Introduction to water-related infectious diseases

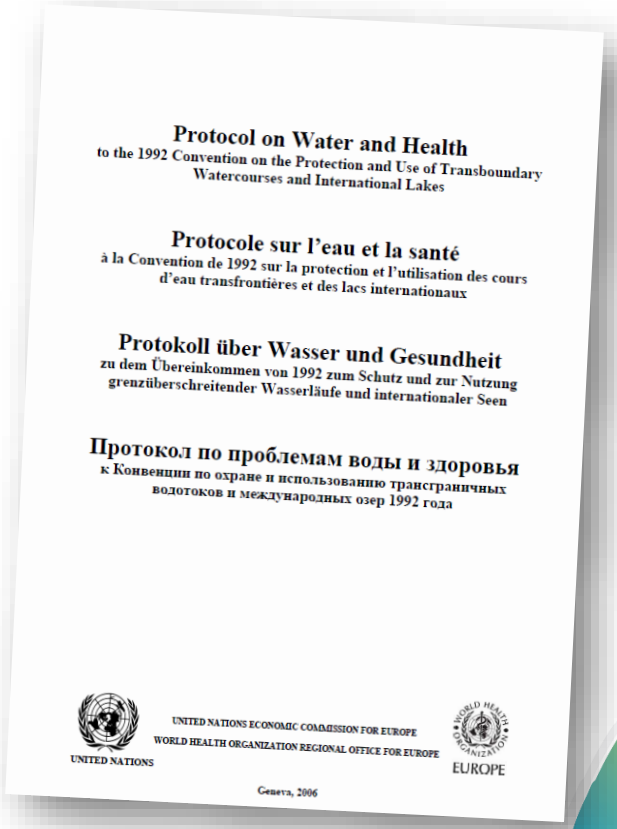
Module 1.1

Overview

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

Protocol on Water and Health

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



IHR Core Capacity Requirements

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

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

2030 Agenda for Sustainable Development

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

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

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

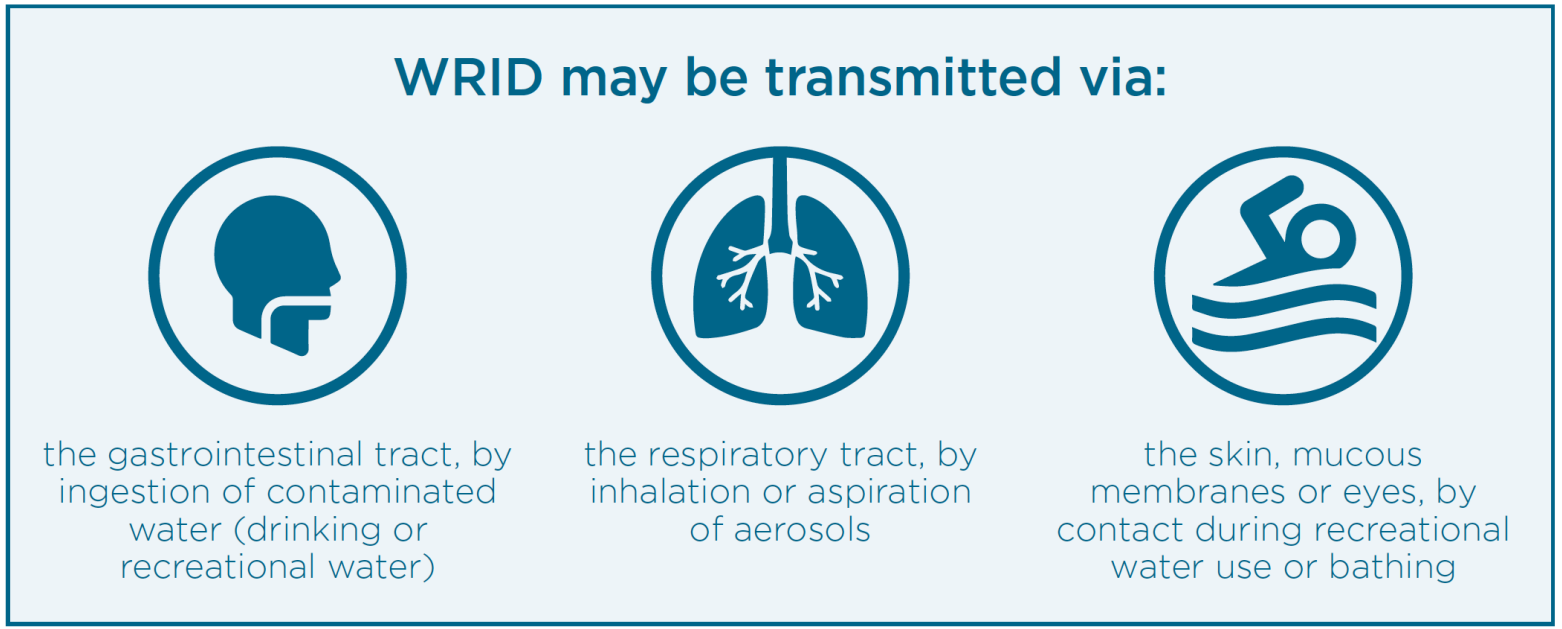
- **Target 6.1:** By 2030, achieve universal and equitable access to **safe** and affordable **drinking-water** for all
- **Target 6.2:** By 2030, achieve access to **adequate and equitable sanitation and hygiene** for all (…), paying special attention to the needs of women and girls (…)

