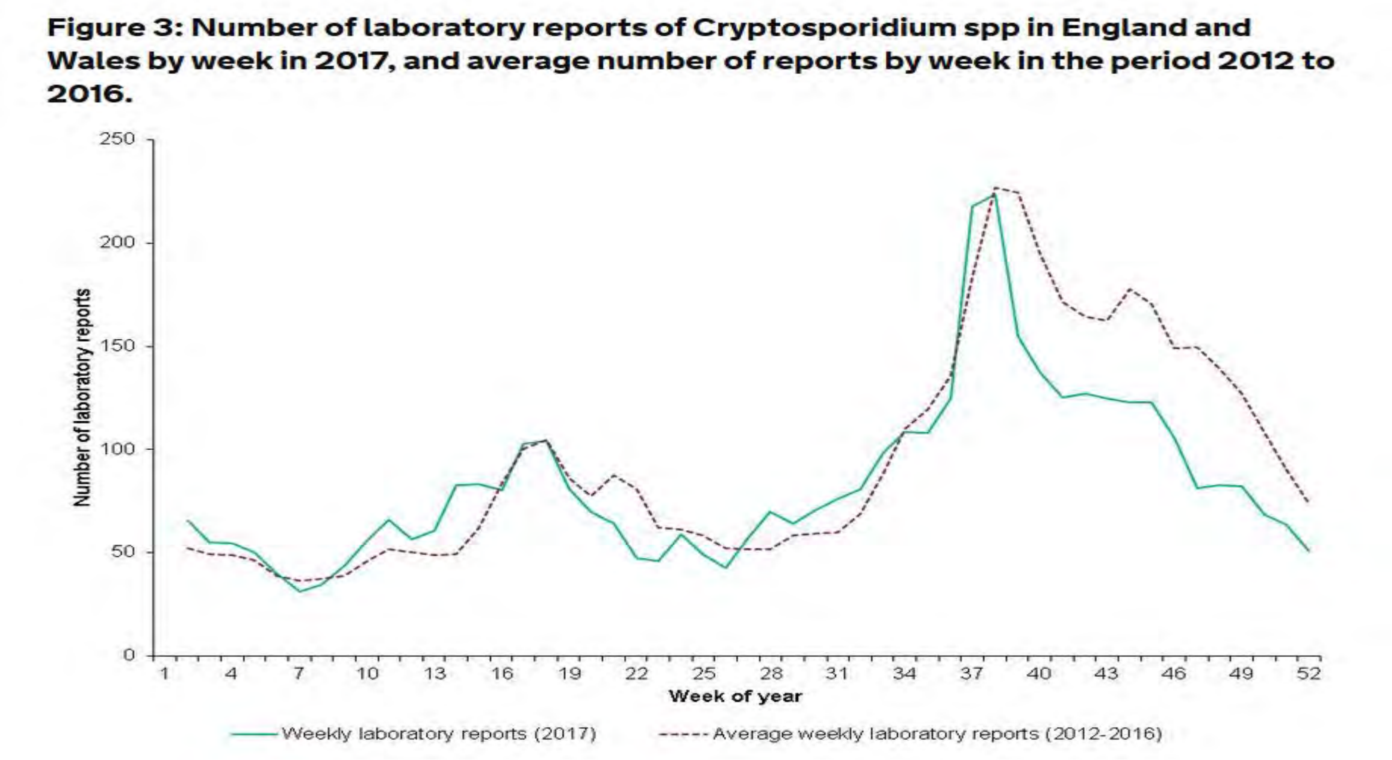


Interpretation: The number of notifications and the population based incidence rate have increased over the past five years; the burden of disease is increasing over time

HSE Health Protection Surveillance Centre (2019): Cryptosporidiosis in Ireland, 2018. https://www.hpsc.ie/a-z/gastroenteric/cryptosporidiosis/publications/epidemiologyofcryptosporidiosisinirelandannualreports/Crypto%20Annual%20Report%202018.pdf

Weekly notifications (or incidence) compared to average notifications (or incidence) for the previous 5 years

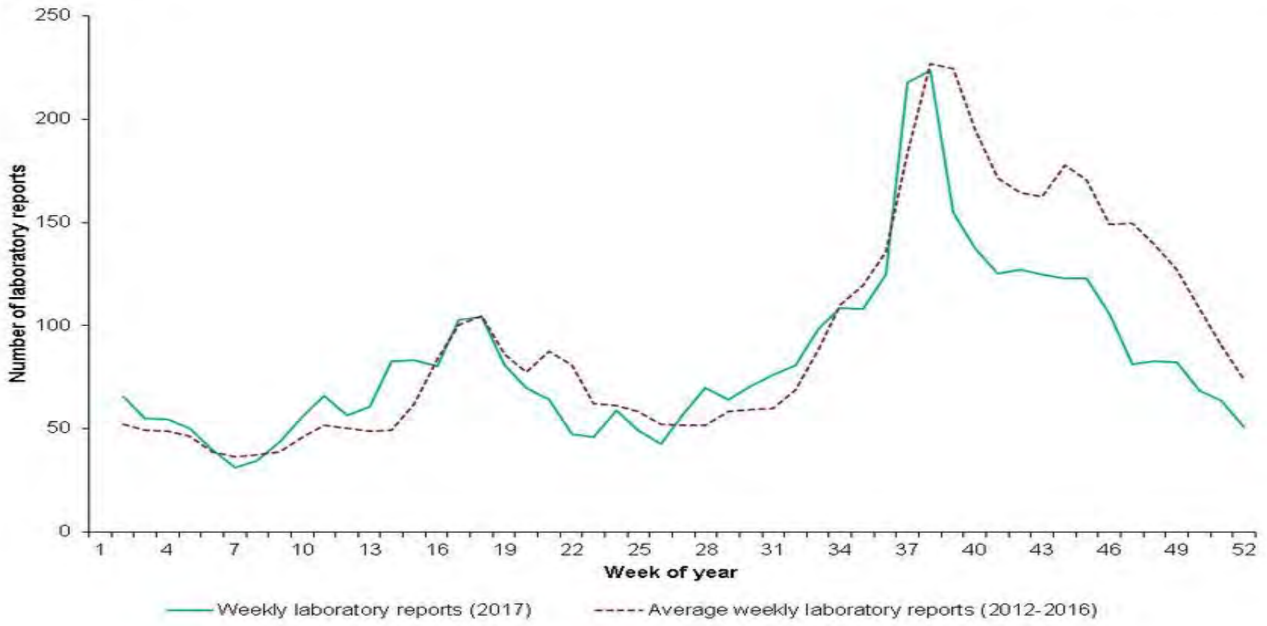


Discussion: *What is your interpretation of this graph?*

Public Health England (2019): Cryptosporidium data 2008 to 2017. https://www.gov.uk/government/publications/cryptosporidium-national-laboratory-data/cryptosporidium-data-2008-to-2017

Weekly notifications (or incidence) compared to average notifications (or incidence) for the previous 5 years

Figure 3: Number of laboratory reports of Cryptosporidium spp in England and Wales by week in 2017, and average number of reports by week in the period 2012 to 2016.

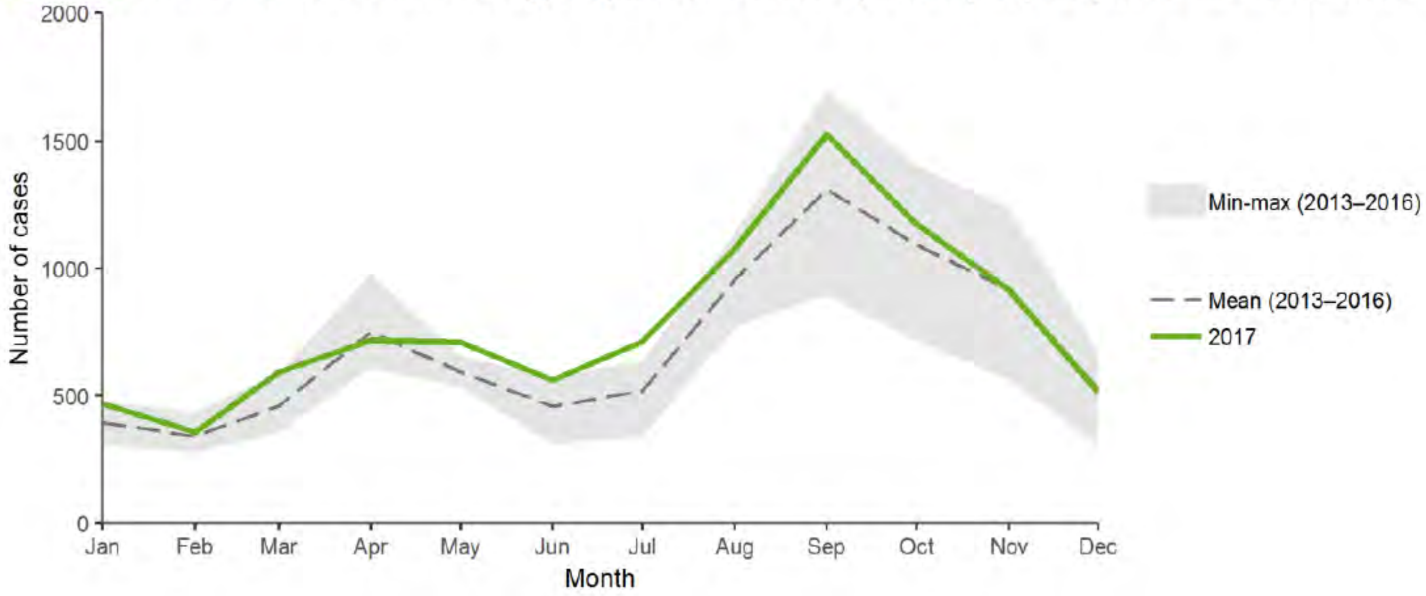


Interpretation: The temporal distribution of Cryptosporidium in 2017 is similar to the previous 5 years, with cases peaking at a similar time. The overall number of cases for 2017 appears to be lower than the average for the previous 5 years.

Public Health England (2019): Cryptosporidium data 2008 to 2017. https://www.gov.uk/government/publications/cryptosporidium-national-laboratory-data/cryptosporidium-data-2008-to-2017

Monthly notifications compared to mean, minimum and maximum notifications for the previous 5 years

Figure 3. Distribution of confirmed cryptosporidiosis cases by month, EU/EEA, 2017 and 2013–2016



Source: Country reports from Cyprus, the Czech Republic, Estonia, Finland, Germany, Hungary, Iceland, Ireland, Latvia, Lithuania, Malta, Norway, Poland, Romania, Slovakia, Slovenia, Spain, Sweden and the United Kingdom.

Discussion: *What is your interpretation of this graph?*

ECDC (2019): Cryptosporidiosis. Annual Epidemiological Report for 2017. https://www.ecdc.europa.eu/sites/default/files/documents/AER_for_2017-cryptosporidiosis.pdf

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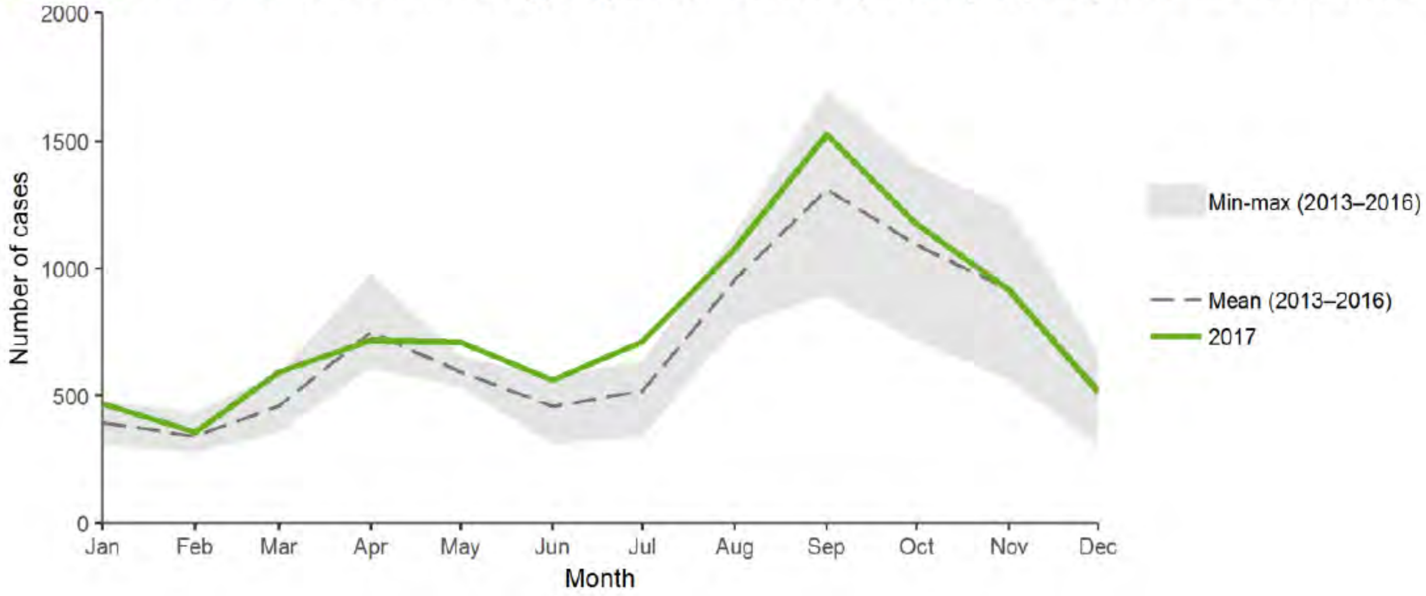
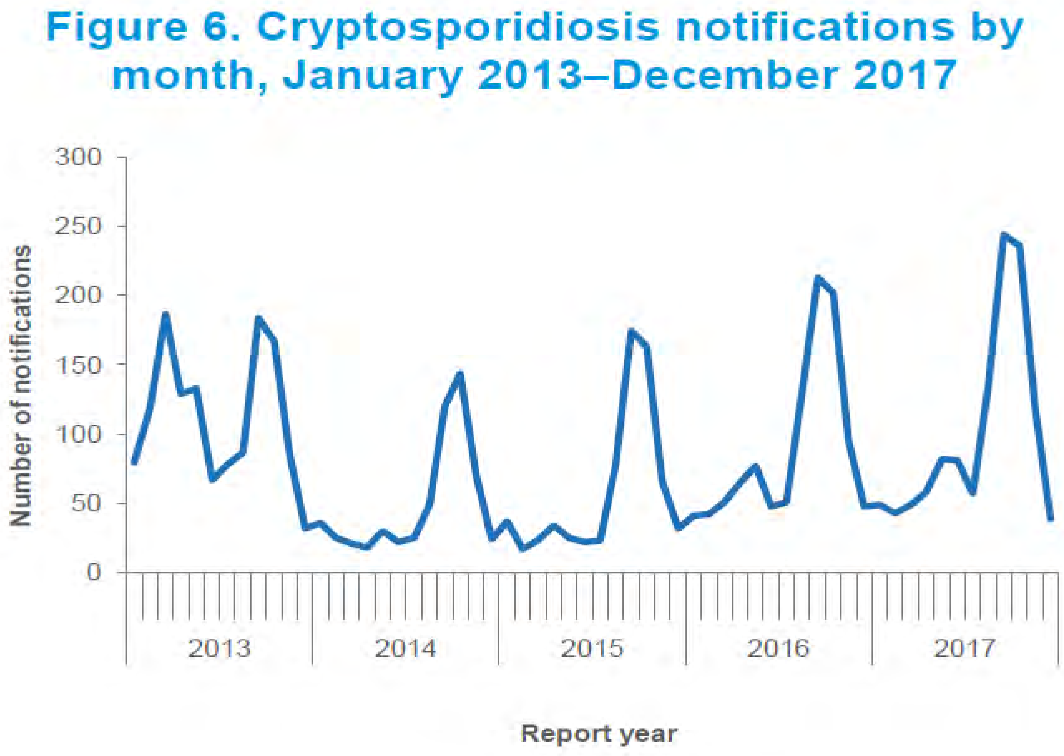


Source: Country reports from Cyprus, the Czech Republic, Estonia, Finland, Germany, Hungary, Iceland, Ireland, Latvia, Lithuania, Malta, Norway, Poland, Romania, Slovakia, Slovenia, Spain, Sweden and the United Kingdom.

Interpretation: The number of monthly notifications of cryptosporidiosis are higher than the 5-year average and are at the higher limit of notifications observed over the past 5 years. There is a higher burden of cryptosporidiosis this year compared to previous years.

ECDC (2019): Cryptosporidiosis. Annual Epidemiological Report for 2017. https://www.ecdc.europa.eu/sites/default/files/documents/AER_for_2017-cryptosporidiosis.pdf

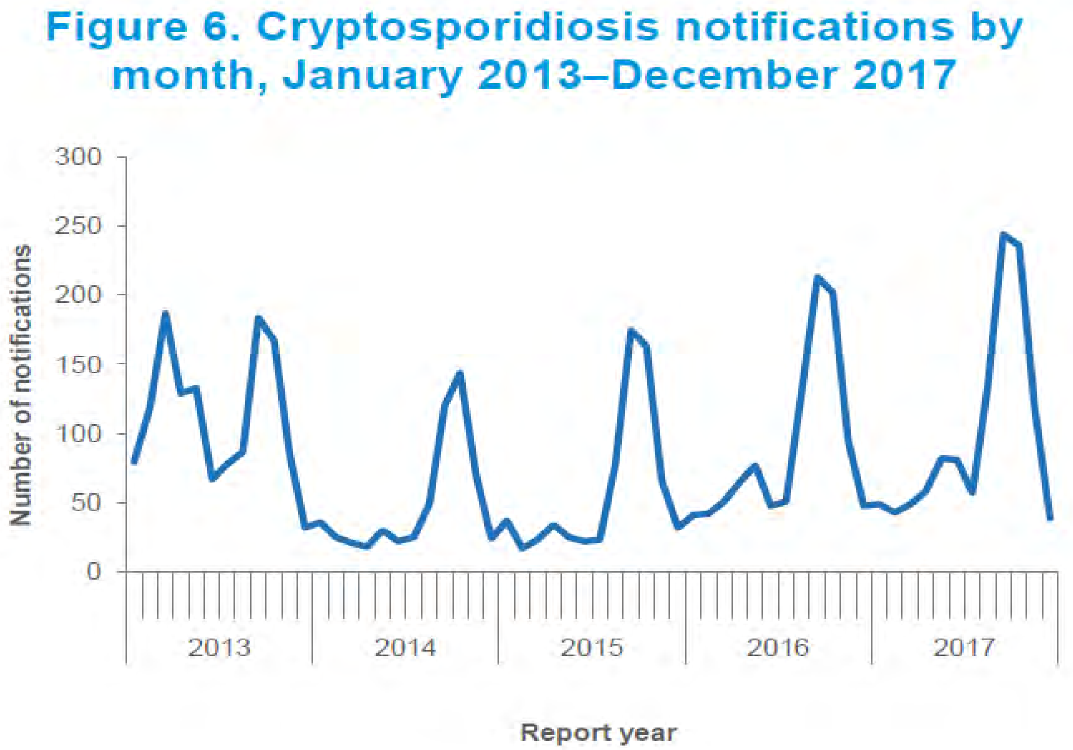
Monthly notifications over time



Discussion: *What is your interpretation of this graph?*

The Institute of Environmental Science and Research Ltd. (2019): Notifiable Diseases in New Zealand: Annual Report 2017.
https://surv.esr.cri.nz/PDF_surveillance/AnnualRpt/AnnualSurv/2017/2017AnnualNDReport_FINAL.pdf

Monthly notifications over time



Interpretation: Cryptosporidium follows a seasonal pattern, with most notifications occurring between October and November. There has been an upward trend in notifications over the past 4 years.

The Institute of Environmental Science and Research Ltd. (2019): Notifiable Diseases in New Zealand: Annual Report 2017. https://surv.esr.cri.nz/PDF_surveillance/AnnualRpt/AnnualSurv/2017/2017AnnualNDReport_FINAL.pdf

Analysis by place

Spatial analyses

- Identify high-risk areas for WRID
- Simple analyses using tables and graphs.
- Use geographic information systems to map the distribution of surveillance indicators by geographical area or water supply zone
  - Number of cases
  - Incidence rates
  - Complaints to water companies
- Need a geographical marker
  - Postcode
  - Place of residence
  - Location of medical facility

Simple tables of cases and rates

Table 2: Regional distribution[2] of laboratory reports of Cryptosporidium in England and Wales: 2017

Country	Region	Number of laboratory reports	per 100,000 population
England	East Midlands	378	7.9
England	East of England	539	8.7
England	London	250	2.8
England	North East	275	10.4
England	North West	554	7.6
England	South East	582	6.4
England	South West	590	10.6
England	Yorkshire and The Humber	450	8.3
England	West Midlands	414	7.1
Wales	Wales	260	8.3

- Compare number of cases and notification rates by region
- **Discussion**: *What is your interpretation of this table?*

Public Health England (2019): Cryptosporidium data 2008 to 2017. https://www.gov.uk/government/publications/cryptosporidium-national-laboratory-data/cryptosporidium-data-2008-to-2017

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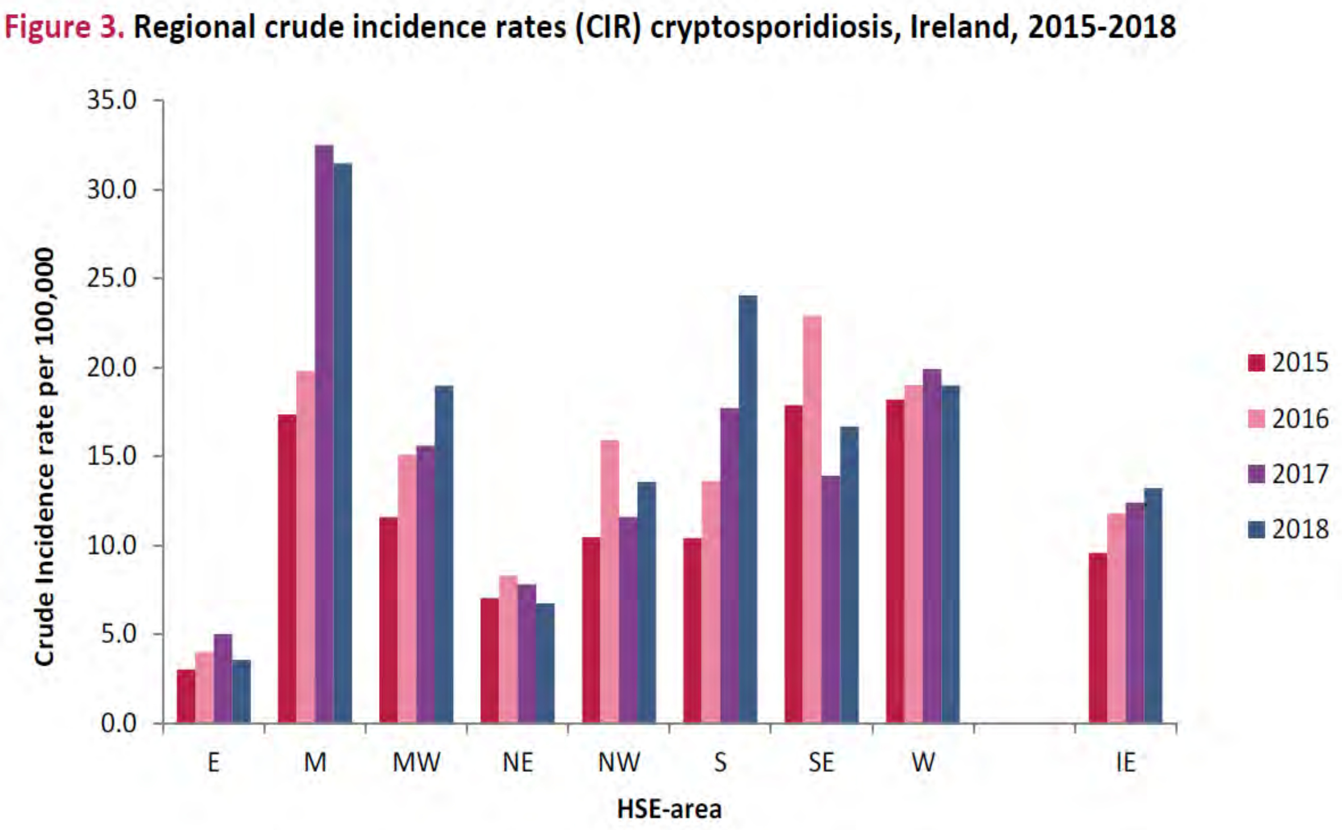
England	South West	590	10.6
England	Yorkshire and The Humber	450	8.3
England	West Midlands	414	7.1
Wales	Wales	260	8.3

Interpretation: The highest number of cases and the highest notification rate was reported from the South West region. The burden of Cryptosporidium is highest in the South West

Public Health England (2019): Cryptosporidium data 2008 to 2017. https://www.gov.uk/government/publications/cryptosporidium-national-laboratory-data/cryptosporidium-data-2008-to-2017

Graph of rates by place over time



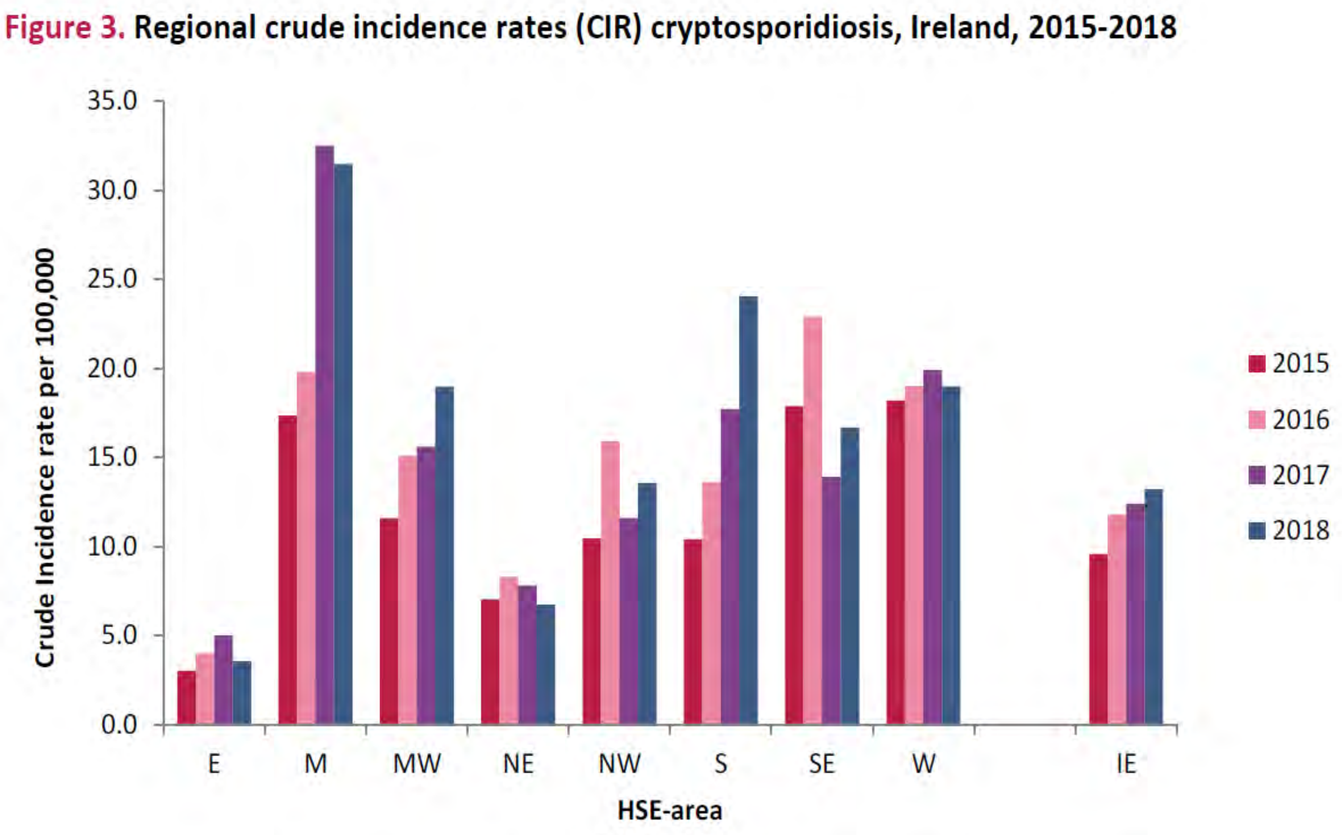
Discussion:

What is your interpretation of this graph?

What are the possible explanations for the different distribution of cryptosporidiosis by region and over time?

HSE Health Protection Surveillance Centre (2019): Cryptosporidiosis in Ireland, 2018. https://www.hpsc.ie/a-z/gastroenteric/cryptosporidiosis/publications/epidemiologyofcryptosporidiosisinirelandannualreports/Crypto%20Annual%20Report%202018.pdf

Graph of rates by place over time



Interpretation: The highest notification rate was reported from the midlands. Consistently over the past 5 years, and particularly in the last two years, the burden of cryptosporidiosis has been highest in the midlands. The eastern region has the lowest burden of disease.

Over the past 5 years the incidence of cryptosporidium in Ireland has been increasing

HSE Health Protection Surveillance Centre (2019): Cryptosporidiosis in Ireland, 2018. https://www.hpsc.ie/a-z/gastroenteric/cryptosporidiosis/publications/epidemiologyofcryptosporidiosisinirelandannualreports/Crypto%20Annual%20Report%202018.pdf

Maps of cases and rates

Figure 7. Cryptosporidiosis notifications by DHB, 2017

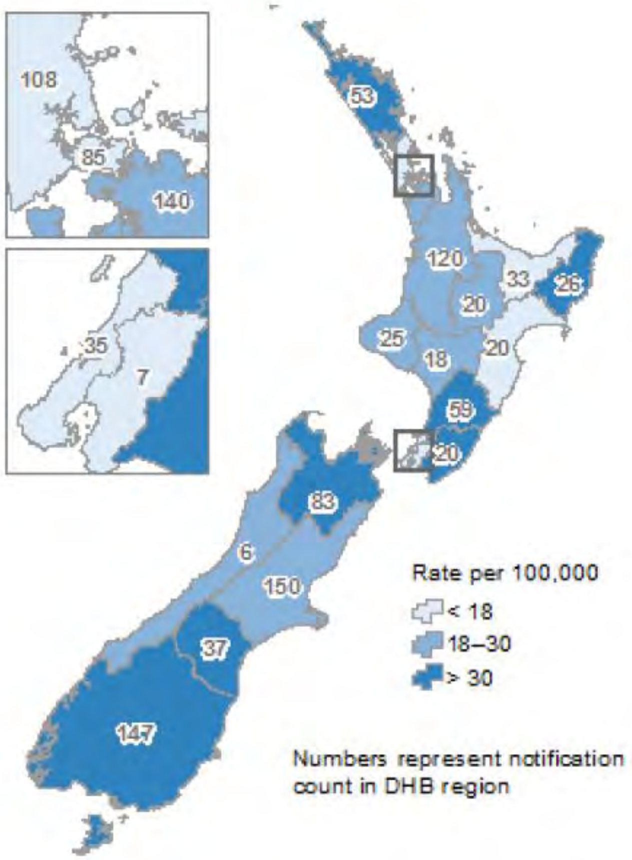
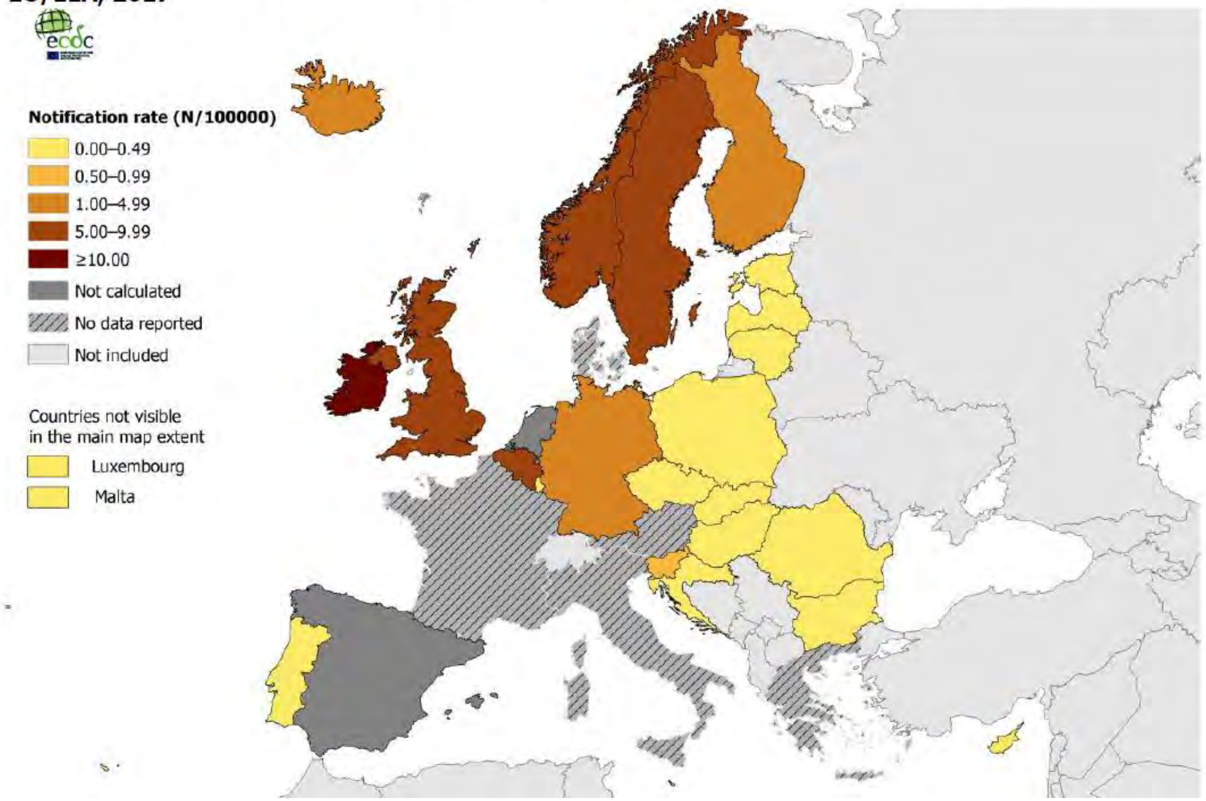


Figure 1. Distribution of confirmed cryptosporidiosis cases per 100 000 population by country, EU/EEA, 2017



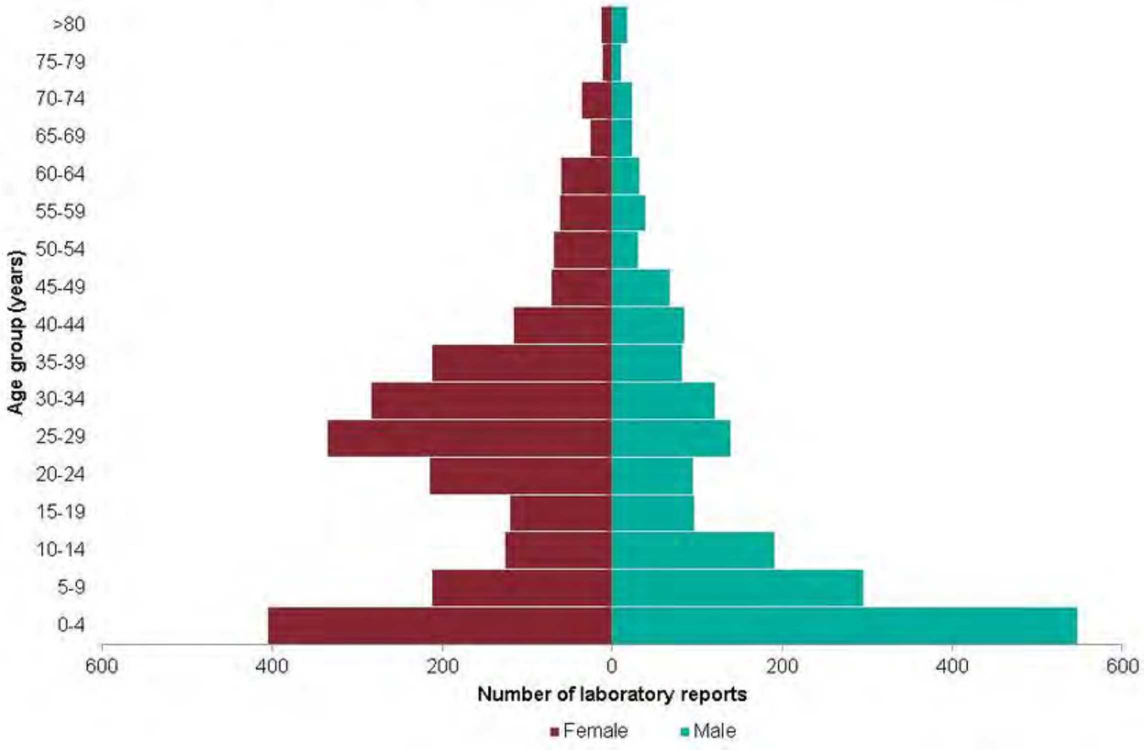
The Institute of Environmental Science and Research Ltd. (2019): Notifiable Diseases in New Zealand: Annual Report 2017. https://surv.esr.cri.nz/PDF_surveillance/AnnualRpt/AnnualSurv/2017/2017AnnualNDReport_FINAL.pdf

ECDC (2019): Cryptosporidiosis. Annual Epidemiological Report for 2017. https://www.ecdc.europa.eu/sites/default/files/documents/AER_for_2017-cryptosporidiosis.pdf

Analysis by person

Analysis by age and sex – number of notifications

Figure 2: Age and sex distribution of laboratory reports of Cryptosporidium spp reported in England and Wales: 2017[3].



