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

Working Group on Water and Health

Thirteenth meeting
Geneva, 19 and 20 May 2022
Item 5 of the provisional agenda
Prevention and reduction of water-related diseases

INFORMAL DOCUMENT

Training module on water-related disease surveillance and outbreak management
(draft)

Programme area 2 on prevention and reduction of water-related disease aims to strengthen implementation of Article 8 of the Protocol on Water and Health, in particular to support countries in building national and/or local surveillance and early-warning systems and develop preparedness and contingency plans for responses to outbreaks of water-related diseases.

The development of training modules on water-related disease surveillance and outbreak management is a planned activity under the Protocol's programme of work for 2020-2022. The modules are based on the technical guidance provided by the publication *Strengthening surveillance and outbreak management of water-related infectious diseases associated with water-supply systems (*WHO Regional Office for Europe, 2019*)* that was published under the 2017-2019 programme cycle, as well as on the training materials developed and piloted in the previous triennium. The training package was peer-reviewed by technical experts. It consists of two main modules:

1. Part on surveillance of water-related disease: technical presentations with annotations, case studies and a guide for interactive group work. This module provides technical background and details on the key principles and building blocks of surveillance systems with a view on water-related disease and practical considerations on how to set up, improve and maintain effective systems for surveillance of water-related disease.

2. Part on outbreak management: technical presentations with annotations, case studies and a guide for interactive group work. This module provides hands-on, step by step guidance for practitioners involved in outbreak management and emphasize specific aspects related to waterborne outbreak investigation.

The Working Group on Water and Health is requested to review the draft training package and provide feedback on its technical content by **10 June 2022** to Enkhtsetseg Shinee at enkhtsetsegs@who.int.

Note: The draft document is for review by the Working Group on Water and Health only and not for wider distribution at this stage.

Introduction to water-related infectious diseases

Module 1.1

1

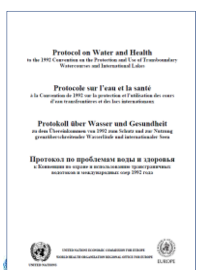
Overview

- The Protocol on Water and Health & 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 & outbreak management capacity

2

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

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


Protocol on Water and Health
Protocole sur l'eau et la santé
Protokoll über Wasser und Gesundheit
Протокол по проблемам воды и здоровья

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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 & functioning
Response	Rapid response capacity	Public health emergency response mechanisms are established & functioning
Preparedness	Public Health Emergency Preparedness and Response	Multi-hazard National Public Health Emergency Preparedness and Response Plan developed and Implemented
Risk communication	Policy & procedures for public communication	Mechanisms for effective risk communication during a public health emergency are established and functioning

IHR Core Capacity Monitoring Framework Questionnaire for Monitoring Progress in the Implementation of IHR Core Capacities in States Parties, WHO 2011

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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 (…)

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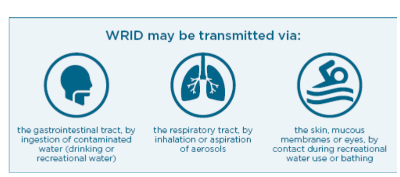
What are water-related infectious diseases?

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



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Classification of WRID

Category	Description	Examples
Water-borne	Ingestion of pathogens in contaminated water	Typhoid, legionellosis, poliomyelitis
Water washed a) Skin & eyes b) Diarrhoeal 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

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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		

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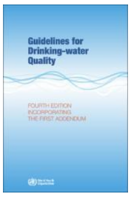
Pathogens transmitted through drinking water

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



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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 & fever
- Reactive arthritis, meningitis & Guillain Barre syndrome
- Reservoir: Poultry, wild birds, cattle & pets.
- Waterborne outbreaks
  - Faecal contamination of water storage reservoirs with bird faeces
  - Consumption of inadequately treated surface water

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Shigella

- *S. dysenteriae*, *S. flexneri*, *S. boydii* and *S. sonnei*.
- Abdominal cramps, fever & 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, & flies
- Waterborne outbreaks are occurring more frequently due to faecally contaminated drinking-water.
- Control of Shigella in drinking wáter is of special public health importance
- Sensitive to disinfection

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Legionella

- Heterotrophic bacteria, widely found in water, proliferate at 25C
- *L. pneumophila*
  - Legionnaires' disease
  - Pontiac fever
- Biofilms in water distribution systems
- Route of infection – inhalation of aerosols from cooling towers, air conditioning, showers & spas – common sources of infection & outbreaks.
- Control strategies:
  - Disinfection
  - Minimising biofilm growth
  - Temperature control (<20C & >50C)

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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 & liver damage – prolonged illness
- Mortality <1%
- Source: faecally contaminated food & water
- Person to person & 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.*

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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

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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, cruise ships

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Cryptosporidium

- 13 species – C. hominis & 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, & outbreaks associated with visiting farms & contact with animals
- Oocysts shed in faeces can survive for weeks or months in fresh water
- Faecal oral & person to person transmission; consumption of contaminated food & water & 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.

