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

Eleventh meeting
Geneva, 3 and 4 April 2019
Item 5 of the provisional agenda
Prevention and reduction of water-related diseases

INFORMAL DOCUMENT 3

Technical guidance on the surveillance and management of outbreaks of water-related infectious diseases associated with water supply systems

– Draft manuscript for comment by the Working Group on Water and Health –

Article 8 of the Protocol on Water and Health calls on Parties to establish, improve or maintain comprehensive national and/or local surveillance and early-warning systems, and develop preparedness and contingency plans for responses to outbreaks of water-related diseases.

Prevention and reduction of water-related disease is a priority programme area under the Protocol's 2017-2019 programme of work with aim to strengthen national capacities for surveillance, outbreak investigation and response of water-related diseases. In response to the needs expressed by the Parties and other States repeatedly, lead Parties of programme area 2 and the WHO secretariat have been guiding the development of a technical guidance document on the surveillance and management of outbreaks of water-related infectious diseases associated with water supply systems.

The tenth meeting of the Working Group on Water and Health (Geneva, 15-16 November 2017) reviewed the initial outline of the document and entrusted the lead Parties and WHO secretariat to further develop the practical guidance document. An expert group meeting (Oslo, 11-12 March 2019) reviewed the draft document and provided conceptual inputs and suggestions on the structure, scope and technical content of the document.

The Working Group on Water and Health is requested to review the draft document, provide feedback on its technical content and endorse its submission to the fifth session of the Meeting of the Parties for adoption.

Please submit comments and feedback to Enkhtsetseg Shinee (enkhtsetsegs@who.int) by **26 April 2019**.

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

Technical guidance on water-related infectious disease surveillance and outbreak management associated with drinking-water systems

Contents

List of tables

List of figures

Abbreviations

AGI	Acute gastrointestinal illness
AR	Attack rate
BOD	Biological oxygen demand
CERC	Crisis and emergency risk communication
COD	Chemical oxygen demand
DALY	Disability adjusted life year
ECDC	European Centre for Disease Prevention and Control
EHEC	Enterohemorrhagic E. Coli
EPA	Environmental Protection Agency
EWGLI	European Working Group on Legionella Infection
FWD	Food and waterborne diseases
GIS	Geographic information systems
HPC	Heterotrophic plate counts
IHR	International Health Regulations
IT	Information Technology
LP1	*Legionella pneumophila* group 1
OR	Odds ratio
OMT	Outbreak management team
PCR	Polymerase chain reaction
RR	Relative risk or risk ratio
M&E	Monitoring and evaluation
MOH	Ministry of Health
NPHA	National public health agency
NTU	Nephelometric turbidity unit
95%CI	Ninety five percent confidence interval
SDG	Sustainable development goal
TOC	Total organic count
TOR	Terms of reference
UNECE	United Nations Economic Commission for Europe
US CDC	United States Centers for Disease Control and Prevention
WHO	World Health Organization
WRD	Water related disease
WRID	Water related infectious disease
WSP	Water safety plan

Preface

This document contains guidance on how to conduct surveillance and manage outbreaks of water related infectious diseases. It addresses specific requirements outlined in the Protocol on Water and Health to the 1992 Convention on the Protection and Use of Transboundary Watercourses and International Lakes.

The Protocol aims to protect human health by improving water management, and by preventing, controlling and reducing water-related diseases. Specifically, Article 8 of the Protocol calls on parties to strengthen capacity for surveillance and outbreak management by ensuring that:

"*(a) Comprehensive national and/or local surveillance and early-warning systems are established, improved or maintained which will:*
(i) Identify outbreaks or incidents of water related disease or significant threats of such outbreaks or incidents, including those resulting from water pollution incidents or extreme weather events;
(ii) Give prompt and clear notification to the relevant public authorities about such outbreaks, incidents or threats;
(iii) In the event of any imminent threat to public health from water-related disease, 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;
(iv) Make recommendations to the relevant public authorities and, where appropriate, to the public about preventive and remedial actions;

(b) Comprehensive national and local contingency plans for responses to such outbreaks, incidents and risks are properly prepared in due time;

(c) The relevant public authorities have the necessary capacity to respond to such outbreaks, incidents or risks in accordance with the relevant contingency plan."

In addition, Article 13 of the Protocol requires that Parties that border the same transboundary waters cooperate and assist each other to prevent, control and reduce transboundary effects of water related disease, in particular by:

- Exchanging information and knowledge about problems and risks
- Establishing with other bordering Parties joint and coordinated water management plans and surveillance and early-warning systems and contingency plans, in accordance with Article 8, paragraph 1, to enable the response to outbreaks, incidents and threats
- Consulting with each other regarding the adverse human health effects due to water-related disease

This document will support the implementation of the Protocol by providing Parties with specific guidance on how to monitor, detect and manage outbreaks of water related infectious disease.

By strengthening Parties capacity for water-related infectious disease surveillance and outbreak management, this document will also serve to support the implementation of the

2005 International Health Regulations (IHR). The IHR requires countries to strengthen their capacity to detect, assess and respond to public health events by developing their core capacities for surveillance and outbreak response.

The Protocol has been recognized as a key instrument to support countries in implementing global and regional goals and commitments, in particular the 2030 Sustainable Development Agenda, the European Framework for Health 2020 and the Ostrava Declaration on Environment and Health. In particular, it will provide a framework to support the achievement of Sustainable Development Goal (SDG) target 3.3 (to combat waterborne diseases), target 3.9 (to substantially reduce the number of deaths and illnesses from water contamination), and Goal 6 (to ensure access to safe water and sanitation for all).

This is especially important given that in the WHO European Region an estimated 14 people die each day due to diarrhoea associated with poor water, sanitation and hygiene and that 18% of the investigated outbreaks in the region are linked to water.

The surveillance and management of outbreaks of water related infectious diseases involves a number of particular activities and techniques which are under-addressed in international guidance documents for surveillance and outbreak management. This document aims to address these gaps by providing technical guidance on how to incorporate these activities and techniques into the surveillance and management of outbreaks of water related infectious diseases.

1.0. Background

Despite increased access to improved water supplies, water related infectious diseases continue to pose a threat to public health in the pan-European region.

Water related infectious diseases (WRID) exert a considerable burden of morbidity and mortality in the pan-European region. Although the true burden of disease is unknown, the World Health Organization (WHO) estimates that 14 people die daily due to diarrhoea caused by inadequate water, sanitation and hygiene[1]. Up to 30 million cases of WRID could be prevented in the region each year through improved water and sanitation[2]. The burden of disease is concentrated in Eastern Europe and Central Asia and there are substantive disparities between countries, socioeconomic groups and rural and urban populations[1]. Public health action, such as efforts to improve, secure and maintain water systems and to control WRID is urgently needed to reduce the burden and public health impact of WRID.

Between 2006 and 2013, camplyobacteriosis, giardiasis, hepatitis and shigellosis were the most common gastrointestinal infectious diseases reported to regional surveillance systems with over 100 000 cases each. However, the number of cases that were water-related was not documented. Other commonly reported diseases that could be water-related were yersiniosis, cryptosporidiosis, legionellosis and *Escherichia coli* (*E. coli*) related disease. Furthermore, an estimated 18% of investigated outbreaks in the region during that time-period were associated with water[3]. The highest proportion of outbreaks linked to contaminated water were those associated with leptospirosis, cryptosporidiosis, giardiasis and legionellosis. Many of these outbreaks are linked to water supply systems.

A number of water-related pathogens such as *Cryptosporidium parvum, Legionella pneumophila* and *Vibrio cholerae 0139A* have emerged or re-emerged in recent years. Climate change and international travel are driving the dissemination of water-related pathogens such as *Giardia lamlia* into new geographic areas. Pathogens which were once only travel associated in certain areas are now becoming endemic. Increased demand for water is putting pressure on water systems. Many communities, especially in rural areas rely on community water supplies, based on untreated groundwater, as their source of drinking water. There may be insufficient quality control of these community systems and they may be vulnerable to environmental contamination from livestock and agricultural practices. Changes in how water is used in industrial, commercial and domestic settings, for instance in cooling towers, air conditioning and spas, is increasing the modes and opportunities for transmission of water-related pathogens. The increasing age of the population, and the increasing number of persons with reduced immunocompetence is increasing the susceptibility of populations to severe sequelae of infection[4,5].

1.1. Why strengthened surveillance and outbreak management capacity is needed

Suboptimal capacity for WRID surveillance and outbreak management hinders identifying the true burden of disease

It is recognised that current capacity for surveillance and outbreak management in the pan-European region is insufficient to control WRID[6]. There is likely to be substantive under-reporting of cases and under-detection or delayed detection of WRID outbreaks. There is wide variation in surveillance practices across the region. The sensitivity of surveillance systems is reportedly low, and varies widely between countries.

Many countries rely on routine passive surveillance which is based on the surveillance of a limited number of pathogens and which will only detect a fraction of cases. Mild or asymptomatic cases where health care is not sought will not be detected. Among those who do seek care, specimens may not be taken for laboratory testing, or the laboratory may not routinely test for the pathogen causing the disease. Cases may be sporadic and so it may be difficult to recognise that an outbreak is occurring. The number of diseases and events that are covered by national notifiable disease surveillance systems varies widely, and standard thresholds and definitions for event-based outbreak detection are lacking[3,7]. Surveillance systems may not contain a mechanism for reporting all water-related conditions[3], and there is variation in sampling and laboratory protocols and in reporting practices[8]. These factors will influence the sensitivity of the system and the timeliness of reporting. A more uniform approach to case detection and diagnosis, and to surveillance practices across the region has been recommended[7].

As surveillance practices vary across the region, systematic, accurate and comparable information between countries is lacking, and the true burden of WRID is unknown[3,6]. An insufficiency of laboratory and epidemiological capacity, and human and financial resources may limit country capacity to detect cases and outbreaks[3], and to investigate outbreaks. Communication and coordination between public health agencies and environment agencies who are responsible for monitoring water quality is frequently inadequate. In many countries there is insufficient capacity for early-warning and response and for event detection.

Without accurate data on the burden of disease, the need for investment to maintain and sustainably manage water systems, and the need for public health action to control WRID is likely to be underestimated.

Water-related pathogens can cause explosive outbreaks affecting tens and hundreds of thousands of persons[9,10]. This is most notable for waterborne pathogens contaminating public water supplies, where large populations are exposed in a short-period of time. Such outbreaks have substantive health, social, economic and political consequences.

Data on the number of cases and outbreaks of WRID may reflect the ability of a surveillance system to detect these outcomes, rather than the actual number of outbreaks or cases[3]. In some European countries, the surveillance systems are considered incapable of detecting waterborne disease. The source of infection in many outbreaks is not determined[4]. There is lesser capacity for detecting outbreaks associated with smaller community water supplies, and those associated with emerging WRID[6] and so the pathogens and burden of disease associated with these sources is not known.

In recognition of the challenges associated with WRID surveillance and outbreak detection, the Protocol on Water and Health to the 1992 Convention on the Protection and Use of Transboundary Watercourses and International Lakes[11], hereafter known as the Protocol, requires Parties to the Protocol (hereafter known as Parties) to strengthen capacity for surveillance and outbreak management. It also requires Parties to cooperate to prevent, control and reduce the transboundary effects of WRID. Strengthening of WRID surveillance and outbreak detection will also address the wider global health security agenda and the requirements of the International Health Regulations (IHR) 2005[12]. The IHR aims to prevent and control against the international spread of disease by strengthening countries core capacities for disease surveillance, outbreak management and emergency response.

Ensuring strong intersectoral collaboration is critical to optimising WRID surveillance and outbreak response

The control of WRID through surveillance and outbreak management is a multidisciplinary task which requires the participation of a number of different stakeholders including national public health agencies, environmental agencies, municipal authorities, water operators, health care providers, public health, diagnostic and private laboratories, food safety authorities, the media and the general public.

Promoting effective coordination and collaboration, particularly between public health agencies, water providers, environment agencies, municipal authorities and laboratories is critical to strengthening WRID surveillance and outbreak response.

1.2. What is water-related disease?

The Protocol defines water-related disease (WRD) as, "any significant adverse effects on human health, such as death, disability, illness or disorders, caused directly or indirectly by the condition, or changes in the quantity or quality, of any waters". WRD can be caused by exposure to microorganisms (bacteria, viruses, protozoa, helminths and cyanobacteria) or chemicals in water. These exposures may occur either through exposure to contaminated water through ingestion, inhalation or contact with the water, or due to hygiene related behaviours associated with a lack of access to clean water or poor hygiene practices[13].

Infectious diseases are classified as water-related based on their transmission route. WRID may be transmitted via

1. the gastrointestinal tract by ingestion of contaminated water (drinking or recreational water)
2. the respiratory tract by inhalation or aspiration of aerosols
3. the skin, mucous membranes or eyes, by contact during recreational water use or bathing

Indirect exposure may occur through consumption of contaminated food, particularly food which has been cultivated, processed or produced using contaminated drinking water, where there has been cross-contamination during food preparation or where there has been insufficient access to safe water to ensure personal and food hygiene.

A number of classification systems have been developed for WRID, including those proposed by Bradley et al[14,15] and Cotruvo et al[4]. These classification systems are further described in Annex 1. Most recently Yang et al, 2012[16] described a general framework for the classification of WRID which included six categories:

Table 1: Classification of water related infectious diseases (adapted from Yang et al, 2012[16])

Category	Description	Example diseases
Waterborne	Caused by enteric microorganisms, which enter water sources through faecal contamination and cause infections in humans through ingestion of contaminated water	Typhoid, cholera
Water carried (a subset of waterborne)	Transmission can be through accidental ingestion of, or exposure to, contaminated water	*Cryptosporidium, Giardia*
Water-based	Diseases caused by infections of worms which must spend parts of their life cycles in the aquatic environment	Schistosomiasis
Water-related	Need water for breeding of insect vectors to fulfil the transmission cycle	Malaria, trypanosomiasis
Water-washed	Transmission is due to poor personal and/or domestic hygiene as a result of lack of appropriate water	*Shigella*
Water-dispersed	Infections of agents which proliferate in fresh water and enter the human body through the respiratory tract	*Legionella*

The most frequently reported WRID in the pan-European region are those belonging to the waterborne, water-carried and water-dispersed categories (**Table 2**). Many of these organisms are transmitted through water-supply systems.

Table 2: Frequently reported WRID† in the pan-European region (adapted from Kulinkina et, al[3])

Sub-region	Case-counts*	Outbreaks¥
Southern	Amoebiasis, Camplyobacteriosis Giardiasis, Hepatitis A, Legionellosis	Gastroenteritis – viral, Hepatitis A Legionellosis, Tularaemia
Northern	Camplyobacteriosis, Cryptosporidiosis Giardiasis, Shigellosis	Cryptosporidiosis, *E. coli* diarrhoea Gastroenteritis – viral, Hepatitis A
Western	Camplyobacteriosis, *E. coli* diarrhoea Giardiasis, Yersiniosis	*E. coli* diarrhoea, Gastroenteritis – viral, Hepatitis A, Legionellosis
Eastern	Camplyobacteriosis, Giardiasis Hepatitis A, Shigellosis	Hepatitis A, Rotavirus, Shigellosis Yersiniosis
Central Asia	*E. coli* diarrhoea, Hepatitis A Shigellosis	Hepatitis A, Leishmaniasis – cutaneous, Typhoid Fever
Caucuses	*E. coli* diarrhoea, Hepatitis A Shigellosis	Tularaemia, Typhoid fever

†*In alphabetical order*
**As reported to the Centralised Information System for Infectious Diseases and The European Surveillance System*
¥ *As reported to the Global Infectious Disease and Epidemiology Online Network*

1.3: Common challenges in the surveillance of WRID

The surveillance of WRID is subject to a number of challenges[3,17,18] including:

1. Determining that a case is water-related

Many surveillance systems focus on the surveillance of enteric pathogens or syndromes such as acute gastrointestinal illness (AGI). Frequently it is not possible to characterise these cases as water-related as there is insufficient or no data on the source of infection. In addition to this, it can be difficult to distinguish between cases of foodborne and waterborne disease. Frequently food may be the vehicle of infection for a disease that is in fact water-related. For instance, if food is prepared using contaminated water, then it will appear as if the food is the source of infection, whereas in reality it is the water which is the source. In order to prevent cases of disease, the safety of the water must be secured. The safety of the food will be secured if the safety of the water is secured.