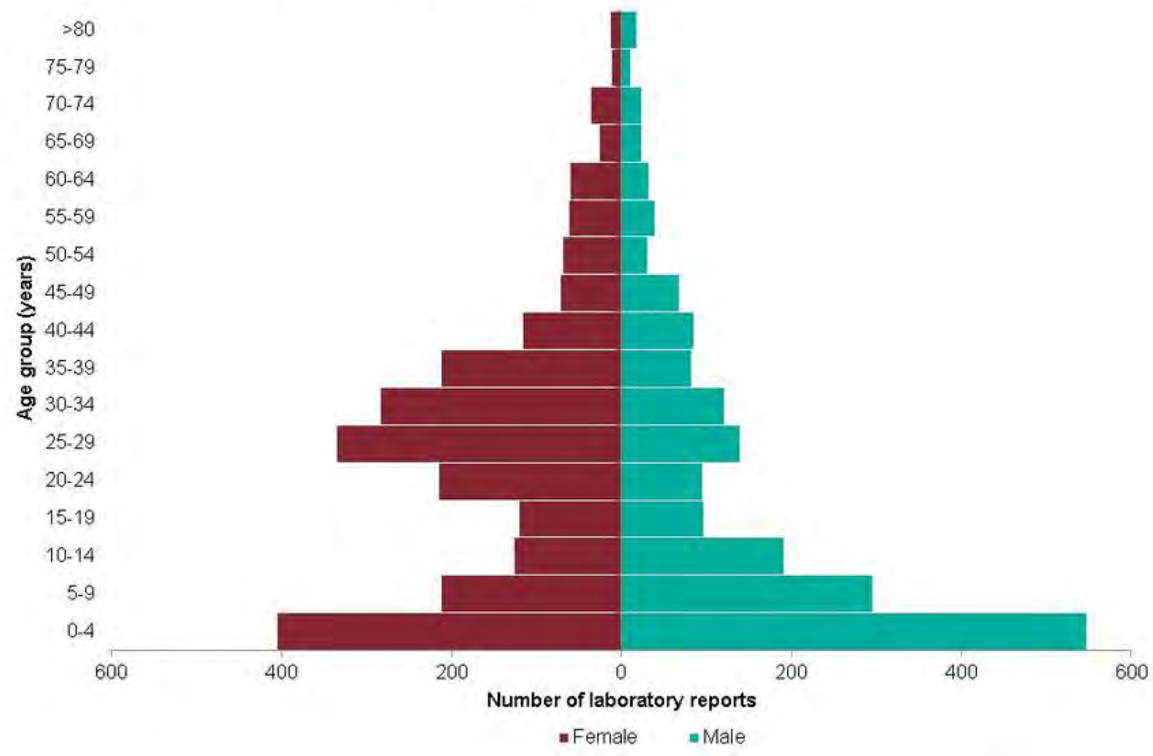
Discussion:

What is your interpretation of this graph?

Public Health England (2019): Cryptosporidium data 2008 to 2017. https://www.gov.uk/government/publications/cryptosporidium-national-laboratory-data/cryptosporidium-data-2008-to-2017

Analysis by age and sex – number of notifications

Figure 2: Age and sex distribution of laboratory reports of Cryptosporidium spp reported in England and Wales: 2017[3].



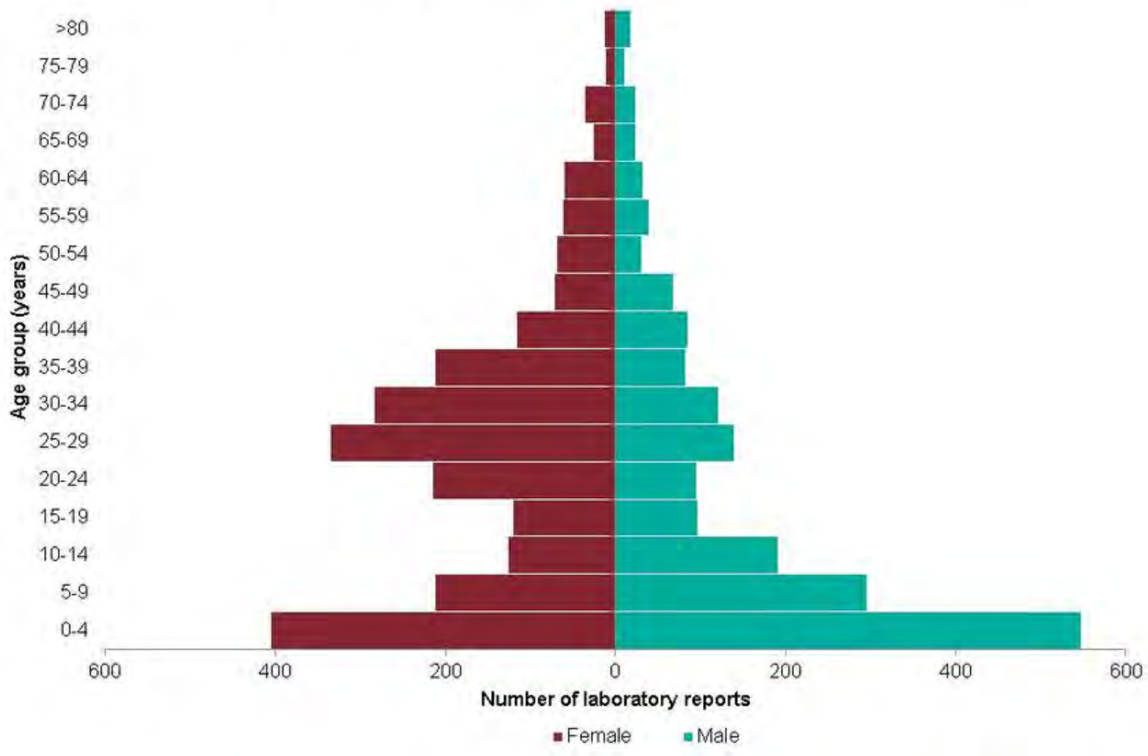
Interpretation: The highest number of laboratory reports of cryptosporidium occurs in children aged 0-4 years old. In this age-group, the burden is highest in males. The burden of cryptosporidium is also high among women aged between 20 and 39.

What are the possible explanations for the different distribution of cryptosporidium by age and sex?

Public Health England (2019): Cryptosporidium data 2008 to 2017. https://www.gov.uk/government/publications/cryptosporidium-national-laboratory-data/cryptosporidium-data-2008-to-2017

Analysis by age and sex – number of notifications

Figure 2: Age and sex distribution of laboratory reports of Cryptosporidium spp reported in England and Wales: 2017[3].



Young children:

- Environmental exposure including exposure to animals
- Greater susceptibility
- More severe disease and greater care seeking

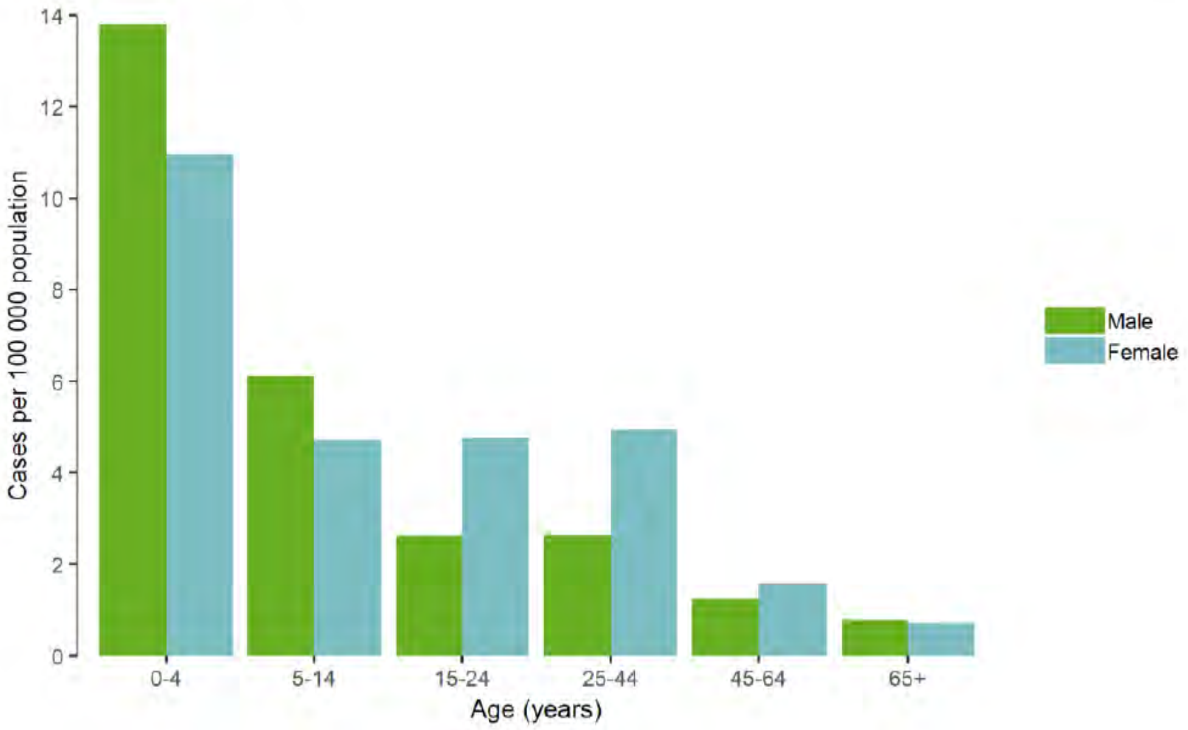
Women aged 20-40:

- Drink more water?
- Eat more salad and raw vegetables?
- More likely to seek care?

Public Health England (2019): Cryptosporidium data 2008 to 2017. https://www.gov.uk/government/publications/cryptosporidium-national-laboratory-data/cryptosporidium-data-2008-to-2017

Analysis by age and sex

Figure 4. **Distribution of confirmed cryptosporidiosis cases per 100 000 population, by age and gender, EU/EEA, 2017**



Discussion:

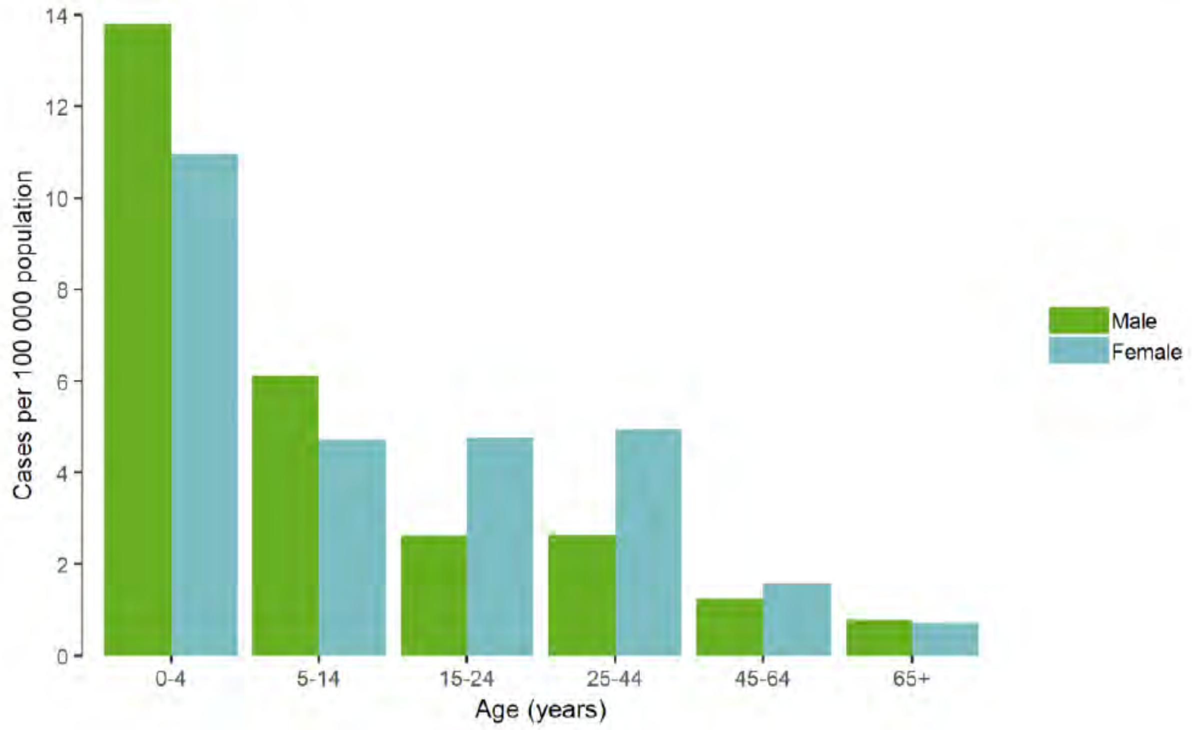
What is your interpretation of this graph?

What is the advantage of this type of graph compared to the previous graph?

ECDC (2019): Cryptosporidiosis. Annual Epidemiological Report for 2017. https://www.ecdc.europa.eu/sites/default/files/documents/AER_for_2017-cryptosporidiosis.pdf

Analysis by age and sex

Figure 4. **Distribution of confirmed cryptosporidiosis cases per 100 000 population, by age and gender, EU/EEA, 2017**



Interpretation: The notification rate is highest in those aged 0-4 years old, and particularly in males aged 0 to 4 years. Higher notification rates are also observed in women aged 15 to 24 and 25 to 44.

Advantages:

Adjust for size of underlying population in each age and sex group

ECDC (2019): Cryptosporidiosis. Annual Epidemiological Report for 2017. https://www.ecdc.europa.eu/sites/default/files/documents/AER_for_2017-cryptosporidiosis.pdf

Analysis by person – risk factors for infection

Table 1. Number of cases (and percentage of cases where information available) where selected risk factors were reported for cryptosporidiosis cases (n=629), Ireland, 2018

Risk factor	Yes	No	UNK/NS	% of known
Travel outside of Ireland[a]	43	435	151	9.0%
Lives/cared for on farm	167	386	76	30.2%
Visited farm	164	329	136	33.9%
Lives/works on or visited farm[b]	296	213	120	58.1%
Swimming pool visit	166	385	78	30.1%
Other water based activities	45	397	187	10.2%
Contact with domestic pets	365	164	100	69.0%

Data source: CIDR

[a]*Based on country of infection variable*
[b]*Composite of the two previous variables*

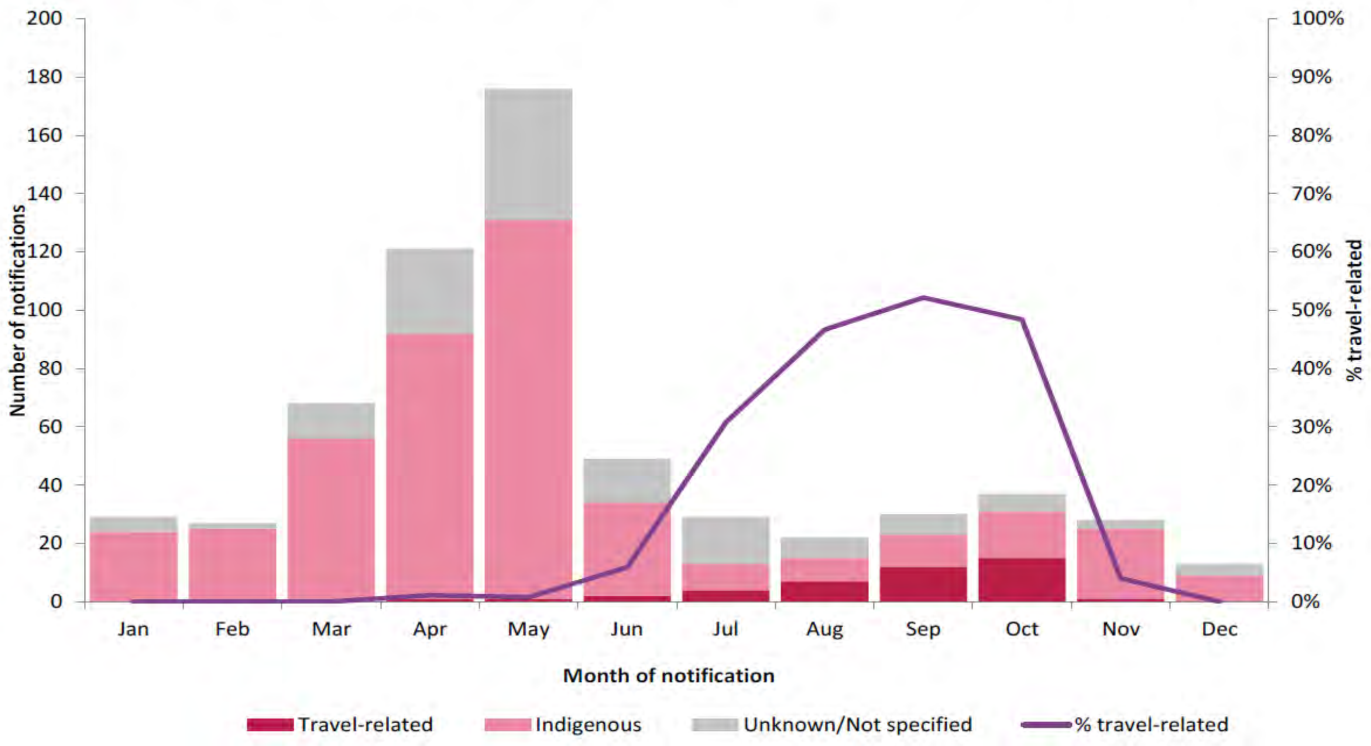
***Discussion**: What is your interpretation of this table?*

HSE Health Protection Surveillance Centre (2019): Cryptosporidiosis in Ireland, 2018. https://www.hpsc.ie/a-z/gastroenteric/cryptosporidiosis/publications/epidemiologyofcryptosporidiosisinirelandannualreports/Crypto%20Annual%20Report%202018.pdf

Other types of analyses

Analysis by person and time –risk factors for infection

Figure 4. **Seasonal distribution of cryptosporidiosis cases by travel status, Ireland, 2018**



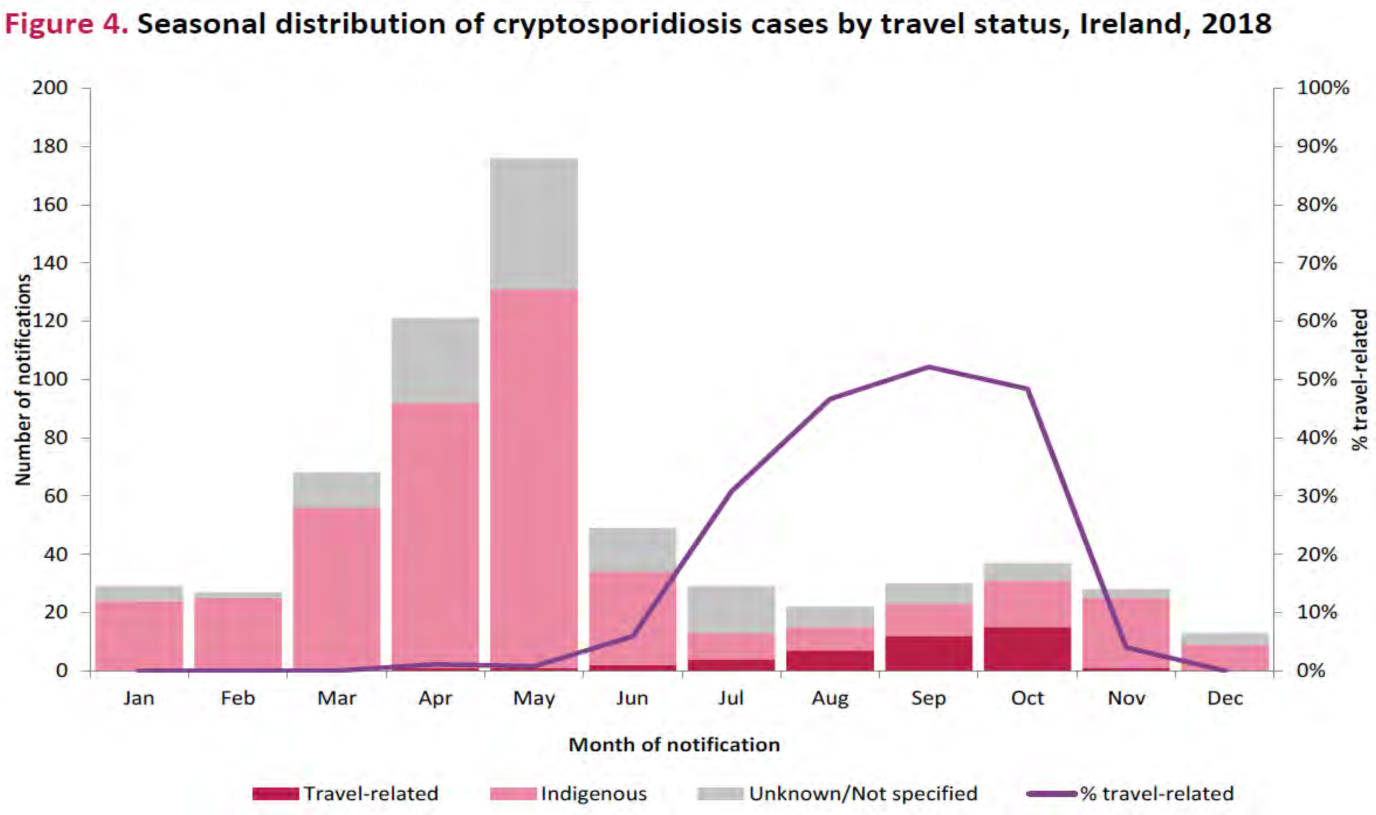
Discussion:

What is your interpretation of this graph?

What are the possible explanations for the varying distribution of cryptosporidiosis in this graph?

HSE Health Protection Surveillance Centre (2019): Cryptosporidiosis in Ireland, 2018. https://www.hpsc.ie/a-z/gastroenteric/cryptosporidiosis/publications/epidemiologyofcryptosporidiosisinirelandannualreports/Crypto%20Annual%20Report%202018.pdf

Analysis by person and time –risk factors for infection



Interpretation:

Cryptosporidiosis notifications peak in the spring. Travel associated cases are most frequently reported between July and October. The percentage of travel associated cases peaks in October.

Explanation:

Most rain falls in spring → increase in environmental exposure (water and farm exposures) and domestic notifications

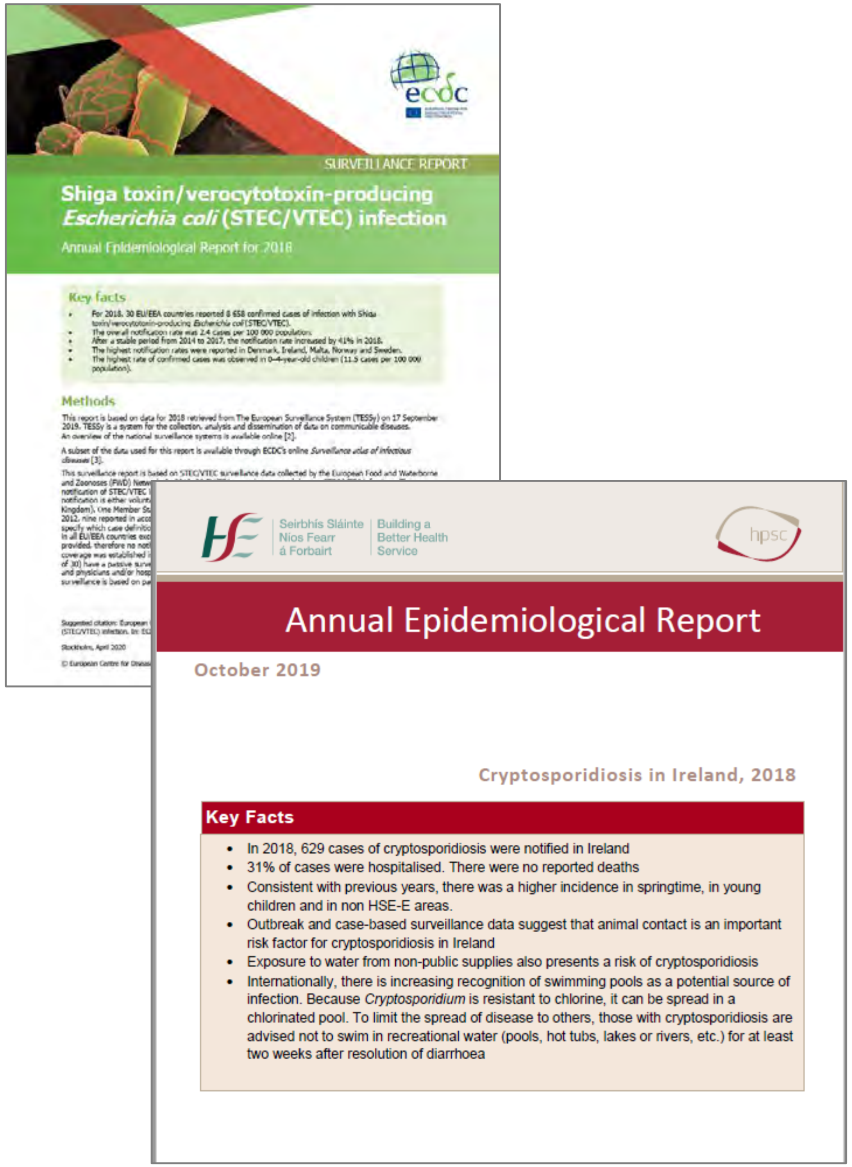
Lambing and calving in spring

Most people travel overseas in the summer – higher numbers of travel associated cases

HSE Health Protection Surveillance Centre (2019): Cryptosporidiosis in Ireland, 2018. https://www.hpsc.ie/a-z/gastroenteric/cryptosporidiosis/publications/epidemiologyofcryptosporidiosisinirelandannualreports/Crypto%20Annual%20Report%202018.pdf

Surveillance Bulletins

- Regularly communicate results of surveillance to stakeholders (weekly, monthly, quarterly)
  - Inform decision making for public health action
  - Demonstrate the purpose and usefulness of surveillance to those working on surveillance
- Incorporate into existing surveillance bulletins (enteric pathogens, food and waterborne illness bulletin, or communicable diseases bulletin)
- Disseminate to stakeholders (water providers, regulators etc)
- Make publicly available (public health agency website)



Outline for a surveillance bulletin

- Key messages / summary
- Introduction (brief)
- Methods (brief)
- Epidemiology
  - Time (trends in notifications or rates)
  - Person (age, sex, other risk factors (travel)
  - Place
- Outbreaks
- Discussion / conclusions

Key messages

- Summarise the main findings and take home messages of the report
  - ***What is the ONE message you want the audience to take away from this report?***
  - ***What is the ONE message the reader needs to understand?***

- Focus the key messages on:
  - The most important conclusions arising from the analyses
  - The most important facts you want to communicate to the reader (3 or 4 facts)

Using surveillance data for advocacy

- Inform development of policy, regulations and guidelines
- Identify priorities and where to target resources for improving the water system
- Estimate impact of WRID –disability adjusted life years, quality adjusted life years, direct costs (healthcare utilisation) and indirect costs (work absenteeism and productivity losses)
- Evaluate impact of control measures
  - impact on incidence after the introduction of the control measure
  - cost benefit analyses

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An Economic Analysis of Water and Sanitation Infrastructure Improvements in the *Colonias* of El Paso County, Texas

JEFFREY A. HAASS, MPIA, GAYLE L. MILLER, DVM, MPH, ANNE C. HADDIX, PHD, LAURANCE N. NICKEY, MD, THOMAS SINKS, PHD

The authors conducted a cost–benefi… improve water supply and sanitation i… community (*colonia*) along the United… The present value of total costs in th… provements was $42,937,507, compare… provements of $34,600,800. It is estim… cess to safe drinking water and … prevented 155 cases of hepatitis A and… testinal illness over 26 years and saved… health care costs, approximately 10%…

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Independent.ie

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In Focus: Newsletter Signup Frontline Star Real Stories Staycations Coronavirus

Cryptosporidium outbreak cost €19m

Stock Image

Paul Melia

July 12 2016 02:30 AM

A Cryptosporidium outbreak that resulted in 120,000 people being forced to boil their water for five months cost €19m, a new study shows.

The 2007 outbreak in Galway cost each household €95 and resulted in one in eight hotel and guesthouse bookings being cancelled.

One in five people in the city refuse to drink the tap water today due to concerns about its safety, the study says.

It found that had the water supply to the city and surrounding areas been subjected to an adequate treatment process costing just €1.6m, it would have resulted in an €11 saving for every €1 invested.

Questions?

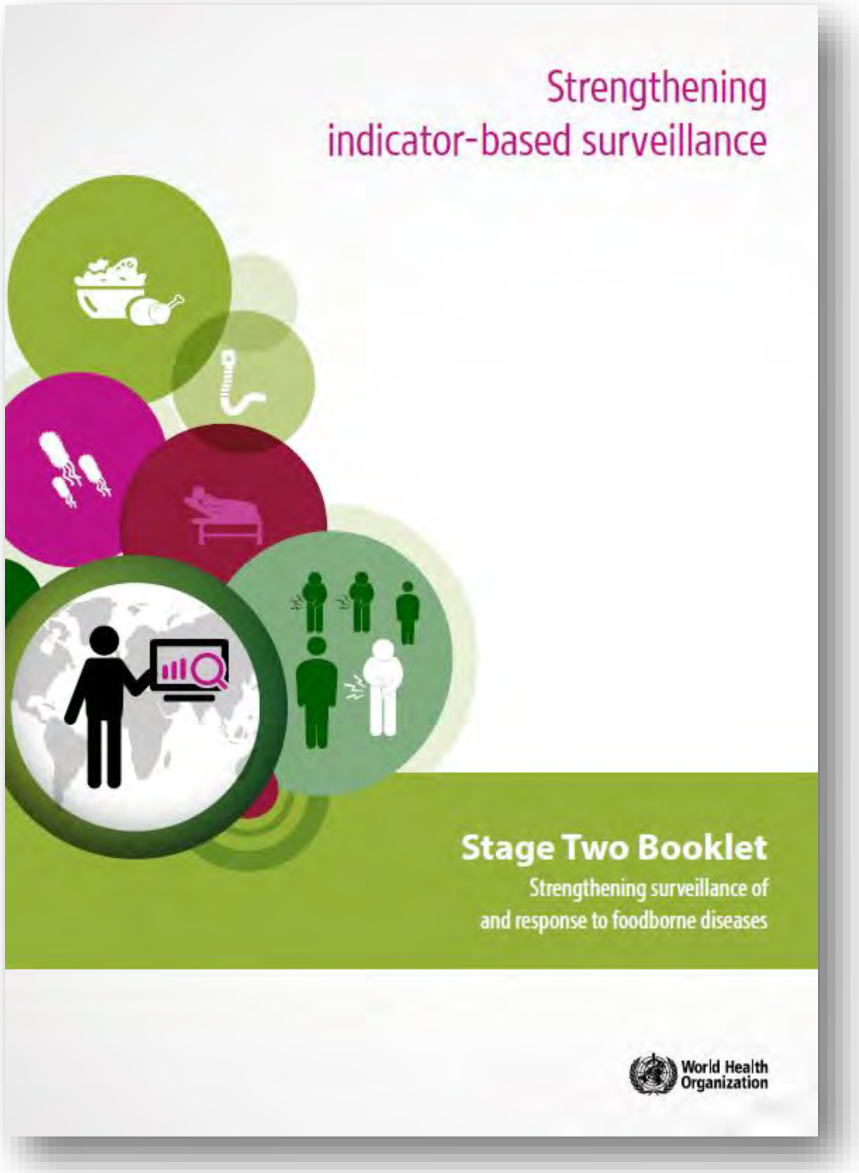
Case Study 1 Strengthening WRID Surveillance Capacity

Case Study 1

PROTOCOL ON WATER AND HEALTH

World Health Organization European Region

UNECE



The content of this case study is adapted from the WHO manual for the surveillance of foodborne diseases

Overview

- Purpose: Work through the steps of strengthening a WRID surveillance system
- Objectives:
  - Assess current WRID surveillance capacity
  - Identify priorities for WRID surveillance strengthening
  - Design a WRID surveillance system
- Approach: Work together in groups
  - Team leader
  - Rapporteur
  - Time keeper
  - Presenter
- Outcome: A draft surveillance protocol
- ***Present protocol to group – template PowerPoint***

Materials

- Case study participant handbook
- Template PowerPoint slide for presentation of results

Scenario

You work in the national public health agency (NPHA) in the division responsible for the surveillance and control of communicable diseases. You work in the team responsible for food and waterborne diseases. You have been tasked with strengthening surveillance for WRID.