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Giardia

- Giardiasis – G. intestinalis/G. lamblia or G. duodenalis
- Diarrhoea, abdominal cramps & 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 & food
- Well established source of waterborne outbreaks
- Resistant to disinfection ⟶ *E.coli or thermotolerant coliforms are not a reliable indicator of their presence/absence.*

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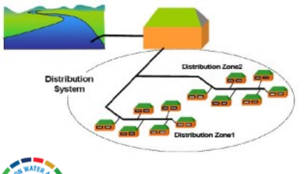
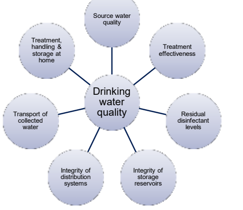
Drinking water systems as a source of WRID





Source: A Guide to the Ministry of Health Drinking-water Standards for New Zealand

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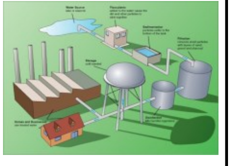
Hazardous events at different points of the water supply system

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

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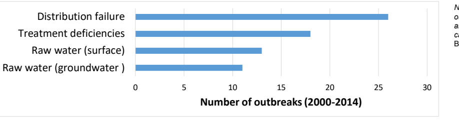
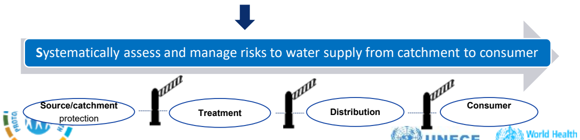
Drinking-water systems as cause of WRID outbreaks



Number of published outbreaks between 2000 and 2014 categorised by cause (Moreira & Bondelind 2017)



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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*)

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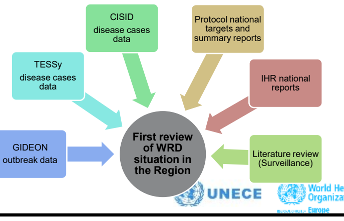
Burden of WRID in the European Region

- Estimated 2700 deaths due to WASH related diarrhoea in 2016 which indicates 7 people die every day (WHO, 2019)



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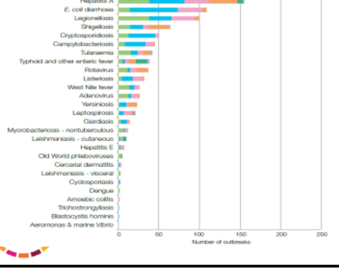
Outbreaks reported to GIDEON, 2000 - 2013



Viral gastroenteritis, hepatitis A, E. coli & Legionellosis – most frequently reported cause of outbreaks

18% of outbreaks linked to water – most caused by contaminated drinking water supplies

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Waterborne outbreaks in Europe

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

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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

Norovirus sickens 39 in Spain with link to mussels

By Joseph James Whitworth

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Burden of mortality

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	105
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.

Source: Gargano et al, Jnl Wtr Hlth, 2017

- 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 & non-tuberculus mycobacteria
  - Caused 91% of WRID deaths in the USA between 2003 and 2009
- Germany: >3 deaths every day due to legionellosis

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Surveillance of Water Related Infectious Diseases

Module 1.2

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Overview

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

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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

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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 & prevention measures
- Identify priorities for drinking water supply system improvement
- Assess effectiveness of control measures
- Inform water quality and WRID policies & regulations

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Ideally WRID surveillance will:

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

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

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

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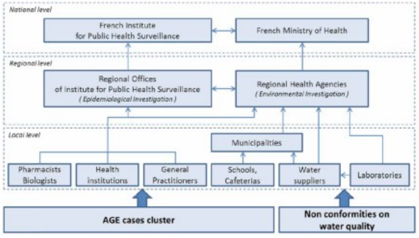
Multilevel approach to WRID surveillance – example France



French system for the detection of waterborne outbreaks
[Source Rambaud et al, Jnl Water Hlth, 2016]
AGE = acute gastroenteritis

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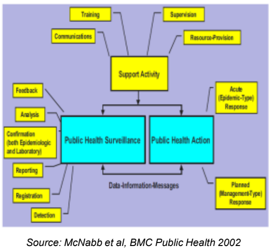
Core activities & building blocks of surveillance

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



Source: McNabb et al, BMC Public Health 2002

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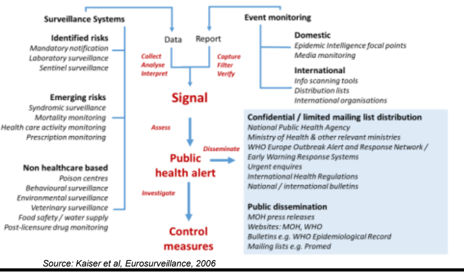
Epidemic intelligence framework



Source: Kaiser et al, Eurosurveillance, 2006

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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

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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.