2. Monitoring small private water supplies

In many countries, a substantive proportion of the population obtain their water from small private water supplies. Monitoring of the safety of water from these supplies is infrequent and not routine. These supplies are not really covered by routine surveillance systems. Cases associated with these water supplies may be less likely to be detected by surveillance, and so the burden of water-related disease associated with private water-supplies may be underestimated or unknown.

3. Limited testing for enteric pathogens

Laboratories may routinely test for only a limited range of enteric pathogens. A special request may need to be made to get the laboratory to test for anything beyond this range. Clinicians may not specify what to test for when sending samples, and if they do specify what to test for, they may also only request testing for a limited number of pathogens. Given this, cases caused by uncommon pathogens or those beyond the routine range of testing may be under-ascertained by surveillance.

4. Delayed detection of cases

As discussed in section 2.0, there may be delayed detection of cases of WRID. This delayed detection may lead to delayed detection of outbreaks of WRID, such that the outbreak only becomes conspicuous when it has already affected a lot of people. Delayed detection of cases and outbreaks may result in bigger outbreaks causing greater public health, economic and social consequences than if cases were detected earlier.

5. Sustainability

Limited human and financial resources, along with high-staff turnover can jeopardise the sustainability of WRID surveillance.

1.4: Water supply systems as a source of water-related infectious disease

Water supply systems are arguably the most important source of WRID in the pan-European region.

These systems include the water source (surface or groundwater) and the water treatment and distribution system. Contamination can occur at any of these stages[14,19,20,21]. Contamination can also occur at the point of use in water systems within buildings, either due to the extension of contamination from the water supply system, or due to contamination events within the building water systems themselves[22]. For the purpose of this document, water supply systems will include both the source, treatment, distribution, and point-of-use systems.

The quality of raw water at the source is influenced by numerous factors including climate (flooding and drought), topography, geology, agricultural practices, surface run-off, wastewater and other point source discharges. Surface waters and shallow aquifers are more susceptible to contamination. Contamination of groundwater can also occur at the point of extraction[20].

Water treatment is a multistage process involving sedimentation, flocculation, filtration and disinfection[14,20]. Contamination during treatment can occur when the treatment process is overwhelmed by high-turbidity in the source water (for instance during flooding) such that enteric organisms can infiltrate the treated water and distribution system, or when suboptimal filtration following filter backwashing allows pathogens to pass into the distribution system[14].

The water distribution system is the system that transports water from the outlet of the primary treatment processes to the point of delivery to customers[21]. It can include many kilometres of distribution pipes, service reservoirs, a water transmission system (if the treatment plant serves several service reservoirs) and standpipes. The distribution system does not include water systems within buildings.

Contamination during the distribution of water can occur due to:

- cross connections between water and wastewater systems
- back-siphonage
- burst or leaking water mains
- contamination during storage
- contamination during repair and upgrading of the system
- pressure fluctuations
- low water pressure
- intermittent water supply
- growth of biofilms

Distribution system failures occasionally cause outbreaks, primarily of waterborne enteric pathogens. It is likely that they also cause sporadic cases of disease which may or may not be detected by surveillance systems, as will be further discussed in section 2.0.

Preventing growth of environmental microorganisms and their biofilms in the distribution pipes and building water systems is an important measure to control water dispersed diseases.

Environmental microorganisms can grow and form biofilms in the pipes of distribution systems, as well as on outlets, mixing valves and on washers[21,23]. Biofilms can harbour water-dispersed pathogens such as *Legionella, Naegleria fowleri and Mycobacterium* species. Once biofilms have developed in a water system, they are extremely difficult to remove. They are resistant to disinfection. Preventing their growth is an important measure to control water-dispersed diseases. Biofilms are more likely to form when there are nutrients present in the source water and in the system, when there is corrosion or scale in the system, when the temperature of the water is warm, and when the flow rates are low or the water is stagnant for instance in dead ends of the system or storage tanks. Biofilms in water distribution systems can inoculate building water systems where they are associated with *Legionella* outbreaks[21,22,23].

Distribution system contamination happens after treatment, consequently pathogens introduced at this stage will flow directly to consumers. The quality of water reaching the consumer will be influenced by[20,21] (Clark 95):

- the quality of the source water,
- the effectiveness of treatment processes and the quality of the treated water,
- the integrity of the water treatment and distribution systems,
- the age, type and design of the distribution system,
- the presence of dead ends in the system,
- water pressure,
- mixing of water from different sources in the distribution system,
- the time it takes to travel from the source to the consumer.

In large urban centres the water supply system can comprise several sources and water treatment plants and distribution systems which may or may not be interconnected.

Building water systems can be contaminated in several ways[22,23]. Inadequate storage tanks and cross-connections with wastewater pipes can lead to faecal contamination of water. Stagnation of water in poorly designed plumbing systems can enable the growth of biofilms which provide a niche for the growth of *Legionella*. Of note, backflow from building water systems into the public distribution system can lead to cross contamination of the drinking water supply outside the building.

Water safety plans (WSPs)[19,24,25] are plans that assess and develop strategies to manage risks to drinking water safety at all steps in the water supply system from catchment to the point of consumption.

WSPs should be prepared and implemented for all water supply systems, and also in some instances for building water systems such as in hospitals or large buildings*[25]*.

1.5: Scope and purpose of the document

As contamination of water supply systems is a frequent source of WRID, this document will address surveillance and outbreak management of WRID associated with water supply systems including the treatment and distribution systems, as well as at the point-of-use. There are particular challenges associated with the surveillance and control of WRID in such systems as this requires the engagement and coordination of a multisectoral response including but not limited to public health, environmental and engineering disciplines. Environmental monitoring and investigation are critical components in surveillance and control, as are techniques such as risk assessment, spatial analyses, and computer modelling. This document builds on existing guidelines for infectious disease surveillance and outbreak response[14,26,27,28,29,30] by providing technical guidance on these specific features, activities and methodologies, and their application within the context of WRID surveillance and outbreak management.

In doing so, this document aims to:
1. support countries to strengthen their capacities for WRID surveillance and outbreak management
2. enhance coordination for transboundary events and multi-country outbreaks
3. promote a harmonised approach in the pan-European Region, in order to increase the comparability of data between countries, and to generate more precise regional estimates on the burden of WRID
4. support countries to meet their requirements under Articles 8 and 13 of the Protocol on Water and Health
5. support countries with their implementation of the IHR and the Sustainable Development Goals

In particular, this document will provide technical guidance on:
1. how to develop and implement a surveillance system for WRID
2. how to investigate, respond to and manage outbreaks of WRID

The surveillance and management of outbreaks of other types of WRID, such as vector-borne WRID and WRID associated with behavioural factors will not be covered in this document, as the approach to their surveillance and control is substantively different to the surveillance and control of WRID associated with water-systems.

Similarly, due to fundamental differences in approach, the surveillance and control of non-communicable water-related diseases such as chemical exposures and accidents is beyond the scope of this document.

1.6: How to use the document

This document will comprise two parts. Part one will provide technical guidance on how to design, implement and operate a WRID surveillance system. Part two will describe how to investigate, respond to and manage an outbreak of WRID, with particular emphasis on the features and techniques of particular relevance to WRID outbreaks.

Part one is targeted towards public health professionals and others involved in WRID surveillance at all levels of the health system, as well as regulators responsible for ensuring the safety of water supply systems.

Part two is targeted towards all those involved in the management of outbreaks of WRID, in particular public health and environmental health professionals, water providers and risk communicators.

This document is supplemented by a number of annexes:
- Annex 1: Classification systems for WRD

- Annex 2: resources related to water systems, surveillance and outbreak management
- Annex 3: Template boil water notice
- Annex 4: *Legionella* resources, including a case study for the investigation of an outbreak of Legionnaires disease.

PART 1: SURVEILLANCE OF WATER-RELATED INFECTIOUS DISEASE

Executive summary

To be added

Part 1: Surveillance of WRID

This section provides practical guidance on how to set up, improve and maintain effective systems for the surveillance of WRID. It explains the key principles of surveillance and the different components that could be included in a surveillance system for WRID. It describes a multisectoral approach to WRID surveillance, and the important role of water quality surveillance data in WRID surveillance.

This section is targeted towards public health professionals and others involved in WRID surveillance at all levels of the health system, as well as regulators responsible for ensuring the safety of water supply systems and the effective surveillance of WRID.

2.0: Overview of WRID surveillance

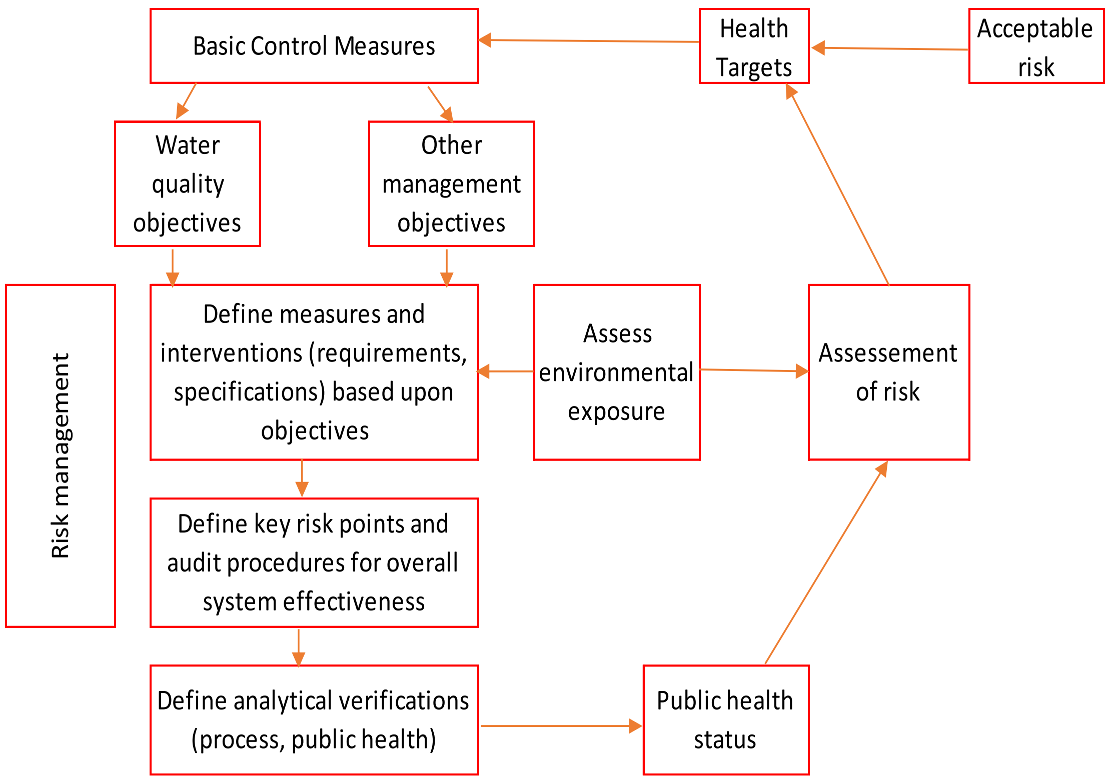
Surveillance is the ongoing systematic collection, analysis and interpretation of health-related data and the timely dissemination of information to those who need to know so that action can be taken REF?.

An important feature of WRID surveillance is that it integrates monitoring of health outcomes with monitoring of environmental outcomes, such as drinking water quality and environmental contaminants.

Water quality data can provide early warning of possible outbreaks and will also trigger a comprehensive risk assessment and risk management response to secure the safety of the water supply in order to prevent human cases of disease.

Controlling microbiological water-related diseases therefore requires an integrated multisectoral approach combining risk assessment, risk reduction and risk management supported by defined (water quality and health) targets[31] (Figure 1).

Figure 1: Framework for the control of water-related infectious diseases



(Source: Bartram et al, 2001[30]).

Disease surveillance includes the following core activities[30]:

- case detection
- case reporting
- investigation and confirmation
- analysis and interpretation
- communication and action: implementation of control procedures, public health response, policy development, feedback to stakeholders

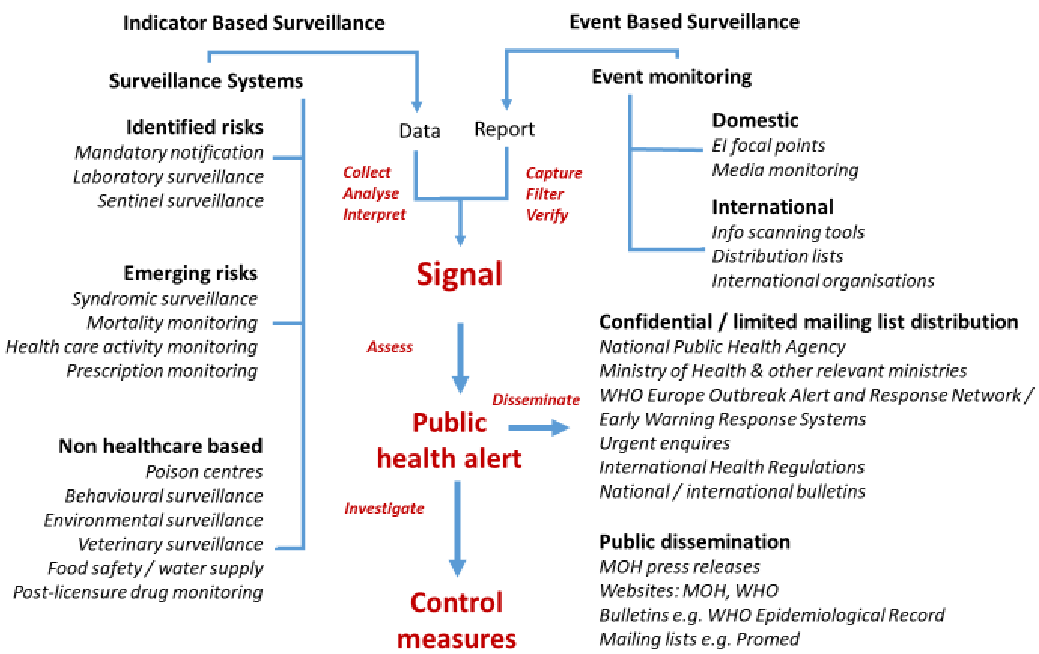
WRID surveillance has a number of objectives including to:

1. identify temporal trends in the incidence and prevalence of WRID
2. detect possible WRID outbreaks
3. identify new, emerging or re-emerging pathogens
4. identify what pathogens are being transmitted by water
5. estimate the burden of WRID
6. identify groups and communities who are at higher risk of WRID
7. target control and prevention measures to specific areas or populations
8. identify areas of the water system to target with resources
9. assess the effectiveness of control measures
10. inform policies and regulations in relation to water quality and WRID

A comprehensive surveillance system for WRID will include both indicator-based and event-based surveillance (Figure 2)[32].

- Indicator based surveillance is the reporting of structured standardised data, such as data on laboratory confirmed infections or the number of cases meeting a syndromic case definition in a week, collected through routine surveillance systems. It can also include surveillance of environmental indicators.
- Event-based surveillance is the collection of unstructured data from any source, for instance media reports of problems with a water supply, or a health facility reporting a surge in the number of persons presenting at the emergency department, or customer complaints to a water company.

Figure 2: The epidemic intelligence framework through which outbreaks are usually detected (*adapted from Pacquet et al, 2006*[¥32] *and Coulombier, 2005*[†]).



¥ Paquet, C., Coulombier, D., Kaiser, R., & Ciotti, M. (2006). Epidemic intelligence: a new framework for strengthening disease surveillance in Europe. Euro Surveillance : Bulletin Européen Sur Les Maladies Transmissibles = European Communicable Disease Bulletin, 11(12), 212–4. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/17370970

† Surveillance, 05.12.05 Epidemic Intelligence - A new paradigm for, & Presentation by Denis Coulombier at the advanced course in epidemiology of infectious diseases (EpiTrain II), E. 2005. (n.d.). No Title.