Quiz

How are water-related infectious diseases transmitted?

What are water-related infectious diseases?

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



Classification of WRID

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

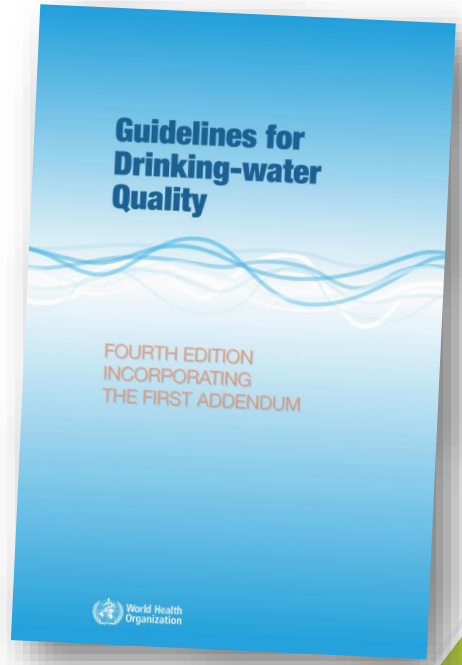
Primary agents of infectious waterborne outbreaks

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

Pathogens transmitted through drinking-water

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

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



Camplyobacter spp

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

Shigella

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

Legionella

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

In rare cases transmitted by aspiration

- Risk management strategies in high-risk settings:
  - Temperature control (in cold water systems <20 ˚C; in hot water systems >55°C)
  - Disinfection
  - Minimise biofilm growth