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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 & public health action

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Other types of surveillance & 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 & 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

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Surveillance attributes

- Completeness
- Timeliness
- Usefulness
- Sensitivity
- Specificity
- Positive predictive value

- Representativeness
- Simplicity
- Flexibility
- Acceptability
- Stability

Table 4 of the guidance document

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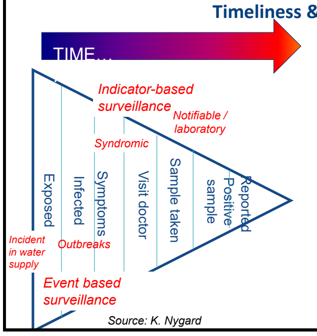
Timeliness & sensitivity



Source: K. Nygard

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

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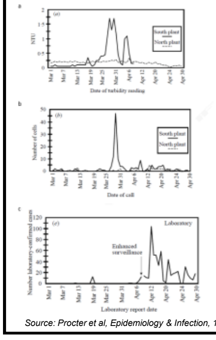

Source: Procter et al, Epidemiology & Infection, 1998

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

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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 & laboratory capacity for collection, transportation, detection
  - Funding for surveillance
  - E-reporting and database
  - Acceptability and participation by health care workers

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Setting up, improving & maintaining national systems for WRID surveillance

Module 1.3

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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

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Approach to WRID surveillance system strengthening

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

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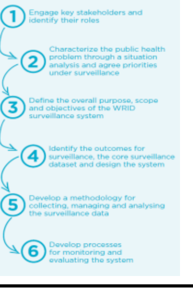
Main activities in WRID surveillance system strengthening



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

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1. Engage stakeholders & agree their roles

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Establish an advisory / working group

- Establish advisory group to provide oversight & expertise
  - Do this early
  - Include decision makers, focal points & 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 & local level
- National advisory group
  - Overall system design & development
  - Priority setting for surveillance
- Local advisory group
  - Operationalise the system

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Advisory groups could include:

At the national level:
- MoH/National public health agency
- Epidemiologist
- Water regulator
- Environment agency
- Environmental health specialists
- Laboratory specialist
- Legal & 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

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Case study 1

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

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Situation analysis

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

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Situation analysis cont.

- Describe current surveillance capacity at national & subnational levels
  - ➢Main actors & stakeholders & their roles in surveillance & disease control
  - ➢Current data sources & potential new sources
  - ➢Data gaps & limitations
  - ➢International surveillance requirements
- At the local level:
  - ➢Describe the local water supply – sources, providers, geographical distribution & population served
  - ➢Review water quality data & condition of water system (WSP if available)
  - ➢Review potential sources of Legionella
  - ➢Identify local vulnerable populations & settings

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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 & intermittent supplies
  - – Areas prone to flooding
  - – Small-scale community supplies
  - – Industrial areas
- Seasonal pathogens - enhance surveillance at certain times of year?

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Criteria for selecting candidate surveillance outcomes

Criteria	Factors to consider
Disease burden – size of the problem & 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 & 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

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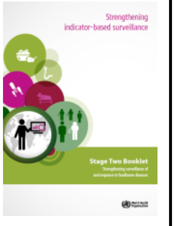
How to select the priority diseases

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



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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 & control

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Example of a strategy grid based on disease burden & feasibility

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.

Disease burden (↑)

Feasibility (→)

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Case study 1 continued.

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

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Purpose & scope

- Situation analysis & prioritization exercise → the purpose & 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 & control measures"*

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

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Surveillance Objectives

- Can have multiple objectives

"The objectives are to:

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

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

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Case study 1 continued.

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

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Define outcomes for surveillance

- Informed by results of situation analysis & by purpose, scope & objectives of system
- List priority outcomes (pathogens, notifiable diseases & 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

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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?

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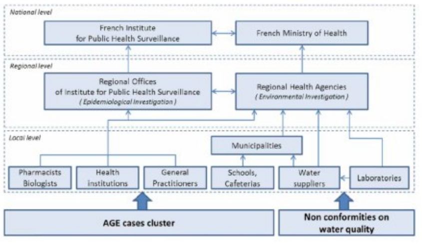
Schematic diagram of the elements of the surveillance system



French system for the detection of waterborne outbreaks
[Source Rambaud et al, Jnl Water Hlth, 2016]
AGE = acute gastroenteritis

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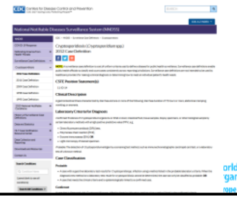
Case definitions

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



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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.

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Define what to collect & how often

- Notifiable disease & laboratory confirmed cases – case based
- Syndromic surveillance –case based or aggregated data

Only collect as much data as you need to

All data must have a specific purpose & help to fulfil a specific surveillance objective

- Frequency of data reporting – depends on purpose of the data
  - Data for outbreak detection → report immediately
  - Data to monitor trends → ongoing reporting e.g. weekly
  - Data for burden of disease → less frequent e.g. monthly or annually

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Example of what to report & how often

Surveillance outcome	Type of data	Suggested core data set	Example reporting frequency
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

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Example of what to report & 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

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Strengths & limitations of the system

- Who is not covered by the system & 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 & duplication of efforts?