Exercise 1: Establish an advisory group and agree roles and responsibilities

You have 10 minutes to complete this exercise

1. Decide membership of advisory group to oversee development and implementation of surveillance system.
2. List types of roles (epidemiologist, laboratory specialist etc), organisations they represent, and responsibility in advisory group and in surveillance.
3. Consider whether to have separate local level advisory groups.
4. Document this information in the table (separate table for the local level group).

Template Table

National Advisory Group for WRID Surveillance		
Role	Organisation	Responsibility in surveillance system development and implementation

Exercise 2: Situation analysis and setting priorities for surveillance

You have 90 minutes to complete this exercise

- Use tools and checklists to:

1. Review the current capacity for WRID surveillance in your country
2. Review the epidemiological situation for WRID in your country
3. Identify and rank the most important WRID
4. Identify surveillance priorities and surveillance options

- Present results (1 minute/group)

Step 1: Assess the current surveillance capacity for WRID in your country

25 minutes

- Use Table 2 in participant handbook

Table 2: Tool for the assessment of current WRID surveillance capacity

Indicator	Yes	Partially	No	Description of what is in place for this indicator	Description of what is not in place for this indicator
1. An indicator-based surveillance system that can monitor trends of WRID, including disease syndromes and identify outbreaks of WRID					
A surveillance system for notifiable diseases that collects data from the local level, and collates the data at the national level on a regular basis					
Existing laws and decrees governing the national notifiable disease surveillance system are up to date and include priority WRID					
A list of priority WRID for surveillance selected through a formal process					

Step 2: Summarise the current epidemiological situation for WRID in your country

25 minutes

- Review surveillance data (past 5 years).

1. What are the most frequently reported diseases and syndromes?
2. Are any of these potentially water-related?
3. Were any events or outbreaks water-related? - causal pathogens, number of cases?
4. What pathogens are detected in the water-supply system?

→ ***What are the most important WRID in your country?***

→ ***What are the gaps and opportunities for strengthening surveillance?***

Step 3: Summarise data on diseases and syndromes as part of the prioritisation process

20 minutes

- Use criteria in Table 3 of the participant handbook to assess what to prioritise

Table 3: Criteria for the priority assessment

Criteria	Factors to consider
Disease burden – size of the problem	Percentage of cases attributable to waterborne transmission Annual incidence rate

- Summarise data in table 4 of the participant handbook

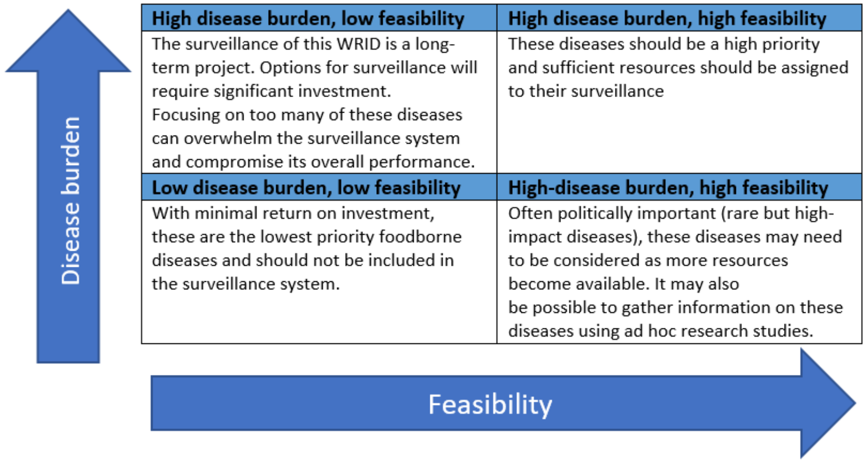
Table 4: Overview of the epidemiological situation for the WRID included in the priority assessment

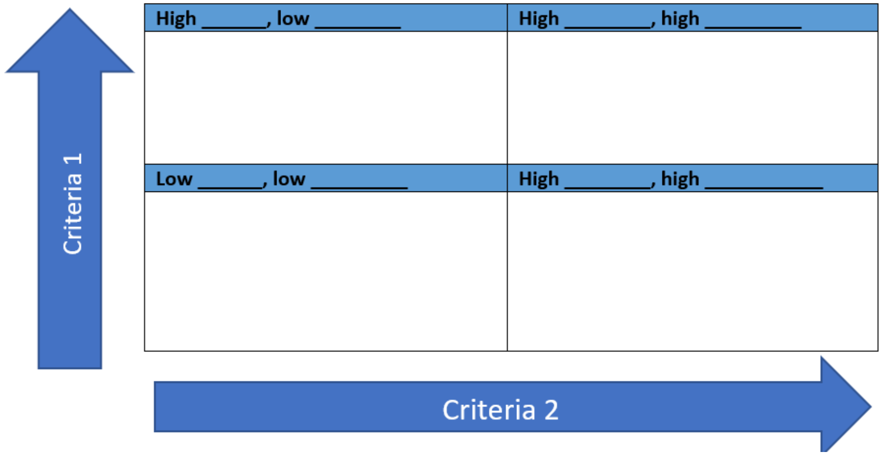
Questions	Disease 1	Disease 2	Disease 3
Disease name			
A. Disease burden			
Percentage of annual cases			

Step 4: Decide what diseases to include

20 minutes

1. Decide which criteria from Table 3 to use in your strategy grid.
2. Rank the diseases for inclusion in surveillance using the blank strategy grid (Figure 1).
3. Pick one pathogen and one syndrome for inclusion in the system
4. Additional surveillance outcomes?
5. List surveillance outcomes (3) to be included
6. Identify surveillance options (Table 5)





Present results using template

Priority surveillance outcomes	Surveillance options for each outcome	Rationale for choosing these outcomes and options

Table 6 of the participant handbook

Exercise 3: Define the purpose, scope and objectives for the surveillance system

20 minutes

- Define the purpose, scope and objectives of the surveillance system
- Complete table in your template presentation (also Table 7 of participant handbook)

Purpose	
Scope	
Objectives	

Exercise 4: Define the surveillance outcomes, the core dataset and design the system

30 minutes

- Link each surveillance outcome to a surveillance objective.
- **Select one surveillance outcome**:

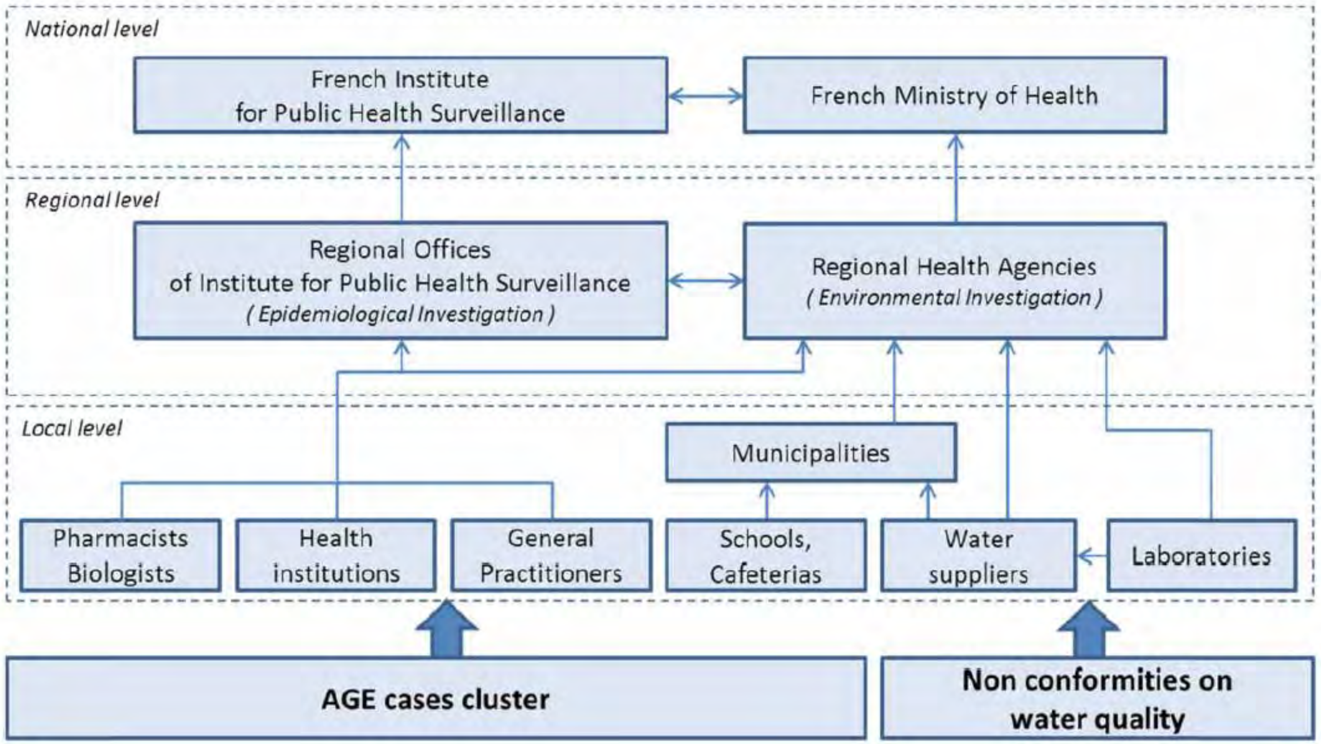
1. Agree the case definition
2. Identify the sources of data for the outcome
3. Define the core dataset and reporting frequency
4. Consider the strengths and limitations of your system

- Use the template tables in the participant guide (Tables 8, 9, 10 and 11) and PowerPoint

Exercise 5: Develop a methodology for collecting, managing and analysing the surveillance data

30 minutes

- Develop diagram describing the system
- Plans to disseminate results in surveillance bulletin
- Present surveillance protocol to group (**10 minutes**)



Rambaud et al. (2016): Automated detection of case clusters of waterborne acute gastroenteritis from health insurance data – pilot study in three French districts. Journal of Water & Health, https://doi.org/10.2166/wh.2015.135

Group presentations (1 hour)

Water-related Infectious Disease Surveillance Case Study 1

Participant Guide

Contents

Advance preparation

To ensure successful work on the case study during the training, participants are requested to familiarise themselves with the instructions provided in this handbook and in particular to collate, in advance of the training workshop, information on the following:

1. A description of their public health system overall and the existing system for WRID surveillance and outbreak management – how is this organised (national, subnational etc)
2. Recent surveillance data on any WRID currently monitored in the country (ideally data from the past 5 years)
3. Background data on WRID outbreaks

This information is needed to undertake steps 1 to 3 of Exercise 2 and so participants are requested to bring this information with them for use during the case study.

Introduction

This case study will take participants through a series of exercises that will mirror the main steps involved in strengthening WRID surveillance. The objectives of the case study are to:

1. Assess current WRID surveillance capacity
2. Identify priorities for WRID surveillance strengthening
3. Design a WRID surveillance system

Organization of the case study

The case study consists of group work on a series of five exercises (taking around 3 hours), followed by a 1-hour plenary debrief. The case study is structured as follows:

GROUP WORK	**180 minutes**
Exercise 1: Establish an advisory group and agree roles and responsibilities	10 minutes
Exercise 2: Situation analysis and setting priorities for surveillance	90 minutes
Step 1	25 minutes
Step 2	25 minutes
Step 3	20 minutes
Step 4	20 minutes
Exercise 3: Define the purpose, scope and objectives for the surveillance system	20 minutes
Exercise 4: Define the surveillance outcomes, the core dataset and design the system	30 minutes
Exercise 5: Develop a methodology for collecting, managing and analysing the surveillance data	30 minutes
PLENARY Session (Group Presentations)	**60 minutes**
Total time	**240 minutes**

Participants will work together in groups of five to six people to complete the case study. We suggest that each group should appoint:

- A team leader and time-keeper who will moderate the group activities, and ensure the group keeps to the allocated time for each exercise
- A rapporteur / note-taker who will be responsible for documenting the work of the group
- A presenter, who will present the group's work during plenary discussions.

Course materials available for this case study

- A case study participant handbook, which takes you through all the exercises in the case study, and which includes tools, checklists and tables for you to work through
- A blank template PowerPoint presentation for you to document the results of your work on the case study. You should complete the PowerPoint as you work through the case study. At the end of the case study, your group will present an overview of your WRID surveillance system using the template presentation.

Outcomes

By the end of this case study each group will have designed and developed a draft outline of a protocol for WRID surveillance. Groups are asked to document the outcomes of the exercises on the provided PowerPoint template for presentation and discussion with the groups at the end of the case study.

Scenario

You work in the national public health agency (NPHA) in the division responsible for the surveillance and control of communicable diseases. You work in the team responsible for food and waterborne diseases. You have been tasked with strengthening surveillance for WRID.

Exercise 1: Establish an advisory group / working group and agree roles and responsibilities

You have 10 minutes to complete this exercise

1. As a group, discuss and agree who to include in the advisory group who will oversee the development and implementation of the surveillance system.
2. Instead of naming individuals, list the types of roles that will be represented in the group (for instance epidemiologist, laboratory specialist etc), name the organisations they represent, and their responsibility in the advisory group and in surveillance.
3. Document this information in the table.
4. Consider whether to have separate local level advisory groups.
5. If you decide to have both national and local level groups, create a separate table for the local level group.
6. Add extra rows to the table as necessary

Table 1: Membership of the national advisory group for WRID surveillance

National Advisory Group for WRID Surveillance		
Role	**Organisation**	**Responsibility in surveillance system development and implementation**

Exercise 2: Situation analysis and setting priorities for surveillance

You have 90 minutes to complete this exercise

This exercise covers four steps and you will use tools and checklists to:

1. Review the current capacity for WRID surveillance in your country
2. Review the epidemiological situation for WRID in your country
3. Identify and rank the most important WRID
4. Identify surveillance priorities and surveillance options

Step 1: Use the following table to assess the current surveillance capacity for WRID in your country (25 minutes)

Table 2: Tool for the assessment of current WRID surveillance capacity

Indicator	Yes	Partially	No	Description of what is in place for this indicator	Description of what is not in place for this indicator
1. An indicator-based surveillance system that can monitor trends of WRID, including disease syndromes and identify outbreaks of WRID					
A surveillance system for notifiable diseases that collects data from the local level, and collates the data at the national level on a regular basis					
Existing laws and decrees governing the national notifiable disease surveillance system are up to date and include priority WRID					
A list of priority WRID for surveillance selected through a formal process					
Laboratory-based surveillance for priority WRID, in which cases detected through the surveillance system are confirmed and further characterized in the laboratory					
Inclusion in the surveillance system diseases and syndromes that may indicate WRID (e.g. diarrhoea)					
There are case definitions for each of the WRID under surveillance					

Table 2 contd

Protocols for testing clinical specimens for all priority WRID that includes: • a description of how laboratory testing is organized e.g. identifying what samples from which reporting sites go to which laboratories, • instructions for the further characterization of priority pathogens.					
Data reporting forms and a data reporting system (e.g. fax number, telephone notification, web-based system)					
Laboratory and healthcare workers who know and are trained in the surveillance procedures					
A database to store the surveillance data, with a data dictionary					
A protocol that documents the functioning of the surveillance system and which describes: • who will send/ enter the data to the surveillance system, • what data will be sent, • how often the data will be sent, • what actions will be taken on the basis of the information sent to the surveillance system					
Capacity to analyse surveillance data on a regular basis (e.g. every week or every two weeks) to monitor trends and detect outbreaks					
Regular publication and dissemination of surveillance bulletins, showing the trends in syndromic data that may indicate WRID					
2. An event-based surveillance (EBS) system capable of detecting WRID events					
A national focal point to receive reports about events					
An event report forms to capture information about an event					

Table 2 contd

An event database to store information about reported events					
Health care workers, sanitary inspectors, environmental and waterworks staff have been trained on reporting WRID events to EBS					
3. Monitoring and evaluating the WRID surveillance system					
Monitoring indicators for each component of the system					
A process for measuring the monitoring indicators (e.g. define when system will be monitored, how it will be monitored and by whom)					
A log of system performance					
Regular evaluation of the WRID surveillance system					

Step 2: Summarise the current epidemiological situation for WRID in your country (25 minutes)

- Review data from the existing event based and indicator-based surveillance systems in your country. Focus on data from the past 5 years.
- What are the diseases and syndromes most frequently reported through indicator-based surveillance?
- Are any of the most frequently reported diseases and syndromes potentially water-related?
- For events and outbreaks detected through event-based surveillance and indicator-based surveillance, were any of these potentially water-related? If yes, what were the causal pathogens and how many people were affected?
- Review any available data on pathogens detected in the water-supply system in your country, including data on the frequency of detection
- Based on the previous questions, what do you consider to be the most important WRID in your country?
- Considering the existing surveillance capacity in your country, are there any gaps or opportunities for strengthening WRID surveillance?

Step 3: Summarise data on diseases and syndromes as part of the prioritisation process (20 minutes)

- Use the following criteria to assess what diseases and syndromes to prioritise for surveillance

Table 3: Criteria for the priority assessment

Criteria	Factors to consider
Disease burden – size of the problem and severity of the clinical outcomes	Percentage of cases attributable to waterborne transmission Annual incidence rate Vulnerability of exposed population groups (by sex, age, ethnicity) Case-fatality ratio Hospitalisation rate Frequency and nature of long-term sequelae of infection
Information about the hazard	Water monitoring data for microbial pathogens
Epidemiological features	Outbreak potential: number and size of outbreaks attributed to this pathogen Trends in disease incidence over time
Societal burden	Economic cost Public perceptions of risk Political context
Feasibility	Diagnostic capacity Capacity to conduct surveillance

- Based on the review in step 2, and in particular focusing on gaps in existing surveillance capacity identified in steps 1 and 2, **select 3 pathogens or syndromes** that are potentially water-related for priority assessment. Summarise the available data on these pathogens and syndromes using the following table.

Table 4: Overview of the epidemiological situation for the WRID included in the priority assessment

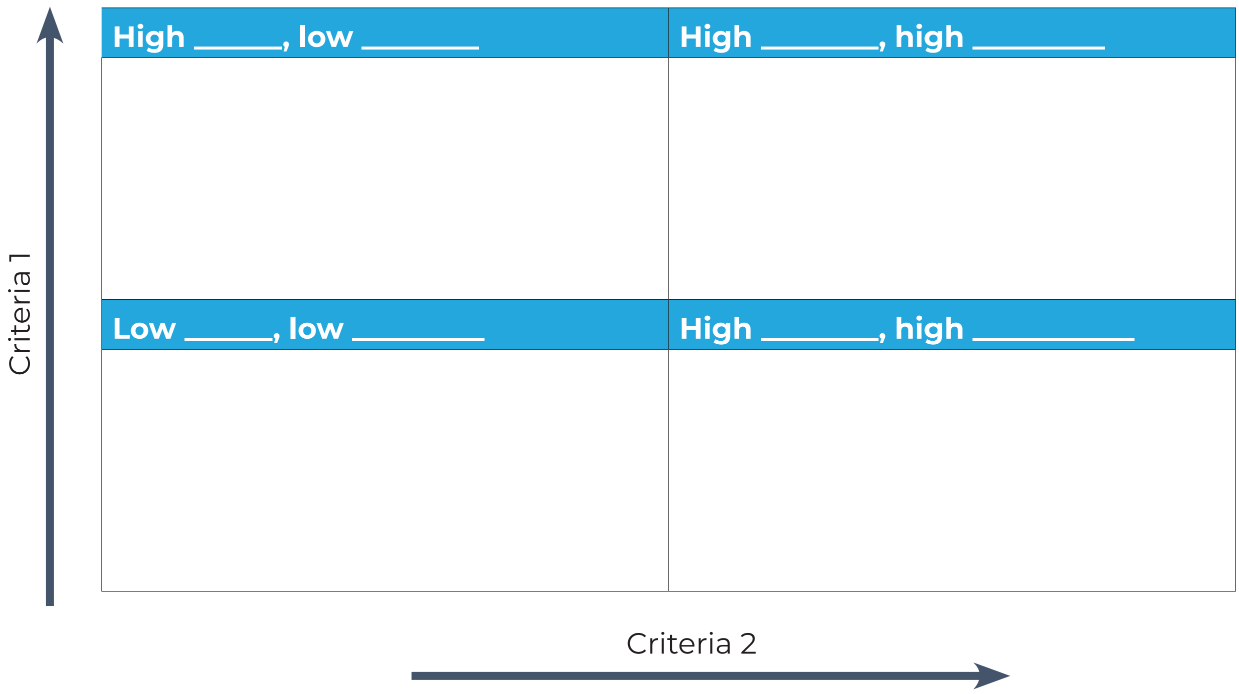
Questions	Disease 1	Disease 2	Disease 3
Disease name			
A. Disease burden			
Percentage of annual cases attributable to waterborne transmission			
Annual number of cases			
Annual incidence rate per 100 000 population			
At-risk populations Male:female ratio Age groups most affected Other high-risk groups			
% of cases hospitalised or hospitalisation rate/ 100 000 population			
Case fatality rate			
Nature and frequency of long-term disabilities			
B. Information about hazards			
Water-monitoring data for microbial pathogens			
C. Epidemiological features			
Outbreak potential: Number of WRID outbreaks associated with pathogen in past 5 years Number of cases in each outbreak			
Is the disease incidence increasing or decreasing over the past 5 years			
D. Availability of treatment and control			
Availability of treatment			
Specific prevention or control measures			
E. Societal burden			
Estimated economic cost per year			
Public perception of risk (high/medium/low)			
Is the pathogen a political priority? Y/N			
E. Feasibility			
Are reliable diagnostic tests readily available?			
Current diagnostic capacity in country?			
Ability to conduct surveillance for the disease in country?			

Step 4: Decide what diseases to include (20 minutes)

We will use strategy grids for this exercise.

1. Decide which criteria from **Table 3** to use in your strategy grid.
2. Use the blank strategy grid (**Figure 1**) to rank the diseases under consideration for inclusion in surveillance.
3. Pick one pathogen and one syndrome for inclusion in the system
4. Are there any additional surveillance outcomes that you would like to prioritise for surveillance?

Figure 1: Blank strategy grid for ranking diseases for inclusion in surveillance



5. List the surveillance outcomes that you will include in surveillance.

- Surveillance outcome 1:
- Surveillance outcome 2:
- Surveillance outcome 3:

6. Translate priorities into surveillance options (**5 minutes**)

Using the following table, for each surveillance outcome, identify what types of surveillance you will conduct for that surveillance outcome, including the rationale for choosing that surveillance option.

Table 5: Selection of surveillance options

	Surveillance options						
Surveillance outcome	Notifiable disease	Syndromic	Laboratory	Sentinel	Other indicator-based -Specify	Event-based	Rationale for selecting these surveillance options
1.							
2.							
3.							

Present the results of the priority setting exercise in the following table

Table 6: Results of the priority setting exercise

Priority surveillance outcomes	Surveillance options for each outcome	Rationale for choosing these outcomes and options

Exercise 3: Define the purpose, scope and objectives for the surveillance system

You have 20 minutes to complete this exercise

1. As a group, discuss and agree the purpose, scope and objectives of the surveillance system, and document these in the following table. We suggest defining 3 objectives for the system.

Table 7: Purpose, scope and objectives of the system

Purpose	
Scope	
Objectives	

Exercise 4: Define the surveillance outcomes, the core dataset and design the system

You have 30 minutes to complete this exercise

In this exercise you will link each surveillance outcome to a surveillance objective.

You will select one of the surveillance outcomes, and for this outcome you will:

- Agree the case definition
- Identify the sources of data for the outcome
- Define the core dataset and reporting frequency
- Consider the strengths and limitations of your system

1. Using the following table, link each surveillance objective defined in exercise 3 to the outcomes selected in exercise 2 (outcomes can be linked to more than one objective)

Table 8: Linkage between the surveillance objectives and the outcomes

	Surveillance objective	Surveillance outcomes
1		
2		
3		

2. Pick one of the surveillance outcomes and specify the case definition for that outcome. You can include confirmed, probable and possible case definitions.

Table 9: Case definitions for the surveillance outcomes

Surveillance outcome	Case definitions

3. Identify and list the sources of data for this surveillance outcome

Table 10: Data sources for the surveillance outcome

Data Sources

4. Define the core dataset and reporting frequency for this outcome using the following table (NB: you might collect more than one type of data on a surveillance outcome)

Table 11: Data to be collected on the surveillance outcome

Surveillance outcome	Type of data	Core dataset	Reporting frequency

5. List two strengths and two limitations of your surveillance system

Strengths:

1.

2.

Limitations:

1.

2.

Exercise 5: Develop a methodology for collecting, managing and analysing the surveillance data

You have 30 minutes to complete this exercise

During this exercise you will:

1. Develop a schematic diagram for the surveillance of the outcome selected in the previous exercise

   This diagram should detail:

   a. The data flows for the system, including who will collect and report the data

   b. How water providers, water regulators and other multisectoral stakeholders will be included in the system

   c. The plan for analysing the data, including who will do this and how often

   d. How the data will be used

2. Describe the plans for disseminating the results of surveillance in a surveillance bulletin.

You can use a whiteboard to develop the schematic diagram, or you can do this electronically using the PowerPoint template or another application like Word.

Throughout the case study you have documented the results of your work in both this handbook and in the PowerPoint template provided. This template now essentially gives an overview of your WRID surveillance protocol. At the end of this exercise you will be given 10 minutes to present this PowerPoint to the group.

Water-related Infectious Disease Surveillance Case Study 1

Facilitator Guide

PROTOCOL ON WATER AND HEALTH

World Health Organization
European Region

UNECE

Contents

Water-related Infectious Disease Surveillance Case Study 1

Objectives

The objective of this exercise is to give participants hands on experience of developing a protocol for the surveillance of water-related infectious disease.

Advance preparation

To ensure successful work on the case study during the training, participants are requested to familiarise themselves with the instructions provided in this handbook and in particular to collate, in advance of the training workshop, information on the following:

1. A description of their public health system overall and the existing system for WRID surveillance and outbreak management – how is this organised (national, subnational etc)
2. Recent surveillance data on any WRID currently monitored in the country (ideally data from the past 5 years)
3. Background data on WRID outbreaks

This information is needed to undertake steps 1 to 3 of Exercise 2 and so participants are requested to bring this information with them for use during the case study.

Structure of the exercise

During this case study you will take participants through a series of exercises that will mirror the main steps involved in strengthening WRID surveillance. The objectives of the case study are to:

1. Assess current WRID surveillance capacity
2. Identify priorities for WRID surveillance strengthening
3. Design a WRID surveillance system

You can use the accompanying PowerPoint presentation to walk participants through the presentation. The presentation includes prompts and instructions for each exercise.

Organization of the case study

The case study consists of group work on a series of five exercises (taking around 3 hours), followed by a 1-hour plenary debrief. The case study is structured as follows:

GROUP WORK	**180 minutes**
Exercise 1: Establish an advisory group and agree roles and responsibilities	10 minutes
Exercise 2: Situation analysis and setting priorities for surveillance	90 minutes
Step 1	25 minutes
Step 2	25 minutes
Step 3	20 minutes
Step 4	20 minutes
Exercise 3: Define the purpose, scope and objectives for the surveillance system	20 minutes
Exercise 4: Define the surveillance outcomes, the core dataset and design the system	30 minutes
Exercise 5: Develop a methodology for collecting, managing and analysing the surveillance data	30 minutes
PLENARY Session (Group Presentations)	**60 minutes**
Total time	**240 minutes**

Ask participants to work together in groups of five to six people to complete the case study. We suggest that each group should appoint:

- A team leader and time-keeper who will moderate the group activities, and ensure the group keeps to the allocated time for each exercise
- A rapporteur / note-taker who will be responsible for documenting the work of the group
- A presenter, who will present the group's work during plenary discussions.

By the end of this case study each group will have designed and developed a draft outline of a protocol for WRID surveillance, which they will present at the plenary session.

Ask groups to document the outcomes of the exercises on the provided PowerPoint template for presentation and discussion with the groups during a plenary session at the end of the case study.

The entire case study should take about 3 hours, with an additional hour for groups to present their protocols

Course materials available for this case study

- Case study facilitator handbook: including facilitator probes to guide the discussion
- Facilitator PowerPoint presentation: a set of slides are available to be used and edited as needed by the workshop facilitators. They include the case study structure and probes for the delivery of the case study.
- A case study participant handbook, which takes participants through all the exercises in the case study, and which includes tools, checklists and tables for them to work through
- A blank template PowerPoint presentation for participants to document the results of their work on the case study. Participants should complete the PowerPoint as they work through the case study. At the end of the case study, ask each group to present an overview of their WRID surveillance system using the template presentation.

Group Work

Scenario

Present the following scenario to the participants:

You work in the national public health agency (NPHA) in the division responsible for the surveillance and control of communicable diseases. You work in the team responsible for food and waterborne diseases. You have been tasked with strengthening surveillance for WRID.

Exercise 1: Establish an advisory group / working group and agree roles and responsibilities

Participants have 10 minutes to complete this exercise.

Walk participants through the following instructions:

1. As a group, discuss and agree who to include in the advisory group who will oversee the development and implementation of the surveillance system.
2. Instead of naming individuals, list the types of roles that will be represented in the group (for instance epidemiologist, laboratory specialist etc), name the organisations they represent, and their responsibility in the advisory group and in surveillance.
3. Document this information in the table provided in either or both of the participant handbook and the template presentation.
4. Consider whether to have separate local level advisory groups.
5. If you decide to have both national and local level groups, create a separate table for the local level group.
6. Add extra rows to the table as necessary

Table 1: Membership of the national advisory group for WRID surveillance

National Advisory Group for WRID Surveillance		
Role	**Organisation**	**Responsibility in surveillance system development and implementation**

Exercise 2: Situation analysis and setting priorities for surveillance

This exercise comprises four steps. The exercise is presented in slides 7 to 12 of the facilitator presentation. Walk the groups through these slides before they start the exercise. Participants have 90 minutes to complete this exercise

Ask the participants to use the provided tools and checklists to:

Step 1: Review the current capacity for WRID surveillance in their country

Step 2: Review the epidemiological situation for WRID in their country

Step 3: Identify and rank the most important WRID

Step 4: Identify surveillance priorities and surveillance options

Step 1: Review the current capacity for WRID surveillance in their country

In **Step 1** of this exercise, ask participants to use **table 2** on **page 3** of the participant handbook (and on the next page of this handbook) to assess the current surveillance capacity for WRID in their country. Ask them to go through each question in the table and assess whether there is complete, partial or no capacity for each indicator in their country. Ask them to note what is in place for each indicator, and what is missing for each indicator. ***Participants have 25 minutes to complete this step, so advise them to keep their responses short.***

Table 2: Tool for the assessment of current WRID surveillance capacity

Indicator	Yes	Partially	No	Description of what is in place for this indicator	Description of what is not in place for this indicator
1. An indicator-based surveillance system that can monitor trends of WRID, including disease syndromes and identify outbreaks of WRID					
A surveillance system for notifiable diseases that collects data from the local level, and collates the data at the national level on a regular basis					
Existing laws and decrees governing the national notifiable disease surveillance system are up to date and include priority WRID					
A list of priority WRID for surveillance selected through a formal process					

Table 2 contd

Laboratory-based surveillance for priority WRID, in which cases detected through the surveillance system are confirmed and further characterized in the laboratory					
Inclusion in the surveillance system diseases and syndromes that may indicate WRID (e.g. diarrhoea)					
There are case definitions for each of the WRID under surveillance					
Protocols for testing clinical specimens for all priority WRID that includes: • a description of how laboratory testing is organized e.g. identifying what samples from which reporting sites go to which laboratories, • instructions for the further characterization of priority pathogens.					
Data reporting forms and a data reporting system (e.g. fax number, telephone notification, web-based system)					
Laboratory and healthcare workers who know and are trained in the surveillance procedures					
A database to store the surveillance data, with a data dictionary					
A protocol that documents the functioning of the surveillance system and which describes: • who will send/ enter the data to the surveillance system, • what data will be sent, • how often the data will be sent, • what actions will be taken on the basis of the information sent to the surveillance system					
Capacity to analyse surveillance data on a regular basis (e.g. every week or every two weeks) to monitor trends and detect outbreaks					

Table 2 contd

Regular publication and dissemination of surveillance bulletins, showing the trends in syndromic data that may indicate WRID					
2. An event-based surveillance (EBS) system capable of detecting WRID events					
A national focal point to receive reports about events					
An event report forms to capture information about an event					
An event database to store information about reported events					
Health care workers, sanitary inspectors, environmental and waterworks staff have been trained on reporting WRID events to EBS					
3. Monitoring and evaluating the WRID surveillance system					
Monitoring indicators for each component of the system					
A process for measuring the monitoring indicators (e.g. define when system will be monitored, how it will be monitored and by whom)					
A log of system performance					
Regular evaluation of the WRID surveillance system					

Step 2: Summarise the current epidemiological situation for WRID in their country

Participants have 25 minutes to complete this exercise

Ask participants to:

- Review data from the existing event based and indicator-based surveillance systems in their country. Focus on data from the past 5 years.
- Identify the diseases and syndromes most frequently reported through indicator-based surveillance
- Identify whether any of the most frequently reported diseases and syndromes are potentially water-related
- For events and outbreaks detected through event-based surveillance and indicator-based surveillance, identify whether any of these potentially were water-related? If yes, what were the causal pathogens and how many people were affected?

- Review any available data on pathogens detected in the water-supply system in their country, including data on the frequency of detection
- Based on the previous questions, identify what they consider to be the most important WRID in their country?
- Considering the existing surveillance capacity in their country, identify any gaps or opportunities for strengthening WRID surveillance?

Step 3: Summarise data on diseases and syndromes as part of the prioritisation process

Participants have 20 minutes to complete this exercise

- Ask participants to use the criteria in Table 3 on page 6 of the participant handbook to assess what diseases and syndromes to prioritise for surveillance

Table 3: Criteria for the priority assessment

Criteria	Factors to consider
Disease burden – size of the problem and severity of the clinical outcomes	Percentage of cases attributable to waterborne transmission Annual incidence rate Vulnerability of exposed population groups (by sex, age, ethnicity) Case-fatality ratio Hospitalisation rate Frequency and nature of long-term sequelae of infection
Information about the hazard	Water monitoring data for microbial pathogens
Epidemiological features	Outbreak potential: number and size of outbreaks attributed to this pathogen Trends in disease incidence over time
Societal burden	Economic cost Public perceptions of risk Political context
Feasibility	Diagnostic capacity Capacity to conduct surveillance

- Based on the review in step 2, and in particular focusing on gaps in existing surveillance capacity identified in steps 1 and 2, ask participants to select 3 pathogens or syndromes that are potentially water-related for priority assessment.