Examples of types of indicator and event-based surveillance for WRID and their relation to specific surveillance objectives are outlined in Table 3.

A valuable addition to indicator and event-based surveillance systems is ad hoc studies to estimate population-based exposure to WRID, or environmental surveys to characterise the organisms circulating in the environment. Population-based surveys, such as seroprevalence surveys may be used to assess exposure to specific pathogens, such as *Campylobacter* or *Cryptosporidium*. This will inform on the burden of disease associated with these organisms, but it will not inform on source of infection and whether these infections are water-related or not. Environmental surveys of wastewater have been used to identify the enteric organisms circulating in urban populations, and can be useful in outbreak detection[33,34].

Table 3: Types of indicator and event-based surveillance and their relevance to WRID

Type	Description	Source of data	Examples of WRID surveillance indicators	Associated WRID surveillance objectives
Indicator-based surveillance				
Notifiable disease surveillance	Legally mandated urgent reporting of rare but serious diseases	All health facilities and diagnostic laboratories	Cholera, *E. Coli 0157 H7* Legionnaires disease, Infectious bloody diarrhoea, Hepatitis A *Cryptosporidiosis* *Giardiasis* *Shigellosis*	WRID temporal trends, outbreak detection, WRID burden estimation, identify & target high-risk groups & areas, target & evaluate control measures
Syndromic surveillance	Reporting of cases that comply with a syndromic case definition	Health facilities	Consultations for acute gastrointestinal illness or diarrhoea	WRID temporal trends, outbreak detection, WRID burden estimation, identify & target high-risk groups & areas, target & evaluate control measures
Laboratory surveillance	Reporting of isolation of specific organisms, number of requested tests	Laboratories	*Vibrio cholera E. coli* (non-0157 H7 species) *Legionella pneumophila* Hepatitis A *Cryptosporidiosis* *Giardiasis* *Shigellosis* Total submitted stool specimens	WRID temporal trends, outbreak detection, identify new, emerging & re-emerging pathogens, identify what pathogens are transmitted by water
Sentinel surveillance	Surveillance from a selection of sentinel sites chosen to represent high-risk areas or high-risk groups, with or without systematic	Health facilities	Acute gastrointestinal illness Enteric pathogens *Legionella pneumophila*	Outbreak detection, WRID burden estimation

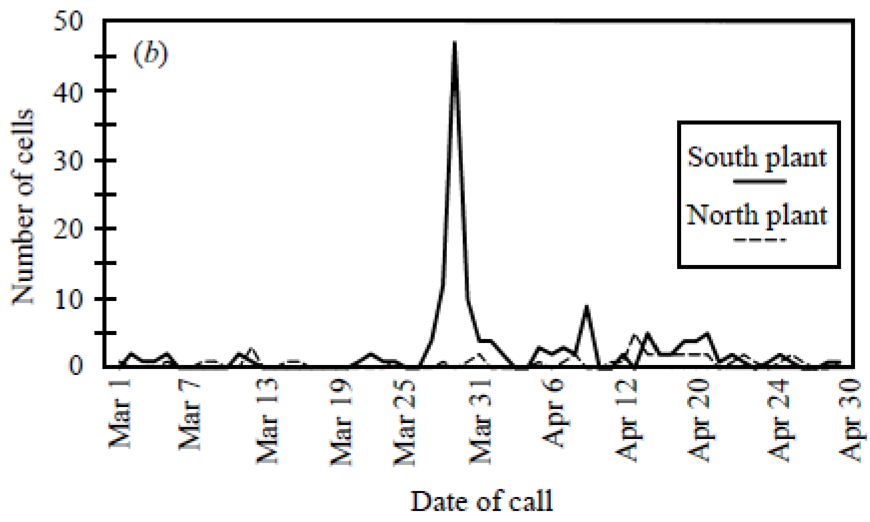
	laboratory testing of cases			
Environmental monitoring	Legally mandated monitoring of key environmental health indicators at set time-intervals	Public health and environment agencies, water providers, municipal authorities	Drinking water quality indicators (E. coli, turbidity, *Legionella* monitoring etc) Main risks in water supply system	Assess water quality Identify hazards and assess risks in water supply system Identify contamination sources Outbreak detection, identify high-risk areas/communities, target control measures & resources, assess effectiveness of control measures
Other	Surveillance of prescriptions or over the counter sales of drugs Emergency room consultations School absenteeism Calls to medical help lines	Insurance claims, pharmacies, schools, medical helplines	Types of prescribed anti-diarrhoeal medicines, Reported acute gastrointestinal illness, Health insurance claims	Outbreak detection, WRID temporal trends
Event-based surveillance				
Outbreak surveillance	Surveillance of outbreaks of WRID (confirmed outbreaks linked to water).	Public health agencies	An outbreak of acute gastrointestinal illness linked to a drinking water supply, An outbreak of legionnaires disease	WRID burden of disease
Media monitoring	Surveillance of media reports of clusters of illness	Internet, radio, TV, newspapers, social media reports	Reports of problems with the water supply, clusters of cases	Outbreak detection, target control measures, target resources
Direct notifications	The public, clinicians, public health personnel or water providers	Water providers Municipal authorities Health facilities	Drops in water pressure, leaks, water contamination events, clusters of cases	Outbreak detection Water quality monitoring Incident/compliance monitoring

	may report unusual events			target control measures, target resources
Ad-hoc studies				
Seroprevalence studies	Population based surveys, convenience sampling of readily available samples (blood samples)	Public health agencies, Laboratories, Research institutes	Secondary testing of blood samples collected from pregnant women	Burden estimation
Environmental surveys	Ad hoc environmental surveys of readily available samples	Environmental agencies, research institutes	Wastewater specimens	Outbreak detection, Assess environmental risks Identify new, emerging & re-emerging pathogens, identify what pathogens are transmitted by water, WRID burden estimation

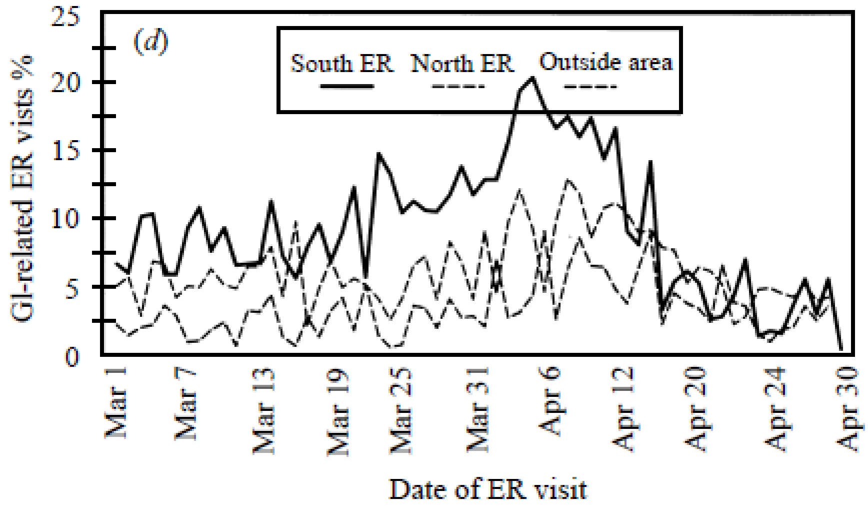
An exposure event, such as contamination of a water supply may manifest as a peak (signal) in associated outcomes, such as school absenteeism several days following the event, and there may be a further delay in the detection of that signal by the indicator-based??? surveillance system. For instance, in a massive outbreak of cryptosporidium in the United States[34], contamination of a water supply was reflected by a peak in complaints to the water company one day after the event, and this peak in complaints was detected by the surveillance system one day later. Conversely, a peak in emergency room consultations for gastrointestinal illness was observed seven days after the event, but it took a further eight days for this to be detected by the indicator based??? surveillance system (Figure 3). If the objective of the surveillance system is outbreak detection, then the timeliness of capture of the surveillance data by the surveillance system can be as important as the timeliness of the occurrence of the signal in the surveillance data. Where this is the objective, the surveillance system should include surrogate indicators of infection (such as water quality indicators) which will facilitate the earlier detection of potential exposures.

Figure 3: Timeliness of event detection using surveillance of a) customer complaints to the water-provider and b) emergency room consultations for gastrointestinal illness, Milwaukee cryptosporidium outbreak, 1993. Reproduced from Procter et al, Epidemiology and Infection, 1998(20)48-54[34].

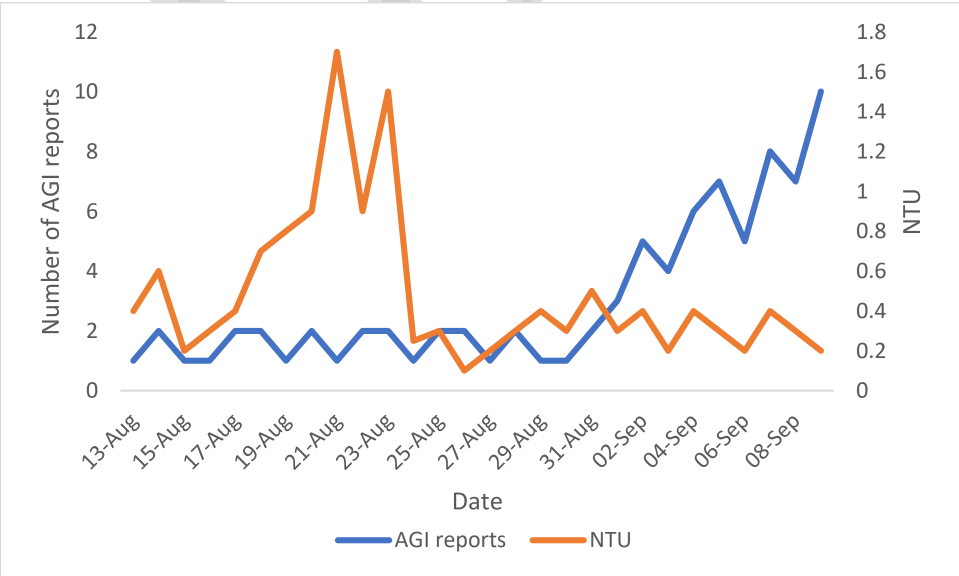
a.



b.



Alternative Figure 3: Timeliness of event detection using environmental monitoring of water supply turbidity (NTU?) versus monitoring of cases of acute gastrointestinal illness

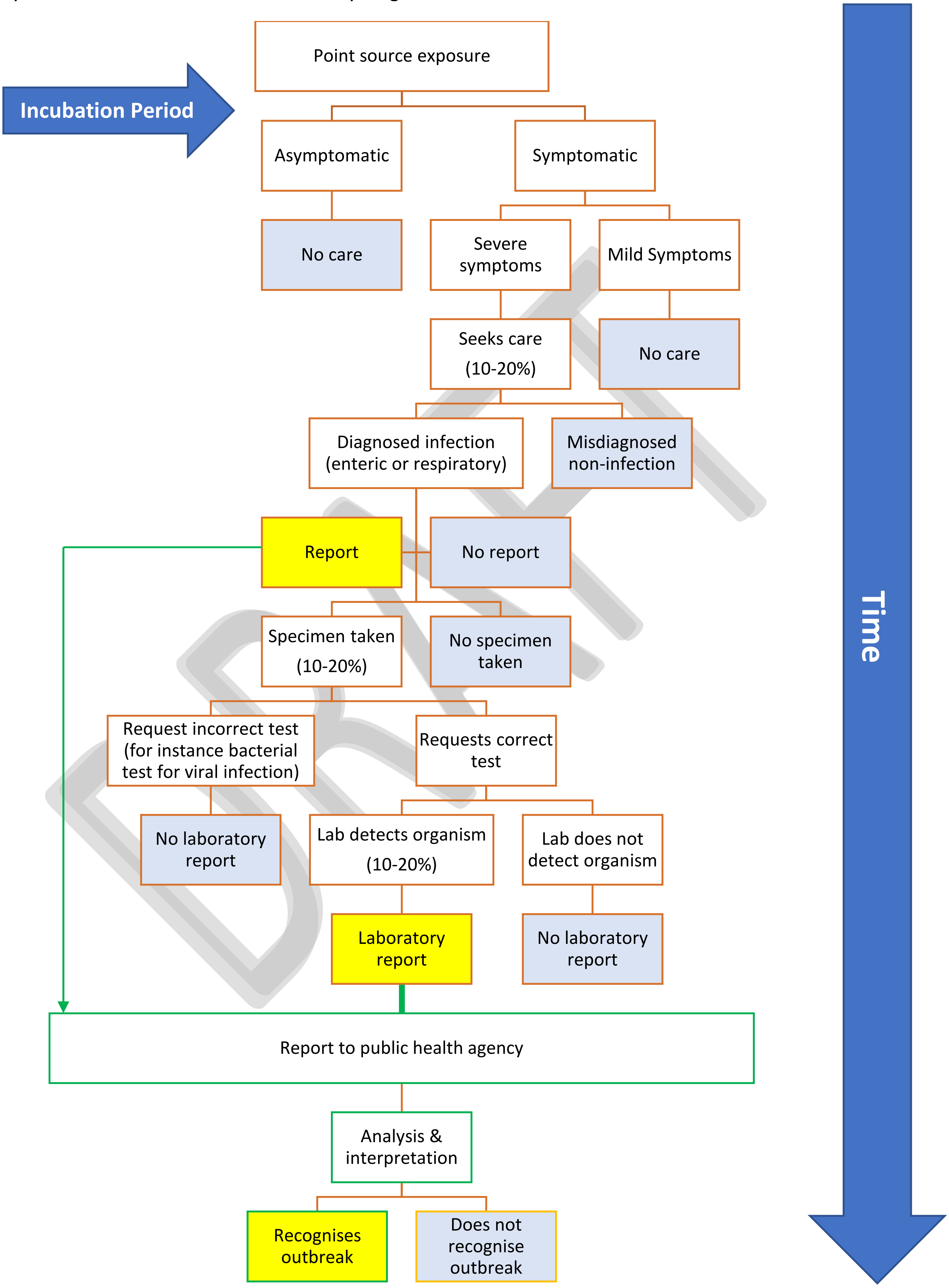


Surveillance systems based on clinical and laboratory diagnoses have a number of limitations. Overall these systems may have low sensitivity for the detection of WRID cases as only the limited number of pathogens that are included in the systems will be captured and monitored. The number of pathogens included in the systems are fixed. Consequently, these systems are relatively inflexible as in order to include new and emerging pathogens, a change in legislation is required. They are often not representative of the general population as they only capture medically attended cases and so milder cases or cases where the person self-medicates using over the counter medicine will not be captured. Furthermore, there is likely to be a considerable delay between the time of exposure and when the public health authorities detect the case and identify whether an outbreak is occurring (Figure 3). The source of infection for these cases is usually not documented so they cannot be definitively linked to water. Finally undertaking this type of surveillance requires the engagement of clinical and laboratory staff. Participating in surveillance will inevitably increase their workload and may therefore not be very acceptable to staff, especially if they cannot see how the data are used to prevent disease. Their advantage is that they are highly specific for the detection of cases of WRID and so have a high positive predictive value for outbreak detection. Other types of surveillance will have similar advantages and disadvantages (Table 4).

The ability of a surveillance system to detect cases is influenced by a number of factors (Figure 4) including the clinical presentation of infection, healthcare seeking behaviour, diagnostic practices, health financing, laboratory capacity and practices and the types of pathogens under surveillance. Sensitivity is particularly influenced by the fact that[17]:

- not all cases are symptomatic
- only 10-20% of symptomatic cases seek care
- stool samples are requested in only 10-20% of those who seek care
- samples are tested for a limited number of pathogens and so the sample may not be tested for the correct pathogen
- laboratory tests are not 100% sensitive and so even if the pathogen is present, it may not be detected by the laboratory
- not all isolated pathogens are notifiable

Figure 4 Patient pathway and timeliness and completeness of cases ascertainment by surveillance systems based on clinical and laboratory diagnoses.