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Case study 1 continued

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

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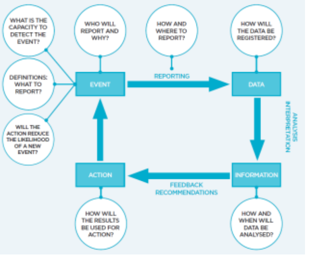
Methodology



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

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Surveillance Thresholds

- Used to identify outbreaks & 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*

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Monitoring and Evaluation

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

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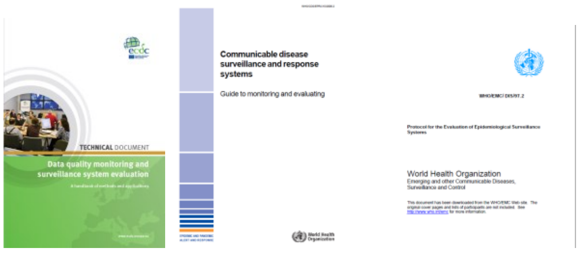
Monitoring and Evaluation Resources



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Enabling factors I

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

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Enabling factors II

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

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Case study 1 continued

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Analysis, interpretation, reporting & use of data

Module 1.4

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Overview

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

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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 & maps

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Target analyses to address surveillance objectives & 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

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Calculating an incidence or notification rate

Notification rate per 100,000 persons = Number of cases (notifications) X 100,000 / Total population

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*

87

Calculating an incidence or notification rate

Notification rate per 100,000 persons = Number of cases (notifications) X 100,000 / Total population

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***

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Analysis by time – monitoring trends

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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

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Alert thresholds & 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 & 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

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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

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Calculating a – 5 year weekly moving average

5-year moving average of weekly cases =
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*

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Calculating a – 5 year weekly moving average

5-year moving average of weekly cases =
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***

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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?*

Source: HSE Health Protection Surveillance Centre. Cryptosporidiosis in Ireland, 2018. Dublin: HSE HPSC; 2019

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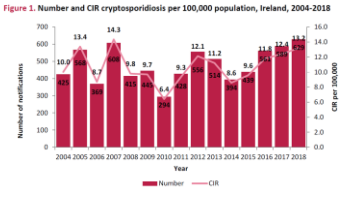
Number of cases and crude incidence rate (CIR) over time

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



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

Source: HSE Health Protection Surveillance Centre. Cryptosporidiosis in Ireland, 2018. Dublin: HSE HPSC; 2019

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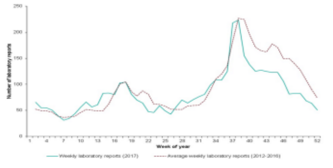
Weekly notifications (or incidence) compared to average notifications (or incidence) for the previous 5 years

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.



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

Source: Public Health England

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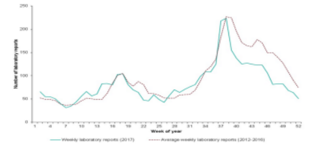

Interpretation: The temporal distribution of Cryptosporidium in 2017 is similar to the previous 5 years, with cases peaking at a similar time. The overall number of cases for 2017 appears to be lower than the average for the previous 5 years.

Source: Public Health England

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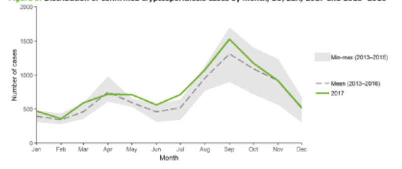
Monthly notifications compared to mean, minimum and maximum notifications for the previous 5 years

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?*

Source: ECDC. Annual epidemiological report for 2017. Stockholm: ECDC; 2019.

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

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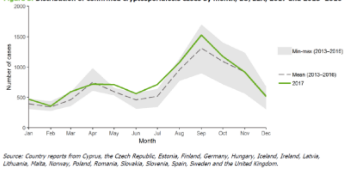

Source: Country reports from Cyprus, the Czech Republic, Estonia, Finland, Germany, Hungary, Iceland, Ireland, Latvia, Lithuania, Malta, Norway, Poland, Romania, Slovakia, Slovenia, Spain, Sweden and the United Kingdom.

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.

Source: ECDC. Annual epidemiological report for 2017. Stockholm: ECDC; 2019.

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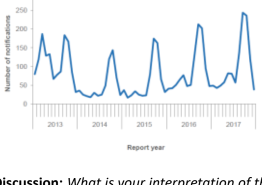
Monthly notifications over time

Figure 6. Cryptosporidiosis notifications by month, January 2013–December 2017



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

Source: The Institute of Environmental Science and Research Ltd. Notifiable Diseases in New Zealand: Annual Report 2017

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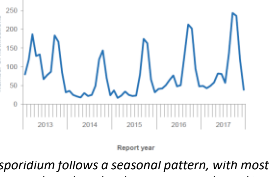
Monthly notifications over time

Figure 6. Cryptosporidiosis notifications by month, January 2013–December 2017



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.