- Ask participants to summarise the available data on these pathogens and syndromes using Table 4, on page 7 of the participant handbook.

Table 4: Overview of the epidemiological situation for the WRID included in the priority assessment

Questions	**Disease 1**	**Disease 2**	**Disease 3**
Disease name			
A. Disease burden			
Percentage of annual cases attributable to waterborne transmission			
Annual number of cases			
Annual incidence rate per 100 000 population			
At-risk populations Male:female ratio Age groups most affected Other high-risk groups			
% of cases hospitalised or hospitalisation rate/ 100 000 population			
Case fatality rate			
Nature and frequency of long-term disabilities			
B. Information about hazards			
Water-monitoring data for microbial pathogens			
C. Epidemiological features			
Outbreak potential: Number of WRID outbreaks associated with pathogen in past 5 years Number of cases in each outbreak			
Is the disease incidence increasing or decreasing over the past 5 years			
D. Availability of treatment and control			
Availability of treatment			
Specific prevention or control measures			
E. Societal burden			
Estimated economic cost per year			
Public perception of risk (high/medium/low)			
Is the pathogen a political priority? Y/N			
E. Feasibility			
Are reliable diagnostic tests readily available?			
Current diagnostic capacity in country?			
Ability to conduct surveillance for the disease in country?			

Step 4: Decide what diseases to include

Participants have 20 minutes to complete this exercise

Participants are provided with a blank strategy grid (Figure 1) on page 8 of the participant hand book.

Ask participants to use the strategy grid to help them to identify the priority diseases to include in surveillance. Ask participants to

1. Decide which criteria from **Table 3** to use in the strategy grid.
2. Use the blank strategy grid (**Figure 1**) to rank the diseases under consideration for inclusion in surveillance.
3. Pick one pathogen and one syndrome for inclusion in the system
4. Identify whether there are any additional surveillance outcomes that they would like to prioritise for surveillance?
5. List the surveillance outcomes to include in surveillance.
6. Translate the priorities into surveillance options using **Table 5** on **page 9** of the participant handbook. In particular, for each surveillance outcome, they should identify what types of surveillance they will conduct for that surveillance outcome, including the rationale for choosing that surveillance option.
7. Ask participants to summarise the results of the priority setting exercise using **Table 6** on **page 10** of the participant handbook (and also in the participant template presentation, as well as on **page 11** of this handbook)

Figure 1: Blank strategy grid for ranking diseases for inclusion in surveillance

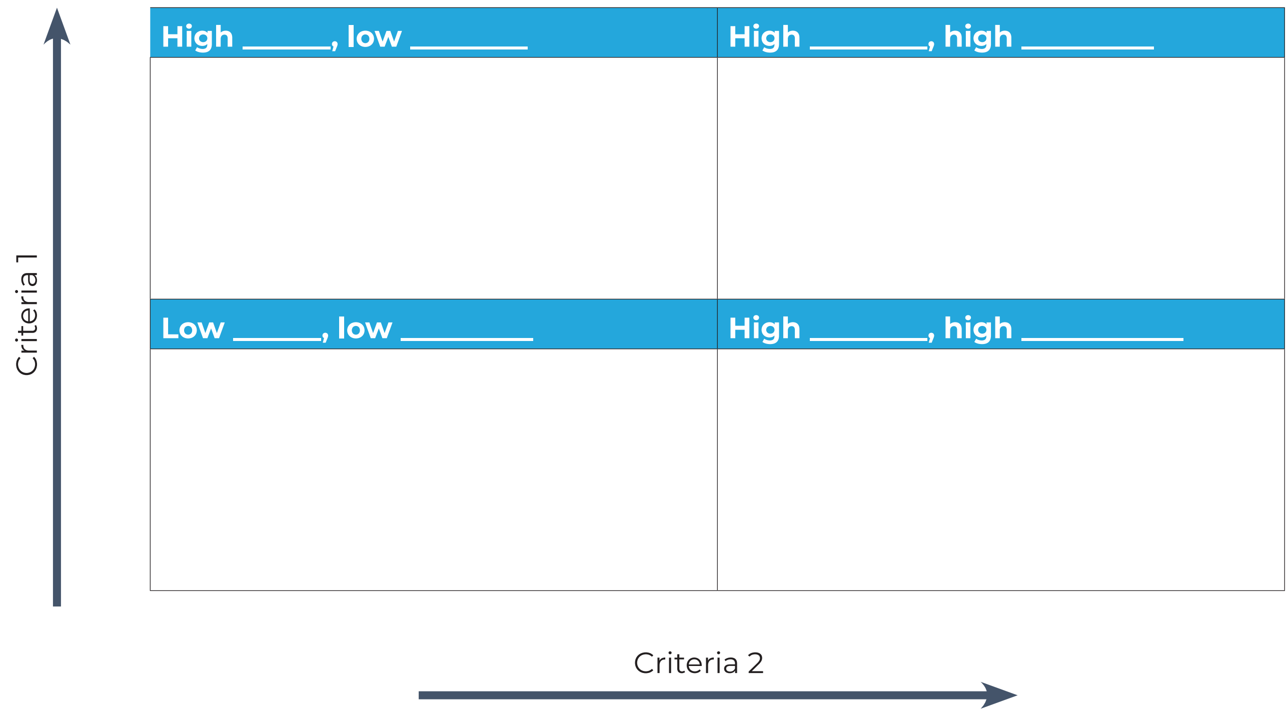


Table 5: Selection of surveillance options

	Surveillance options						
Surveillance outcome	Notifiable disease	Syndromic	Laboratory	Sentinel	Other indicator-based -Specify	Event-based	Rationale for selecting these surveillance options
1.							
2.							
3.							

Table 6: Results of the priority setting exercise

Priority surveillance outcomes	Surveillance options for each outcome	Rationale for choosing these outcomes and options

Exercise 3: Define the purpose, scope and objectives for the surveillance system

Participants have 20 minutes to complete this exercise

Ask participants as a group, to discuss and agree the purpose, scope and objectives of the surveillance system, and to document these in the **Table 7**, on page 10 of the participant hand book (and in the participant template presentation). Suggest that they define 3 objectives for the system.

Table 7: Purpose, scope and objectives of the system

Purpose	
Scope	
Objectives	

Exercise 4: Define the surveillance outcomes, the core dataset and design the system

Participants have 30 minutes to complete this exercise

In this exercise ask participants to link each surveillance outcome to a surveillance objective. Advise the participants to select a single surveillance outcome. For that outcome they should:

- Agree the case definition
- Identify the sources of data for the outcome
- Define the core dataset and reporting frequency
- Consider the strengths and limitations of your system

Remind the participants that surveillance outcomes can address more than one surveillance objective. Participants can draw the schematic diagram on a whiteboard or using word or excel. Remind participants that they can collect more than one type of data on a surveillance outcome (for instance both they can collect both case based and aggregate data for an outcome).

Participants can use Table 8 on page 11 of the participant handbook (and in the template participant presentation) to link each surveillance objective defined in exercise 3 to the outcomes selected in exercise 2 (outcomes can be linked to more than one objective).

Participants should pick one of the surveillance outcomes and specify the case definition for that outcome. They can specify confirmed, probable and possible case definitions. Ask participants to document the case definition in Table 9 on page 11 of the participant handbook (the table can also be found in the template participant presentation).

Table 8: Linkage between the surveillance objectives and the outcomes

	Surveillance objective	Surveillance outcomes
1		
2		
3		

Table 9: Case definitions for the surveillance outcomes

Surveillance outcome	Case definitions

Ask the participants to identify the sources of data for this surveillance outcome and to list the sources of these data in Table 10 on page 12 of the participant handbook (and in the template participant presentation).

Table 10: Data sources for the surveillance outcome

Data Sources

Ask participants to define the core dataset and reporting frequency for this outcome and to document these in Table 11 on page 12 of the participant handbook (and in the template participant presentation). Remind them that they can collect more than one type of data on a surveillance outcome.

Table 11: Data to be collected on the surveillance outcome

Surveillance outcome	Type of data	Core dataset	Reporting frequency

Ask participants to identify and list two strengths and two limitations of their surveillance system and to detail these in the participant handbook and / or the template participant presentation.

Exercise 5: Develop a methodology for collecting, managing and analysing the surveillance data

Participants have 30 minutes to complete this exercise

In this final exercise ask participants to:

1. Develop a schematic diagram for the surveillance of the outcome selected in the previous exercise

   This diagram should detail:

   a. The data flows for the system, including who will collect and report the data

   b. How water providers, water regulators and other multisectoral stakeholders will be included in the system

   c. The plan for analysing the data, including who will do this and how often

   d. How the data will be used

2. Describe the plans for disseminating the results of surveillance in a surveillance bulletin.

Participants can use a whiteboard to develop the schematic diagram, or they can do this electronically using the PowerPoint template or another application like Word.

Plenary session: Group presentations

Throughout the case study participants have documented the results of their work in both the participant handbook and in the PowerPoint template provided. This template now essentially gives an overview of their WRID surveillance protocol. At the end of this exercise ask participants to present their protocol to the group.

Each group has 10 minutes to present their surveillance protocol

Monitor the time they spend on the presentation

Ring the bell after 8 minutes to ensure they keep to time.

For each presentation make sure to ask the group to describe:

1. How the data will be collected and reported, including by whom and to whom
2. How the system will link to multisectoral stakeholders, such as the water providers and water regulators
3. What the plans are for analysing the data and disseminating the results in a surveillance bulletin

Invite other participating groups to ask questions and to give feedback on the surveillance system of the presenting group.

Principles and steps of an outbreak investigation

Module 2.1

World Health Organization
European Region

UNECE

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 int
- Unknown source
- Unknown cause
- Severe and/or
- Larg

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

However, it will still be important to identify the cause and contributing factors in order to prevent new outbreaks

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

Communication Measures

Step 1. Detect and confirm the outbreak and agent

Health-care systems

- Detection by surveillance systems
  - Indicator and event based surveillance
  - Epidemiological
  - Microbiological
- Health-care facilities reports

Water quality

- Routine samples with faecal bacteria
- Water treatment or distribution failures
- User complaints

Other signals

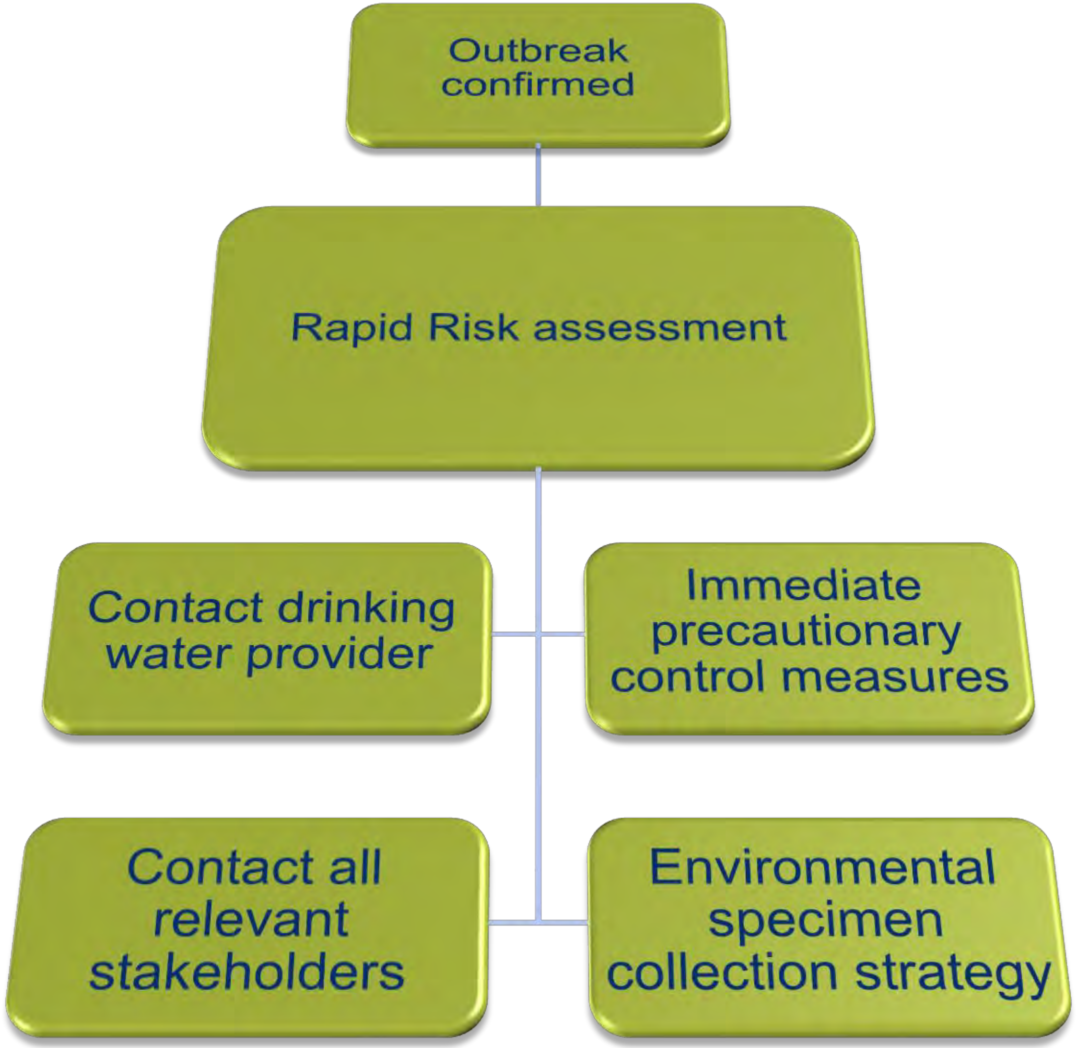
- Absenteeism from work, schools
- Increased sales of certain medications
- Media reports

Step 1. Detect and confirm the outbreak and agent

Is the outbreak real? → More cases than expected?

Seasonal variations?
Notification artefacts?
New surveillance system?
Diagnostic bias?

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

- *Do not wait for lab results to start the investigation*
- *Confirm a proportion of cases*

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:
https://doi.org/10.2807/1560-7917.ES.2020.25.35.2000011

Country example

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, abdominal pain and diarrhea, and 30 **consultations** from out-of-hours primary healthcare services.
- Many patients presenting with gastroenteritis **had home addresses near each other**

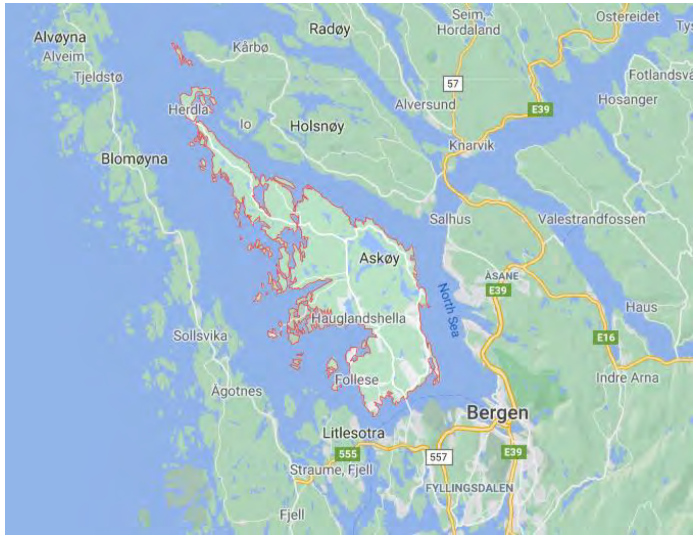
  → drinking-water?
- One person tested positive for **Campylobacter**
- Medical Officer in Askøy **reports the outbreak** to the Norwegian Institute of Public Health.

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, https://doi.org/10.2807/1560-7917.ES.2020.25.35.2000011

Country example

Outbreak context

- Island municipality Askøy, Norway
- 29,500 inhabitants



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, https://doi.org/10.2807/1560-7917.ES.2020.25.35.2000011

Outbreak context

- Three different water supply systems in Askøy: A,B,C
- Water Supply System A (WSS-A) from the 1950s, serves ca. 12,000 people in
 the south of the island.
- WSS-A has 9 reservoirs, including 3 built as unlined mountain 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, https://doi.org/10.2807/1560-7917.ES.2020.25.35.2000011

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, https://doi.org/10.2807/1560-7917.ES.2020.25.35.2000011

Step 2. Form the Rapid Response Team (RRT)

Outbreak confirmed

↓

Investigation needed

↓

Form the Rapid Response team

Step 2. Form the Rapid Response Team (RRT)

Stakeholder	Role
Local/regional public Health agency	Overall coordination
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 planned
  - Epidemiological
  - Microbiological
  - Environmental

- Municipal services
- Norwegian Food Safety Authority
- Norwegian Institute of 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, https://doi.org/10.2807/1560-7917.ES.2020.25.35.2000011

Step 3: Define cases

Case definition components

- Time
- Place
- Person

Case Classification

- Possible
- Probable
- Confirmed

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?)**."

Step 4: Identify cases and obtain information

In order to:

- Estimate the size of the outbreak and its distribution
- Determine the population at risk
- Enroll patients
  - hypothesis-generating pilot interviews
  - descriptive and analytical epidemiology
- Identify patients who need treatment

Step 4: Identify cases and obtain information

How?

- Passive case finding→ Existing surveillance system.
- Active case finding
  - Additional laboratories not part of national surveillance systems
  - Public and private hospitals or primary healthcare centers
  - People at risk: school children, nursing homes, mass gatherings
  - Invitation lists, reservation lists, guest lists

Step 4: Identify cases and obtain information

Line List

- Basic information on each case
  - ID, age, type of case, sex, phone number, residence, clinical information....
- One line per case
- Spreadsheet
- Updated as the investigation develops

- **Facilitates systematization of the information**
- **Provides an overall picture**

Step 4: Identify cases and obtain information

	A	B	C	D	E	F	G	H
1	**ID**	**Sex**	**Age**	**District**	**Adress**	**Phone**	**Hospital admision**	**Interviewed?**
2	1	M	17	A	Water Street	99999	N	Y
3	2	M	27	A	Water Street	88888	N	Y
4	3	F	53	A	Water Street	77777	N	Y
5	4	F	81	A	Water Street	66666	N	Y
6	5	F	23	B	Water Street	55555	Y	Y
7	6	M	44	B	Lake Street	44444	N	N
8	7	F	38	B	Pound Square	33333	?	N
9	....	....	....	....	....	....	....	....

Step 4: Identify cases and obtain information

Pilot interviews

- Standardized questionnaire:
  - clinical information, risk factors and demographics
- Comprehensive: all relevant exposures
- Few interviewers
- Sample of cases

- **Obvious common exposures?**
- **Exclude exposures?**

Step 4: Identify cases and obtain information

9. What kind of water supply do you have in your household?

Does the water come from a water work or do you have a private water supply for just your household?

	Yes	No	Unsure	Details (for instance name of the water work):
Water work for at least 20 households	☐	☐	☐	
Water work for fewer than 20 households	☐	☐	☐	
Private water supply for just your household	☐	☐	☐	

If you have a private water supply for just your household, or if you receive water from a
What kind of source does the water come from?

	Yes	No	Unsure	Deta
Lake, river or brook	☐	☐	☐	
Borehole, groundwater well	☐	☐	☐	
Dug well	☐	☐	☐	

10. Is your drinking water treated (disinfected with chlorine or UV)?

Yes ☐ No ☐ Unsure ☐ If yes, what kind of treatment?

11. Did you drink tap water, either at home or elsewhere, during the week before you got

Also include water used to make juice, lemonade or ice cubes

At home: Yes ☐ No ☐ Unsure ☐ If yes, how many glasses per day? (1-2,

Elsewhere: Yes ☐ No ☐ Unsure ☐ If yes, how many glasses per day? (1-2,

Where?	What kind of water s

12. Did you drink water directly from a lake, pond, river or brook? (for instance while hiki

Yes ☐ No ☐ Unsure ☐ If yes, where?

13. Did you drink any water from a well or cistern? (for instance at a holiday cabin or tourist cabin)

Yes ☐ No ☐ Unsure ☐ If yes, where?

14. Did you drink bottled water or water from a container?

Yes ☐ No ☐ Unsure ☐ If yes, what kind of water?

1. What kind of symptoms did you have?

Please specify when the symptoms started (date, time) and how long they lasted (no. of days or hours)

	Yes	No	Unsure	When did the symptoms begin? Duration?
Nausea	☐	☐	☐	
Vomiting	☐	☐	☐	
Abdominal pain	☐	☐	☐	
Diarrhea (how frequent?)	☐	☐	☐	
Bloody stools	☐	☐	☐	
Fever	☐	☐	☐	
Joint pain	☐	☐	☐	
Other symptoms (what kind?)	☐	☐	☐	

If the fever was measured: How many degrees?

2. When did you become ill? Date / time: (Date when you first noticed symptoms)

3. How long lasted your illness? Days / hours: Are you still sick?

4. Do you know other persons who had similar symptoms in the week before or the week after the day when your illness started?
If the answer is yes, did the person(s) become ill before or after your illness began?

Norwegian Institute of Public Health (2018): Guidelines for investigation of outbreaks, of food and waterborne diseases.

Step 4: Identify cases and obtain information

Questionnaires distribution

- Email
- Web questionnaires
- Telephone interviews
- Paper questionnaires by mail
- Social media

Step 5: Descriptive epidemiological investigation

What do cases have in common? → Generate hypothesis

Time

When were they infected?

Place

Where were they infected? Where do they live?

Person

What are the symptoms and etiology? Who was infected?

Country example

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

- **Outbreak monitoring → Determine the extend of the outbreak**
  - **Case finding:** gastroenteritis consultations
  - **Map** gastroenteritis consultations
  - **Trawling questionnaires** to first campylobacteriosis cases

- **Survey childcare centres → Ascertain start and distribution of the outbreak and document absence for illness**

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, https://doi.org/10.2807/1560-7917.ES.2020.25.35.2000011

Country example

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

Outbreak monitoring → Determine the extend of the outbreak

- **Case finding:** Gastroenteritis consultations **(who?)** at primary care in Askøy **(where?)** between 3 June and 15 June **(when?)**
- **Map** consultations by household address and water supply
- **Trawling questionnaires** to first campylobacteriosis cases
  - Food consumption
  - Animal contact
  - Environmental exposures
  - Clinical and demographical information

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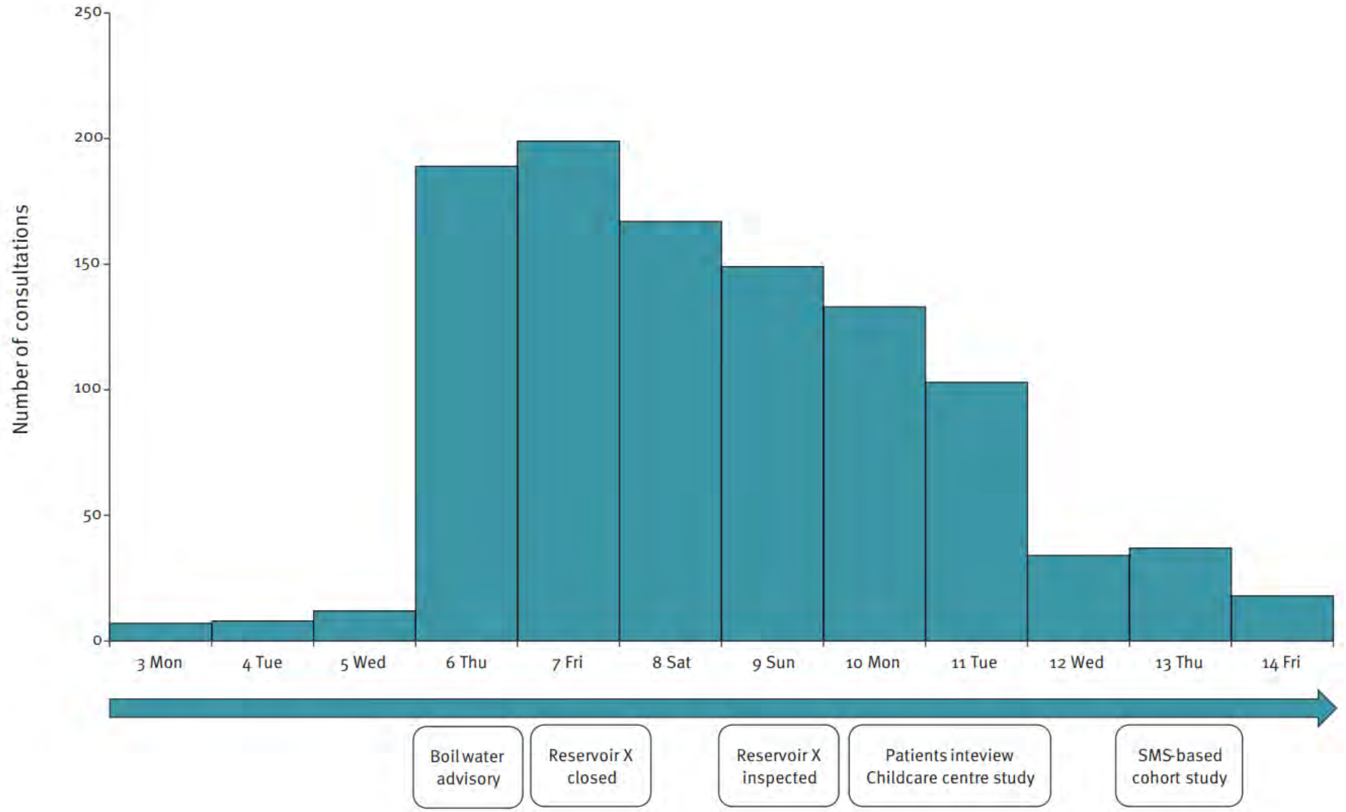
Step 3: Define cases
Step 4: Identify cases and obtain information
Step 5: Descriptive epidemiological investigation

Number of gastroenterititis consultations at general practitioner and out-of-hours primary healthcare services



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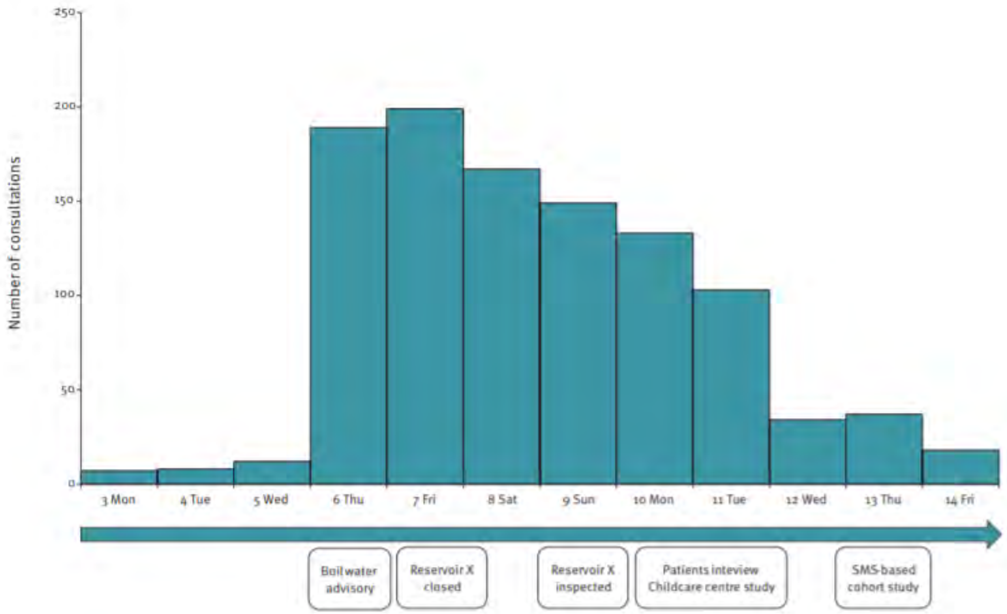
Step 3: Define cases
Step 4: Identify cases and obtain information
Step 5: Descriptive epidemiological investigation

Outbreak monitoring

- Sharp increase in **gastroenteritis consultations** (from 12 to 182 consultations) on Thursday 6 June
- Consultations evenly distributed among all age groups, although in-person consultations were primarily for children



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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

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Country example

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

Outbreak monitoring

Gastroenteritis patients’ residences were coincided with three water supply zones served by Reservoir X.

The three zones with Incidence Rate > 1 are the ones 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, https://doi.org/10.2807/1560-7917.ES.2020.25.35.2000011

Country example

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

Outbreak monitoring

- Trawling questionnaires to five campylobacteriosis cases.
  - Diarrhoea, stomach pain and fever (onset 4-5 June)
  - Tap water at home in the week before symptom onset
  - **Attendance to events, food items, contact with animals or recreational water not common to all five cases**

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, https://doi.org/10.2807/1560-7917.ES.2020.25.35.2000011

Country example

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

Survey of childcare centres

- **Case definition**: any person absent from the childcare centre (child or employee) because of diarrhoea or vomiting **(who?, where?)** between 28 May and 7 June **(when?)**
- Comparison of **attack rates** in childcare centres served/not served by Reservoir X

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

Survey of childcare centres

- All childcare centres (n=27) in the municipality participated in the study. Eight (769 children and employees) in areas supplied by Reservoir X and 19 (1,761 children and employees) in areas supplied by other reservoirs.
  - Childcare centres in affected areas: Attack rate: 20%
  - Childcare centres in unaffected areas: Attack rate 2%
- Absences started to increase at the childcare centres in affected areas on 3 June (n=26) and peaked on 7 June with 81 absences

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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

Country example

Step 6: Additional studies (environmental, laboratory)

Environmental investigation – Description of the water supply network

Under normal conditions, Reservoir X supplies Zone 6 (1,350 residents)

Before the outbreak, a valve opened from Reservoir X to ensure replacement of water in response 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

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Country example

Step 6: Additional studies (environmental, laboratory)

Environmental investigation – Visual inspection of Reservoir X

- Basin constructed as an unlined rock cavern. Its entrance sealed by a locked door
- 400 m3 of water, located above a residential area in mountainous terrain
- Natural cracks located in the back of the reservoir, leaks in the concrete construction and water running from inside the roof.
- Large antenna with power lines above the reservoir, were birds could gather
  - Risk of bird faeces contaminating the area below
- No animals observed
- No unusual malfunctions reported before the outbreak

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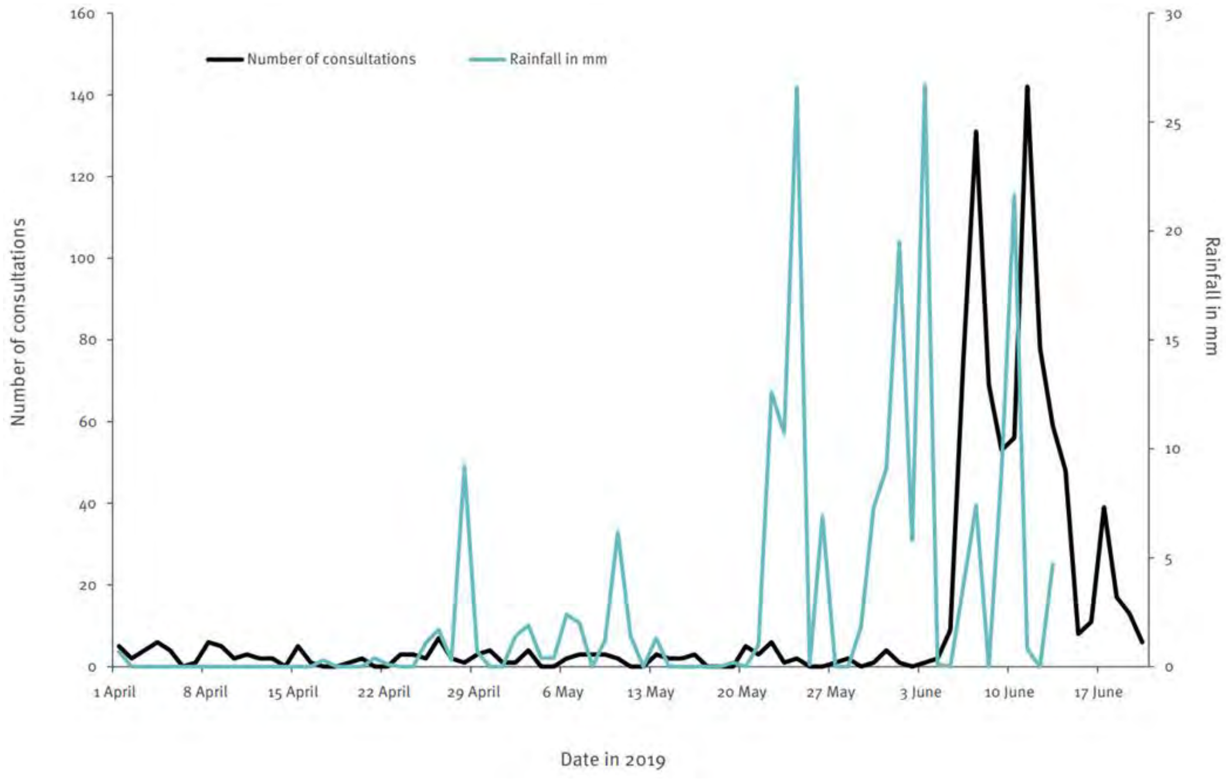
Country example

Step 6: Additional studies (environmental, 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 Syndromic Surveillance System.



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Country example

Step 6: Additional studies (environmental, laboratory)

Analysis of water in WSS-A or in Reservoir X.

- Routine samples prior to the outbreak did not detect any faecal indicator bacteria after the outbreak, extra sampling in WSS-A was conducted
- Routine samples for WSS-A on 3 June were also negative
- On 6 June, samples collected from Reservoir X and areas supplied by Reservoir X were contaminated.
- Several samples positive for *Campylobacter* (7 June).

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Step 7:
Generate hypotheses

Descriptive epidemiology

- Age
- Sex
- Residence
- Work place
- Routines

Microbiology

- Incubation period
- Mode of transmission
- Previous outbreaks

Environment

- Risk assessments
- Inspections

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

Country example

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

Cohort study of households

All residents who received water from WSS-A were included

Exposed: people in households receiving water from Reservoir X

Case definition: person with gastroenteritis with symptom onset 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, https://doi.org/10.2807/1560-7917.ES.2020.25.35.2000011

Country example

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

Cohort study of households

SMS with link to a questionnaire sent to all households served by WSSA

One person should respond on behalf of all household members.