The degree of laboratory testing will be influenced by whether there is an associated cost to either the patient or the health facility. The type of tests conducted will be influenced by the season and the practices of the individual laboratory. Generally, there is less testing of viruses and parasites than bacteria, and there is limited subtyping of specimens[8].

Table 4 describes the advantages and disadvantages of the different types of surveillance.

Table 4: Advantages and disadvantages of the different types of surveillance

Surveillance type	**Advantages**	**Disadvantages**
Notifiable disease surveillance	Highly specific (low degree of misclassification of cases) / high positive predictive value Simple	Not timely Low sensitivity to detect cases and outbreaks No data on source of infection Not representative of the general population Low flexibility to modify in response to changing surveillance needs Low acceptability due to workload associated with reporting
Syndromic surveillance	Simple Timelier & more sensitive than notifiable disease & laboratory surveillance Useful	Low sensitivity to detect cases and outbreaks (medically attended cases only) Less specific than notifiable & laboratory surveillance / lower positive predictive value No data on source of infection Not representative of general population Low flexibility to modify in response to changing surveillance needs Low acceptability (workload)
Laboratory surveillance	Highly specific (low degree of misclassification of cases) / high positive predictive value Simple Acceptable Useful	Not timely Low sensitivity to detect cases and outbreaks Low flexibility to modify in response to surveillance needs No data on source of infection Not representative of the general population
Sentinel surveillance	Timelier & more sensitive than notifiable disease & laboratory surveillance Flexible Representative of sub-populations / high-risk groups Useful - enables collection of higher-quality data on risk factors Simple	More resource intensive Low acceptability (workload) Low positive predictive value Not always representative of general population

Environmental monitoring	Timely & continuous Acceptable Useful (early warning of contamination events)	Testing episodes may not correspond to contamination events Low sensitivity (need very large samples to isolate organisms) Low positive predictive value False negatives (negative results do rule-out contamination) Not representative of all circulating pathogens as only test for limited number of pathogens
Other (surveillance of prescriptions or over the counter sales of drugs, emergency room consultations, school absenteeism, calls to medical help lines)	Timely More sensitive Cheap and readily available sources of data Simple Useful (early warning, prompts further investigation)	Less specific (prone to misclassification) / low positive predictive value Lower acceptability Data influenced by external factors (such as promotions on anti-diarrhoeal medications, public awareness / perceptions of risk) Not representative
Outbreak surveillance	Specific Useful in monitoring burden of WRID outbreaks	Not timely as outbreaks are reported after demonstrated to be water-related (at end of investigation) and often only quarterly or annual reporting Low sensitivity since many outbreaks are not detected and many are not linked to water Not representative (larger outbreaks more likely to be detected and reported)
Media monitoring	Timely Sensitive Cheap and readily available sources of data Representative Flexible Simple Acceptable Useful – can prompt investigations	Low specificity / low positive predictive value Noisy data difficult to interpret
Direct notifications	Timely Cheap and readily available sources of data Simple Flexible Useful (can prompt environmental investigation of water supply)	Low sensitivity (smaller outbreaks with milder illness less likely to be reported) Not representative as smaller outbreaks and those with milder illness may not be reported Low positive predictive value
Seroprevalence studies (for instance of readily available specimens such as from pregnant women)	Specific Cheap (if using readily available specimens) Flexible Useful	Not timely No data on source of infection Not representative (usually such studies are representative of population

		subgroups rather than the general population) Simplicity (labour intensive)
Environmental surveys	Specific Representative Useful Flexible	Not timely Simplicity (labour intensive & costly)

2.1: Considerations for improving WRID surveillance

Surveillance systems should be enhanced in areas where WRID are endemic or where outbreaks are known to occur[6]. This may include:

- areas where the drinking water is extracted from surface waters
- areas where livestock are farmed in close proximity to the water supply
- areas subject to droughts, where drops in pressure may allow intrusion of organic material into the water distribution system
- areas prone to flooding and heavy rainfalls
- areas served by community water supplies
- industrial areas.

Surveillance can also be enhanced at certain times of the year to reflect the seasonality of WRID.

Ideally systems for WRID surveillance will be embedded within existing surveillance structures, by either building on existing surveillance systems or by expanding existing systems to include WRID. For instance:

- existing media surveillance could be expanded to include information searches on water quality, prevailing risks of contamination or diarrhoea
- water quality data and/or risk assessment data from water providers and public health agencies could be linked to notifiable disease surveillance data by time, or by geographical identifiers
- notifiable disease and laboratory surveillance systems could be expanded to include more WRID relevant to the country context.

As mentioned in section 2.0, surveillance of WRID is a multidisciplinary task requiring strong coordination and cooperation between, among others, disease surveillance agencies, water providers, regulators, and environmental agencies. This is critical to ensure the timely mutual sharing of data on water supply system incidents and possible water-related outbreaks.

3.0: How to set up, improve and maintain national systems for surveillance of WRID

Most countries will already have some surveillance of WRID and the main priority will be to further develop and complement existing systems in order to improve their surveillance of WRID.

WRID surveillance systems should only be as complicated as they need to be to address the objectives of the surveillance system.

3.1: Key principles and building blocks of surveillance systems

Developing and setting up a WRID surveillance system can involve several steps:

Step 1: characterising the public health problem and identifying priorities for WRID surveillance
Step 2: engaging key stakeholders and defining their roles in the development and implementation of surveillance
Step 3: defining the purpose, scope and objectives of the surveillance system to address specific water related issues
Step 4: designing the surveillance system including selecting and defining the surveillance indicators and defining the core surveillance dataset and data flows
Step 5: developing methodology for collecting and managing the WRID surveillance data
Step 6: Evaluating the surveillance system

Ideally a short surveillance protocol will be developed to document the rationale, design and methodology for the system, especially if a new surveillance system is being developed or if substantive changes to an existing system are required. This will be useful for current and future users of the system. A template surveillance protocol is provided in Annex 2. The process of developing a protocol will enable the responsible persons to systematically consider the design of the system and the purpose of each surveillance activity. It can also provide the basis for any legislation that will need to be enacted to support the operation of the system. Ideally for setting up new surveillance systems, or where substantive changes to an existing system are proposed, the development of the system will be guided by an expert group or steering committee.

Step 1: Characterise the public health problem and identify priorities for WRID surveillance

It is essential to undertake a situational analysis to describe the epidemiological situation for WRID in the country considering:

A. the pathogens of interest that are circulating in the country; these data may be obtained from a number of sources including existing surveillance systems, laboratory records, outbreak investigation reports, published and unpublished research studies, and data from water quality surveillance and environmental monitoring systems
B. diseases caused by these pathogens, including their, severity, long-term sequelae, fatality rate, incubation periods, modes of transmission and infectiousness
C. propensity of each pathogen to cause outbreaks and the overall risk of outbreaks
D. available data on number of cases, prevalence and incidence during a defined time-period (for instance the past five or ten years), and any trends in these data, overall and for each pathogen
E. estimated burden of disease and disability due to these pathogens, collectively or individually depending on the available data, and the associated economic cost to the country
F. available data on number of outbreaks due to these pathogens, and overall due to WRID during a defined time period
G. high-risk groups or high-risk areas for infection and disease
H. where there is any public or political concern related to these pathogens
I. likely sources of these pathogens, including environmental and zoonotic reservoirs
J. limitations to the available data, especially gaps in the data
K. current sources of data and potential new sources
L. main actors and stakeholders and their roles in the surveillance and control of these organisms
M. international requirements for surveillance

Ideally a comprehensive description of the country's water system will be included in the situation analysis. Map out the main sources and providers of drinking water in the country, including the geographic distribution of these sources, population served, and any available data on water quality and the state of drinking water infrastructure, with a particular emphasis on weaknesses in the system which may result in WRID. Similarly, an overview of potential sources of water-dispersed diseases (such as the number and geographical distribution of industrial cooling towers) should be included. It is advisable to obtain and document these data in supply systems implementing WSPs.

Surveillance case study. Step 1: Identify the public health problem under surveillance

Background: Country X has a population of ten million people and is located in central Europe. It is a mountainous country with many rivers and lakes. Sixty percent of the population live in urban centres, including three million people residing in the capital city. All urban centres, and some surrounding rural areas, are served by local public water supplies, extracted from either surface or groundwater sources. The infrastructure of many public water supplies is aging and is vulnerable to contamination. The water supply of the capital city is sourced from a large lake which borders two neighbouring countries. An estimated two million rural residents are served by either community water supplies or private wells, sourced from groundwater. Agriculture is the third biggest industry. It is concentrated in rural areas and includes a small amount of intensive farming. There are 200 registered industrial cooling towers in country X, associated with power plants, food processing and other industrial processes. Most of these are located in and around the capital city.

Notifiable diseases: Health facilities are required to notify cases of cholera, typhus and infectious bloody diarrhoea under the national notifiable disease surveillance system. Public health laboratories are required under the same system to notify laboratory confirmed cases of campylobacter, hepatitis A and E, salmonella, shigella and Vibrio cholerae.
The source of infection for these cases are rarely determined unless they are investigated as part of an outbreak investigation and so the burden of WRID is greatly underestimated and there is inadequate capacity for outbreak detection.

Outbreak detection and reporting: Outbreaks are usually detected by district offices of the NPHA, primarily due to reports of clusters of cases by health facilities, and occasionally by direct reports from the public. Outbreaks of acute gastrointestinal illness associated with public and private water supplies are occasionally reported. In the past five years several outbreaks of cryptosporidium and giardia have occurred, including a number of outbreaks associated with public water supplies. A cluster of five cases of community acquired pneumonia was also reported in the previous year. This cluster, subsequently confirmed as Legionnaires disease, occurred in a suburb of the capital city. The suspected source was an industrial cooling tower, although the source was not definitively identified.

Problem statement: Country X has inadequate capacity for the surveillance of WRID. New pathogens are emerging which are not covered by the existing surveillance system. The country is vulnerable to outbreaks of WRID due to ageing infrastructure and inadequate capacity for the timely detection and response to WRID outbreaks.

Recommendations for improvement: The capacity for the surveillance and management of outbreaks of WRID needs to be strengthened. Surveillance needs to be expanded to include emerging pathogens and syndromic and event-based surveillance for the early detection of outbreaks.
Based on the situation analysis, the NPHA identifies the following priority indicators for addition to the existing surveillance system:

- Cryptosporidium species
- Enteropathogenic E. coli
- Giardia species
- Legionella species
- Acute gastrointestinal illness
- Outbreaks of waterborne diseases

The NPHA would also like to strengthen event-based surveillance for outbreaks of WRID, by monitoring exceedances of water-quality standards and public complaints relating to the water supply.

TIP

Collating and summarising data and information on the situation in a country will help to:

- ✓ *clarify the importance of and characteristics of WRID in the country*
- ✓ *identify the degree to which these are a public health problem*
- ✓ *identify the priority WRID and areas for surveillance to be strengthened, plan for and target resources for public health improvement action*

Step 2: Engage key stakeholders and identify their roles

It is important to engage key stakeholders as early as possible in the process of designing and establishing the surveillance system for WRID surveillance. These stakeholders can form an advisory group to oversee and guide the development of the system. They may also be consulted a various time-points during the process or asked to comment on advanced drafts of the surveillance protocol. Additional stakeholders may be identified as the system is developed. It is especially important to engage those who will be actively involved in running the surveillance system, including those who will provide data and those who will be tasked with responding based on the results of surveillance. Possible stakeholders to engage will include:

Categorise by national and local levels

Ministry of health / national public health agency

1. water providers (can include municipal water supplies, private companies & smaller suppliers from community supplies (at local level))
2. water regulators
3. environment agencies – add possible roles and responsibilities (Table)
4. environmental health specialists
5. laboratory specialists
6. representatives of health facilities / clinicians
7. legal and data protection experts
8. Information Technology (IT) specialists
9. media monitoring specialists / event-based surveillance specialists
10. data managers

Surveillance case study. Step 2: Engage Key Stakeholders

<u>Stakeholders and their roles</u>: The National Public Health Agency (NPHA) includes a Department of Disease Surveillance and Control, which is responsible for the surveillance and control of communicable diseases in country X. The department includes a team with primary responsibility for the surveillance and control of food and waterborne diseases. The Environmental Protection Agency (EPA) has overall responsibility for monitoring water and wastewater and for the conservation of water resources. Public water supplies are provided by municipal authorities, who undertake testing for water quality indicators. Water samples are tested at national and regional branches of the EPA laboratory service. Clinical specimens are tested at laboratories attached to health facilities, at district, regional or national NPHA laboratories or sometimes private laboratories, depending on the facility and the type of test requested.

The head of the Food and Waterborne Disease (FWD) team of the NPHA convenes a multidisciplinary advisory group including members of xxxxx, to steer the development of the WRID surveillance system in country X. The advisory group defined the roles and responsibilities of the membership

The advisory group The membership of the advisory group and their roles and responsibilities are detailed in the following table:

Person	Role/Responsibility in surveillance system development & implementation

Head of the FWD team	Overall coordination & national focal point for surveillance
Principal epidemiologist from the FWD team	Protocol development, design of the system, development of data analysis plan, data analysis & reporting
Statistician from the FWD team	Development of data analysis plan, data analysis
Data manager from the FWD team	Database development & management
Head of event-based surveillance at the NPHA	Lead on expansion of existing event-based surveillance system to include WRID, management of WRID component of EBS, reporting of water-related events to the national focal point
Representatives from the sub-national level of the NPHA	Engagement of sub-national level, implementation at subnational level
National Programme Manager for Water Quality and Safety of the EPA	Advise on how to use water quality surveillance data & other useful data in surveillance & establishment of links between two systems. Water safety focal point
Representative from the National Association of Water Providers	Engagement of water suppliers in surveillance
Representative from the National Reference Laboratory for Infectious Diseases	Advise on laboratory aspects of surveillance, lead on laboratory capacity development for surveillance, engagement of labs in surveillance
Representative from the National Water Quality Monitoring Laboratory	Advise on how to use water quality data in surveillance, data analysis & reporting
Specialist in environmental health	Advise on environmental monitoring for surveillance
Specialist in enteric and waterborne infections	Advise on clinical considerations, engage clinicians
Specialist in Legionnaires disease	Advise on requirements for surveillance of Legionnaires disease, including environmental sampling

TIP

- ✓ *The decision makers and technical experts from the organisations who will participate in surveillance should be involved in the process of designing and implementing the surveillance system so that they can contribute their expertise and inform the process.*
- ✓ *By engaging these stakeholders, you will engage and build relationships with the key organisations who will participate in surveillance which will help with surveillance implementation*

Step 3: Define the overall purpose, scope and objectives of the WRID surveillance system

Based on the situational analysis, define the overall purpose and scope of the surveillance system and the surveillance objectives.

The scope will detail the types of water-related infectious diseases to be included in the system, the geographic coverage of the system, the population to be covered by the system, and the time-period for surveillance.

Surveillance systems can have more than one objective as described in section 2.0.

The elements of the system need to be sufficiently timely, representative, sensitive and specific to address their respective objectives, which will in turn influence the methods of data collection, including the frequency of data collection.

For instance, if the objective is outbreak detection, then ensuring that the system is sensitive and can readily identify cases will be a priority, as will the timely collection of data, so that outbreaks can be identified early to enable their rapid management.

If the objective is to identify high-risk groups, then ensuring that the data are representative of the general population will be important.

Surveillance systems should be sufficiently sensitive to be able to detect both changes in disease incidence and a high and ongoing level of sporadic cases of WRID.