Hepatitis A virus

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

Hepatitis E

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

Norovirus

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

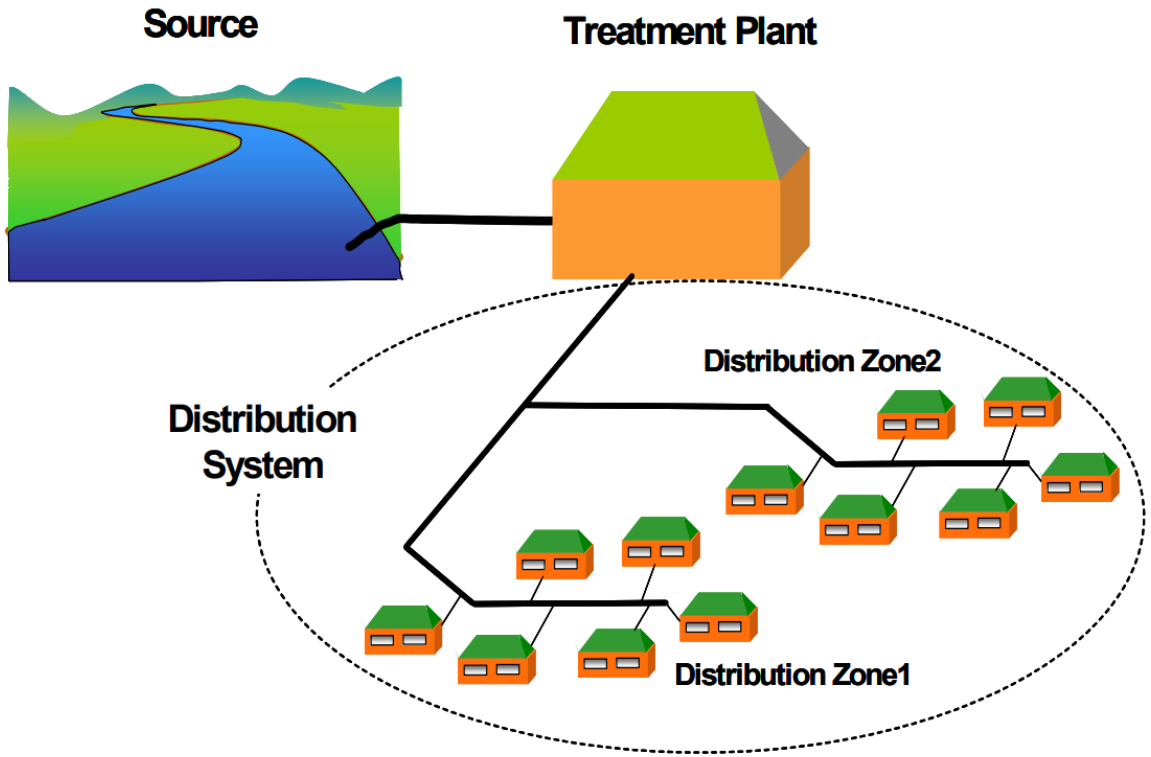
Cryptosporidium

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

Giardia

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

Drinking-water systems as a source of WRID

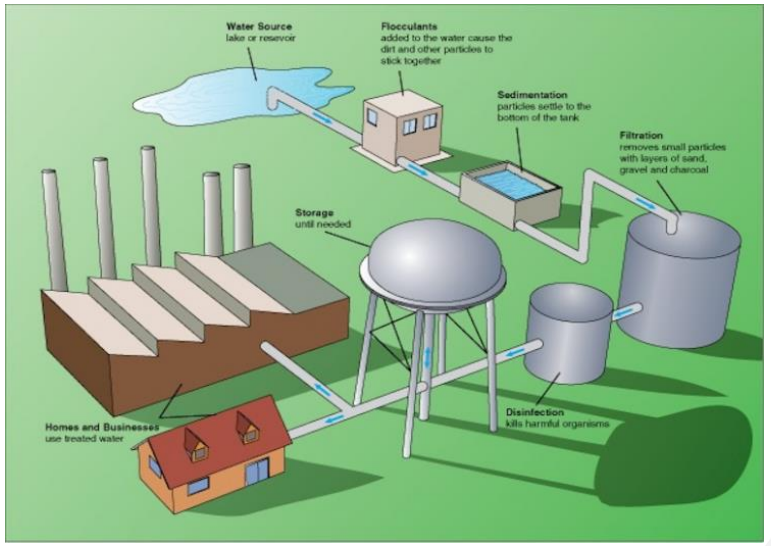


Nokes (2008): A Guide to the Ministry of Health Drinking-water Standards for New Zealand, https://environment.govt.nz/assets/Publications/Files/guide-moh-drinking-water-standards-nz-jun08.pdf

Hazardous events at different points of the water supply system

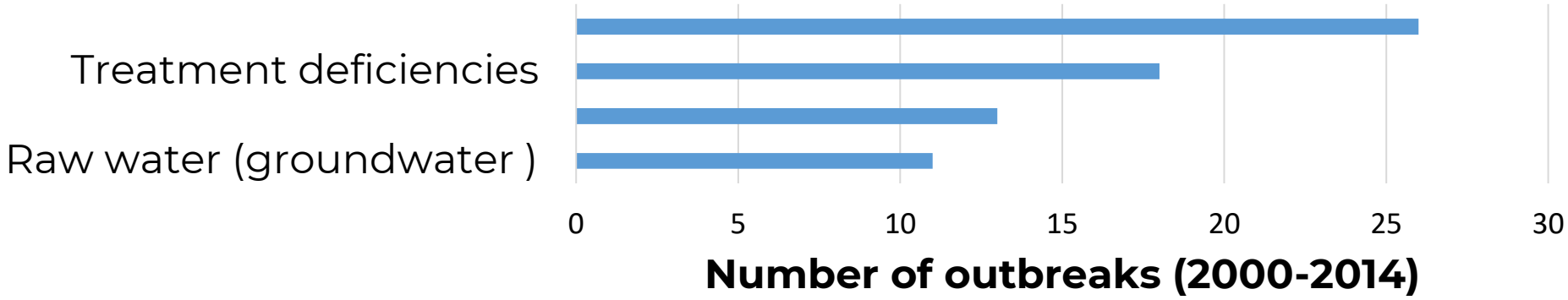
Point of contamination	Examples of hazardous events
Source water (surface or groundwater)	• Runoff of animal and human waste and sewage during wet weather • Leakage of faecal matter from on-site sanitation or damaged sewers
Treatment system	• Inundation of filtration beds with contaminated water during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

The water treatment and distribution process



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

Drinking-water systems as cause of WRID outbreaks



Systematically assess and manage risks to water supply from catchment to consumer