The questionnaire included items on illness and tap water consumption

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Country example

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

Cohort study of households

- Information available from 2,526 persons who responded on behalf of 6,108 household members
- Coverage of 51% (6,108/11,995) of the residents supplied by WSSA

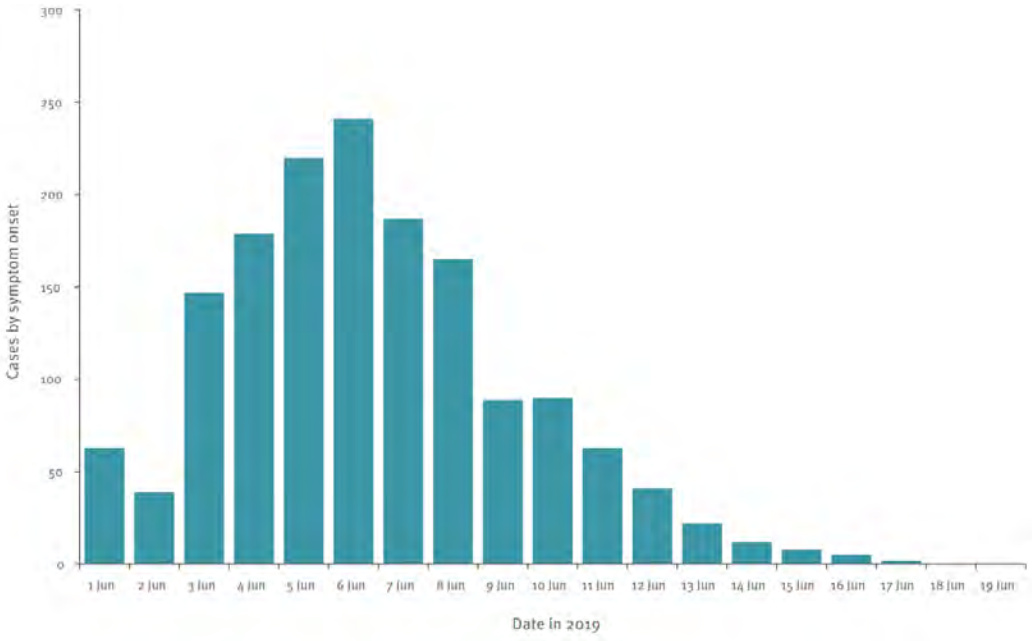
Hyllestad et al. (2020): Large waterborne *Campylobacter* outbreak: use of multiple approaches to investigate contamination of the drinking water supply system, Norway, June 2019. Eurosurveillance, https://doi.org/10.2807/1560-7917.ES.2020.25.35.2000011

Country example

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

Cohort study of households

- Mean age : 34 years (0- 93)
- 50% were female
- 1,573 respondents met the case definition
- Attack rate: 26%.
- Number of cases peaked on 6 June and decreased gradually thereafter



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Country example

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

Cohort study of households

Attack rates and risk ratio for areas supplied by Reservoir X and other areas

Reservoir	Households	Individuals	Cases	Attack rate	Risk ratio (95% confidence interval)
Other reservoirs in WSS-A (zones 1–5)	1,653	4,098	481	12%	Reference
Reservoir X (zones 6–8)	873	2,010	1,092	54%	4.6 (4.2–5.0)

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, https://doi.org/10.2807/1560-7917.ES.2020.25.35.2000011

Country example

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

Cohort study of households

Risk of gastrointestinal illness by consumption of tap water

Daily tap water consumption	Individuals	Cases	Attack rate	Risk ratio (95% confidence interval)
0 glasses	381	27	7%	Reference
1–3 glasses	2,562	586	23%	3.2 (2.2–4.7)
4–6 glasses	2,255	654	29%	4.1 (2.8–5.9)
≥ 7 glasses	910	306	34%	4.7 (3.3–6.9)

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, https://doi.org/10.2807/1560-7917.ES.2020.25.35.2000011

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

Country example

Step 9: Implement control measures

Immediate precautionary control measures

- Boil water advice issued
- Reservoir X taken out of service
- Emergency water supply distribution from water tanks located in public areas
- Infection control measures in public services were strengthened

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, https://doi.org/10.2807/1560-7917.ES.2020.25.35.2000011

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, https://doi.org/10.2807/1560-7917.ES.2020.25.35.2000011

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, https://doi.org/10.2807/1560-7917.ES.2020.25.35.2000011

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 investigate contamination of the drinking water supply system, Norway*. June 2019. Euro Surveill. 2020;25(35):pii=2000011. https://doi.org/10.2807/1560-7917.ES.2020.25.35.2000011
- Additional references are:
  - European Centre for Disease control and prevention. *Toolkit for investigation and response to food and waterborne outbreaks with an EU dimension*. Available at: https://www.ecdc.europa.eu/en/publications-data/toolkit-investigation-and-response-food-and-waterborne-disease-outbreaks-eu
  - Norwegian Institute of Public Health. *Guidelines for investigation of outbreaks of food and waterborne diseases*. Available at: https://www.fhi.no/globalassets/dokumenterfiler/rapporter/2018/guidelines-for-investigation-of-outbreaks-of-food--and-waterborne-diseases.pdf
  - 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)

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Epidemiological studies

Module 2.2

Steps in outbreak management

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

Communication Measures

Epidemiological studies

- Descriptive
- Ecological
- Analytical
  - Cohort studies
  - Case-control studies

Descriptive analysis

They answer the question *"What's going on?"*

Person	Place	Time
• Who?	• Where?	• When?

Descriptive analysis

- Generate hypotheses on the possible source, etiology and modes of transmission
- Identify the population at risk
- Estimate when the initial exposure to the causative pathogen occurred
- Identify opportunities for control

Descriptive analysis

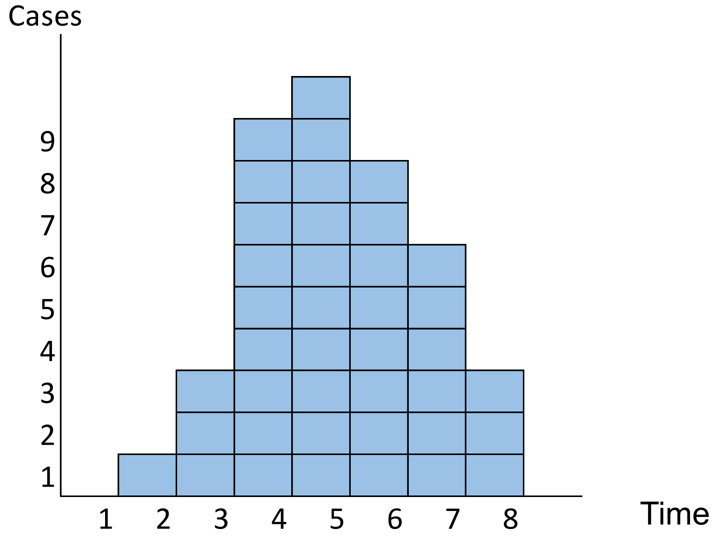
- Results visualized in tables and maps or curves
- Not possible to identify causality or risk factors

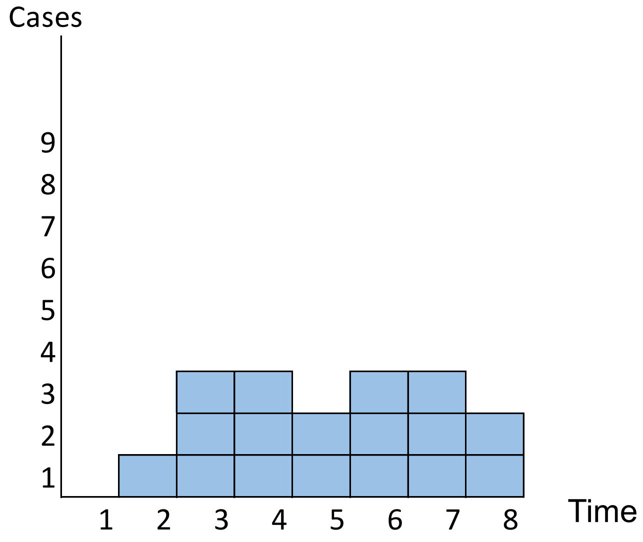
Time- when?

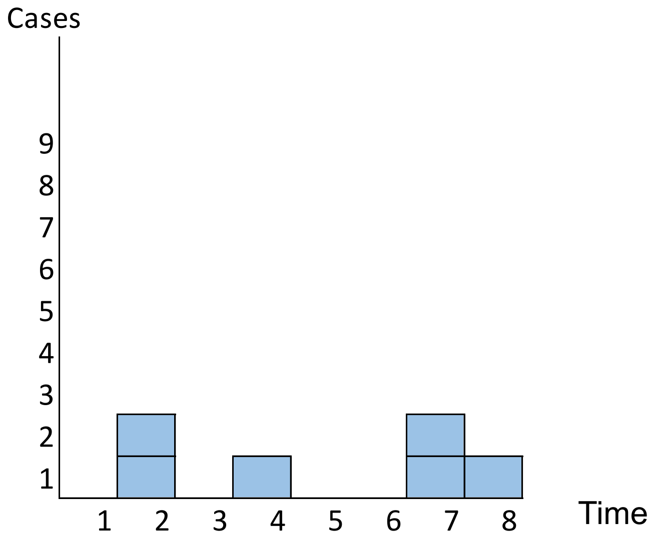
The epidemic curve indicates

1) Type of source: point source, continuous, intermittent

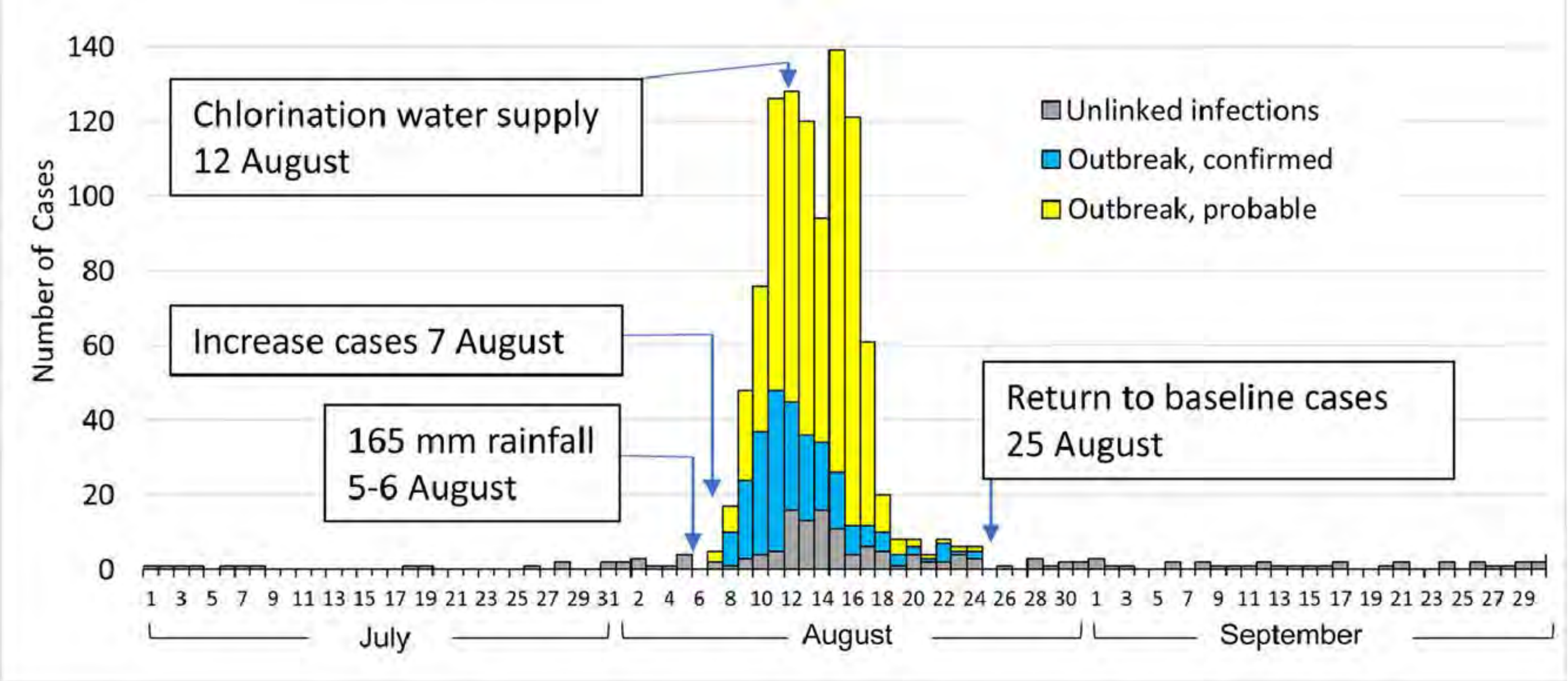
2) Mode of transmission







Time- when?

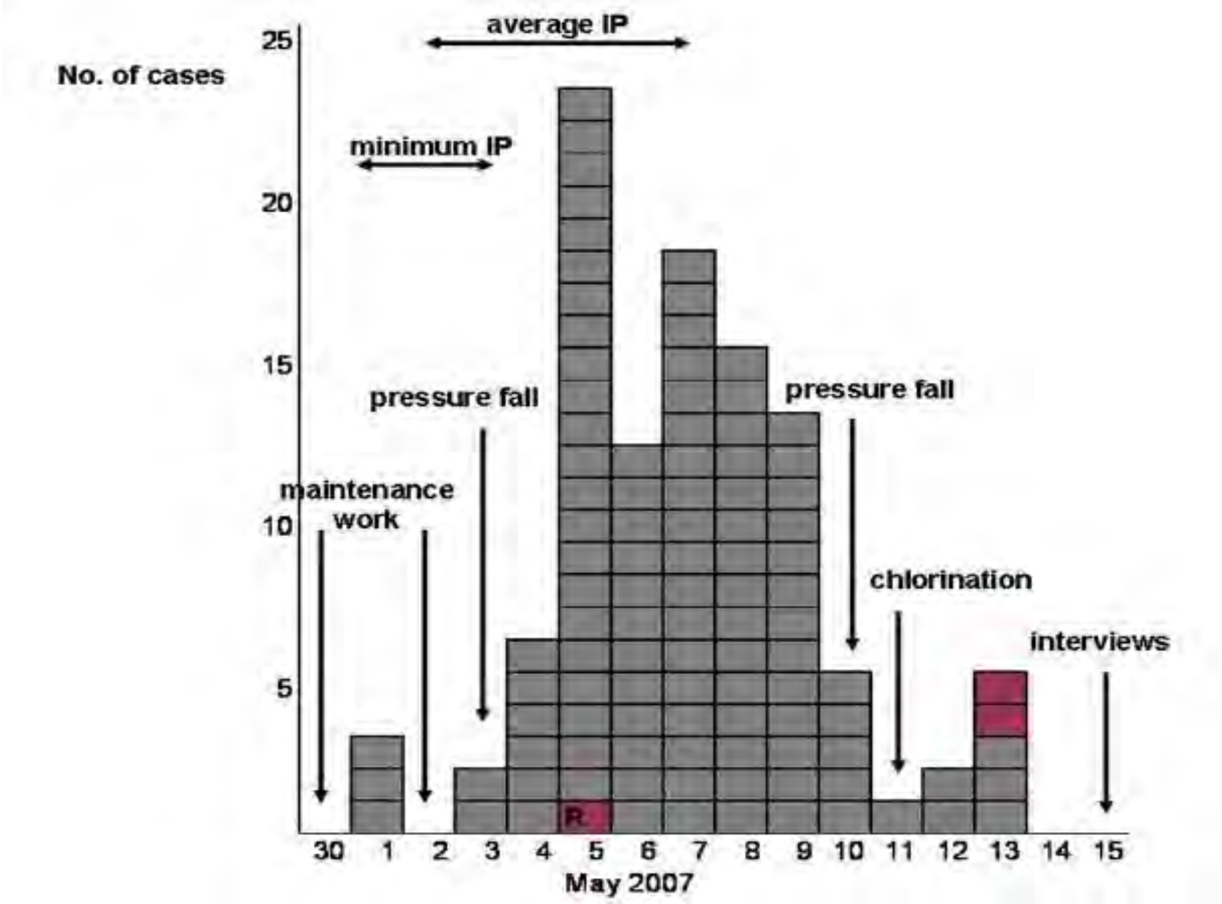


Reported campylobacteriosis in Hawke´s Bay from July to September 2016 graphed according to onset of symptoms.

Confirmed, probable and unlinked reported campylobacteriosis cases

Gilpin et al. (2020): A large scale waterborne Campylobacteriosis outbreak, Havelock North, New Zealand. Journal of Infection, https://doi.org/10.1016/j.jinf.2020.06.065

Time- when?



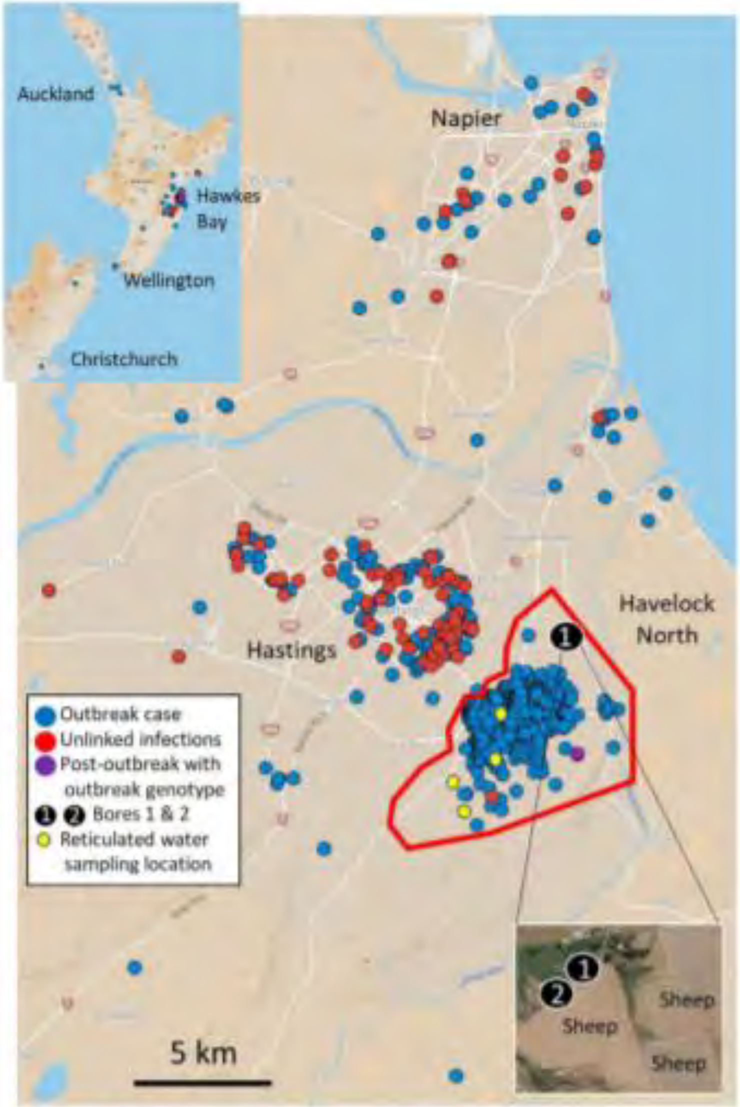
Cases of gastroenteritis in a sample of Røros (Grey) and Holtalen (Plum) household members by date of illness onset (n = 105), from April 30 to May 14, 2007 and the timeline of events, which may be relevant to the water contamination.

Jakopanec et al. (2008): A large waterborne outbreak of campylobacteriosis in Norway: The need to focus on distribution system safety. BMC Infectious Disease, https://doi.org/10.1186/1471-2334-8-128

Place- where?

- Cases mapped to assess the geographical extent of the outbreak
- Visualize and explore the spatial distribution of cases
- A cluster of cases might suggest exposure to a particular source
- Attack rates by exposure to particular water sources and by place
- Visualize and explore the spatial distribution of cases

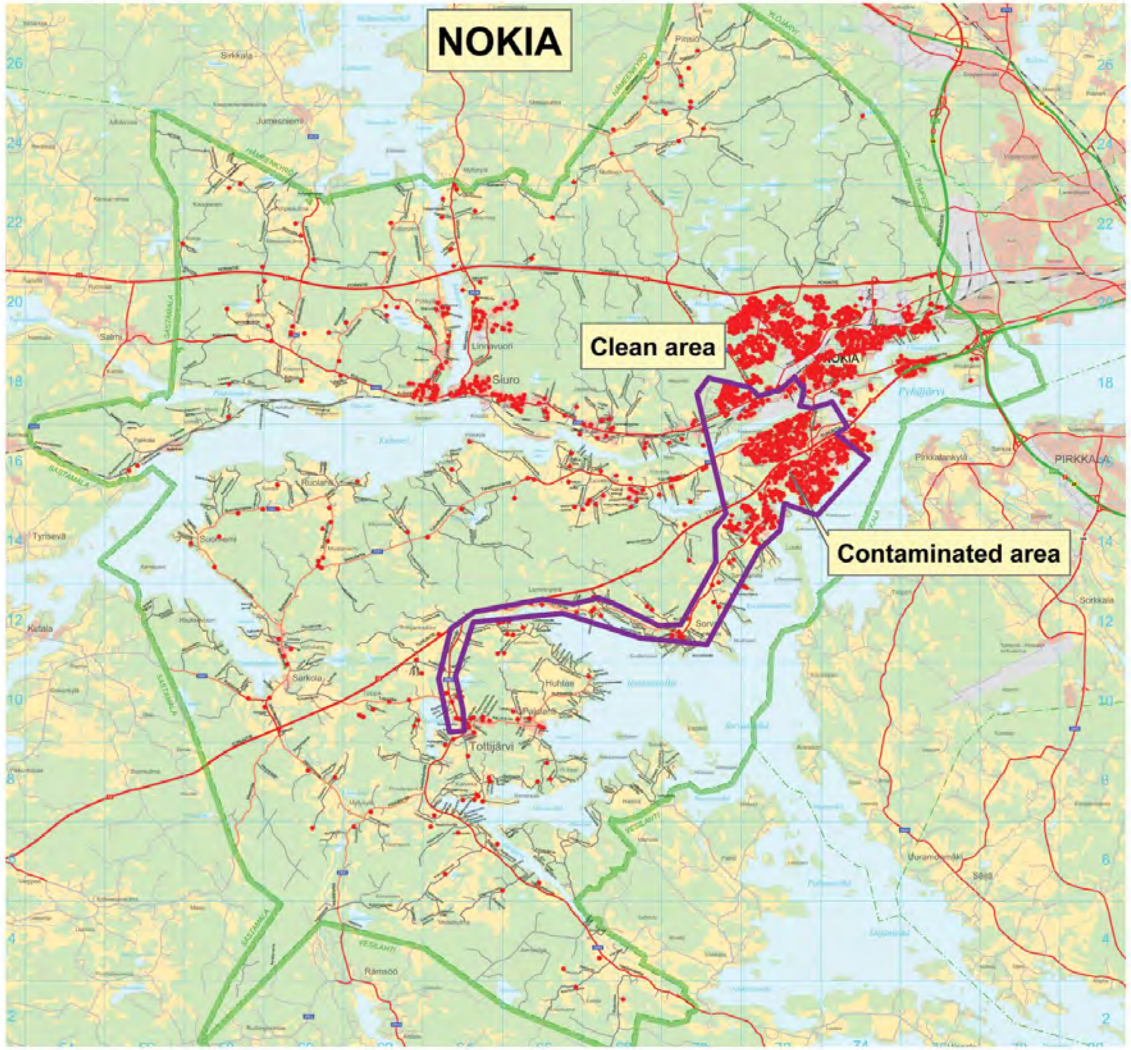
Place- where?



Geographic distribution of outbreak cases, and unlinked infections with onset of illness of 7–24 August 2016. Also shown is the Havelock North contaminated reticulation area (red box), and locations of the reticulated network sampling points, bores and sheep paddocks

Gilpin et al. (2020): A large scale waterborne Campylobacteriosis outbreak, Havelock North, New Zealand. Journal of Infection, https://doi.org/10.1016/j.jinf.2020.06.065

Place- where?



Halonen et al. (2012): Waterborne Outbreak of Gastroenteritis: Effects on Sick Leaves and Cost of Lost Workdays. PLOS ONE, https://doi.org/10.1371/journal.pone.0033307

Person- who?

- Age
- Sex
- Number of cases
- Attack rate
- Symptoms
- Hospital admission
- Deaths
- Case fatality rate
- Other?: Ocuppation….

Person-who?

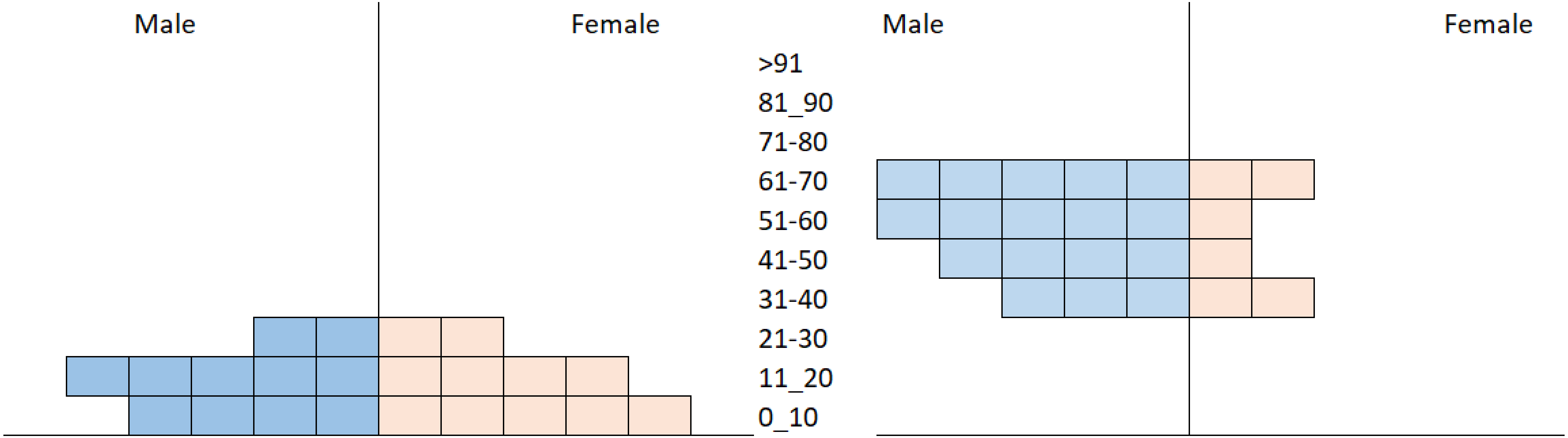
Demographic	Cases	Rates per 100,000 with 95% confidence intervals	p-value by group
Sex			0·795
Female	497	595·2 (544·1, 649·7)	
Male	456	584·7 (532·4, 640·8)	
Age group			<0·001
<5	61	553·3 (423·5, 710·2)	
5–19	184	532·4 (458·4, 614·9)	
20–59	326	425·5 (380·6, 474·1)	
≥60	382	972·4 (877·7, 1074·4)	
Ethnicity			<0·001
Māori	100	296·4 (241·2, 360·3)	
Pacific	17	284·0 (165·6, 454·4)	
Asian	29	580·2 (388·9, 832·3)	
European	802	716·8 (668·2, 768·0)*	
Other	5	146·1 (47·5, 340·6)	
Age group amongst hospitalized			<0·001
<5	1	9·1 (0·2, 50·5)	
5–19	1	2·9 (0·1, 16·1)	
20–59	7	9·1 (3·7, 18·8)	
≥ 60	31	78·9 (53·6, 112·0)*	
Serious outcomes			
Deceased	4		
Guillain-Barré syndrome	3		

*Rate in European ethnicity and hospitalized ≥60 years is significantly higher than other sub populations.

Demographic characteristics and clinical outcomes of confirmed and probable campylobacteriosis cases.

Gilpin et al. (2020): A large scale waterborne Campylobacteriosis outbreak, Havelock North, New Zealand. Journal of Infection, https://doi.org/10.1016/j.jinf.2020.06.065

Person- who?


Male
Female
>91
81_90
71-80
61-70
51-60
41-50
31-40
21-30
11_20
0_10
Male
Female

Descriptive analysis, in conclusion

The W's of descriptive epidemiology:

- **W**hat → health issue of concern
- **W**ho → person
- **W**here → place
- **W**hen → time

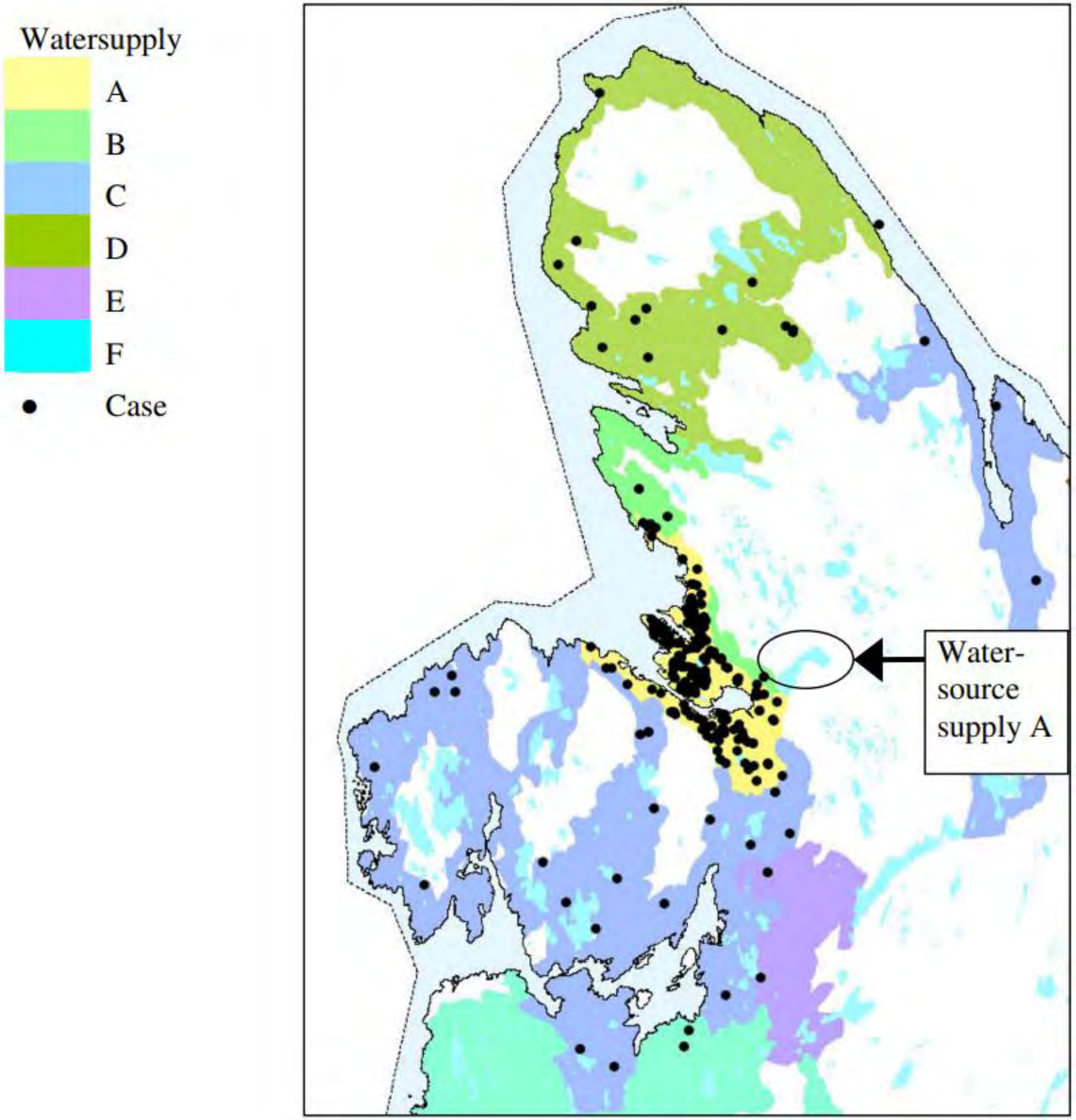
Descriptive analysis, in conclusion

- **Analyse by person:**
  - calculate attack rates by exposure to particular water sources
- **Analyse by place:**
  - calculate attack rates by place
  - map cases distribution to assess the geographical extent of the outbreak
  - Undertake spatial analyses to visualize the spatial distribution of cases in relation to suspect sources.
- **Analyse by time:**
  - if the causative agent is known, use the epidemic curve to estimate the likely time period of exposure
  - Assess if the epidemic curve correlates with events in the water-supply system and implementation of control measures

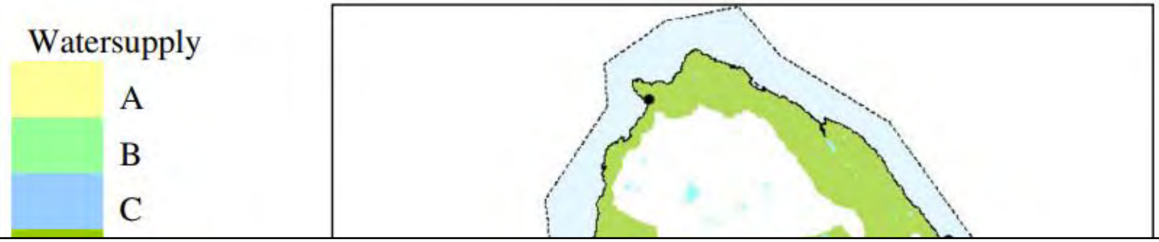
Water supply zones of water supply system WSS-A defined by different reservoirs Zones 6, 7 and 8 were served by Reservoir X.