Source: The Institute of Environmental Science and Research Ltd. Notifiable Diseases in New Zealand: Annual Report 2017

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Analysis by place

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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

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Simple tables of cases & 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 & notification rates by region
- **Discussion**: *What is your interpretation of this table?*

Source: Public Health England

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Simple tables of cases & rates

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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

Source: Public Health England

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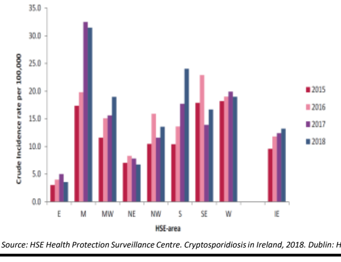
Graph of rates by place over time

Figure 3. Regional crude incidence rates (CIR) cryptosporidiosis, Ireland, 2015-2018



Discussion:

What is your interpretation of this graph?

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

Source: HSE Health Protection Surveillance Centre. Cryptosporidiosis in Ireland, 2018. Dublin: HSE HPSC; 2019

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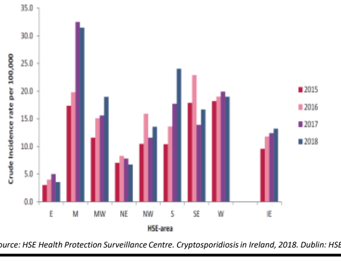
Graph of rates by place over time

Figure 3. Regional crude incidence rates (CIR) cryptosporidiosis, Ireland, 2015-2018



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

Source: HSE Health Protection Surveillance Centre. Cryptosporidiosis in Ireland, 2018. Dublin: HSE HPSC; 2019

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Maps of cases & rates

Figure 7. Cryptosporidiosis notifications by DHB, 2017

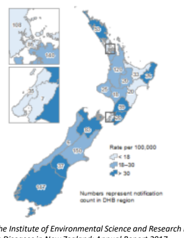
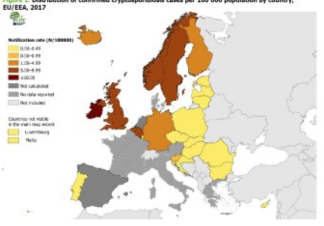


Figure 1. Distribution of confirmed cryptosporidiosis cases per 100 000 population by country, EU/EEA, 2017



Source: The Institute of Environmental Science and Research Ltd. Notifiable Diseases in New Zealand: Annual Report 2017

Source: ECDC. Annual epidemiological report for 2017. Stockholm: ECDC; 2019.

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Analysis by person

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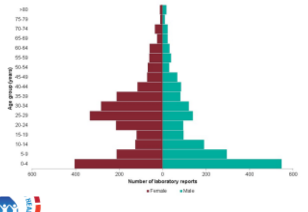
Analysis by age and sex – number of notifications

Figure 2: Age and sex distribution of laboratory reports of Cryptosporidium spp reported in England and Wales: 2017[1].



Discussion:

What is your interpretation of this graph?

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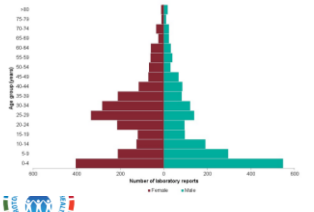
Analysis by age and sex - interpretation

Figure 2: Age and sex distribution of laboratory reports of Cryptosporidium spp reported in England and Wales: 2017[1].



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?

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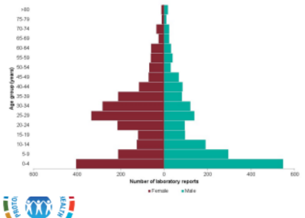
Analysis by age and sex - explanation

Figure 2: Age and sex distribution of laboratory reports of Cryptosporidium spp reported in England and Wales: 2017[1].



Young children:

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

Women aged 20-40:

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

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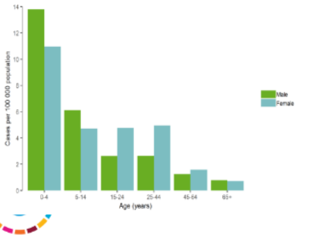
Analysis by age and sex

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?

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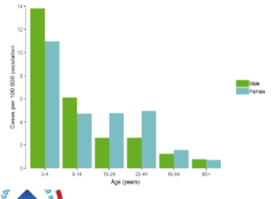
Analysis by age and sex

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 & sex group

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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?*

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Other types of analyses

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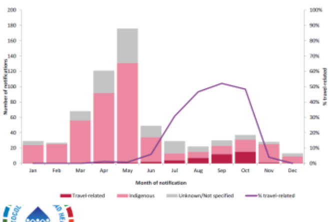
Analysis by person & time –risk factors for infection

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?

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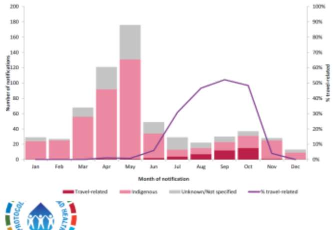
Analysis by person & time –risk factors for infection

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



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 & farm exposures) & domestic notifications

Lambing & calving in spring

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

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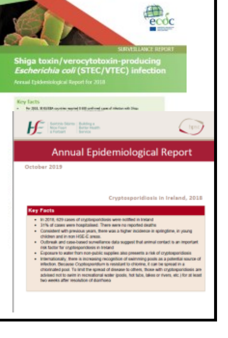
Surveillance Bulletins

- 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)



120

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

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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)

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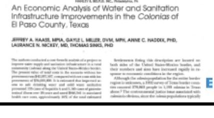
Using surveillance data for advocacy

- Inform development of policy, regulations and guidelines
- Identify priorities & 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) & indirect costs (work absenteeism & productivity losses)
- Evaluate impact of control measures
  - impact on incidence after the introduction of the control measure
  - cost benefit analyses


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

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Principles and steps of an outbreak investigation

Module 2.1

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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

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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

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(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 consultations
- Clustering of cases in a particular water-supply zone

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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

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When to investigate a waterborne outbreak?