Source/catchment protection

Treatment

Distribution

Consumer

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

Water safety plans

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

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

Burden of WRID in the European Region

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

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

Waterborne outbreaks in Europe, 2000 - 2013

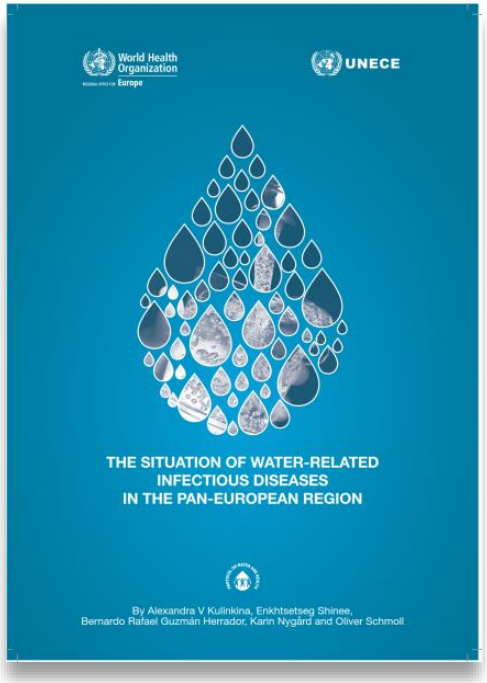


Table 4. Outbreaks attributed to water according to publications in GIDEON (2000–2013)

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

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

Viral gastroenteritis

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

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

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

Norovirus sickens 39 in Spain with link to mussels

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

Burden of mortality

- Burden of disease ≠ burden of mortality
  - *the **burden of disease** caused by pathogens transmitted by the faecal oral route is greatest, BUT*
  - *the **burden of mortality** may be caused by pathogens transmitted by other routes is greatest*

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

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

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

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

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

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

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

Drivers of WRID in the pan-European region

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

Surveillance and outbreak management capacity in the pan-European region

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

Surveillance and outbreak management capacity cont.

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

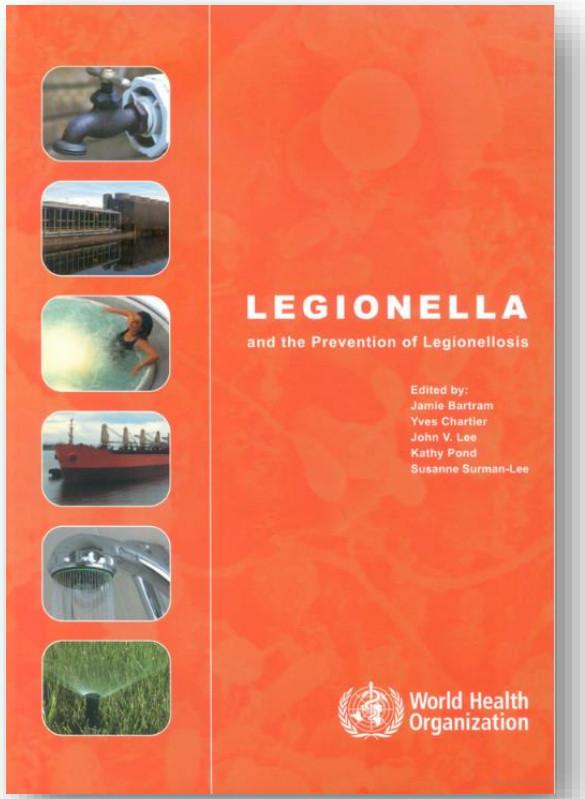
The need to strengthen WRID surveillance and outbreak management capacity

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

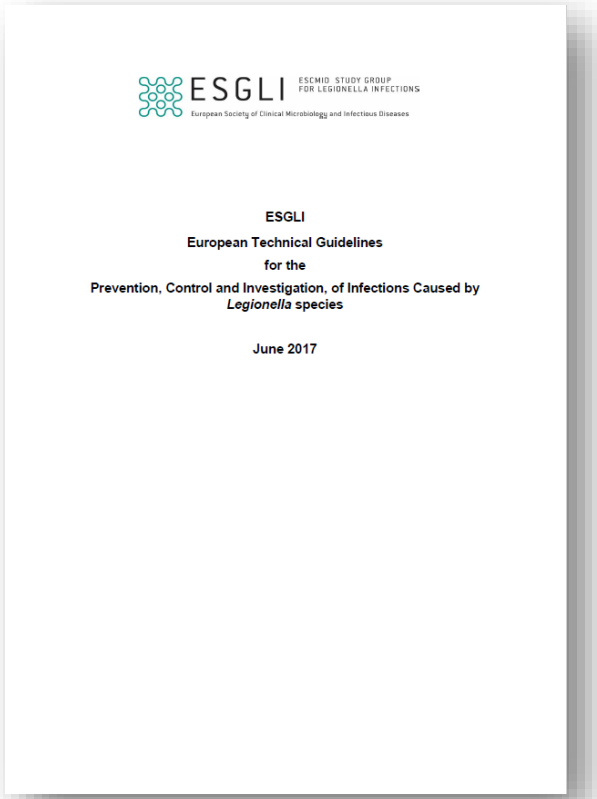
→ *Inform investments in water supply systems*

→ *Inform public health action to control WRID*

Useful references for further reading



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



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

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