Estimated incidence rates for gastroenteritis consultations linked to reservoir supply zones

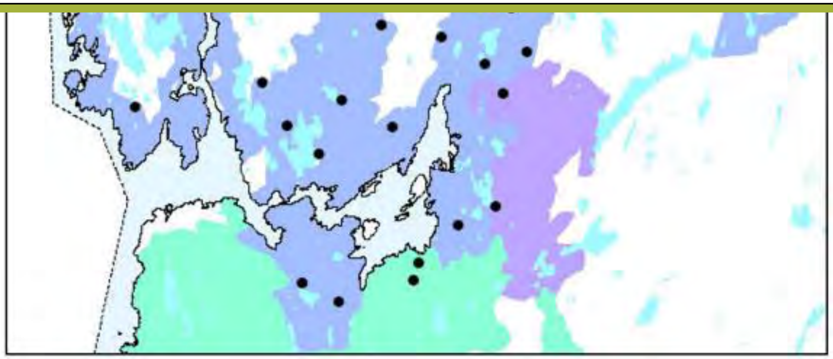
Hyllestad et al. (2020): Large waterborne *Campylobacter* outbreak: use of multiple approaches to investigate contamination of the drinking water supply system, Norway, June 2019. Eurosurveillance, https://doi.org/10.2807/1560-7917.ES.2020.25.35.2000011



Nygård et al. (2006): A large community outbreak of waterborne giardiasis- delayed detection in a non-endemic urban area. BMC Public Health, https://doi.org/10.1186/1471-2458-6-141

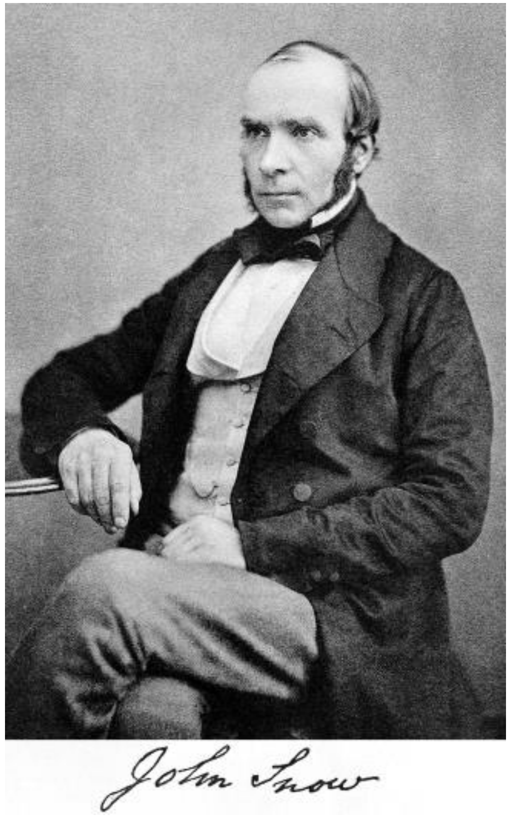


Watersupply	Cases	Number of recipents	Attack-rate (per 10,000)		
A	637	42,774	148.9		
B	15	9,685	15.5		
C	89	105,440	8.4		
D	33	34,406	9.6		
E	4	14,266	2.8		
F	13	23,848	5.5		
				Risk ratio	95% confidence interval
B+C+D+E+F	158	194,519	8.1	Ref.	
A	637	42,774	148.9	18.3	15.4 – 21.8

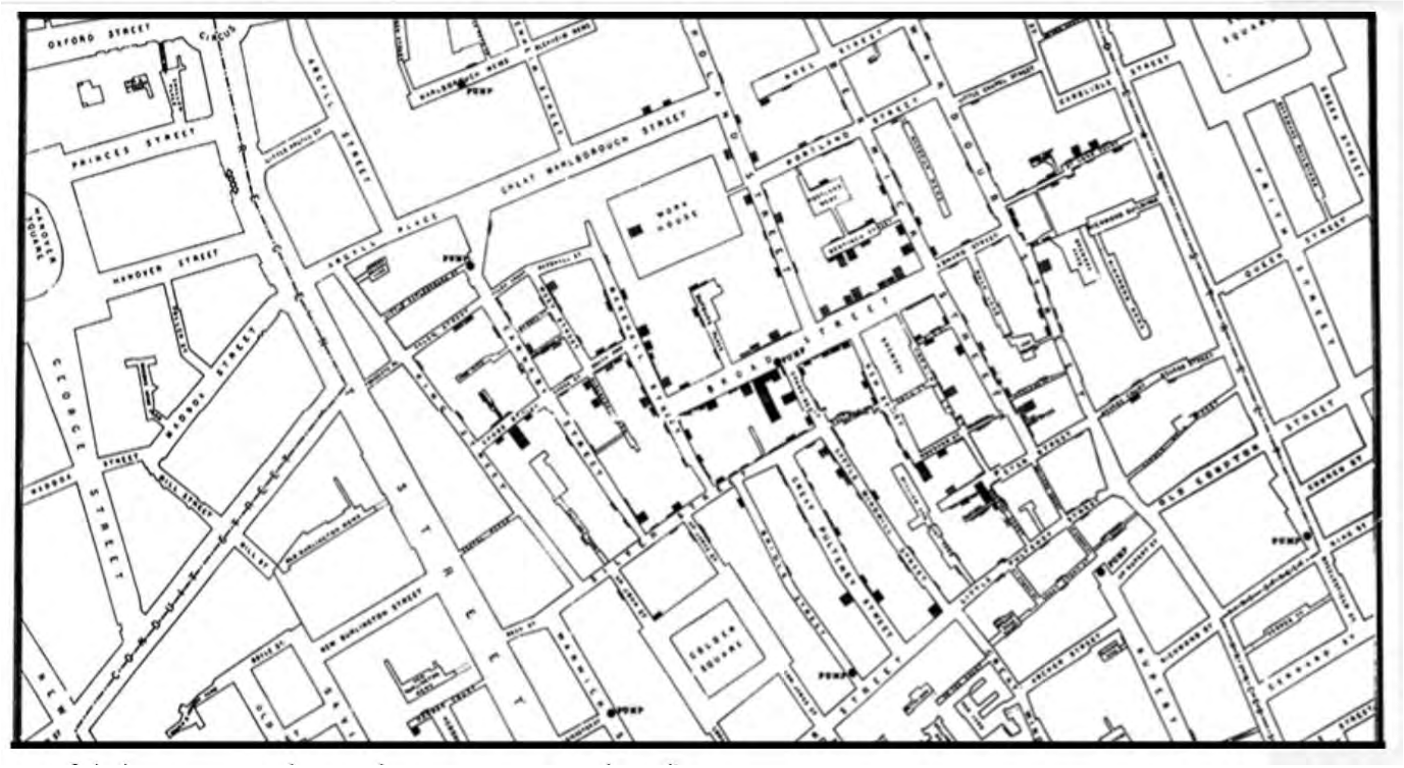


Nygård et al. (2006): A large community outbreak of waterborne giardiasis- delayed detection in a non-endemic urban area. BMC Public Health, https://doi.org/10.1186/1471-2458-6-141

John Snow and Cholera outbreak in London



Source: Field epidemiology manual wiki



Source: CDC

Ecological studies

- Quite useful for outbreaks associated with public water supplies
- They relate to population level, not individual level
- Rates of disease and their association with exposures are compared among defined populations.

Analytical studies

"Are there any differences between what sick and not sick people did?"

- They help to identify exposures associated with disease
- Generate evidence to support the hypothesis under investigation
- Estimate the strength of the association between an exposure and an outcome.
- In outbreak investigations: **retrospective cohort studies, case-control studies**

Analytical studies

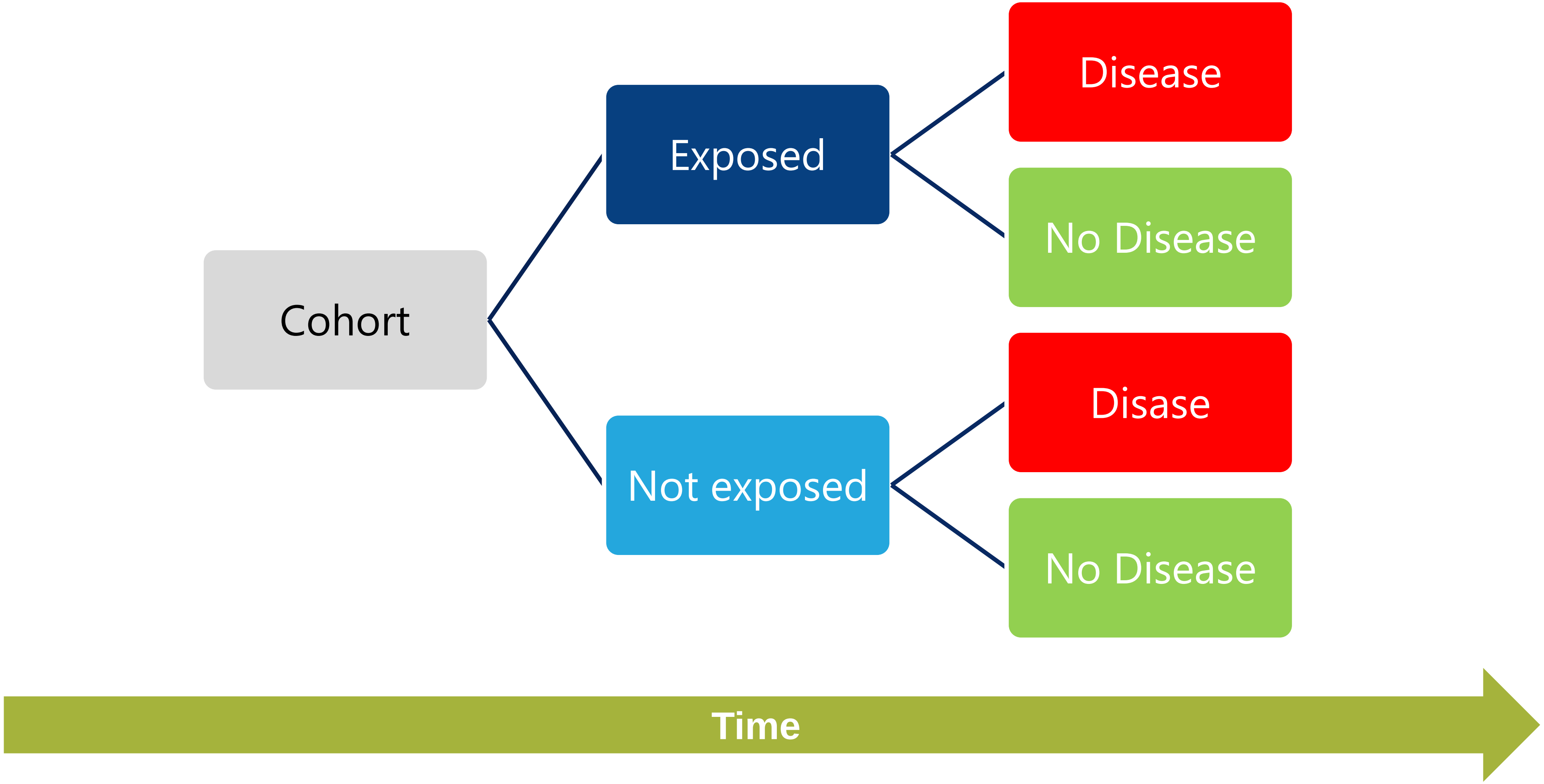
(retrospective) cohort studies

case-control studies

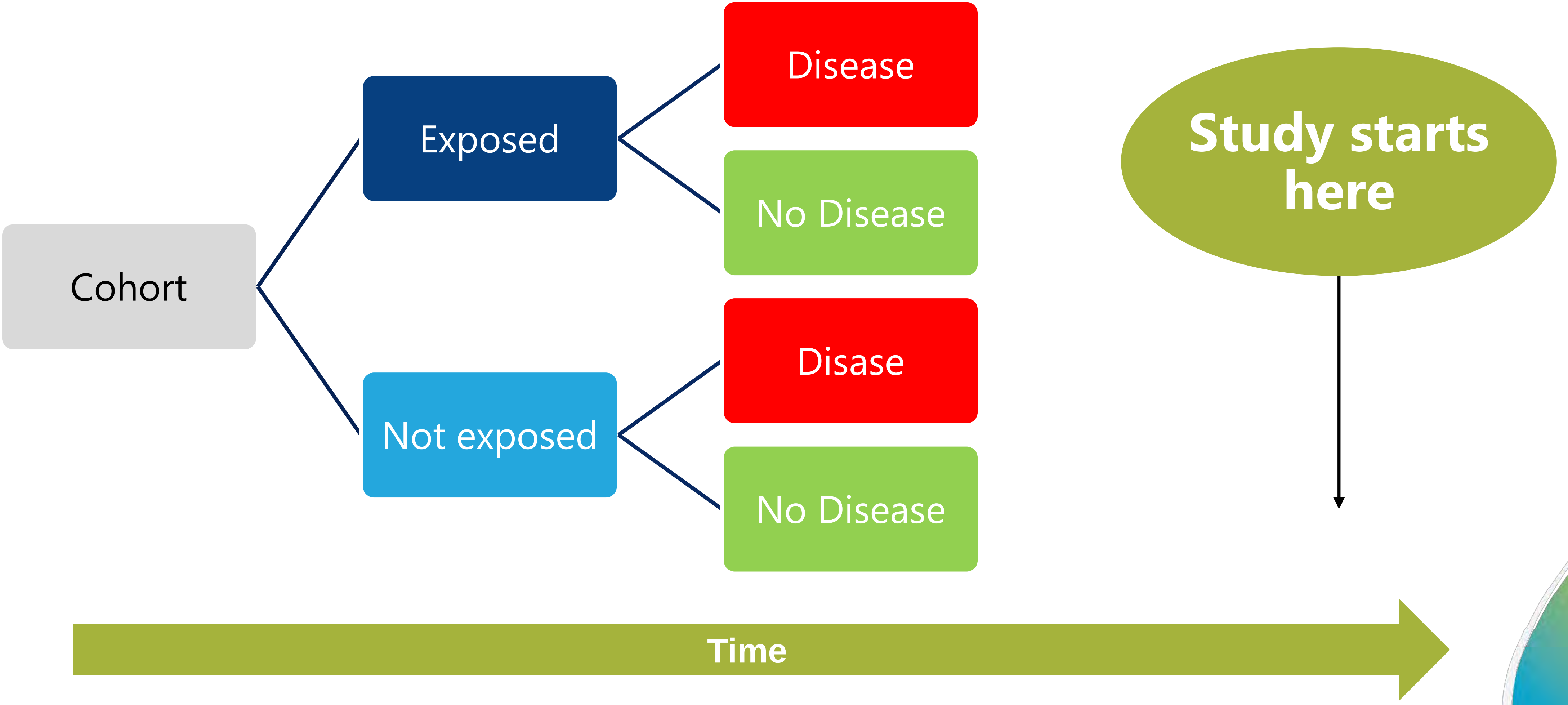
Analytical studies - Cohort studies

- Comparison of risk of disease over a defined time period among those exposed to factor X, versus those not exposed
  - Two cohorts: exposed and not exposed
- If those exposed have a higher rate of disease, this provides evidence that the factor is the cause of the disease.
- This assumes that both groups are the same, except in terms of their exposure to the factor.

Analytical studies- Cohort studies



Analytical studies- <u>Retrospective</u> Cohort studies



Analytical studies- Cohort studies

	Disease	No disease	
Exposed	a	b	a+b
Not Exposed	c	d	c+d
	a+c	b+d	

Attack rate (incidence) in exposed: a/a+b

Attack rate (incidence) in not exposed: c/c+d

→ **Relative Risk (RR):** Incidence in exposed/incidence in not exposed

Relative Risk- Interpretation

- RR = 1; no association
- RR > 1; the exposure is a **risk** factor
- RR < 1; the exposure is a “protective” factor

Country example

Cohort study - example

Boccia et al. (2002): Waterborne Outbreak of Norwalk-Like Virus Gastroenteritis at a Tourist Resort, Italy. Emerging Infectious Diseases, https://wwwnc.cdc.gov/eid/article/8/6/01-0371_article

Country example

Cohort study- example

Outbreak context

- July 2000, outbreak of gastroenteritis at a tourist resort in southern Italy.
- Illness in 344 people, 69 staff members
- Norwalk-like virus was found in stool specimens
- The source was likely contaminated drinking water
  - Breakdown in the water system
  - Tap water samples with fecal bacteria

Boccia et al. (2002): Waterborne Outbreak of Norwalk-Like Virus Gastroenteritis at a Tourist Resort, Italy. Emerging Infectious Diseases, https://wwwnc.cdc.gov/eid/article/8/6/01-0371_article

Country example

Cohort study- example

Epidemiological investigation

Case definition: Guest/employee at the resort during July 1–31 and who had diarrhea (≥3 loose stools in 24-hour period) or vomiting (at least 1 episode) or both, in the same period.

Retrospective Cohort study: Because of the high number of cases in staff members, performed to assess risk factors in this group.

- Inclusion criteria: staff members employed from July 1 to 31.
- Questionnaires sent to all 224 staff members in the first week of August.
- A month had elapsed between onset of symptoms and distribution of the questionnaires.

Boccia et al. (2002): Waterborne Outbreak of Norwalk-Like Virus Gastroenteritis at a Tourist Resort, Italy. Emerging Infectious Diseases, https://wwwnc.cdc.gov/eid/article/8/6/01-0371_article

Country example

Cohort study- example

Epidemiological investigation

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- Inclusion criteria: staff members employed from July 1 to 31.
- Questionnaires sent to all 224 staff members in the first week of August.
- A month had elapsed between onset of symptoms and distribution of the questionnaires.

- 181 questionnaires from 224 staff members were analyzed.
- Attack rate = 38.1% (69/181)

Boccia et al. (2002): Waterborne Outbreak of Norwalk-Like Virus Gastroenteritis at a Tourist Resort, Italy. Emerging Infectious Diseases, https://wwwnc.cdc.gov/eid/article/8/6/01-0371_article

Country example

Cohort study- example

Table 3. Attack rates and relative risks according to usual behaviors and activities of staff members, tourist resort, Italy, July 2000

Exposure	No. (n=69)	No. exposed	Attack rate (%)	Relative risk	95% CI [a]
Shower on the beach	22	14	63.6	1.8	1.2–2.6
Swimming in the pool	45	22	48.9	1.4	0.9–2.0
Drinking tap water	104	47	45.2	1.4	0.9–2.2
Drinks with ice	128	55	43.0	1.8	1.0–3.2
Swimming in the sea	72	31	43.0	1.2	0.8–1.7
Eating at resort restaurant	159	64	40.2	1.5	0.5–3.9
Eating ice cream	140	56	40.0	1.1	0.6–1.9
Eating meat	151	60	39.7	1.2	0.6–2.4
Eating salad	123	48	39.0	1.0	0.6–1.6
Eating fruit	139	54	38.8	1.0	0.6–1.8
Eating pasta	142	55	38.7	1.2	0.6–2.1
Consuming drinks on draught	91	35	38.5	1.0	0.7–1.4
Eating fish	112	40	35.7	0.7	0.5–1.1
Eating seafood	85	28	32.9	0.7	0.5–1.1

[a]CI, confidence interval.

Boccia et al. (2002): Waterborne Outbreak of Norwalk-Like Virus Gastroenteritis at a Tourist Resort, Italy. Emerging Infectious Diseases, https://wwwnc.cdc.gov/eid/article/8/6/01-0371_article

Analytical studies

(retrospective) cohort studies

case-control studies

Analytical studies - Case-control studies

- Most frequent analytical approach in waterborne outbreaks
- Cases are compared to individuals unaffected by the disease in question to find out whether there is a difference in their exposures
- These unaffected individuals are called “controls”

Analytical studies - Case-control studies

- Who are right controls? That is crucial for success
- Controls must represent the population at risk of disease and must not have the disease under investigation at the time of their recruitment.
- Prevent and address the confounding and selection bias in sampling controls
- Controls represent the background level of exposure in the population.
- If the level of exposure is greater among cases than controls, this provides evidence that the exposure is associated with disease.

Example of control selection

135 cases of *Cryptosporidium hominis*

- **Where?** City XX (population 350.000)
- **When?** Second week September 2020-first week October 2020
- **Who?** 47% Women; mean age 37 years old. Range: 19-91

Example of control selection

135 cases of *Cryptospori*...

- **Where?** City XX (po... ...0)
- **When?** Secon... ...ber 2020-first week October 2020
- **Who?** 4... ...ean age 37 years old. Range: 19-91

Who are the right controls for a case-control study?

Example of control selection

135 cases of *Cryptosporid* ...

- **Where?** City XX (po ...)
- **When?** Secon ... ber 2020-first week October 2020
- **Who?** 4 ... ean age 37 years old. Range: 19-91

Who are the right controls for a case-control study?

They have to be representative of the population where cases belong

Example of control selection

135 cases of *Cryptosporidium* hominis

- **Where?** City XX (population 350.000)
- **When?** Second week of September–first week of October 2020
- **Who?** 47% Women; mean age 37 years old. Range: 19-91

Source population:

People living at City XX > 19 years
Not travelled outside the city in the relevant period

How to select controls

- Random sample for population registry or list
  - Complete
  - Accesible
  - Feasible to stratify (sex, age, district….)

How to select controls

- Telephone / mobile register
- Challenges:
  - Who has a mobile?
  - Who will answer?

How to select controls

- Friends, family, neighbours
  - Can be efficient
  - Similar to cases
  - Low cooperation

How to select controls- Challenges

- Disease with high rate of asymptomatic
- Immune people
- 100% exposure

How to select controls

- Never perfect
- Balance strenghts and weaknessess
- Balance urgency, resources
- Defend your choices
- Take into account how limitations may affect results

Analytical studies- Case-control studies
Calculation of OR

- The odds ratio (OR) is the ratio between the probability that someone with disease has experience of the potential factor and the probability that someone without the disease has experience of the same factor
- Relative risk (RR) is used in cohort study and odds ratio (OR) is used in a case-control study

Odds ratio- Interpretation

- An OR = 1; no association
- An OR > 1; the study factor is a risk factor
- An OR < 1; the study factor is a "protective" factor

Case-Control study example

Outbreak context

- October 2004: Municipal medical officer in Bergen (Norway) alerted by the university hospital to an increase of patients with giardiasis
- During two weeks: 27 cases with unknown or no travel history
- Mainly young adults from the central part of the city
- 1–2 domestic cases of giardiasis are normally reported annually in Bergen

Nygård et al. (2006): A large community outbreak of waterborne giardiasis- delayed detection in a non-endemic urban area. BMC Public Health, https://doi.org/10.1186/1471-2458-6-141

Country example

Case-Control study example

The epidemiological investigation included:

- **Active case-finding, descriptive and ecological analysis**
  - Cases identified through the laboratory conducting giardia diagnostics in the area.
  - All laboratory-confirmed cases mapped based on address of residence
  - Attack rates and relative risks were calculated for each water supply zone.
- **Case control study**
  - Among people living in the central area of Bergen
  - Age- and sex matched controls randomly selected from the population register.

Nygård et al. (2006): A large community outbreak of waterborne giardiasis- delayed detection in a non-endemic urban area. BMC Public Health, https://doi.org/10.1186/1471-2458-6-141

Country example

Case-Control study example

Selection of controls and information collection

- Potential controls contacted by telephone (two controls per case)
- Cases and controls were asked about exposures two weeks before symptom onset for the case.
- Cases and controls that had travelled to a highly endemic country for giardiasis were excluded.
- Information was collected by telephone interviews
  - Structured questionnaire: food and drinks consumed different activities, clinical illness, use of health services
- Additional analysis to assess risk associated with quantity of water consumed
  - Group matched analysis including interviewed cases for whom we did not interview individually matched controls.
  - Group matching was based on gender and 10-year age groups.

Nygård et al. (2006): A large community outbreak of waterborne giardiasis- delayed detection in a non-endemic urban area. BMC Public Health, https://doi.org/10.1186/1471-2458-6-141

Case-Control study example

Matched univariate conditional logistic regression analysis of selected dichotomous risk factors among cases of giardiasis and matched controls, water-supply zone A, Bergen municipality 1/9 – 15/11 2004.

	Cases (%) (n = 27)		Controls (%) (n = 54)		Matched OR	95% CI	p-value
Having children in household	8	33%	17	34%	1.2	0.3 – 4.5	0.8
Having dog/cat	8	30%	7	13%	5.3	1.0 – 26.6	0.04
Salad	20	87%	45	90%	0.7	0.2 – 3.3	0.7
Tomato	19	83%	44	85%	0.8	0.2 – 3.2	0.8
Cucumber	20	83%	41	82%	1.2	0.3 – 4.3	0.8
Raw leek	9	38%	9	18%	7.1	0.9 – 58.9	0.1
Mineralwater	11	42%	27	51%	0.6	0.2 – 1.8	0.4
Coffee	18	72%	28	52%	2.4	0.7 – 7.9	0.2
Beer	8	33%	8	15%	3.3	0.9 – 12.7	0.06
Water at home (>5 glass)	20	74%	12	22%	7.3	2.4 – 21.8	<0.01
Water at the gym	10	38%	8	15%	5.2	1.1 – 26	0.03
Water in cafe or restaurant	10	38%	13	25%	1.8	0.6 – 5.2	0.3
Drinking water at work	14	56%	24	45%	1.6	0.6 – 4.4	1.6
Supermarket A	22	88%	27	55%	6.5	1.4 – 29.2	<0.01
Supermarket B	12	52%	19	40%	1.2	0.4 – 3.5	0.7

Nygård et al. (2006): A large community outbreak of waterborne giardiasis- delayed detection in a non-endemic urban area. BMC Public Health, https://doi.org/10.1186/1471-2458-6-141

Country example

Case-Control study example

Case- control study - Risk of giardiasis associated with quantity of water consumed among residents in water zupply zone A, Bergen municipality 1/ 9 – 15/11 2004. Group matched analysis by sex and 10-year age groups (83 cases, 54 controls).

Water intake	Cases	%	Controls	%	OR*	95% CI
< 1 glass	1	1 %	4	7 %	Ref	-
1 – 2 glasses	8	10 %	11	20 %	3.2	0.2 – 69.5
3 – 5 glasses	23	28 %	27	50 %	4.8	0.4 – 64.7
more than 5 glasses	51	61 %	12	22 %	7.4	1.2 – 44.5

* chi-square test for linear trend: 19.7; $p < 0.001$.

Nygård et al. (2006): A large community outbreak of waterborne giardiasis- delayed detection in a non-endemic urban area. BMC Public Health, https://doi.org/10.1186/1471-2458-6-141

In summary….

Descriptive epidemiology

What is happening?

↓

Ecological epidemiology

Explore associations

↓

Analitical epidemiology

Test hypothesis

Analytical studies

Small defined populations — *Meetings, courses, restaurants, parties, weddings*

- Retrospective cohort study
- Relative risk

Large open populations — *Cities, countries*

- Case control study
- Odds ratio

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.
- Additional used references are
  - Norwegian Institute of Public Health. Guidelines for investigation of outbreaks of food and waterborne diseases. Available at: https://www.fhi.no/globalassets/dokumenterfiler/rapporter/2018/guidelines-for-investigation-of-outbreaks-of-food--and-waterborne-diseases.pdf
  - 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)
- References used for the country examples are embedded in the presentation

Risk communication

Module 2.3

PROTOCOL ON WATER AND HEALTH

World Health Organization
European Region

UNECE

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

Communication Measures

Key points

- Crucial component of risk management
- Should be guided by risk communication planning
- Used to guide public participation to support outbreak´s control
- Communication opportunities exist throughout the investigation → skilled communication is critical

Risk communication under the Protocol and IHR

- Article 8 of the **Protocol of Water and Health** stipulates that Parties give prompt and clear notification about outbreaks, incidents or threats in the event of any imminent threat to public health from water-related disease

Parties shall "disseminate to members of the public who may be affected all information that is held by a public authority and that could help the public to prevent or mitigate harm".

- Core requirement for countries within the framework of the **International Health Regulations (IHR)**

Effective risk communication and planning can mitigate complications during outbreaks

- Outbreaks are unpredictable and alarming to the public and attract media attention
- Public health authorities communicate through the media
- Official information has to be rapid to meet the increasingly rapid media cycle, mitigating rumors
- Communication failures can impede outbreak control measures, undermine public trust and engagement and prolong social, economic and political turmoil

Key elements of risk communication

- Trust
- Announce early
- Transparency
- Understand the public
- Integration in contingency planning

Key elements- Trust

- Communicate in ways that build, maintain or restore trust
- Acknowledge uncertainty
- Trust is hard to win and easy to lose
- No trust → fear and lack of compliance
- Build trust between those leading on communication
- Trust public's ability to tolerate incomplete or alarming information
- Ensure accountability and transparency
- Listen to and be aware of public concerns

Key elements- Announce early

It helps to build public trust and prevent rumors and misinformation spreading

- Those responsible for risk communication should:
  - avoid withholding information to “protect” the public
  - acknowledge that the announcement is based on preliminary information, so the situation may change as further information emerges
  - ensure clear communication channels between key stakeholders so they are aware in advance of the announcement
  - The way the initial announcement is done may impact on the reception to all subsequent communication

Key elements- Transparency

It leads to greater trust

- Communication should be frank, easily understood, complete and accurate
- Those responsible for risk communication should:
  - keep the public informed about the activities of the investigation, including the information-gathering, risk assessment and decision-making process of outbreak management
  - focus on what is being done and the next steps
  - explain the unknowns
  - be aware that pride, embarrassment, fear of revealing weaknesses and fear of being blamed can lead to a lack of trust

Key elements- Understand the public

- Knowing who the public is, and what they think, is essential in developing effective public health messages
- Those responsible for risk communication should:
  - understand the public's beliefs, opinions and knowledge about specific risks
  - involve representatives of the public in the decision-making process
  - respect the public's concern, regardless of its validity
  - address the concern in any policies developed
  - publicly acknowledge and correct mistaken concerns
  - include information in risk-communication messages on how the public can protect themselves

Key elements- Integration in contingency planning

- Risk communication should be integrated into contingency planning for major events and outbreak response.
- Those responsible for risk communication should:
  - develop the risk-communication plan as part of the outbreak-management plan from the start of the outbreak
  - ensure media training for relevant members of the response team
  - develop partnerships with the media
  - organize press conferences to answer multiple media enquiries in an organized way
  - prepare pre-approved public health messages that can be adapted for the outbreak

Preparing public Health messages

Important to provide clear information and advice to the public during the outbreak

Best done through prepared communication messages with clear public health advice

Who is the target audience for the message?
What is their relationship to the event?
What is their level of education and the nature of their interest in the event?

Example messaging: “boil water advisory”

- Explain current risk: e.g. potential microbial contamination in specific area
- Stipulate under what circumstances: e.g. water for drinking and food preparation
- Describe action to be taken: e.g. bring the water to a rolling boil and allow to cool naturally

Preparing public health messages

The target audience can absorb only a limited amount of information, so the **single overarching communication outcome** and the key message that needs to be understood by the audience should be determined:

- simple, accurate, credible, relevant, consistent and timely
- should not contain technical language
- should describe clearly what needs to be done, by whom, when it needs to be done, how it needs to be done and for how long
- should be capable of being understood by, and be accessible to, different groups

Communication channels

- Institutional website
- Social media
  - important tool for directly and immediately communicating with the public.
  - enables those who use it to become involved in the response to the outbreak through commentary
  - useful for monitoring response and public concerns including community resistance, and can be used to monitor and counter rumors about the outbreak.
- Traditional media
  - Television, radio, printed press
  - Press releases
- Partners and stakeholders (internal & external)

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.
- 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

Case study on waterborne outbreak of Cryptosporidiosis

PROTOCOL ON WATER AND HEALTH

World Health Organization
European Region

UNECE

Scope and objectives

- Purpose: Work through the steps of outbreak management
- Fictional event
- Participants will respond to questions focused on the investigation of a waterborne outbreak 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.

Materials and exercise structure

- Case study participant handbook
- Template PowerPoint slide for presentation of results
- The exercise consists of group work and plenary debrief

Group work

- 240 minutes (4 hours) divided in two parts
  - Part 1: 150 minutes (2.5 hours): Steps I-V
  - Part 2: 90 minutes (1.5 hours): Steps VI-X
- Participants divided in groups (5-6 persons)
- At least two computers per group
- All groups will work through and discuss the entire scenario
- Each group will be responsible for presenting one specific question during the plenary debrief

Group work

- Each group should appoint:
  - A moderator-time keeper
  - A note taker-spokesman
- The workshop facilitator will be available to solve doubts during the entire session

Debrief in plenary

- 60 minutes
- Each group´s spokesman will briefly present (no more than 5 minutes each) and discuss the solution to their question.
- Free format for the presentation

Exercise structure

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

CASE STUDY

PART ONE. STEPS I-V

I. Outbreak alert and detection. First hypotheses

QUESTION 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)

I. Outbreak alert and detection. First hypotheses

QUESTION 2

Any hypothesis so far about what is going on?

Please, discuss with your group.

(5 minutes)

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

QUESTION 3

Who has a role in the response to this outbreak?

Please, discuss with your group.

(15 minutes)

III. Define cases

QUESTION 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)

IV Identify cases and obtain information. Microbiological confirmation

QUESTION 5

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

Please, discuss with your group.

(10 minutes)

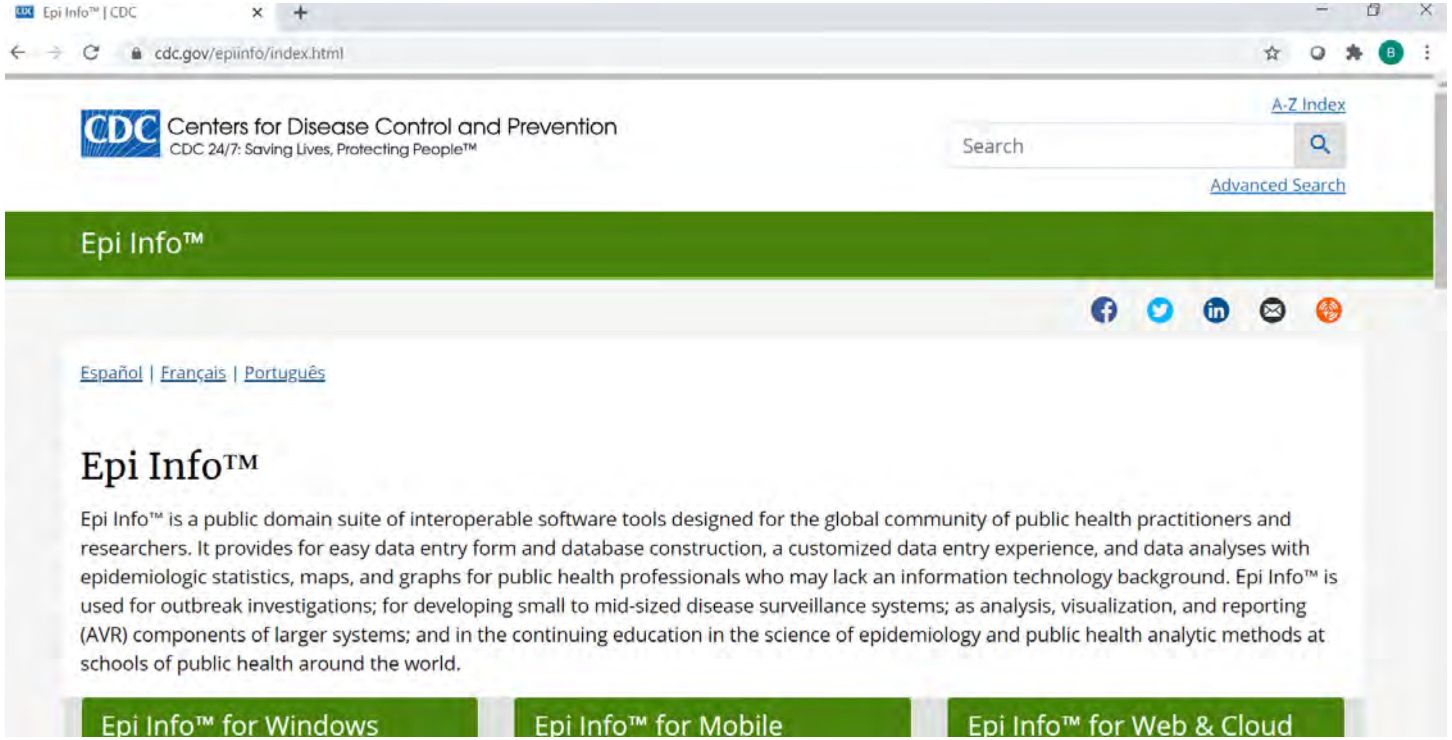
V. Conduct a descriptive epidemiological investigation (time, place, person)

	A	B	C	D	E	F	G	H	I	
1	ID	Case type	Date	Sex	Age group	Age	Diarrhoea	Adbominal Pain	Nausea	Vo
2	1	Probable	27/08/2018	Female	0_4	2	1	1	1	
3	2	Confirmed	29/08/2018	Female	15_24	16	1	1	0	
4	3	Probable	30/08/2018	Male	15_24	21	1	0	1	
5	4	Confirmed	01/09/2018	Male	15_24	24	1	1	0	
6	5	Probable	01/09/2018	Male	5_14	7	1	1	0	
7	6	Probable	02/09/2018	Male	45-64	47	1	0	1	
8	7	Probable	03/09/2018	Male	25_44	26	1	0	1	
9	8	Probable	03/09/2018	Female	25_44	25	1	0	1	
10	9	Probable	03/09/2018	Female	0_4	1	1	1	0	
11	10	Probable	04/09/2018	Male	0_4	2	1	1	0	
12	11	Probable	04/09/2018	Female	15_24	23	1	1	0	
13	12	Probable	04/09/2018	Male	25_44	43	1	1	0	
14	13	Probable	04/09/2018	Male	5_14	13	1	1	0	
15	14	Probable	04/09/2018	Male	45-64	61	1	0	1	
16	15	Probable	05/09/2018	Male	0_4	4	1	1	1	
17	16	Probable	05/09/2018	Female	45-64	60	1	1	1	
18	17	Probable	05/09/2018	Male	25_44	34	1	1	1	
19	18	Probable	05/09/2018	Male	25_44	39	1	1	1	

Descriptive dataset

For questions 6,7,8 you will use Epi Info…
What is Epi Info?