✓The outbreak is likely to continue if no ...
✓Unknown source
✓Unknown cause
✓Severe ...

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

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Outbreak investigation objectives

✓Confirm the outbreak
✓Identify the source and contributing factors
✓Implement control measures

→ ***In order prevent further cases***

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Outbreak investigation steps

- Differ from outbreak to outbreak
- Simultaneous and in parallel
- Control measures as early as possible
- Communication on an ongoing basis

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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

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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

Other signals

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

Water quality

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

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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?

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Step 1. Detect and confirm the outbreak and agent

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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

- ✓ *Not wait lab results to start the investigation*
- ✓ *Confirm a proportion of cases.*

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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 iceberg*”)
- Longer delay→ lower probability of detecting the agent in water
- Relevant water samples may no longer be available

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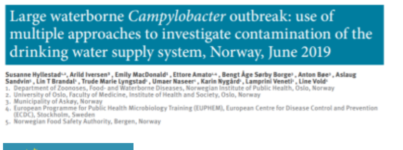
Country example



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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 **hospitalised** with fever, abdominal pain and diarrhoea, 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.

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Outbreak context

- Island municipality Askøy, Norway
- 29,500 inhabitants

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Outbreak context

- Three different water supply systems in Askøy: A,B,C
- Water Supply System A (WSSA) 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

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

Immediate precautionary control measures

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

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Step 2. Form the Rapid Response Team

Outbreak confirmed
↓
Investigation needed
↓
Form the Rapid Response team

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Step 2. Form the rapid response team

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!!

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Step 2. Form the rapid response team

Coordinating activities across agencies can be difficult

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

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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

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Step 3: Define cases

Case definition components
- Time
- Place
- Person

Case Classification
- Possible
- Probable
- Confirmed

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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?)."

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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

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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

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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

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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	….	….	….	….	….	….	….	….

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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?

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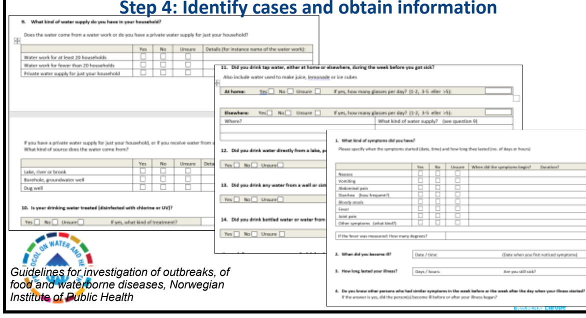
Step 4: Identify cases and obtain information



Guidelines for investigation of outbreaks, of food and waterborne diseases, Norwegian Institute of Public Health

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Step 4: Identify cases and obtain information

Questionnaires distribution

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

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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?

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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.**

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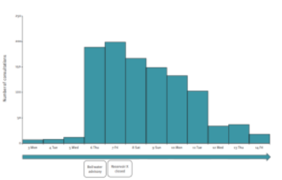
Step 3: Define cases
Step 4: Identify cases and obtain information
Step 5: Descriptive epidemiological investigation

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



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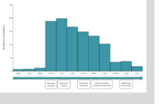
Step 3: Define cases
Step 4: Identify cases and obtain information
Step 5: Descriptive epidemiological investigation

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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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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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.

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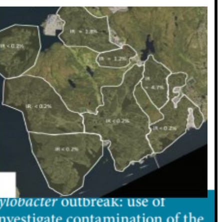

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Step 3: Define cases
Step 4: Identify cases and obtain information
Step 5: Descriptive epidemiological investigation

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.

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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.**

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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**

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Step 6: Additional studies
Environmental investigation

1) Description of the water supply system
- Water source
- Abstraction points and distribution network
- Treatment processess
- Storage tanks
- Distribuition network
- Location of potential contamination sources

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Step 6: Additional studies

Environmental investigation

2) Rapid system assessment→ Hazarous 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 collecton, transport and handling
- Map potential exposures of interest

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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

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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 distribution system
  - Stored water

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Step 6: Additional studies

Laboratory investigation of the water-supply system

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

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

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Step 6: Additional studies (environmental, laboratory)

Environmental 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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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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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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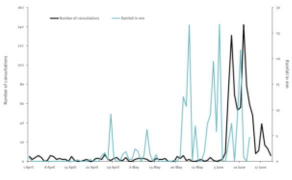

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Step 6: Additional studies (environmental, laboratory)

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 transmisión
- Previous outbreaks

Environment
- Risk assessments
- Inspections

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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

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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.