Surveillance case study. Step 3: Define purpose, scope and objectives of the national WRID surveillance system

Based on the results of the situational analysis of WRID in country X, the advisory group agree the following:

Purpose of surveillance: to collect and analyse public health and environment data to inform actions to reduce and control WRID

Scope of the WRID surveillance system will include:
- Type of disease: Waterborne diseases associated with drinking water contamination, and water-dispersed diseases (specifically diseases caused by legionella species) (example of diseases provided in Table 1 and 3)
- Geographic coverage: the entire country
- Population coverage: the entire population
- Monitoring all year round

Objectives:
1. To strengthen the capacity to detect outbreaks and changes in disease incidence and sporadic cases
2. To enhance the capacity for environmental monitoring and risk assessment of water supply systems
3. To monitor trends in water quality and waterborne and water-dispersed diseases
4. To identify high-risk areas to target with control measures

5. To estimate the burden and impact of WRID and publish regular updates to inform policy and improvement measures

TIP

- ✓ *Clearly define the purpose, scope and objectives to address the problems and priorities identified from the situation analysis*
- ✓ *Ensure that all objectives are SMART: Specific, Measurable, Achievable, Realistic and Time-bound*
- ✓ *Ensure that all surveillance activities address specific objectives*

Step 4: Identify the monitoring parameters, the core surveillance dataset and design the system

Based on the results of the situational analysis, and having agreed the purpose, scope and objectives of the system:

1) Decide on the priority pathogens, notifiable diseases and syndromes for the country to monitor. Factors to consider include:
    a) the public health importance of the problem and of individual pathogens (as identified from the situation analysis (step 1))
    b) the degree to which it is possible to prevent, control and treat the problem
    c) the resources that will be required to undertake surveillance of a particular pathogen, and whether there is capacity to undertake surveillance and control the problem
2) Where necessary, select additional surrogate indicators, such as water complaints, which will enable the earlier detection of potential exposure events and outbreaks.
3) Link all indicators under surveillance to specific surveillance objectives.

Identify appropriate sources for the provision of data on each surveillance indicator. For instance;

- water-providers who can report water-quality data,
- readily available databases that can be accessed to automatically capture data on laboratory diagnoses, prescriptions for anti-diarrhoeal medications or school absenteeism.

These sources of data and the data provide by them will comprise the elements of the surveillance system.

Surveillance case study. Step 4: Design the surveillance system

Based on the results of the situation analysis, the advisory committee agree that the surveillance system should include both indicator and event-based surveillance. The types of surveillance, indicators under surveillance, sources of data and to be included in the system are summarised as follows:

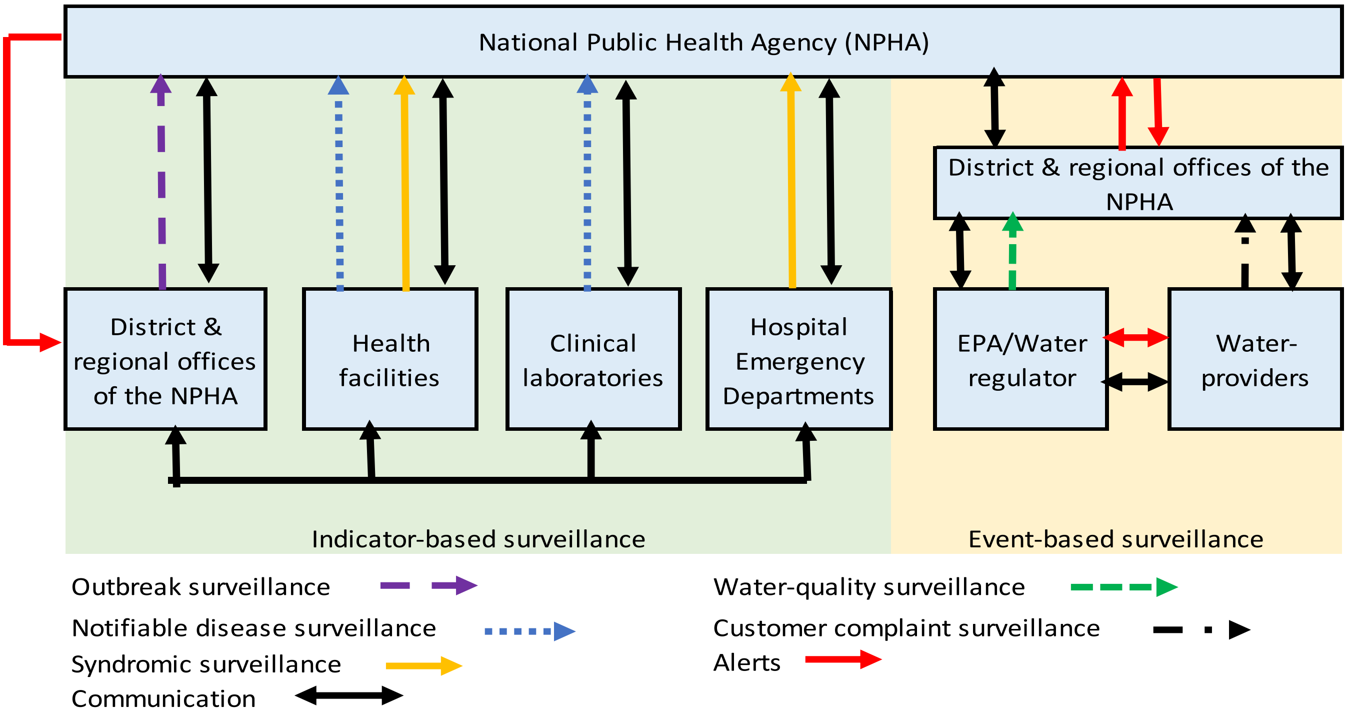
Associated WRID surveillance objective	Type of Surveillance	Surveillance indicators	Data sources	Population under surveillance
Indicator based surveillance				

Detect outbreaks Monitor trends Identify high-risk areas Estimate burden and impact Use surveillance data for policy and control of WRID	Notifiable disease surveillance	Clinical diagnoses of: • cholera • typhus • infectious bloody diarrhoea • community acquired pneumonia	Health care facilities	Patient population
		Laboratory diagnoses of • Campylobacter • Cryptosporidium • Enteropathogenic E. coli • Giardia • Hepatitis A and E • Legionella • Salmonella • Shigella • Vibrio cholera	Public and private clinical laboratories	Patient population
Detect outbreaks Monitor trends	Syndromic surveillance	Acute gastrointestinal illness	Primary care facilities & hospital emergency departments	Patient population
Identify high-risk areas Estimate burden and impact of WRID Use surveillance data for policy and control of WRID	Outbreak surveillance	Waterborne outbreaks	District / regional offices of the NPHA	Total population
Event-based surveillance				
Detect outbreaks Identify high-risk areas Use surveillance data for policy and control of WRID	Water-quality surveillance	Exceedance of threshold limits for water quality: • Turbidity • Residual chlorine (for supplies subject to disinfection) • E. Coli	EPA /water-regulator Waterworks	Customers of water supplies
Detect outbreaks Identify high-risk areas	Customer complaint surveillance	Exceedance of threshold limit for customer complaints on water quality and/or water supply system operation	Water-provider	Customers of water supplies

- The existing notifiable disease surveillance system will be expanded to include additional water-related pathogens.
- A new syndromic surveillance system for acute gastrointestinal illness will be developed.
- Existing outbreak surveillance will be expanded to include surveillance of water-related outbreaks.
- The existing event-based surveillance system will be expanded to include surveillance of water-quality alerts and water-provider customer complaints surveillance.

A recommended core-data set and frequency of reporting for common surveillance indicators is detailed in Table 6.

Box X. Case study, Step 4 continued: Schematic diagram of the surveillance system



Define the case definitions for each indicator under surveillance.
The European Union has published a list of standard case definitions for communicable disease surveillance[34] that can be used by members of the European Union and European Economic Area. Box 1 presents an example of the EU case definition for cryptosporidium.

Box 1. Example 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 NA

B. Probable case: Any person meeting the clinical criteria with an epidemiological link
C. Confirmed case: Any person meeting the clinical and the laboratory criteria

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

Define the data to be collected and reporting frequency.
Typically, data on notifiable disease cases or laboratory confirmed cases will be case based. Syndromic surveillance data may be either case based or surveillance sites may report aggregated data.

- Ensure that all data collected has a defined purpose and that it can be used to prevent or control the disease under surveillance. For instance, data on geographic distribution of WRID may help to identify weaknesses in the water distribution system or geographic areas where there is a higher incidence of water-dispersed diseases which is suggestive of an outbreak. If the data does not have an actual purpose, do not collect it.
- Define the frequency of data reporting. This will depend on the purpose of the data. Data intended for outbreak detection will need to be reported as soon as possible. Data used to monitor trends and seasonality should be collected on an ongoing basis, for instance weekly. Data used for burden of disease estimates or to monitor what pathogens are associated with WRID could be collected less frequently, for instance monthly or annually.

Table 5 outlines typical data that are collected for different indicators. **Annex 4 presents** a recommended dataset for the surveillance of *Legionella*.

Table 5: Data commonly collected for different surveillance indicators

Surveillance indicator	**Type of data**	**Suggested core data set**	**Suggested reporting frequency**
Notifiable cases of WRID	Case based	Name, age, date of birth, sex, address, occupation, work address, date of onset of illness, underlying comorbidities or other risk factors for infection such as smoking, date and place of hospitalisation, case outcome (alive, died), recent travel history	Within 24 hours
Laboratory confirmed cases of WRID	Case based	Reporting laboratory, patient name, age, sex, residential postcode, date of onset of illness, specimen type, specimen date, pathogenic organism (full organism name and any typing results), identification methods	Within 24 hours for urgent notifications, otherwise weekly
Syndromic surveillance data (acute gastrointestinal illness, diarrhoea)	Aggregate	Total weekly cases by age-group, sex and place	Weekly
WRID outbreaks	Case-based	Location & date of outbreak Total cases, hospitalised, died Causative agent Source of outbreak (public or private water supply, cooling tower etc)	Quarterly

	Water quality Main risks of water supply system contamination Contributory factors

Identify other sources of data that can be used to inform surveillance.
Other data such as climatic data could be used to identify high-risk periods for outbreaks or to identify risk factors for WRID, which may pinpoint areas that could be targeted for control measures.

Consider the strengths and limitations of the surveillance system
Having decided on what data to collect and the sources of these data, it is useful to consider the strengths and limitation of the surveillance system. In particular consider:

- Representativeness: Will any populations, such as users of individual and small private water supplies, not be captured by the surveillance system? What impact if any is this likely to have on the control of WRID in the country.
- Bias: What are the potential sources of bias associated with the data?
- Sensitivity: How likely are cases to be missed by the system?
- Specificity: How likely are cases to be misclassified as non-cases and non-cases to be misclassified as cases and how could this impact the surveillance estimates and conclusions derived from the data?
- Timeliness: Will the system be sufficiently timely to enable early outbreak detection?
- Flexibility: How easy will it be to adapt or modify the system, for instance in the event of an emergency. Can the system be expanded or reduced in response to the public health need?
- Simplicity: Is the system overly complicated?
- Redundancies and duplication: Are there any redundancies or duplications in the data collected? Are all data being collected for a specific purpose?

TIP

- ✓ *The design of the surveillance system will depend on the scope and the country-specific objectives*
- ✓ *Develop a schematic overview of the surveillance system, based on the identified types of surveillance (building blocks), indicators and sources of data (elements) of the system.*
- ✓ *Define the specific objectives for each type of surveillance (or data to collect), as each type will have its own objectives and outputs.*
- ✓ *Define the population under surveillance for each surveillance type, as each type may cover different populations.*
- ✓ *Surveillance case definitions may differ from clinical case definitions or case definitions used during outbreaks.*
- ✓ *Only collect as much data as you need to collect and make sure that all data collected has a specific purpose in helping to fulfil a specific surveillance objective*
- ✓ *Consider how the design could be strengthened to address any identified limitations.*

- ✓ *Ideally be aware of the limitations of the system from the very outset of surveillance.*

Step 5: Develop a methodology for collecting and managing the surveillance data

1. Develop a methodology which describes:
    - the roles and responsibilities of each participant in operating the surveillance system at each level of the system, including the responsible persons for the collection, reporting and receipt of data
    - the process for the identification of cases at health facilities, and for the reporting of data on cases to the public health agency
    - the process for the electronic capture of data from other systems, such as laboratory, environmental, prescribing or absenteeism databases
    - the data that are to be collected from each data source
    - the reporting forms, including case-based reporting forms for notifiable disease surveillance
    - data flows from the local to the sub-national to the national level
    - data management, including how data will be coded and entered into the system, and how it will be stored; who will have “ownership” of the data or be the guardian of the data; how the data will be protected
    - the process for the analysis and interpretation of the data, the generation of surveillance reports
    - the process for investigating individual cases of notifiable diseases
    - the process for reporting to other jurisdictions / countries about travel associated cases or suspected outbreaks or contamination events that may impact transboundary waters.

2. Develop processes for disseminating and using the surveillance data

The results of surveillance should be communicated and disseminated to stakeholders on a regular basis to:

a) Inform decision making for public health action.
b) Demonstrate the purpose and usefulness of surveillance data to those who are reporting data in order to motivate them and engage them in surveillance

This is best achieved through the regular generation and publication of a surveillance report or bulletin.

Ideally these bulletins will be

- disseminated to all stakeholders involved in surveillance, including water providers and water regulators.
- made publicly available on for instance the website of the public health agency.

3. Develop processes for monitoring and evaluation

Surveillance data may not be of the highest quality. None-the-less, in accordance with the requirements of Article 8 of the Protocol (that surveillance systems be established, improved or maintained), some effort is needed to deliver a basic level of quality to ensure the stability and validity of the surveillance results. This is achieved through monitoring and evaluation (M&E). M&E can include ongoing monitoring of data quality and periodic evaluations of the surveillance system.

For ongoing monitoring, automated data checks can be incorporated into electronic data management systems by building into the system:

a) data entry checks which control against data errors at the time of data entry
b) inter-database checks which cross check the consistency of data between different data tables and databases in the data management system
c) checks on the completeness and timeliness of data reporting into the system, for instance by checking that all reporting sites (such as laboratories) have reported into the system

Periodic evaluations are conducted to assess:

a) the degree to which the system is meeting its surveillance objectives
b) the timeliness and completeness of reporting
c) the sensitivity, specificity and positive predictive value of the system
d) the utility of the system
e) resourcing of the system

The evaluation should generate recommendations for improvement of the system.

Detailed information on how to evaluate a surveillance system is given in the guidance documents listed in Annex 2.

Surveillance case Study. Step 5: Develop a methodology for collecting and managing the surveillance data

- All organisations involved in surveillance, including health facilities, laboratories, water providers, the environmental protection agency, and offices of the NPHA at national, regional and district level are asked to appoint one or more responsible persons for surveillance
- Case-based and aggregated data reporting forms and associated databases are developed and officially adopted
- A web-based reporting system is developed for notifiable disease, syndromic surveillance and outbreak surveillance data reporting
- Procedures for the reporting of exceedances of thresholds for water-quality standards and customer complaints are developed involving notification by email and phone to either the district or regional offices of the NPHA, depending on the geographical coverage of the water supply system.
- The design of the system, case definitions and surveillance procedures are documented in a surveillance protocol which is officially adopted by all parties
- Routine data analyses plans are developed and a template surveillance bulletin and plan for its dissemination to key stakeholders is developed

TIP

✓ *Detail the surveillance methodology in a surveillance protocol and develop standard operating procedures for all those working at each level of the system*

- ✓ *Reporting the results of surveillance in a weekly surveillance bulletin will help to engage those reporting data to the system and will raise the profile of WRID in the country*
- ✓ *Incorporate automated data checks into the system to ensure the quality of the surveillance data*
- ✓ *Conduct periodic surveillance system evaluations to monitor and optimise surveillance implementation.*

4.0: Prerequisites (or enabling factors) for setting up, maintaining and sustaining the effective surveillance of WRID

1. Set legal requirements or formal procedures for surveillance of WRID
    - Review and update the national legislation and/or guidelines and establish formal requirements for surveillance of WRID as an integral part of the national disease (public health) surveillance system
    -
    - Ensure that the surveillance system complies with all national legislation relating to research ethics and data protection.
    - Seek legal advice to ensure that due consideration has been given to these factors

2. Ensure there are adequate resources and infrastructure for surveillance
    - Develop a budget for setting up/running the system and secure the necessary resources.
    - Develop a training programme for all staff working on WRID surveillance at all levels of the system. Develop standard operating procedures and instruction manuals to guide their day-to-day work.
    - Put in place the necessary IT, transportation, and communication infrastructure to operate the system. This could include computers, internet, an electronic data management system, transportation for specimen collection, laboratory supplies, or a web-based reporting system.
    - Ensure that there is adequate laboratory capacity to support surveillance activities, including capacity to test for the priority pathogens under surveillance.