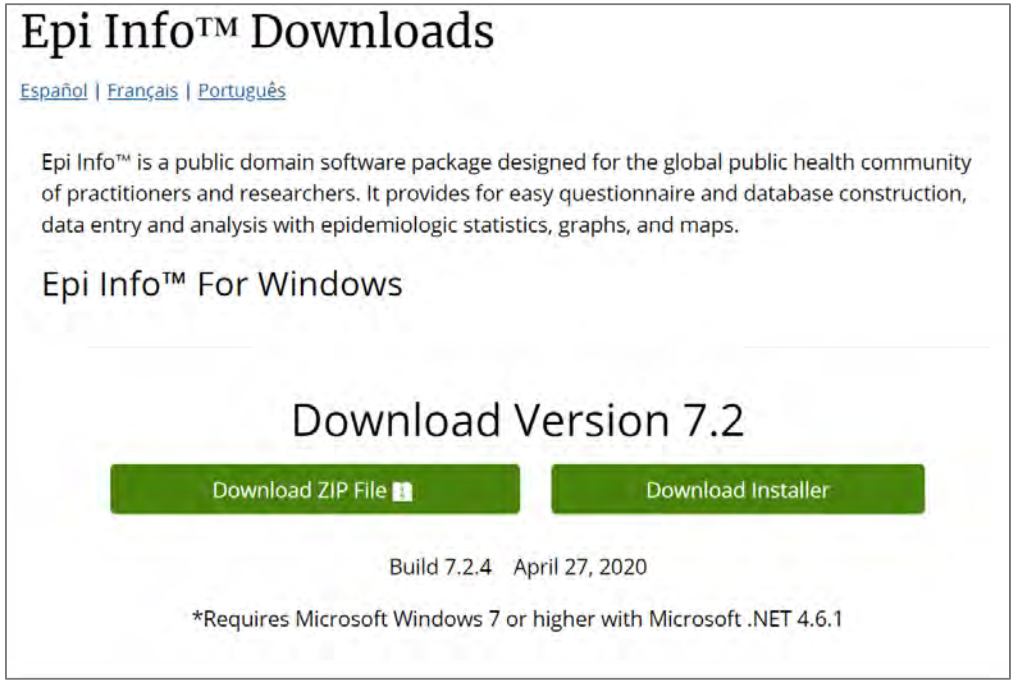
For the next questions you will use Epi info!



Epi Info

Downloads

Epi Info Tools are in the public domain and free to download and use



Epi Info™ Downloads

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Epi Info™ is a public domain software package designed for the global public health community of practitioners and researchers. It provides for easy questionnaire and database construction, data entry and analysis with epidemiologic statistics, graphs, and maps.

Epi Info™ For Windows

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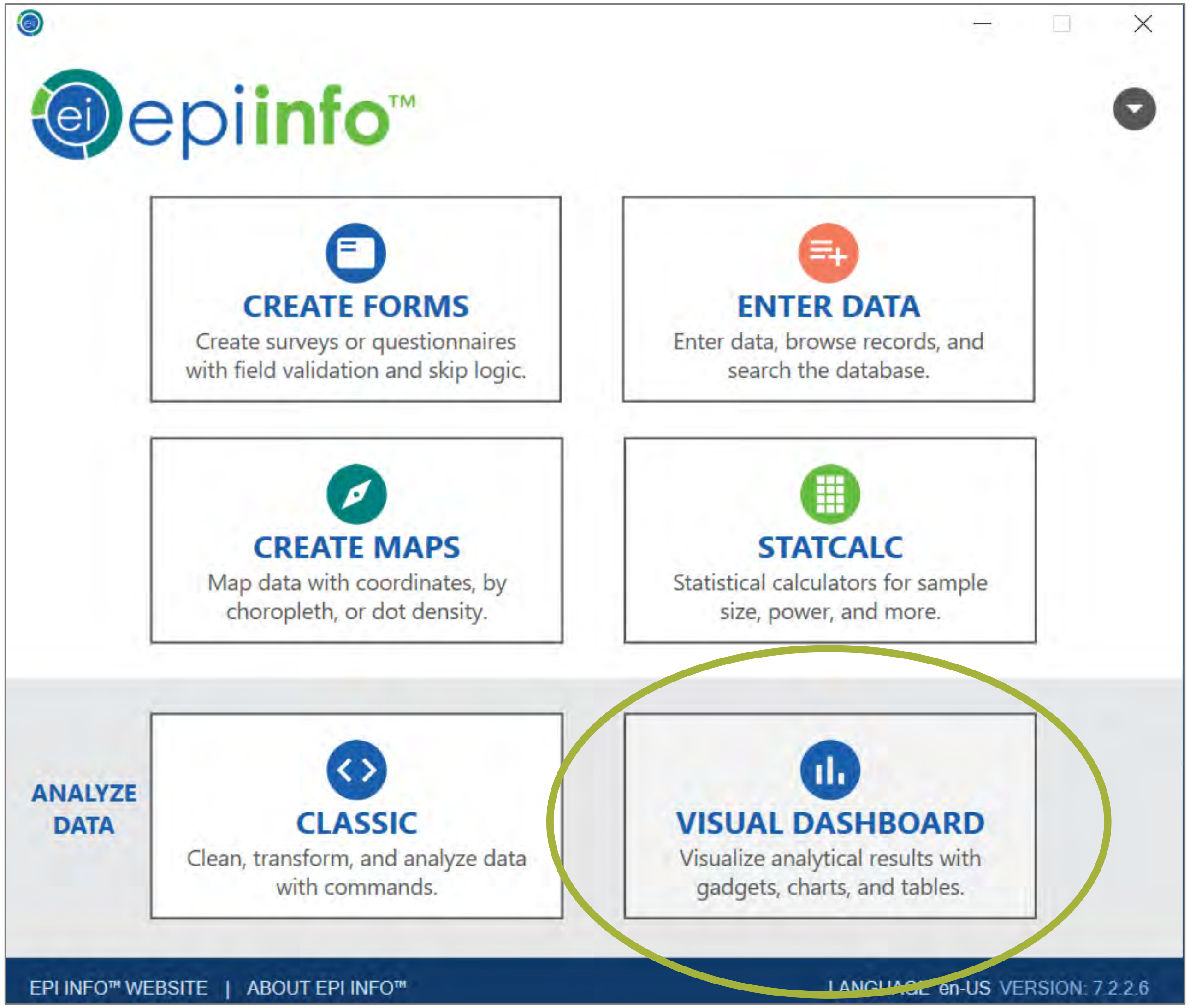
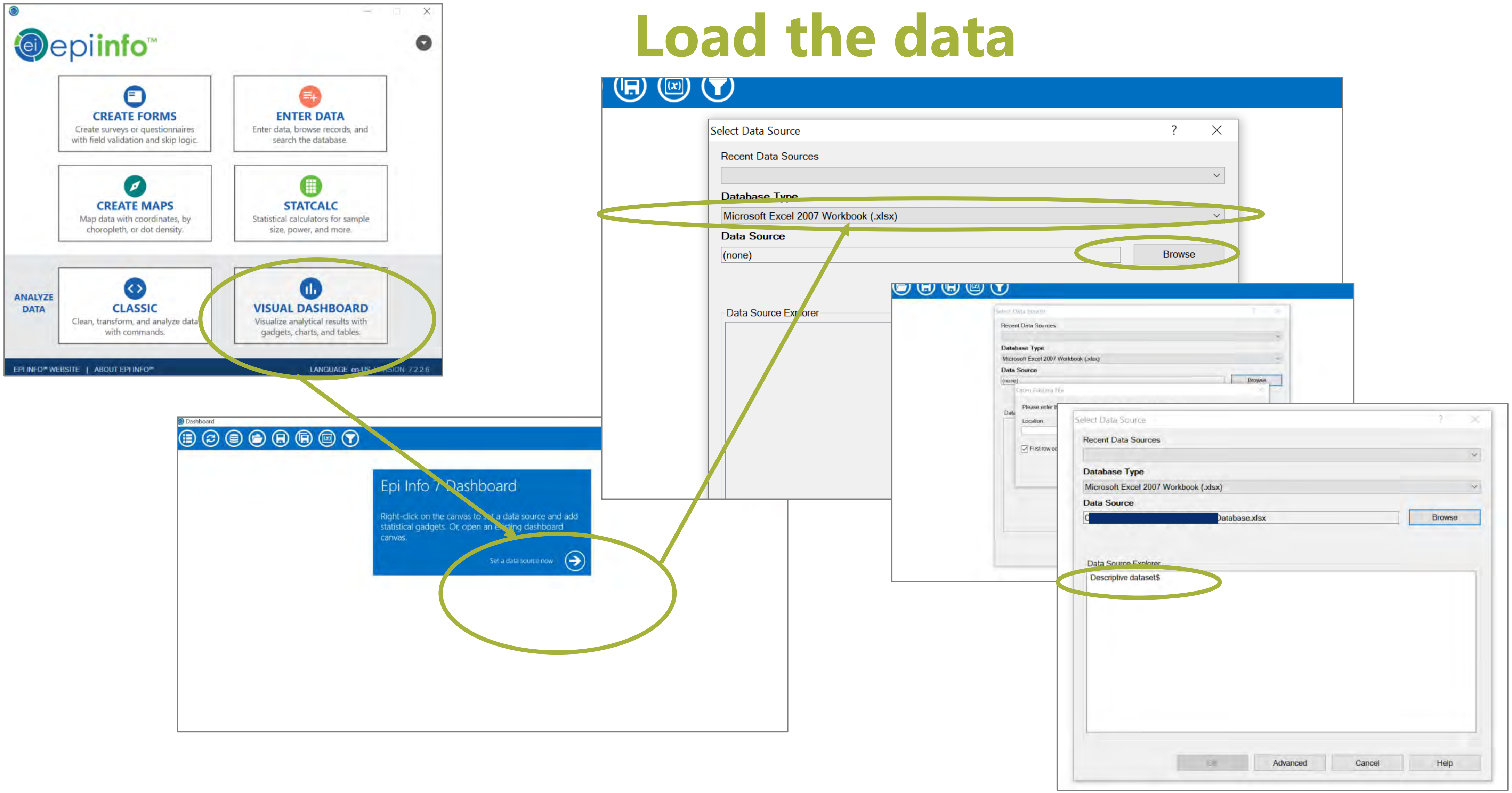
Build 7.2.4 April 27, 2020

*Requires Microsoft Windows 7 or higher with Microsoft .NET 4.6.1


epiinfo™
CREATE FORMS
Create surveys or questionnaires with field validation and skip logic.
ENTER DATA
Enter data, browse records, and search the database.
CREATE MAPS
Map data with coordinates, by choropleth, or dot density.
STATCALC
Statistical calculators for sample size, power, and more.
ANALYZE DATA
CLASSIC
Clean, transform, and analyze data with commands.
VISUAL DASHBOARD
Visualize analytical results with gadgets, charts, and tables.
EPI INFO™ WEBSITE | ABOUT EPI INFO™
en-US VERSION: 7.2.2.6

Load the data



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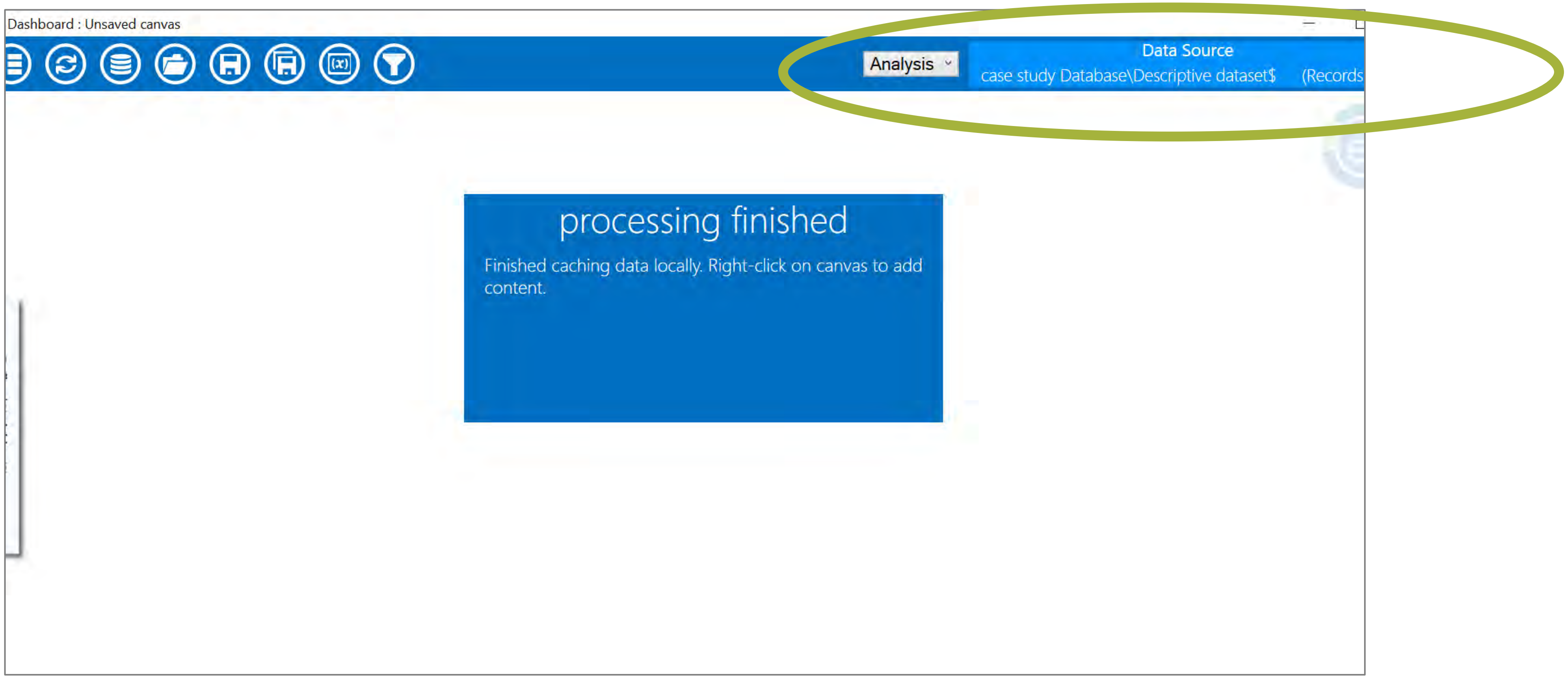


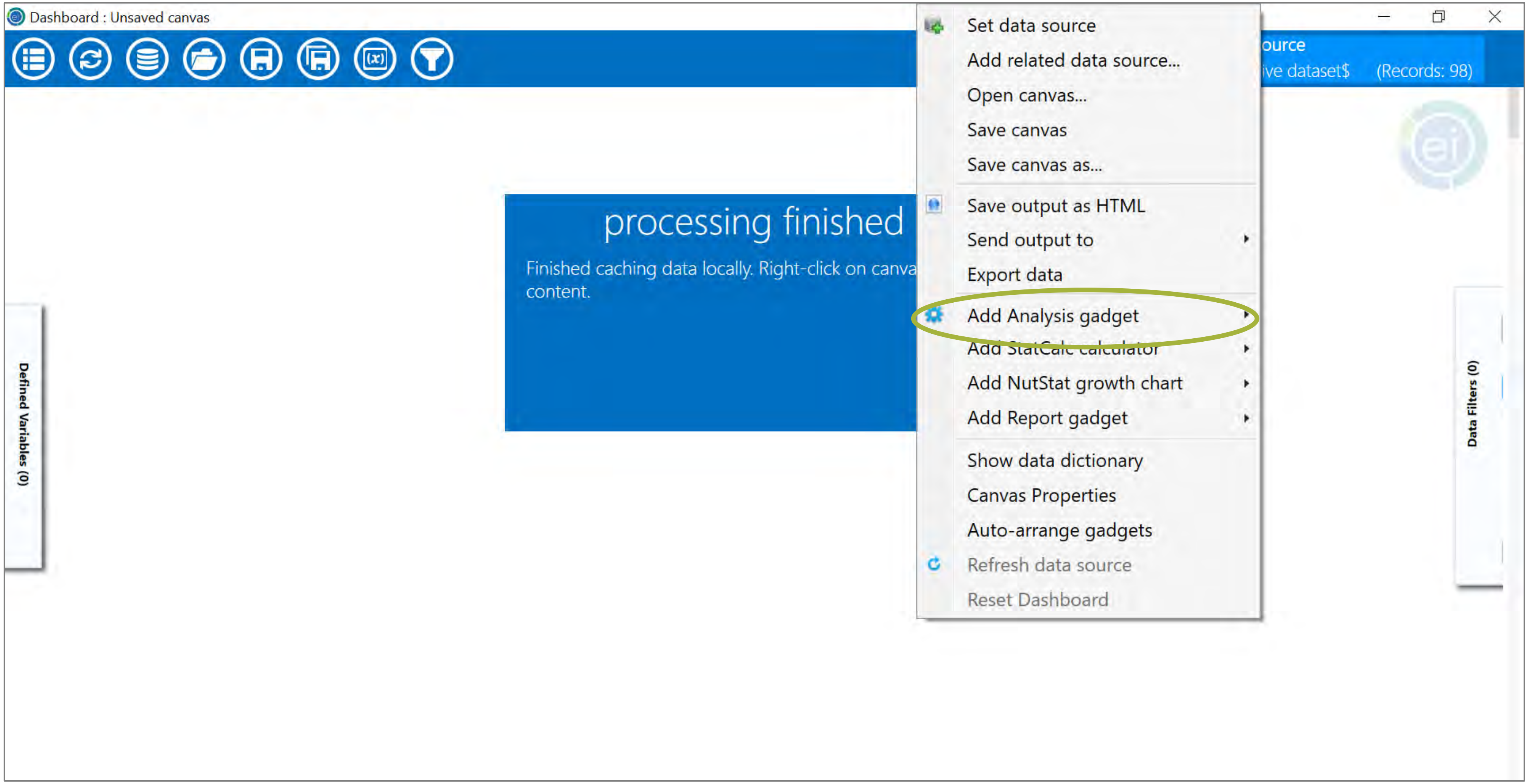
V. Conduct a descriptive epidemiological investigation (time, place, person)

Descriptive analysis: TIME

QUESTION 6

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

(25 minutes)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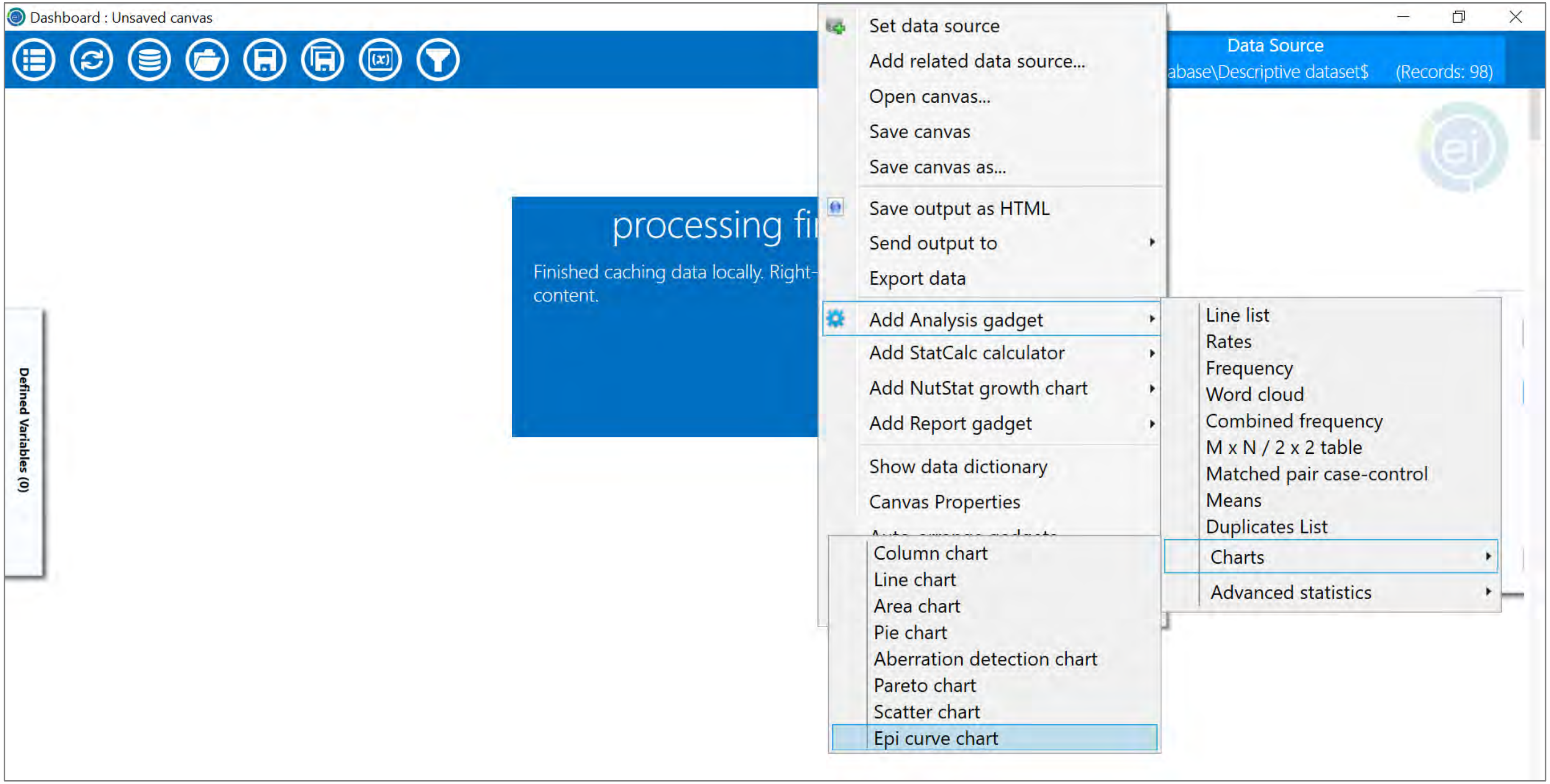
Set data source
Add related data source...
Open canvas...
Save canvas
Save canvas as...
Save output as HTML
Send output to
Export data
Add Analysis gadget
Add StatCalc calculator
Add NutStat growth chart
Add Report gadget
Show data dictionary
Canvas Properties
Auto-arrange gadgets
Refresh data source
Reset Dashboard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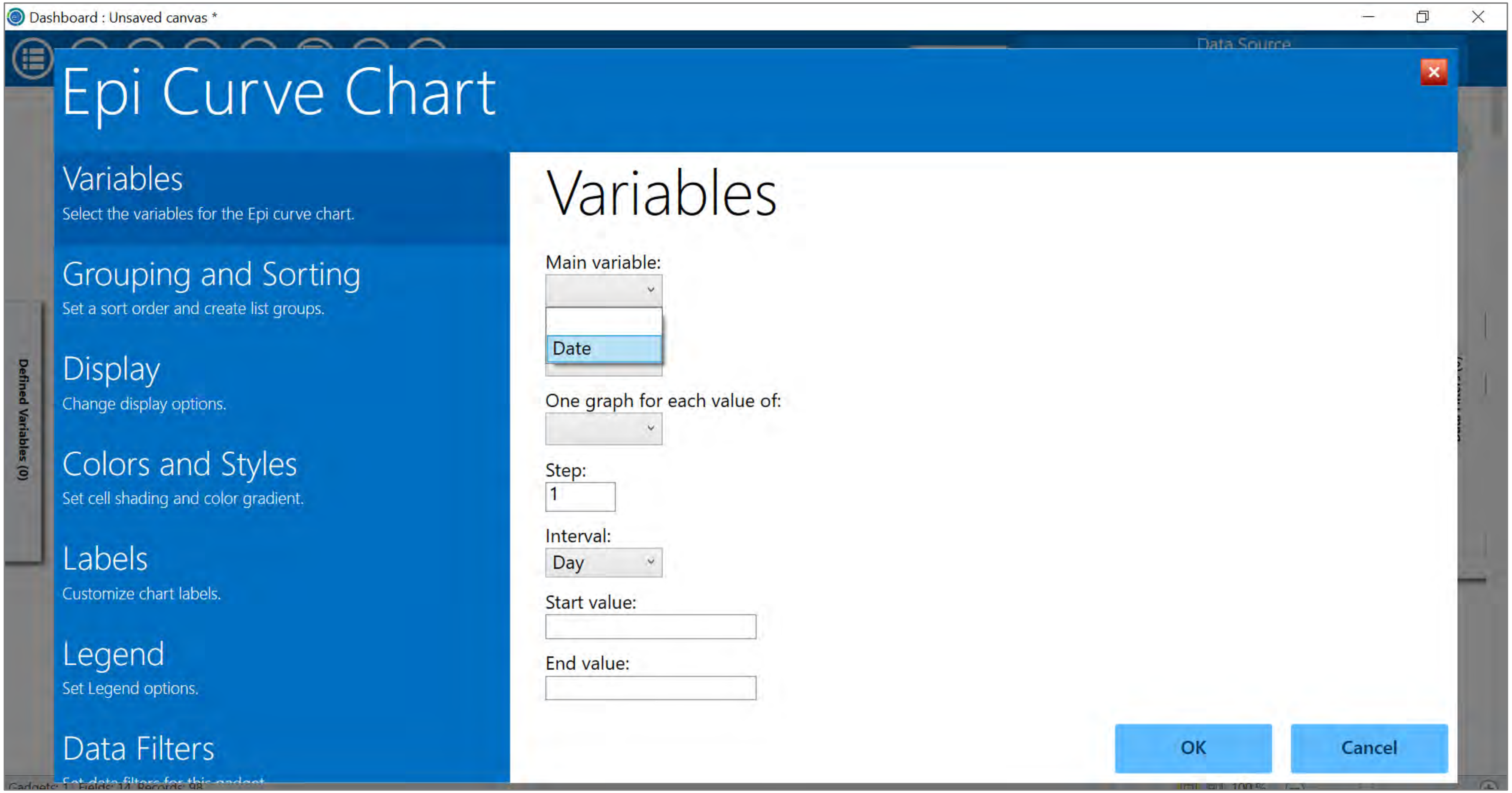
Add related data source...
Open canvas...
Save canvas
Save canvas as...
Save output as HTML
Send output to
Export data
Add Analysis gadget
Add StatCalc calculator
Add NutStat growth chart
Add Report gadget
Show data dictionary
Canvas Properties
Line list
Rates
Frequency
Word cloud
Combined frequency
M x N / 2 x 2 table
Matched pair case-control
Means
Duplicates List
Charts
Advanced statistics
Column chart
Line chart
Area chart
Pie chart
Aberration detection chart
Pareto chart
Scatter chart
Epi curve chart



Dashboard : Unsaved canvas *
Epi Curve Chart
Variables
Select the variables for the Epi curve chart.
Grouping and Sorting
Set a sort order and create list groups.
Display
Change display options.
Colors and Styles
Set cell shading and color gradient.
Labels
Customize chart labels.
Legend
Set Legend options.
Data Filters
Variables
Main variable:
Date
One graph for each value of:
Step:
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Interval:
Day
Start value:
End value:
OK
Cancel
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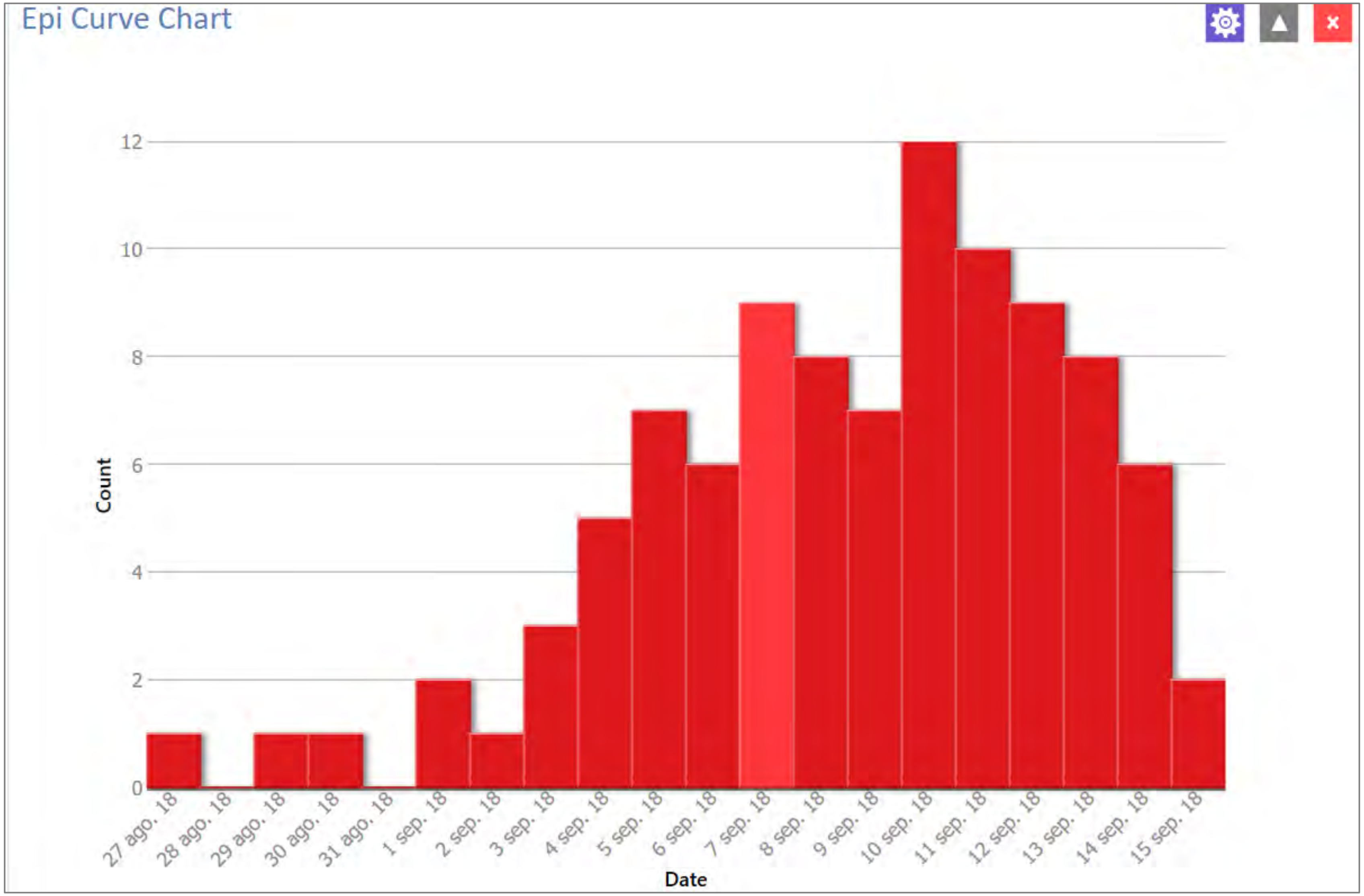