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Step 8: Analytical studies- Considerations

Everyone is exposed to the same water source?

Measure Dose response
Risk increases with increasing amounts of water

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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

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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 1 and 19 June 2019.

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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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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

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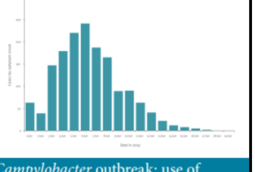
Step 8:
Evaluate the hypotheses
Analytical studies
Assessing the strength of evidence

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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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)

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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)

Eurosurveillance

Large waterborne *Campylobacter* outbreak: use of multiple approaches to investigate contamination of the drinking water supply system, Norway, June 2019

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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

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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

Eurosurveillance

Large waterborne *Campylobacter* outbreak: use of multiple approaches to investigate contamination of the drinking water supply system, Norway, June 2019

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Final 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.

Eurosurveillance

Large waterborne *Campylobacter* outbreak: use of multiple approaches to investigate contamination of the drinking water supply system, Norway, June 2019

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Final 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.

Eurosurveillance

Large waterborne *Campylobacter* outbreak: use of multiple approaches to investigate contamination of the drinking water supply system, Norway, June 2019

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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

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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

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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

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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

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Epidemiological studies

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

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Descriptive analysis

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

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

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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

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Descriptive analysis

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

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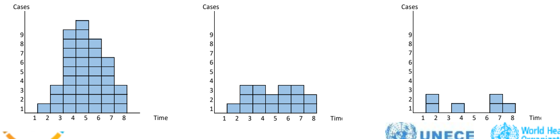
Time- when?

The epidemic curve indicates

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

2) Mode of transmission



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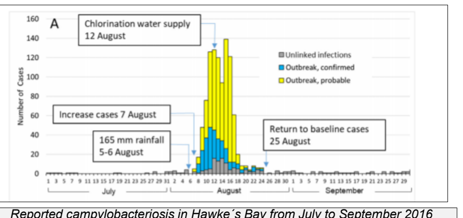
Time- when?



Reported campylobacteriosis in Hawke´s Bay from July to September 2016 graphed according to onset of symptoms.
Confirmed, probable and unlinked reported campylobacteriosis cases

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

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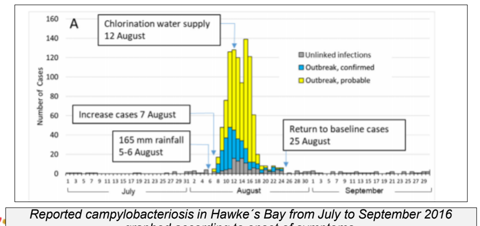
Time- when?



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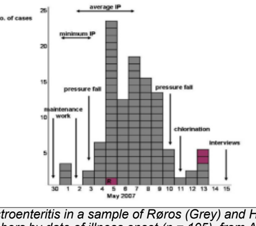
Time- when?



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. A large waterborne outbreak of campylobacteriosis in Norway: The need to focus on distribution system safety. BMC Infectious Diseases 2008, 8:128 doi:10.1186/1471-

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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

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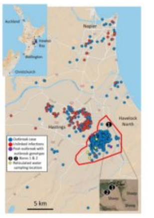
Place- where?



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

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

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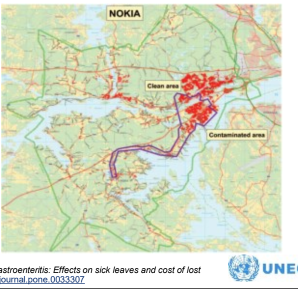
Place- where?



J Hanolen, et al. Waterborne Outbreak of Gastroenteritis: Effects on sick leaves and cost of lost workdays. Plos One https://doi.org/10.1371/journal.pone.0033307

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Person- who?

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

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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.

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

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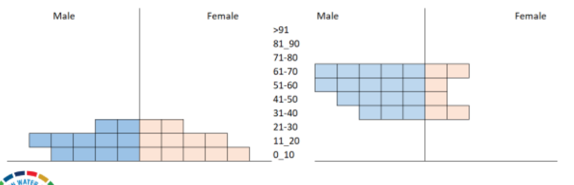
Person- who?



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Descriptive análisis, in conclusion

The W's of descriptive epidemiology:

- **What** →health issue of concern
- **Who** →person
- **Where** →place
- **When** →time

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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

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Water supply zones of a water supply system 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, The three zones with incidence rate > 1 are the ones served by Reservoir X

Hyllestad Susanne, et all 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

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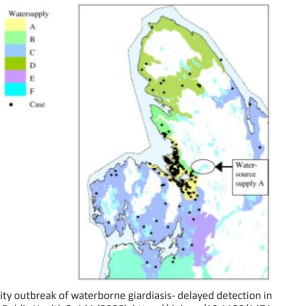

Nygård, K. *et al.* A large community outbreak of waterborne giardiasis- delayed detection in a non-endemic urban area. *BMC Public Health* **6,** 141 (2006). https://doi.org/10.1186/1471-2458-6-141

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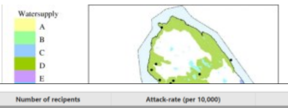

Watersupply	Cases	Number of recipents	Attack-rate (per 10,000)		
A	637	42,774	148.9		
B	15	9,685	15.5		
C	89	105,440	8.4		
D	33	34,406	9.6		
E	4	14,266	2.8		
F	13	23,848	5.5		
				Risk ratio	95% confidence interval
B+C+D+E+F	158	194,519	8.1	Ref.	
A	637	42,774	148.9	18.3	15.4 – 21.8

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

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John Snow and Cholera outbreak in London

Source: Field epidemiology manual wiki

Source: CDC

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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.