3. Collect baseline data and establish thresholds for different indicators
    - Thresholds can be established for outbreak detection, and also to monitor seasonal epidemics
    - Thresholds for outbreak detection may be
        a) A defined number of cases that will prompt an outbreak investigation, for instance a single case of acute watery diarrhoea or suspected cholera[35], or five cases of suspected shigellosis or bloody diarrhoea[36].

b) An increase of a defined magnitude beyond the background rate for a specific disease, for instance a two-fold increase in the rate of cryptosporidiosis above the baseline surveillance rate for the previous five years [CDC cryptosporidium guideline] or a doubling of the weekly average number of cases of shigellosis[36].

- Thresholds for monitoring seasonal epidemics are based on increases above the baseline incidence rate and can be used to define the start of a seasonal epidemic and the intensity of the epidemic.
- Baseline incidence rates are usually calculated based on at least five years' worth of data.
- Resources relating to the calculation of thresholds are listed in Annex 2.

4. Use of surveillance data to protect public health
   - The results of surveillance can be used to:
     a) identify possible WRID outbreaks and prompt the launch of investigations to confirm and if necessary, manage the outbreaks.
     b) prompt inspections of the water-system and works to maintain the integrity of the system and the safety of the water supply
     c) inform on the need to invest in and allocate resources for maintenance of the water-system
     d) target resources for water-system maintenance to areas with higher rates of disease
     e) inform the development of guidelines for water treatment and quality
     f) prompt control measures, including legislation, to control water-dispersed diseases

Surveillance Case Study. Enabling surveillance

- Memoranda of understanding are agreed and signed by all parties to govern the sharing of data
- Standard operating procedures governing all surveillance activities are developed and training is given at all levels of the system
- The surveillance system will be financed using core funding from the MoH and NPHA
- As laboratory surveillance is being extended to include a greater number of microorganisms, additional resources for the testing of these organisms is directed to the laboratory network and additional training on testing methodologies is given
- The legislation governing notifiable disease surveillance is updated to include the reporting of additional pathogens
- Alert thresholds are developed for the notifiable, syndromic and event-based surveillance elements of surveillance

TIP

✓ *Ensure that all surveillance activities are supported by either a legal framework or explicit agreements between stakeholders*

- ✓ *Include private laboratories that may be contracted to test clinical and environmental specimens in laboratory surveillance and if necessary, mandate them to report to the system through statutory legislation or formal agreements.*
- ✓ *If WRID surveillance and control is mostly conducted at the local level, then target resources to the local level, rather than the national level.*
- ✓ *Surveillance data must be frequently and routinely analysed to assess whether cases are linked by time and place or to assess whether trends in case-reports suggest a possible outbreak.*

5.0: Water supply surveillance

Water supply systems are subject to routine monitoring for microbes and other indicators of contamination (Table 6) and their potential risks[19,20]. The ***water provider*** will typically undertake routine ***operational monitoring*** at different stages to validate the functioning of the water supply system.

The ***drinking water regulator*** will conduct ***surveillance*** of the water system, so as to verify the overall performance of the drinking water supply system, and the safety of the drinking water supply. Surveillance involves audits of the WSP, including a review of the results of routine monitoring that is conducted by the water provider. It may also involve direct assessment of the water supply by the drinking water regulator through routine sampling and testing.

Indicators under water quality surveillance and the location and frequency of water sampling will be specified in the monitoring plan and will depend on the characteristics and risks associated with the individual water supply system. The Guidelines for Drinking Water Quality[19] advises on factors to consider when designing a sampling strategy for the water supply system. Sampling should be intensified during high-risk periods such as during floods, following interruptions to the supply and during repair work.

E. coli is typically monitored to verify the microbial quality of drinking water. E. coli does not usually constitute a danger to human health, but indicates the presence of faecal pollution and therefore of the potential presence of enteric pathogens. Its absence in drinking water does not completely verify the safety of the water. For instance, enteric viruses and protozoa are more resistant to disinfection and may still be present in water, even in the absence of *E. coli.* Where the water supply is at risk of contamination with these organisms, more resistant indicators such as bacteriophages or bacterial spores may be monitored in addition to E. coli. Similarly, environmental pathogens such as *Legionella* may still be present in the water, even in the absence of *E. coli*.

Detailed guidelines on monitoring of building water systems for *Legionella* are also available[23,37]. Depending on the building water system, this can include the monthly monitoring of heterotrophic colony counts and the biannual monitoring of *Legionella* in the source water and at the water outlet. Trends in colony counts are monitored as an indicator of the safety of the system. Heterotrophic plate counts (HPC) is the parameter for general bacteriological quality of drinking-water and is not directly related to *Legionella pneumophila* or other opportunistic pathogens. Meeting the HPC standard is not sufficiently protective against *Legionella pneumophila* and other opportunistic pathogens.

Monitoring water quality indicators will provide early warning that the water may not be safe and may trigger corrective action to prevent the supply of unsafe water.

The triggers and corrective actions can be defined in an incident management plan. Such plans have a range of alert levels. Certain alert levels may require notification of the health authorities if the incident is likely to lead to human cases of disease.

Establishing links and good collaboration between water providers and national public health agencies

5.1: Use of environmental indicators in WRID surveillance

Establish mechanisms to report events to the health department
Indicators that are routinely monitored can be incorporated into WRID surveillance. For instance, water supply incident alerts could be reported to the public health agency as part of event-based surveillance. The public health agency could then investigate whether this breach is correlated with an increase in human cases of gastrointestinal illness or another health-related outcome under surveillance.

List possible examples that could be included as events to be reported –

Table 6: Use of microbial and physicochemical indicators in environmental monitoring of different stages of the water supply system

Purpose of monitoring	**Microbial Indicators**	**Physicochemical Indicators**
Sanitary survey of the water catchment	Escherichia coli, Enteric viruses, Giardia cysts, cryptosporidium oocysts *Alternatives* Thermotolerant coliforms, Faecal streptococci (enterococci), Somatic coliophages, F specific RNA phages, Bacteroides phages, Clostridium perfringens	Rainfall events, Flow, Solids (total and dissolved), Conductivity, Turbidity, Organic matter (TOC, BOD, COD), Ammonia
Source water characterisation	Escherichia coli, Enteric viruses, Giardia cysts, cryptosporidium oocysts *Alternatives* Thermotolerant coliforms, Faecal streptococci (enterococci), Somatic coliophages, F specific RNA phages, Bacteroides phages, Clostridium perfringens	Flow, Solids (total and dissolved), Conductivity, Turbidity, Organic matter (TOC, BOD, COD), Ammonia
Groundwater characterisation	Escherichia coli, Enteric viruses *Alternatives* Thermotolerant coliforms, Somatic coliophages, F specific RNA phages, Bacteroides phages, Clostridium perfringens, Giardia cysts, cryptosporidium oocysts	Solids (total and dissolved), Conductivity, Turbidity, Microscopic particulate analysis Organic matter (TOC, BOD, COD), Ammonia
Treatment efficiency (removal)	Escherichia coli, Heterotrophic bacteria, Aerobic spore forming bacteria, Giardia cysts, cryptosporidium oocysts *Alternatives* Total bacteria (microscopic), Viable bacteria (microscopic), Clostridium perfringens	Turbidity, Particle size analysis

Treatment efficiency (disinfection)	Escherichia coli, Heterotrophic bacteria, Aerobic spore forming bacteria *Alternatives* Total coliforms, Thermotolerant coliforms, Total bacteria (microscopic), Viable bacteria (microscopic), Somatic coliophages, F specific RNA phages, Bacteroides phages	Flow, PH, Disinfectant residual
Treated water	Total coliforms *Alternatives* Thermotolerant coliforms, Escherichia coli	Flow, Colour, Disinfectant residual
Distribution system (ingress)	Escherichia coli, Heterotrophic bacteria *Alternatives* Total coliforms, Thermotolerant coliforms, Total bacteria (microscopic), Viable bacteria (microscopic)	Disinfectant residual
Distribution system (regrowth)	Total coliforms, Escherichia coli, Thermotolerant coliforms, Total bacteria (microscopic) Viable bacteria (microscopic), Heterotrophic bacteria, Pseudomonas, Aeromonas	Flow, Organic matter (TOC, BOD, COD)
Outbreak investigation	Total coliforms, Thermotolerant coliforms, Escherichia coli, Faecal streptococci (enterococci), Total bacteria (microscopic), Viable bacteria (microscopic), Heterotrophic bacteria, Aerobic spore-forming bacteria, Somatic coliphages, F specific RNA phages, Bacteroides phages, Sulphite-reducing clostridia, Clostridium perfringens, Enteric viruses, Giardia cysts, Cryptosporidium oocysts	Rainfall events, Flow, Colour, pH, Solids (total and dissolved), Conductivity Turbidity, Particle size analysis, Microscopic particulate analysis, Disinfectant residual, Organic matter (TOC, BOD, COD), Ammonia

TIP

- ✓ *The alert levels requiring engagement of the health authorities, and the nature of that engagement can be defined in the incident management plan for the water supply system.*
- ✓ *Continuously monitored drinking water indicators can be analysed alongside disease surveillance data, such as syndromic surveillance data on gastrointestinal illness, using time-series analysis, to determine the degree to which they are correlated.*

6.0: Approaches to WRID surveillance data analyses

WRID surveillance data should be analysed by time, person and place on a continuous basis. Most surveillance data will be analysed using descriptive methods. Target the analyses to address specific surveillance objectives and the surveillance questions associated with those objectives. Table 7 presents common types of analyses of WRID surveillance data and the surveillance questions that these analyses may address.

Table 7: Surveillance analyses to address specific surveillance objectives

Types of analyses	Surveillance objectives addressed by the analyses
Analysis by time	
Table of total number of cases and incidence or prevalence rate for specific notifiable diseases, laboratory confirmed cases or syndromes (such as diarrhoea) compared across different time periods (last 5 years, this quarter compared to last quarter, this week compared to last 2 weeks, this time-period compared to the same time period last year). Can also present cumulative number of cases.	Identify temporal trends Detect possible outbreaks Estimate disease burden
Line graph of incidence over time. Comparison of the line-graph for the current year, with previous years	Identify temporal trends Assess whether the incidence is increasing or decreasing Detect possible outbreaks Identify seasonality.
Bar-chart of the number of stool specimens submitted for laboratory analysis over time (for instance by week) and the number positive for a specific enteric pathogen. Can overlay with a line-graph of the % positive for that pathogen	Detect possible outbreaks
Line graph of long-term secular trends of the incidence (or number of cases) for specific notifiable diseases, laboratory confirmed cases or syndromes (such as diarrhoea)	Identify temporal trends Assess the effectiveness of control measures
Analysis by person	
Table of total number of cases and incidence or prevalence rate for specific notifiable diseases, laboratory confirmed cases or syndromes (such as diarrhoea) by age and sex	Identify groups who are at higher risk of WRID Target control and prevention measures to specific populations
Bar-chart of total number of cases and incidence or prevalence rate for specific notifiable diseases, laboratory confirmed cases or syndromes (such as diarrhoea) by age and sex	Identify groups who are at higher risk of WRID Target control and prevention measures to specific populations
Analysis by place	
Table or map of the number of cases or the incidence rate by geographical area.	Detect possible outbreaks or clusters of cases

	Identify communities who are at higher risk of WRID Target control and prevention measures to specific areas Identify areas of the water system to target with resources
Use of geographic information systems (GIS) to combine different types of information about a place. For instance, data on the water distribution system can be over-layed with data on the occurrence of cases of enteric pathogens, or gastrointestinal illness.	Detect possible outbreaks or clusters of cases Identify communities who are at higher risk of WRID Target control and prevention measures to specific areas Identify areas of the water system to target with resources
Analysis by time and place	
Series of maps highlighting disease incidence in different time-periods by place. For instance, a series of maps of the incidence of cryptosporidium by district for the past five years.	Identify temporal and spatial trends Identify communities who are at higher risk of WRID Target control and prevention measures to specific areas Identify areas of the water system to target with resources
Analysis by person, time and place	
Series of maps highlighting disease incidence in different populations (age-groups or sex) over different time-periods by place. For instance, a series of maps of the incidence of cryptosporidium in males by district for the past five years.	Identify temporal and spatial trends among sub-groups of the population Identify populations who are at higher risk of WRID Target control and prevention measures to specific populations in specific areas.
Laboratory data	
Table of number and percentage of laboratory confirmed cases of enteric pathogens by year	Identify temporal trends Estimate disease burden Identify new, emerging or re-emerging pathogens Identify what pathogens are being transmitted by water
Table of number and percentage of laboratory confirmed cases of specific sub-types or variants of specific enteric pathogens by year	Identify temporal trends Estimate disease burden Identify new, emerging or re-emerging pathogens Identify what pathogens are being transmitted by water

The calculation of incidence rates requires denominator data, which may not always be easily available. General population data are frequently used, which are often derived from census data.

6.1: Time series analyses

Time series analysis uses regression methods to analyse trends in water-related disease over time, to identify possible outbreaks based on aberrations in these trends, and to identify seasonality in disease occurrence[38,39]. It is also a very useful way to link water quality data or other drivers of WRID with disease occurrence. For instance, several studies have summarised water quality data on turbidity and case counts of AGI within small time periods (usually daily), and correlated these data over time, in order to estimate the incidence of AGI across different turbidity levels[39,40].

A limitation of routine surveillance of enteric pathogens and gastrointestinal illness is that it is difficult to determine a causal link between the occurrence of these diseases and water quality issues. Time-series analyses can therefore generate evidence to support such a link. Other water quality indicators, and other explanatory variables such as meteorological data can also be modelled using time-series analyses.

Time series analyses can utilise many different sources of surveillance data including syndromic surveillance data on AGI, notifiable disease surveillance data based on ICD-10 codes, physician diagnosis or laboratory confirmation, prescription data, and calls to medical helplines[40], as well as water quality data[39,40,41] and meteorological data[42]. Some methods require five-year's worth of baseline data, which can either be collected retrospectively when the surveillance system is established, or gathered prospectively during the first years of surveillance. It may be possible to calculate thresholds based on rapid increases in disease incidence, which can be used as alerts to identify the presence of an outbreak.

A detailed explanation of the time-series methods is beyond the scope of this document, although these methods have been described elsewhere[38,40,43]. Many time-series models are freely available, and the performance of these models has been evaluated and discussed elsewhere[44].

6.2: Spatial Analyses

Spatial analyses use GIS to map the distribution of cases and other surveillance indicators such as complaints to water companies. They can also be used to map disease incidence and the intensity of epidemics. In order to do this, a geographical marker, such as the residential postcode of the case, or the location of the reporting medical facility will need to be collected as part of surveillance. Spatial analyses are discussed in detail in sections 11.5.2 and 11.6.5, where their application to outbreak investigation is described. Many of these described techniques can also be applied to surveillance data.

TIP

- ✓ *Time-series analyses can also be used for forecasting the future trajectory of a disease or an outbreak and so can be a useful way to prioritise areas for public health action.*
- ✓ *Seek specialist statistical expertise when setting up time-series analyses for the analysis of WRID surveillance data.*

7.0: Strengthening surveillance of WRID through national policy action

The Protocol on Water and Health requires that Parties to the Protocol must establish and publish national and local targets for the reduction of outbreaks and incidents of water-related disease.

These must be supported by a legal and institutional framework. Parties are required to prepare national and local plans for response to outbreaks, incidents and risks, as well as surveillance and early-warning systems for water-related disease. Progress towards achieving these targets must be evaluated. Parties are also required to assess the degree to which the achievement of these targets has prevented, controlled and reduced water-related disease.