Epi Curve Chart
Count
12
10
8
6
4
2
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28 ago. 18
29 ago. 18
30 ago. 18
31 ago. 18
1 sep. 18
2 sep. 18
3 sep. 18
4 sep. 18
5 sep. 18
6 sep. 18
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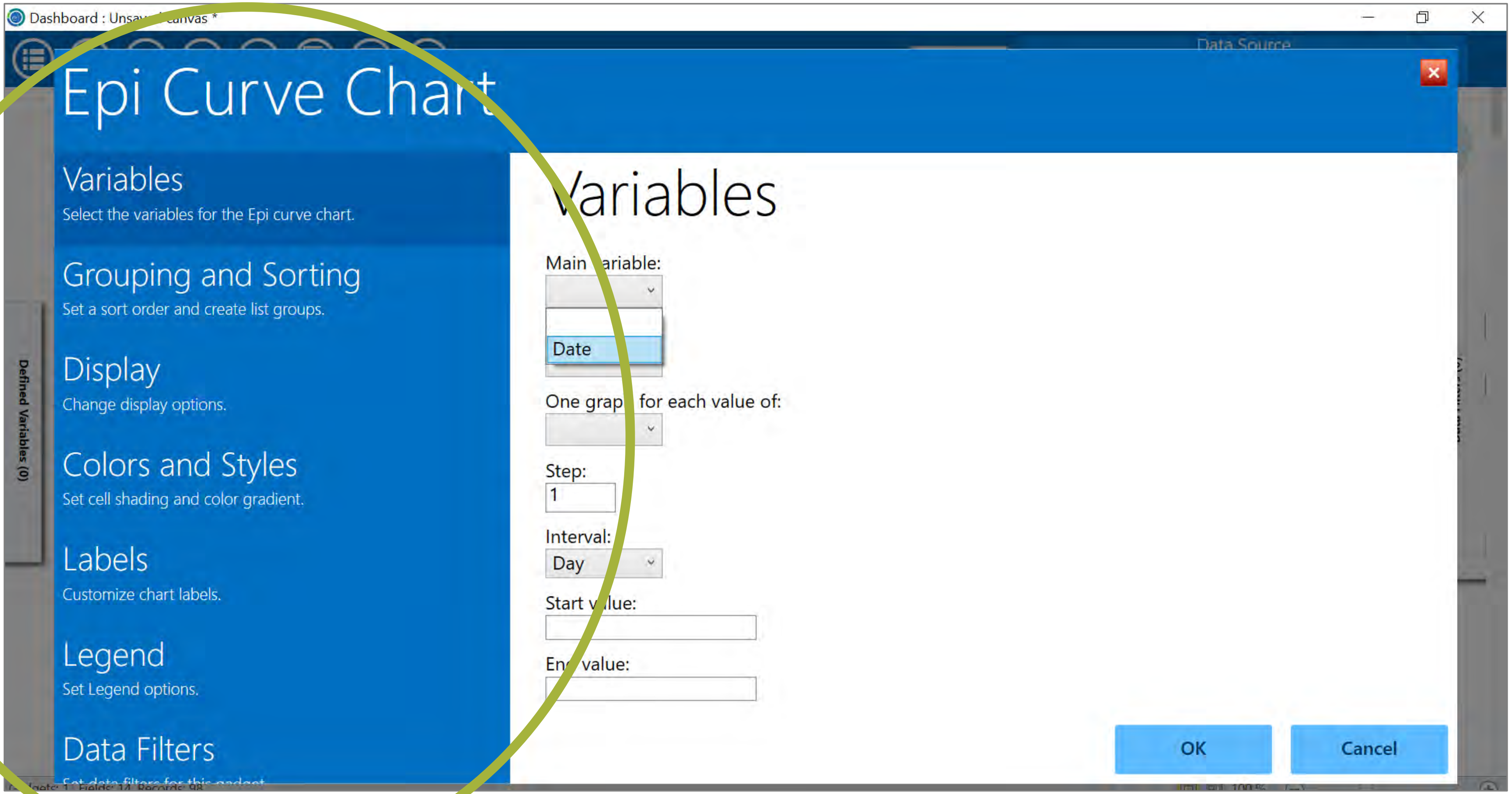
12 sep. 18
13 sep. 18
14 sep. 18
15 sep. 18
Date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Epi Curve Chart
Variables
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Grouping and Sorting
Set a sort order and create list groups.
Display
Change display options.
Colors and Styles
Set cell shading and color gradient.
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Variables
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V. Conduct a descriptive epidemiological investigation (time, place, person)

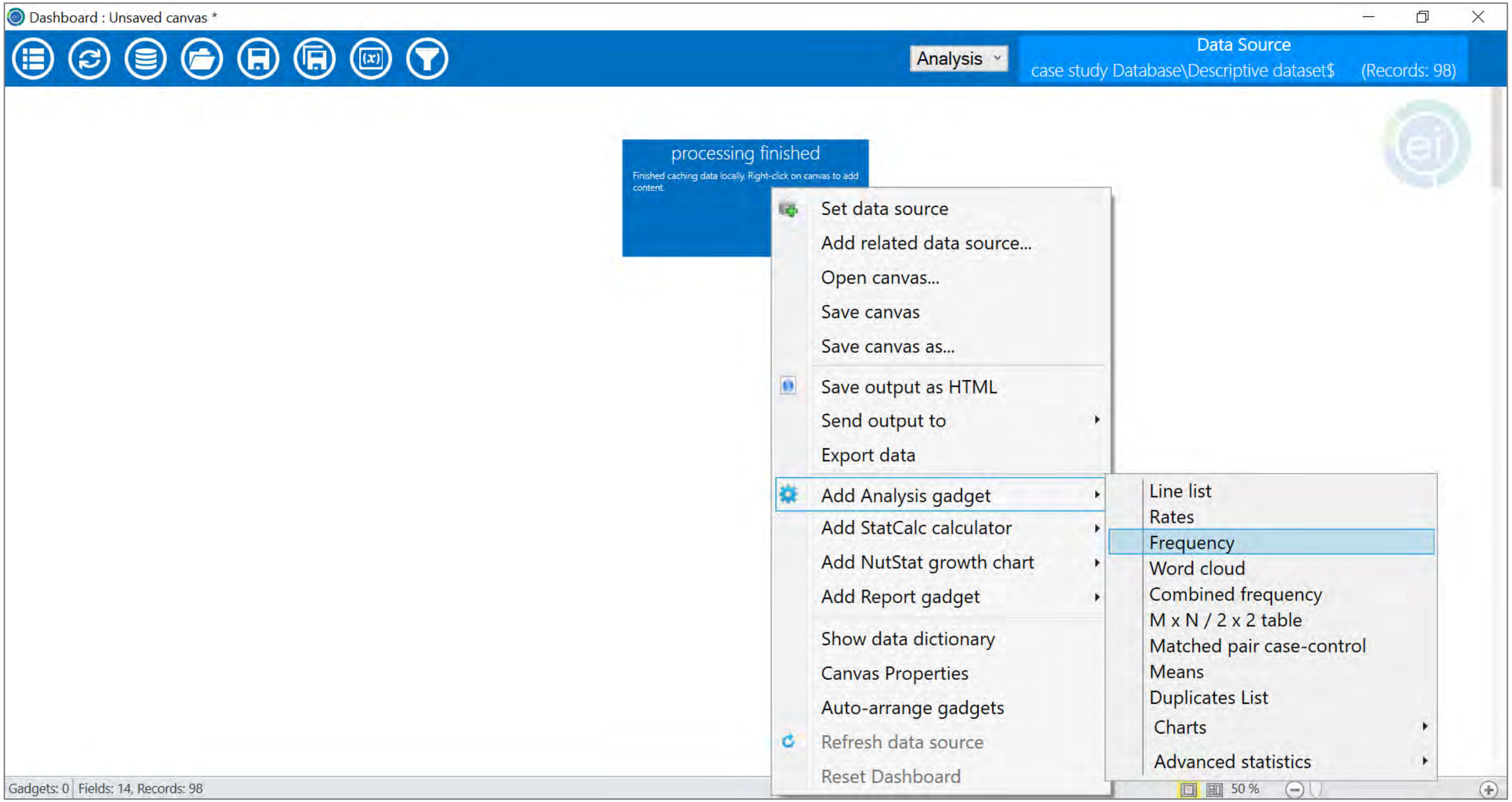
Descriptive analysis: PERSON

QUESTION 7

Describe cases by age, sex, symptoms, and severity.

(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		



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Analysis
Data Source
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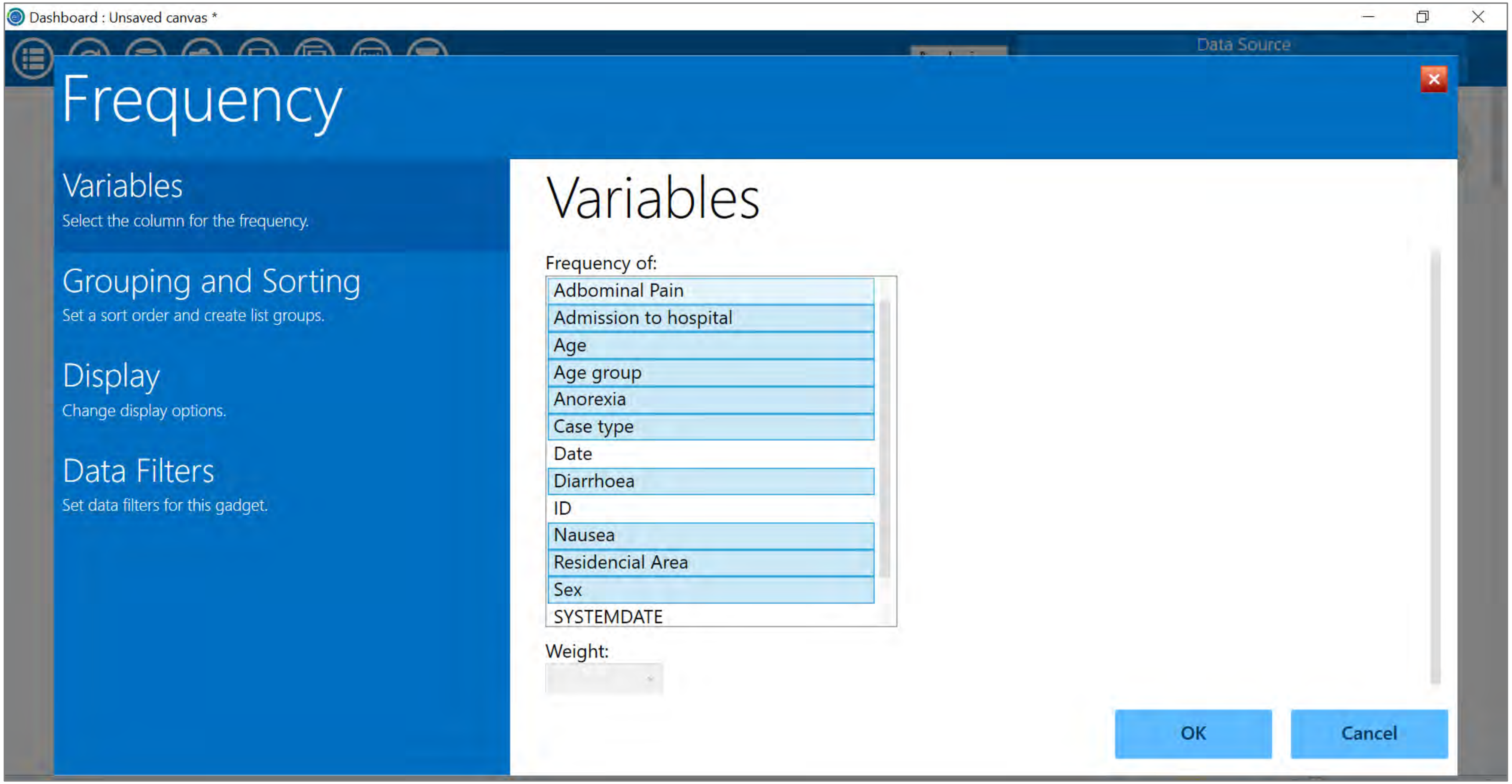
processing finished
Finished caching data locally. Right-click on canvas to add content.
Set data source
Add related data source...
Open canvas...
Save canvas
Save canvas as...
Save output as HTML
Send output to
Export data
Add Analysis gadget
Add StatCalc calculator
Add NutStat growth chart
Add Report gadget
Show data dictionary
Canvas Properties
Auto-arrange gadgets
Refresh data source
Reset Dashboard
Line list
Rates
Frequency
Word cloud
Combined frequency
M x N / 2 x 2 table
Matched pair case-control
Means
Duplicates List
Charts
Advanced statistics
Gadgets: 0
Fields: 14, Records: 98
50 %


Dashboard : Unsaved canvas *
Data Source
Frequency
Variables
Select the column for the frequency.
Grouping and Sorting
Set a sort order and create list groups.
Display
Change display options.
Data Filters
Set data filters for this gadget.
Variables
Frequency of:
Adbominal Pain
Admission to hospital
Age
Age group
Anorexia
Case type
Date
Diarrhoea
ID
Nausea
Residencial Area
Sex
SYSTEMDATE
Weight:
OK
Cancel

Dashboard : Unsaved canvas *

Analysis

Data Source
case study Database\Descriptive dataset$ (Records: 98)

Age group	Frequency	Percent	Cum. Percent	Exact 95% LCL	Exact 95% UCL
≥65	11	11,22 %	11,22 %	5,74 %	19,20 %
0 4	11	11,22 %	22,45 %	5,74 %	19,20 %
15, 24	21	21,43 %	43,88 %	13,78 %	30,87 %
25 44	28	28,57 %	72,45 %	19,90 %	38,58 %
45-64	17	17,35 %	89,80 %	10,44 %	26,31 %
5 14	10	10,20 %	100,00 %	5,00 %	17,97 %
TOTAL	**98**	**100,00 %**	**100,00 %**		

Anorexia	Frequency	Percent	Cum. Percent	Exact 95% LCL	Exact 95% UCL
0	55	56,12 %	56,12 %	45,73 %	66,13 %
1	43	43,88 %	100,00 %	33,87 %	54,27 %
TOTAL	**98**	**100,00 %**	**100,00 %**		

Case type	Frequency	Percent	Cum. Percent	Exact 95% LCL	Exact 95% UCL
Confirmed	2	2,04 %	2,04 %	0,25 %	7,18 %
Probable	96	97,96 %	100,00 %	92,82 %	99,75 %
TOTAL	**98**	**100,00 %**	**100,00 %**		

Diarrhoea	Frequency	Percent	Cum. Percent	Exact 95% LCL	Exact 95% UCL
1	98	100,00 %	100,00 %	96,31 %	100,00 %
TOTAL	**98**	**100,00 %**	**100,00 %**		

Nausea	Frequency	Percent	Cum. Percent	Exact 95% LCL	Exact 95% UCL
0	51	52,04 %	52,04 %	41,71 %	62,24 %
1	47	47,96 %	100,00 %	37,76 %	58,29 %
TOTAL	**98**	**100,00 %**	**100,00 %**		

Residencial Area	Frequency	Percent	Cum. Percent	Exact 95% LCL	Exact 95% UCL
Centre	11	11,22 %	11,22 %	5,74 %	19,20 %
Eastern	5	5,10 %	16,33 %	1,68 %	11,51 %
Northern	4	4,08 %	20,41 %	1,12 %	10,12 %
Southern	28	28,57 %	48,98 %	19,90 %	38,58 %
Western	50	51,02 %	100,00 %	40,72 %	61,26 %
TOTAL	**98**	**100,00 %**	**100,00 %**		

Sex	Frequency	Percent	Cum. Percent	Exact 95% LCL	Exact 95% UCL
Female	52	53,06 %	53,06 %	42,71 %	63,22 %
Male	46	46,94 %	100,00 %	36,78 %	57,29 %
TOTAL	**98**	**100,00 %**	**100,00 %**		

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

Descriptive analysis: PERSON

QUESTION 7

Describe cases by age, sex. symptoms, and severity

(25 minutes)

		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

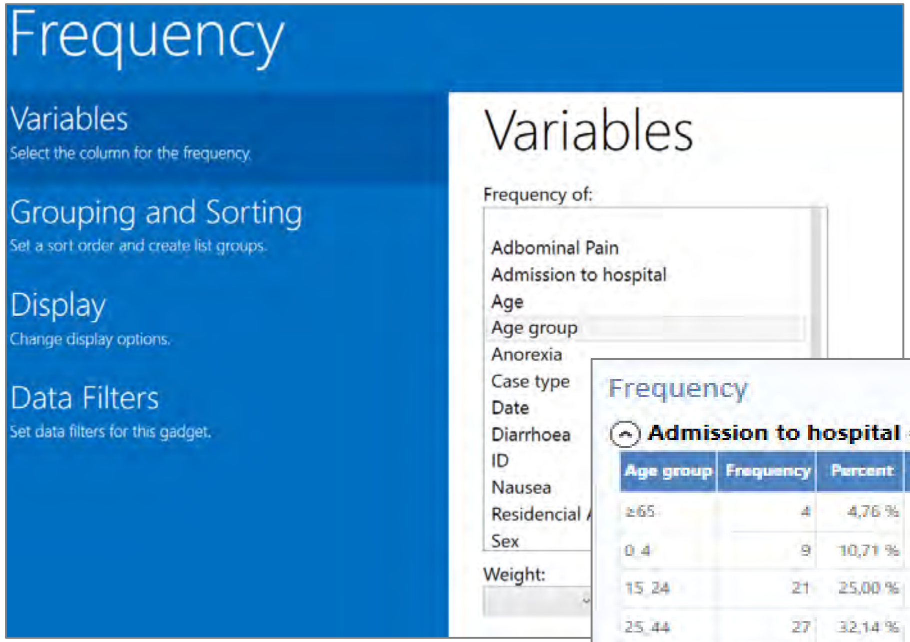
V. Conduct a descriptive epidemiological investigation (time, place, person)

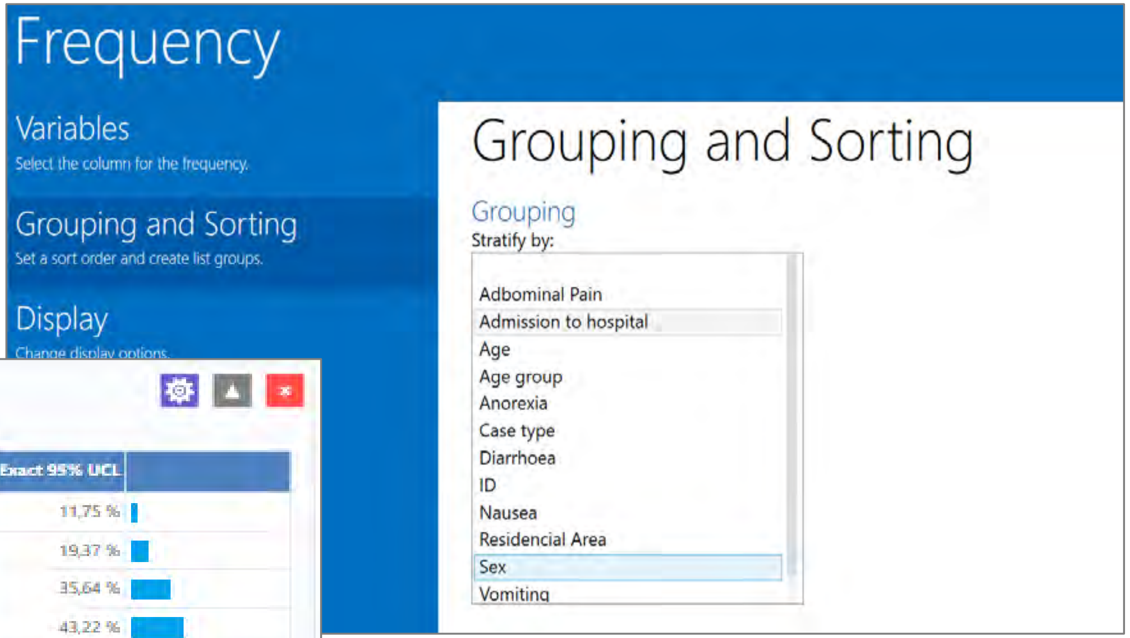
Descriptive analysis: PERSON

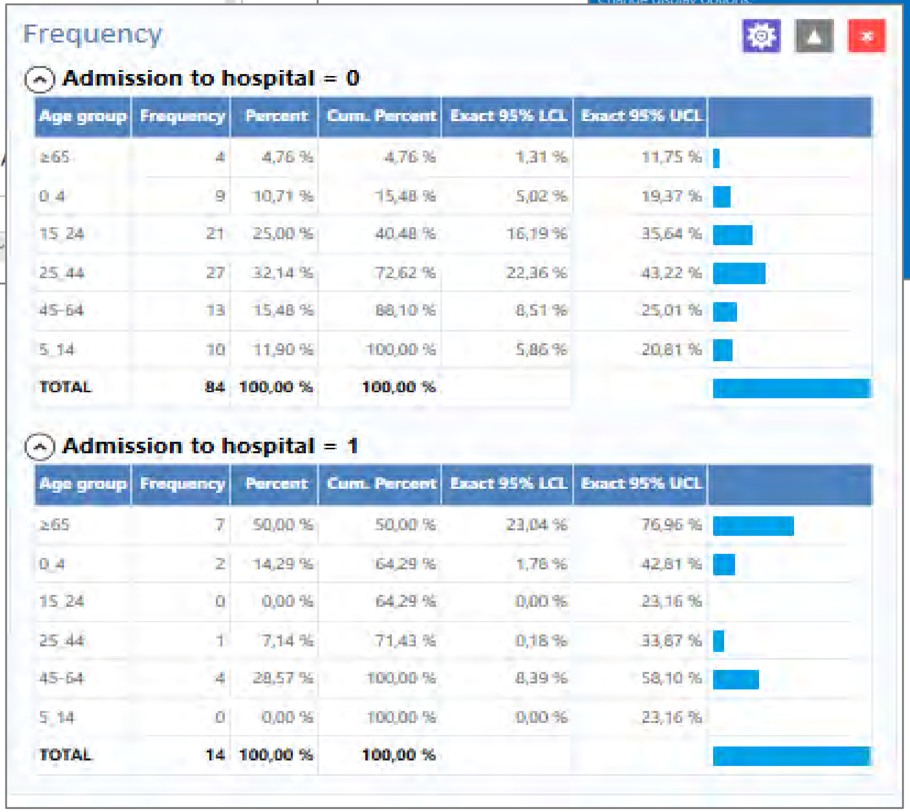
QUESTION 8

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

(25 minutes)






Frequency

Admission to hospital = 0

Age group	Frequency	Percent	Cum. Percent	Exact 95% LCL	Exact 95% UCL
≥65	4	4,76 %	4,76 %	1,31 %	11,75 %
0_4	9	10,71 %	15,48 %	5,02 %	19,37 %
15_24	21	25,00 %	40,48 %	16,19 %	35,64 %
25_44	27	32,14 %	72,62 %	22,36 %	43,22 %
45-64	13	15,48 %	88,10 %	8,51 %	25,01 %
5_14	10	11,90 %	100,00 %	5,86 %	20,81 %
TOTAL	84	100,00 %	100,00 %		

Admission to hospital = 1

Age group	Frequency	Percent	Cum. Percent	Exact 95% LCL	Exact 95% UCL
≥65	7	50,00 %	50,00 %	23,04 %	76,96 %
0_4	2	14,29 %	64,29 %	1,78 %	42,81 %
15_24	0	0,00 %	64,29 %	0,00 %	23,16 %
25_44	1	7,14 %	71,43 %	0,18 %	33,87 %
45-64	4	28,57 %	100,00 %	8,39 %	58,10 %
5_14	0	0,00 %	100,00 %	0,00 %	23,16 %
TOTAL	14	100,00 %	100,00 %		

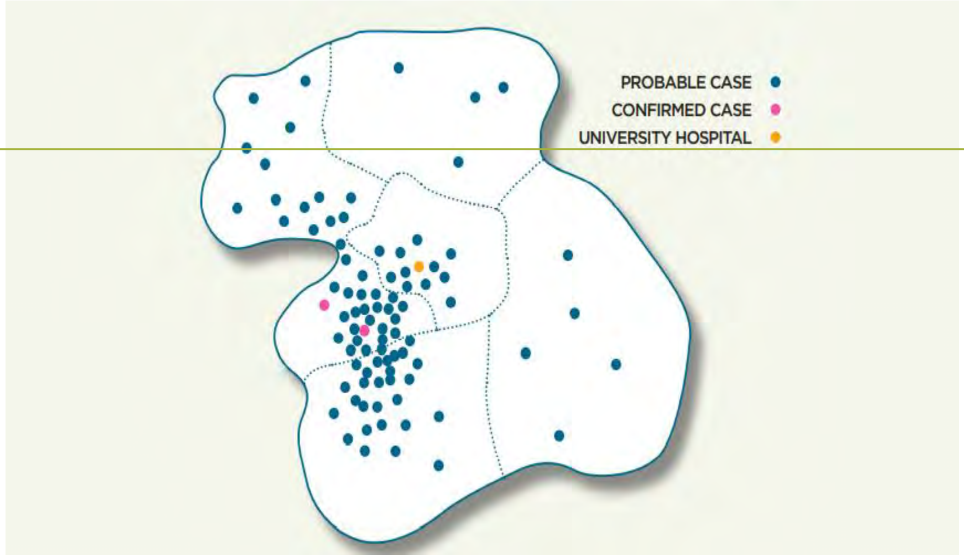
V. Conduct a descriptive epidemiological investigation (time, place, person)

Descriptive analysis: PLACE

QUESTION 9

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

(10 minutes)



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

Descriptive analysis: PLACE

QUESTION 10

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

(25 minutes)

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	

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

Descriptive analysis: PLACE

QUESTION 10

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

(25 minutes)

Frequency

Residencial Area	Frequency	Percent	Cum. Percent	Exact 95% LCL	Exact 95% UCL
Centre	11	11,22 %	11,22 %	5,74 %	19,20 %
Eastern	5	5,10 %	16,33 %	1,68 %	11,51 %
Northern	4	4,08 %	20,41 %	1,12 %	10,12 %
Southern	28	28,57 %	48,98 %	19,90 %	38,58 %
Western	50	51,02 %	100,00 %	40,72 %	61,26 %
TOTAL	**98**	**100,00 %**	**100,00 %**		

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

PART TWO. STEPS VI-X

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

QUESTION 11

Would you conduct any environmental investigation in this context?

(5 minutes)

VII. Generate hypotheses

QUESTION 12

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

(10 minutes)

VIII. Evaluate hypotheses

QUESTION 13

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

(10 minutes)

VIII. Evaluate hypotheses

QUESTION 14

Please comment on the table. Which are the factors associated with infection?

(10 minutes)

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

VIII. Evaluate hypotheses

QUESTION 15

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

(15 minutes)

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.

Tillet et al. (1998): Surveillance of Outbreaks of Waterborne Infectious Disease: Categorizing Levels of Evidence. Epidemiology and Infection, https://www.jstor.org/stable/3864259

IX. Implement control measures and risk communication

QUESTION 16

Communication to the public is key to keep trust and to promptly inform about recommended preventive 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)

X. Communication and evaluation of the outbreak response

QUESTION 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)

Case study on waterborne outbreak of Cryptosporidiosis

Participant Guide

Contents

Case study on waterborne outbreak of Cryptosporidiosis

Participant Guide

Case study on waterborne outbreak of Cryptosporidiosis

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.

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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**
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	Question 2	5 minutes
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Step VI. Conduct additional studies and collect additional information (environmental, laboratory)	Question 11	5 minutes
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	Question 14	10 minutes
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Step X. Communication and evaluation of the outbreak response	Question 17	30 minutes
PLENARY DISCUSSION		60 minutes

Sources

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- Case study participant handbook: it includes the case scenario and participant questions
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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)

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)

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)

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)

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)

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:

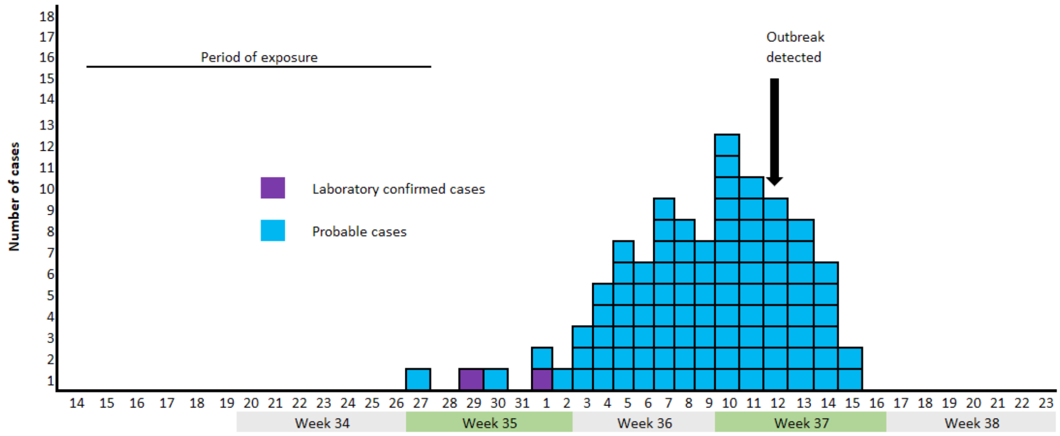
6) Describe the distribution of cases over time, using Epi-info

(25 minutes)

Epicurve in Epi-info:

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

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

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"

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:

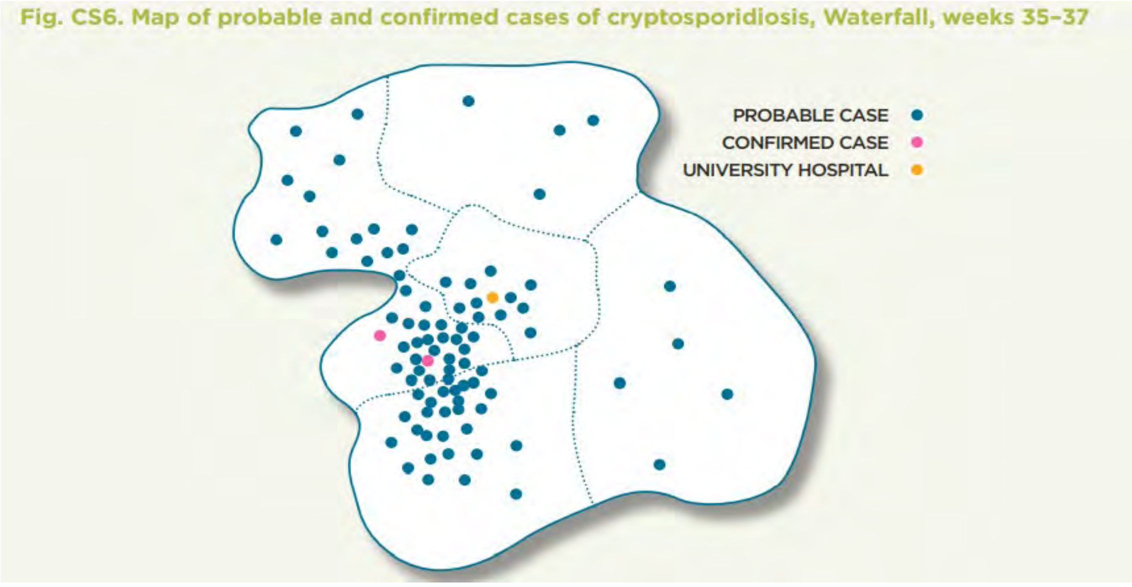


Figure 1 Map of probable and confirmed cases related to the outbreak. Municipality XX. Weeks 35-37

Questions to participants:

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

(10 minutes)

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	

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.

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)

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)

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)

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)

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)

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)

Case study on waterborne outbreak of Cryptosporidiosis

Facilitator Guide

PROTOCOL ON WATER AND HEALTH

World Health Organization
European Region

UNECE

Contents

Case study on waterborne outbreak of Cryptosporidiosis

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.

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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
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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

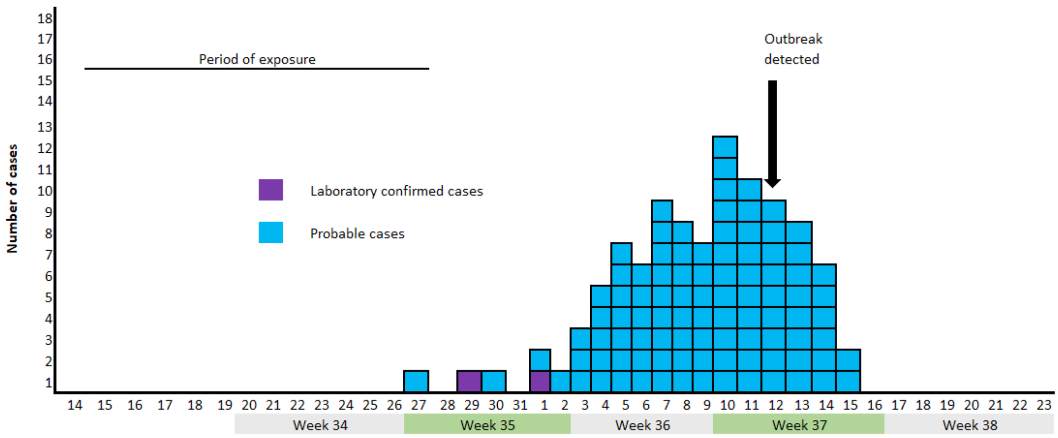
Make sure all group members participate actively in this activity and not only those that own the computer in the group. At least one computer per three members is recommended so that all group members can easily see the screen and follow the process.

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

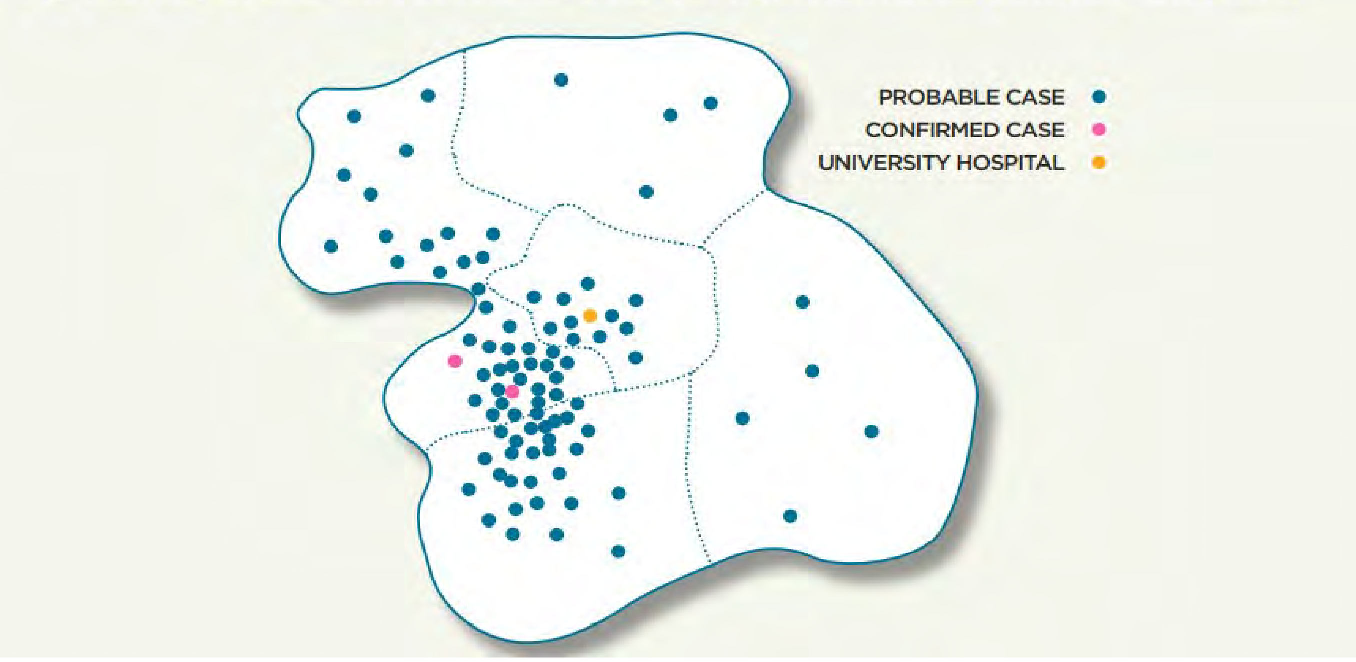


Figure 1 Map of probable and confirmed cases related to the outbreak. Municipality XX. Weeks 35-37

> **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…

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