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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**

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Analytical studies

- **(retrospective) cohort studies**
- **case-control studies**

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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.

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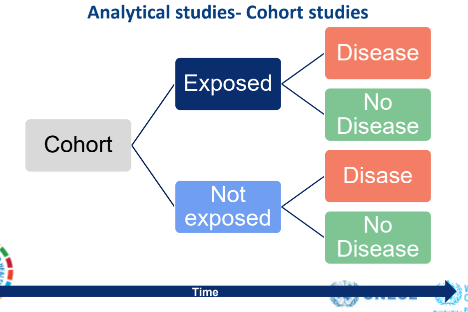
Analytical studies- Cohort studies



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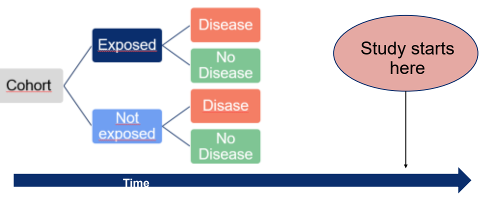
Analytical studies- <u>Retrospective</u> Cohort studies



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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

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Relative Risk- Interpretation

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

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Cohort study- example

Waterborne Outbreak of Norwalk-Like Virus Gastroenteritis at a Tourist Resort, Italy

Delia Boccia,* Alberto Eugenio Tozzi,* Benvon Cotter,*§ Caterina Rizzo,† Teresa Russo,‡ Gabriele Buttinelli,* Alfredo Caprioli,* Maria Luisa Marziano,* and Franco Maria Ruggeri*

EMERGING INFECTIOUS DISEASES

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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

Waterborne Outbreak of Norwalk-Like Virus Gastroenteritis at a Tourist Resort, Italy

EMERGING INFECTIOUS DISEASES

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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.

Waterborne Outbreak of Norwalk-Like Virus Gastroenteritis at a Tourist Resort, Italy

EMERGING INFECTIOUS DISEASES

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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.

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

Waterborne Outbreak of Norwalk-Like Virus Gastroenteritis at a Tourist Resort, Italy

EMERGING INFECTIOUS DISEASES

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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

Waterborne Outbreak of Norwalk-Like Virus Gastroenteritis at a Tourist Resort, Italy

EMERGING INFECTIOUS DISEASES

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Analytical studies

- **(retrospective) cohort studies**

- **<u>case-control studies</u>**

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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"

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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.
- 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.

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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

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Example of control selection

135 cases of *Cryptosporidi*...

- **Where?** City XX (po... ...00)
- **When?** Seco... ...nber 2020-first week October 2020
- **Who?** ...mean age 37 years old. Range: 19-91

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

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Example of control selection

135 cases of *Cryptosporidi*...

- **Where?** City XX (po...0)
- **When?** Seco...ber 2020-first week October 2020
- **Who?** ...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

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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

Source population:

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

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How to select controls

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

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How to select controls

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

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How to select controls

- Friends, family, neighbours
  - Can be efficient.
  - Similar to cases

  - Low cooperation

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How to select controls- Challenges

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

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How to select controls

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

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Analytical studies- Case-control studies
Calculation of OR

		Exposure: consumption of seafood		Total
		Yes	No	
Disease (cholera)	Yes	50[a]	11[b]	61
	No	16[c]	41[d]	57
	Total	66	52	118

Note. OR = (a*d)/(b*c) = (50*41)/(11*16)=11.6.

Funary et al Technical guidance on water related disease surveillance

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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

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Case-Control study example

BMC Public Health BioMed Central

Research article **Open Access**

A large community outbreak of waterborne giardiasis- delayed detection in a non-endemic urban area

Karin Nygård*[1], Barbara Schimmer[1,2], Øystein Søbstad[3], Anna Walde[4], Ingvar Tveit[3], Nina Langeland[5,6], Trygve Hausken[6,7] and Preben Aavitsland[1]

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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

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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.

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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.

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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

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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

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In summary….

Descriptive epidemiology
What is happening?

Ecological epidemiology
Explore associations

Analitical epidemiology
Test hypothesis

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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

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- 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 for the country examples are embedded in the presentation

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Risk communication

Module 2.3

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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

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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

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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)**

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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

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Key elements of risk communication

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

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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

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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

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Key elements- Transparency

It leads to greater trust

- Those responsible for risk communication should:
  - Communication should be frank, easily understood, complete and accurate
  - 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

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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

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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

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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?

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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.

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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

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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)

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