WHO Regional Office for Europe and the United Nations Economic Commission for Europe (UNECE) have published guidelines on target setting and evaluation[45]. Targets should be set and published at the national and local levels. The guideline describes an overall framework for target setting which includes:

1. Identification of key stakeholders and establishment of a coordination mechanism
    - The setting of targets relating to the reduction of outbreaks and cases of water-related disease should be led by the Ministry of Health, in collaboration with other stakeholders responsible for implementation of the protocol
    - Define the terms of reference of the coordination mechanism, identify who to involve and define their roles and responsibilities
    - Implementation of some targets may take years to achieve and so ongoing institutional support, as well as human and financial resources will be required
    - Define the agenda, work plan and resources needed to achieve the target

2. Undertake a baseline analysis of the current situation relating to the incidence of cases and outbreaks of WRID and use this to identify priority areas for target setting. This can be similar to the situational analysis described in section 3.1, and can include:
    - The current legislative and institutional framework
    - Current systems for disease surveillance, early-warning, outbreak detection and response, including the current list of indicators under surveillance
    - National and local contingency plans for responses to WRID outbreaks, incidents and risks
    - Current capacity of the relevant public authorities for preparedness and response to WRID outbreaks, incidents or risks
    - Current data sources, including the data flow, quality of the data from these sources
    - Available data from surveillance, multiple indicator cluster surveys and demographic and health surveys

Aggregated data such as national averages can mask specific problems, such as locally occurring problems. In order to address this, make sure to investigate disaggregated data and to include expert knowledge from the sub-national and local levels.

3. Identify the priority areas, such as priority diseases for surveillance, priority issues related to outbreak detection and response, including any gaps, that will need to be addressed in order to achieve the targets
4. Agree draft targets (Table 8) and associated quantitative and qualitative indicators to monitor progress in achieving those targets.

Table 8: Sample draft targets for the reduction of the scale of outbreaks and incidents of water-related disease

Sample targets
1. By 2020 a 50% reduction in the occurrence of the following waterborne diseases compared to 2010: typhoid fever, bacillary dysentery, viral hepatitis, diarrhoeal diseases and parasitic diseases
2. Strengthen national capacity for the surveillance of cryptosporidiosis and giardia by extending laboratory and notifiable disease surveillance to include these diseases
3. Development and implementation of a national protocol for the epidemiological investigation and management of waterborne outbreaks
4. Strengthen laboratory capacity for detection of water-related disease outbreaks by providing them with equipment and training
5. Five-yearly report on detected water-related disease outbreaks in the country

[Adapted from collection of good practices and lessons learned on target setting and reporting under the Protocol on Water and Health, UNECE 2016[46]]

Consider the time-required to achieve each target and differentiate between what can be achieved in the short, medium and long-term, as well as the resources and capacity required to achieve those targets. Ensure the targets are specific, measurable, achievable, relevant and time-bound (SMART).

5. Consult with relevant stakeholders, professional groups and the public on the proposed targets, target dates and programme of measures. Make the targets and the associated programme of work publicly available.
6. Finalise, publish and adopt the targets and communicate these to stakeholders and the public, accounting for the results of the public consultation.
7. Develop and implement a programme (including indicators) to monitor progress in achieving the targets in accordance with the agreed time-frame.

Once targets have been adopted, progress towards achieving those targets must be assessed and reported to the Meeting of the Parties to the Protocol. For further information on how to review and report progress, refer to the joint WHO/UNECE documents "Collection of good practices and lessons learned on target setting and reporting under the protocol on Water and Health"[46] and "Guidelines for the setting of targets, evaluation of progress and reporting"[45].

SURVEILLANCE OF WATER-RELATED INFECTIOUS DISEASE

Parties are recommended to:

1. Take preventive action to avoid outbreaks and incidents of water-related disease and to protect water resources used as sources of drinking water because such action can be more cost-effective than remedial action
2. Systematically gather data on suspected outbreaks form a wide range of formal and informal sources
3. Collect real time data on outbreaks of cholera, shigellosis, EHEC, viral hepatitis A and typhoid fever, including data on the total number of outbreaks and affected persons.
4. If possible, emerging infections such as camplyobacteriosis, cryptosporidiosis, giardiasis, legionellosis and acute gastroenteritis of unknown but suspected infectious origin should also be monitored.

Examples of national targets set by Parties to the Protocol are detailed in Table 9. Some countries set time-bound targets for a number of outcomes including the reduction or elimination of specific WRID or the strengthening of surveillance capacity. These targets and target dates may be revised following review or in response to the speed at which progress is made.

Table 9: National targets relating to the reduction of outbreaks and incidents of water-related disease

<table>
<tr><th>Country</th><th>Time-bound targets</th><th>Planned due date</th></tr>
<tr><td>Finland</td><td>The number of persons falling ill in water-related epidemics shall be reduced to an annual level of 0.01% of the population at most</td><td>31 December 2015</td></tr>
<tr><td>Moldova</td><td>An “Integrated information system of the State Supervision over Non-infectious Diseases” in place
Maintain a zero level of incidence of cholera and typhoid
Reduce the incidence of viral hepatitis A and dysentery by 20%</td><td>2014

2020
2020</td></tr>
<tr><td>Switzerland</td><td>Develop a reporting system for incidents and outbreaks of disease cause by water, in collaboration with the reporting systems for infectious diseases</td><td>1.1.2022</td></tr>
<tr><td>Ukraine</td><td>Reduction of morbidity rates of diseases: cholera, dysentery cocci, bacillary (shigellosis), acute intestinal infection caused by enterohemorrhagic Escherichia coli (EHEC), hepatitis A, typhoid fever, aqueous nitrate methemoglobinemia related to the poor use of drinking water quality
<table>
<tr><th></th><th colspan="2">Number of cases / 100,000 persons</th></tr>
<tr><th></th><th>2015</th><th>2020</th></tr>
<tr><td>Cholera</td><td>0</td><td>0</td></tr>
<tr><td>Shigellosis</td><td>2500</td><td>2000</td></tr>
<tr><td>EHEC</td><td>100</td><td>80</td></tr>
<tr><td>Viral hepatitis A</td><td>2500</td><td>2000</td></tr>
<tr><td>Typhoid fever</td><td>0</td><td>0</td></tr>
<tr><td>Aqueous nitrate Methaemoglobinaemia</td><td>0</td><td>0</td></tr>
</table></td><td>2015 & 2020</td></tr>
</table>

TIP

- ✓ *Targets should address those diseases that pose the greatest risk to public health and that will optimise the efficient and sustainable use of available resources.*
- ✓ *Parties to the Protocol are required under Article 4 to create stable legal frameworks which facilitate contributions from the public, private and voluntary sectors to improve water management in order to prevent, control and reduce WRID.*
- ✓ *In order to set and monitor targets countries will need an adequately financed legally mandated WRID surveillance system, reliable information on water quality from community water supplies, public health agencies that are authorised to request information from water-providers and to take action during outbreak investigations and adequate laboratory and human resources to investigate outbreaks*

8.0: Surveillance in emergencies

Certain situations may necessitate the enhancement of surveillance activities for WRID. These situations may include public health events requiring notification under the IHR, including:

1. Detection of cases of that have the capacity to cause a serious public health impact and to spread internationally, such as cholera
2. Events of potential international public health concern, including those of unknown causes or sources, where the public health impact is serious, where the case is unusual or unexpected and where there is a risk of international spread.

This could include the spread of pathogens through public water supplies, where there is a risk to a population or large geographical area, or events associated with environmental contamination that could spread across borders. Cases with a history of international travel may be suggestive of international spread of a disease. A common example of this is legionellosis which is frequently reported to be travel associated, and which necessitates international notification to ensure the implementation of control measures in the country of infection[47].

It is important that all countries have developed and adequately invest in their core surveillance, laboratory and response capacities for such public health events, as required under the IHR[48]. For instance, countries are recommended to strengthen their event-based surveillance capacity for outbreak detection, their infection control capacity for outbreak response and the coordination of their delivery systems for public health and clinical care during emergencies. Improved collaboration with the private sector, local healthcare providers, local communities and civil society is also recommended as these stakeholders can play a valuable role in surveillance, logistics and community mobilisation. A stable, well-trained, adequately sized and stable workforce of among others epidemiologists, clinicians, public health specialists, laboratory specialists, health information specialists, communication experts and social science specialists is needed[48].

TIP

- ✓ *Surveillance may be enhanced when there is an increased risk of WRID, such as during extreme climatic events such as flooding or heatwaves.*
- ✓ *Enhancement of surveillance activities may include increasing the frequency of reporting from the surveillance system, asking health care facilities to actively report cases or enhancing event-based surveillance activities through monitoring of social media or rumours.*

PART 2: MANAGEMENT OF OUTBREAKS OF WATER-RELATED INFECTIOUS DISEASE

Executive summary

To be added.

Part 2: Management of outbreaks of WRID

This section provides an overview of the steps involved in investigating, responding to and managing outbreaks of WRID. The approach to outbreak investigation described here is broadly similar to that described elsewhere[28,29,30,52,50]. It highlights some of the specific considerations related to the management of waterborne outbreaks associated with drinking water supply systems. Additional information on the investigation of legionella outbreaks associated with environmental exposures is documented in Annex X.

This section is targeted towards all those involved in the management of outbreaks of WRID, in particular public health and environmental health professionals, water providers and risk communicators.

9.0: Introduction to outbreaks

Outbreaks may be defined in a number of different ways[29,30] including:

1. An unexpected increase in the number of cases of disease or another health outcome beyond what is expected in a particular group of people or in a particular place, during a specific time.
2. Two or more cases of disease among persons linked to the same source
3. An exceedance of a predefined alert threshold (as discussed in section 4.0).

The World Health Organisation defines an outbreak of waterborne disease as "a situation in which at least two people experience a similar illness after exposure to water and the evidence suggests a probable water source"[49].

Outbreaks are investigated if:

- The outbreak is likely to continue and/or spread without intervention to stop it
- The source of the outbreak is unknown
- The cause of the outbreak is unknown
- The disease is severe and/or unusual
- There are a large number of cases

Outbreaks may also be investigated if

- Controlling the outbreak addresses existing public health programme requirements such as disease elimination targets
- There is public or political expectation of a formal response or if there is a legal requirement to do so.
- As a training opportunity or as an opportunity to conduct research.

When the causative agent and source can be readily identified without the need for epidemiological and other supporting investigations, and when the outbreak has already been brought under control, a full investigation may not be required. For WRID outbreaks, the root cause of the outbreak will ideally always be investigated, and preventative measures taken to avert future outbreaks. The available resources for outbreak investigation, the characteristics of the outbreak and the local context will inform the extent of the investigation.

Typically, the main objectives of outbreak management are to:

- Confirm the outbreak
- Identify the source of the outbreak
- Implement control measures

in order to prevent further cases and to control the spread of the outbreak.

Depending on the size and complexity of the outbreak, considerable effort may need to be invested in the overall process of managing the outbreak.

10.0: Preparedness planning

The occurrence of WRID outbreaks can be unpredictable, sudden and of a scale that can overwhelm the capacity of the public health system. The potential health, social, economic and political impact is such that a rapid and coordinated response involving multiple agencies, working together under highly stressful conditions may be required. Advance preparedness planning is critical to enable a rapid, coordinated, effective, multi-sectoral response. Preparedness planning involves ensuring that functioning systems are in place, that appropriate persons are engaged and trained, and that both supplies and medicines are available to enable a rapid response in the right place at the right time.

Emergency preparedness and response planning is a key activity under the implementation of the Protocol (Article 8) and of the IHR. Ideally preparedness planning for WRID outbreaks will be conducted within the broader process of national preparedness and response planning for public health emergencies.

This chapter is informed by the following sources:

- World Health Organization, Regional Office for Europe (2011). Technical guidance on water-related disease surveillance [ref]
- US CDC. A national strategic plan for public health preparedness and response, September 2011 [ref]
- Preparedness, Emergency Response, and Recovery Critical Infrastructure Partnership Advisory Council (CIPAC) Working Group. All Hazard Consequence Management Planning for the Water Sector. November 2009 [ref].
- Washington State Department of Health, Environmental Public Health Office of Drinking Water. Emergency Response Planning Guide for Public Drinking Water Systems. January 2017 [ref].

Within the context of WRID outbreaks, emergency preparedness and response planning would ideally encompass both a public health response to contain the spread of an outbreak, and an incident management response to secure access to a safe water supply.

10.1: Considerations in preparedness planning

WRID outbreak detection and response primarily occurs at the local level. Given this, national authorities are encouraged to support local authorities in developing preparedness plans for the management of WRID outbreaks. Existing local emergency preparedness plans could be expanded to include WRID preparedness planning. The following factors could be considered when developing emergency preparedness and response plans for WRID outbreaks.

- Identify and appoint members of the national and local outbreak management team. Ideally identify in advance those persons who could be called on to support an outbreak response and start building relationships with them. The membership of the OMT is discussed in section 10.0 and 11.1.3. At the preparedness stage this could include:
  - Representatives from the national, regional and district level of the national public health agency
  - Representatives from other government agencies such as the Ministry of the Environment, or the Ministry of Water Resources or the Ministry of Agriculture
  - Municipal authorities, water providers and utility companies
  - Laboratory specialists
  - Environmental engineers or environmental health officers
  - Specialists in risk communication

  Maintain an up-to date list of the names and contact details of the OMT members, including back-up persons for each role if the primary member is unavailable. Agree the roles and responsibilities of each member of the OMT and the chain of command

- In the event of an outbreak ensure that you will have rapid access to information about the water system, such as:
  - Monitoring and maintenance records;
  - Water supply surveillance data
  - Plans, descriptions and maps of the entire water supply system,
  - GPS locations of key infrastructure that may impact the water system (such as wastewater systems or recreational sites

  Detailed information on the water supply system is usually available in the WSP. It is particularly useful to know i) the system vulnerabilities, hazards and risks and their associated consequences, and ii) an estimate of the supply needed to meet the average daily demand.

- Formally agree the procedures for the reporting and sharing of information and data between different agencies and stakeholders involved in the response Ensure these procedures are formally adopted through an appropriate legal framework such as a memorandum of understanding or other such agreement. Develop protocols and notification flow charts describing these procedures

- Develop procedures, toolkits and templates for outbreak management and emergency response
  - Develop and agree procedures for responding to WRID outbreaks (such as those outlined in section 11.0)
  - Develop toolkits to support the response. Such toolkits can include template outbreak protocols, line-listings, case investigation forms and other tools that can be rapidly adapted for use in an outbreak. Template line listings, case investigation forms and other tools for outbreak investigation are available [ref] and their use is described in section 11.0.

https://www.who.int/foodsafety/publications/foodborne_disease/surveillancemanual/en/
http://www.who.int/foodsafety/publications/foodborne_disease/outbreak_guidelines.pdf

- Provide training and exercises on outbreak response and emergency management
  - Regular training is important to keep members of the OMT engaged, and to maintain strong collaborative relationships between the members of the OMT and the different agencies and organisations involved in outbreak response. It is also essential to ensure that all parties are fully competent in the processes and procedures for outbreak response.
  - Train all members of the OMT on WRID outbreak response and emergency response procedures.
  - Conduct simulation exercises of different outbreak scenarios, to test emergency procedures and the coordination between the different agencies and parties involved in outbreak response.
  - Agree an ongoing programme of training with the OMT. Such trainings should be conducted regularly, for instance biannually and would ideally include simulation exercises.
  - Review the lessons learned from each training exercise and update preparedness plans as needed, and in accordance with those lessons learned.

- Strengthen laboratory capacity
  - Identify the laboratories (at local, national and international level) who will be responsible for the testing of clinical and environmental specimens and engage them in the emergency planning process.
  - Develop template laboratory investigation plans for use in outbreaks, agreeing in advance details such as the number of cases to test to confirm the cause of an outbreak, or the number and types of environmental specimens to collect for different types of WRID outbreaks.
  - Agree the process for referring specimens for testing at other laboratories, including a process for international referrals, especially where there is limited capacity at the local or national level
  - Ensure that these laboratories have all the necessary equipment, reagents and other consumables needed to provide testing in an outbreak, or that they can rapidly access these in the event of an outbreak.
  - Ensure that the laboratory personnel are trained on all analytical procedures and on procedures specific to outbreak response, such as ID allocation and reporting of results to the OMT.
  - In the event of a large outbreak, agree processes to provide surge capacity for laboratory testing, such as mobilising additional laboratory staff and materials from other institutions, sectors and agencies to support the response.

- Prepare contingency and control plans for public water supplies, such as plans for:
  - Advising the public to treat the water, usually by boiling it.
  - Advising the public to switch to a safe alternative source of water
  - Terminating the supply of tap water and replacing it with another source
  - Implementing alternative treatment of the water supply

- Identify in advance those critical customers such as hospitals who will need both a secure supply and the earliest restoration of service.

- Develop protocols for the provision of emergency water supplies. These may include accessing back-up water supplies, mutual aid agreements with neighbouring supplies, bulk supply using water tankers or the provision of bottled water. Ensure there are available resources to supply the minimum requirement of water.

- Develop a communication plan covering
  - A list of the key actors (agencies, institutions and stakeholders) and identify communication focal points for each agency involved in the response.
    - If an outbreak involves a large public water supply, the water provider should be included.
    - Appoint a communications lead and a deputy lead for the OMT
  - The processes for internal communication within agencies, such as the reporting procedures within the public health agency or MoH
  - The processes for communication between the different agencies, institutions and stakeholders involved in the outbreak response,
  - Procedures for communicating with the media and the public.
    - Ensure all communication leads and spokespersons receive media training
    - Develop a template communication plan that can be adapted for different outbreak and emergency scenarios. The plan should include pre-developed and approved advisories such a boil water notices, and predefined public health messages. Tailor these to different audiences. Engage stakeholders such as water providers and municipal authorities in the development of these messages.
    - Work to strengthen relationships with stakeholders, the media and the public to promote trust in the event of an outbreak.
    - Pre-test public health messages extensively in the community, especially in high-risk and hard-to-reach communities

10.2: Boil water notices

The WHO guidance for drinking water quality [ref] recommends that a protocol for the issuance of boil water notices be developed. This could include:

- The criteria and process for issuing and revoking notices. Boil water notices may be issued in the event of:
  - Considerable deterioration of the source water quality;
  - Treatment failures;
  - Breaches to the integrity of the distribution system;
  - Inadequate disinfection;
  - Detection of pathogens or faecal indicators in drinking water;
  - Evidence of an outbreak associated with the drinking water supply.

- The information to be provided to the general public and specific groups

- The mechanisms for the communication of boil water notices.

The Drinking Water Guidelines recommend that the notice include:

- A description of the problem,
- Possible health risks and symptoms,
- Activities that are affected, such as consumption, food preparation, bathing and laundry
- Current investigation and control measures
- The expected timescale to resolve the problem.
- Information that the water can be made safe by bringing it to a rolling boil and then allowing it to cool down on its own, without the addition of ice. This procedure is effective at all altitudes and can be used with turbid water.
- Information that un-boiled water cannot be used for drinking, preparing cold drinks, making ice, preparing or washing food or brushing teeth. Un-boiled water is usually safe for bathing and washing clothes unless it is heavily contaminated.

The notice may include specific advice for vulnerable groups such as pregnant women or the immunocompromised, as well as for health care facilities such as dentists, dialysis centres, inpatient and outpatient facilities, child care facilities, schools, the food industry and operators of public pools and spas.

Boil water notices can be revoked when:

- The safety of the drinking water supply has been secured by restoring the quality of the source water,
- Failures in the treatment or distribution systems or with disinfection process have been resolved,
- When there is evidence that microbial contamination has been removed or inactivated,
- When the epidemiological data suggests that the outbreak is over.

Information regarding the revocation of boil water notices are usually made using the same channels deployed to issue the notice.

The US CDC has developed a toolbox to support the issuance of boil water notices [ref] (https://www.cdc.gov/healthywater/emergency/dwa-comm-toolbox/index.html).

A basic template boil water notice is provided in annex x. This can be adapted by countries for use at the local level.

10.3: Revising and updating emergency response plans

After each outbreak, the response to the outbreak would ideally be evaluated, as discussed in section 11.10.3. Based on this review it may be necessary to update the emergency preparedness plan to reflect lessons learned from the outbreak.

In addition to this, preparedness plans will ideally be reviewed and updated on a periodic basis, for instance every five years.

11.0: Steps in outbreak management

The management response to an outbreak will vary from outbreak to outbreak and will reflect the size, complexity and potential public health, social, economic and political impact of that outbreak. The detection of an outbreak triggers a multifaceted response involving:

- The investigation of the outbreak,
- The implementation of control measures
- Ongoing communication to stakeholders and the public.

This guidance document uses the following 10 step approach for outbreak management:

1. Detect and confirm the existence of the outbreak and confirm the diagnosis
2. Form the outbreak response team
3. Define cases
4. Identify cases and obtain information
5. Conduct a descriptive epidemiological investigation (time, place, person)
6. Interview cases and generate hypotheses
7. Conduct additional studies and collect additional information (environmental, microbiological)
8. Evaluate the hypotheses
9. Inform risk managers and implement control measures (throughout response)
10. Communicate findings (throughout the response), make recommendations and evaluate the response

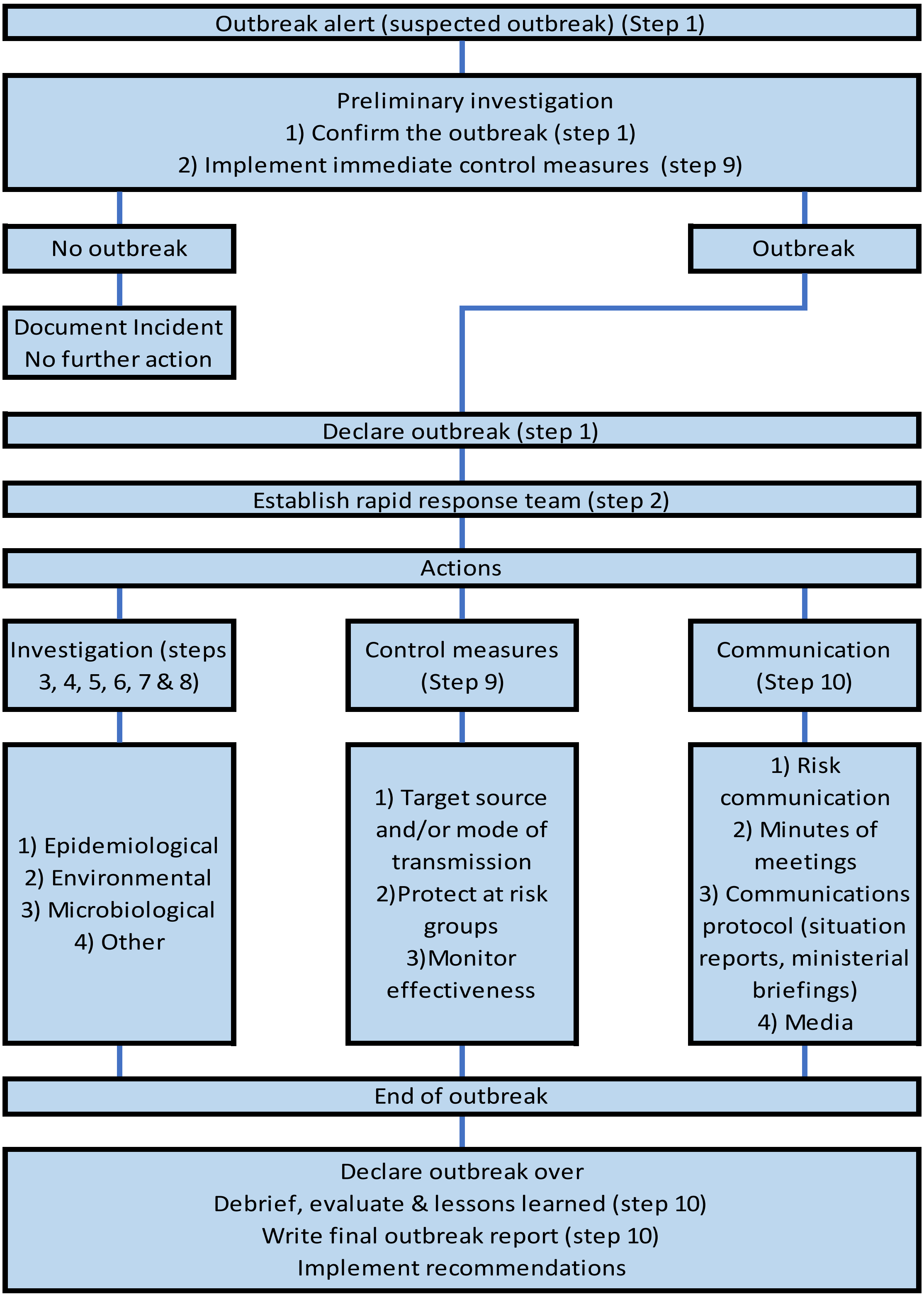
Outbreak management is not a linear process, rather these steps are conducted simultaneously and in parallel throughout the process (Figure 5). In particular, control measures are implemented as early as possible in the response, and as needed throughout the response, and communication is conducted on an ongoing basis.

The steps of outbreak investigation have been described in detail elsewhere. Consequently, this chapter provides only a brief overview of the general aspects on each step involved in managing an outbreak and highlights specific factors that are important in the investigation of WRID outbreaks. Each step is illustrated with a case study. For a further in-depth explanation of the steps, the following sources can be consulted:

- World Health Organization. (2008). Foodborne disease outbreaks : guidelines for investigation and control. Geneva : World Health Organization.[52]
- WHO | Strengthening surveillance of and response to foodborne diseases. *WHO* 2017. [27]
- Funari E, Kistemann T, Herbst S, Rechenburg A, editors. Technical guidance on water-related disease surveillance. World Health Organisation Regional Office for Europe, 2011[14]
- European Programme for Intervention Epidemiology training (EPIET) Field Epidemiology Manual Wiki, Lecture 03 - Outbreak Investigations
- The Centres for Disease Control and Prevention; Principles of Epidemiology | Lesson 6 [29]
- Public Health England, Communicable disease outbreak management: operational

guidance[50].

Figure 5: Overall process for the management of outbreaks (adapted from Public Health England. Communicable Disease Outbreak Management Operational Guideline. London: PHE; 2014[50])



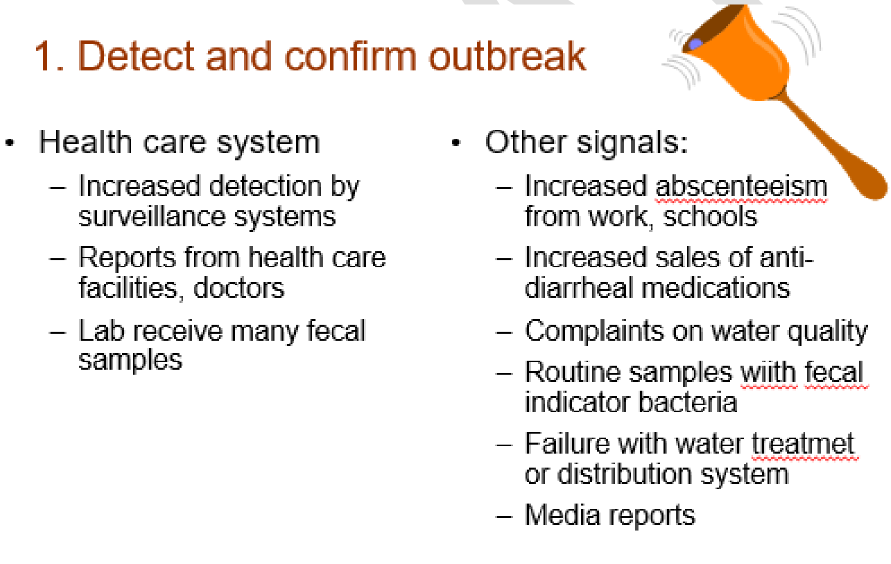
Step 1: Detect and confirm the existence of the outbreak and confirm the causative agent

Outbreaks can be detected in varying ways (Figure X), for instance as clusters of cases presenting to health facilities, an increase in cases reported through surveillance or an increase in customer complaints to the water provider. The health authorities will need to verify that the outbreak is real by conducting a preliminary investigation to assess whether cases are linked by person, place and time. They will also need to identify and confirm the pathogen that is causing illness among cases. This is done by characterising the clinical features of the illness and by taking additional specimens in order to isolate the causative agent in the outbreak.

Identifying the pathogen may help to

- Develop hypothesis about the source based on previous events and known reservoirs
- Identify the most likely time of exposure based on the incubation period
- Choose control measures to prevent secondary transmission from the cases

Figure x: Signals for WRID outbreak detection



Once the outbreak is confirmed, it is recommended to conduct a rapid risk assessment to assess whether there is an ongoing risk to public health. Detailed guidance on how to conduct a risk assessment is available[53] .

Based on the results of the rapid risk assessment, the relevant authorities may decide to take immediate action and to declare the outbreak.

Special considerations for WRID outbreaks:

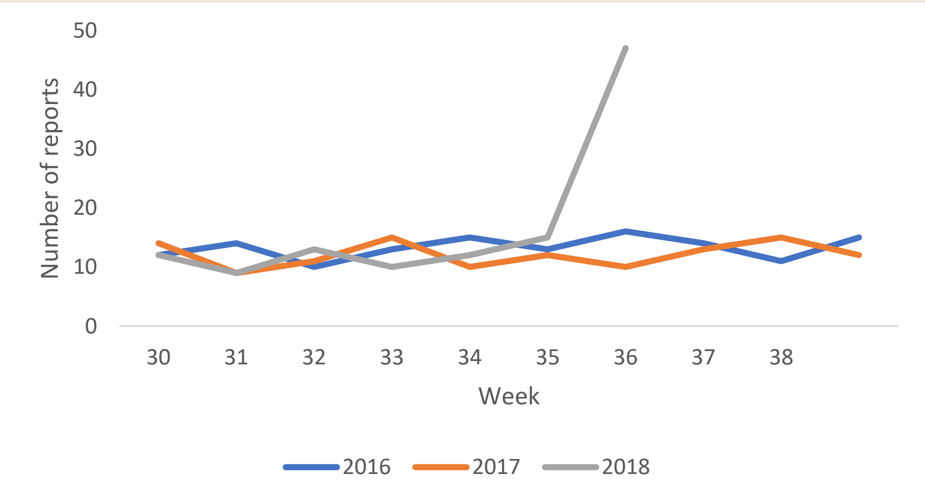
- If water is suspected as the source, speak to the water-provider to find out about any recent events relating to the water supply and check if other geographical areas are also experiencing an increase in cases.

- Decide on whether water and environmental specimens need to be collected. If so, decide on the sampling locations, number and types of samples to be located, the indicators to be tested, the sampling and testing methodology including the needed equipment and materials. For waterborne disease outbreaks, sample from drinking-water sources, water stored in households or other water sources to which cases were commonly exposed.
- Once the outbreak is confirmed, report to relevant stakeholders such as environment agencies, water providers and municipal authorities.
- Consider whether additional specialised laboratory analyses would help to strengthen the evidence of either the diagnosis or the link between cases and possible sources of the outbreak. Consider confirmatory testing in a reference laboratory; DNA, chemical or biological fingerprinting, or polymerase chain reaction (PCR).
- Even if an outbreak is detected, substantive amounts of time may have elapsed between the time when the water was contaminated and the outbreak is detected, especially for illnesses such as cryptosporidiosis, giardiasis and hepatitis A, which have lengthy incubation periods. Delays in outbreak detection can severely reduce the probability of detecting the causative agent in clinical and environmental specimens and may reduce the quality of data collected during the epidemiological and environmental investigations due to declining accuracy of recall on the events at the time of exposure and illness. Water and environmental samples from the time period under investigation may no longer be available.

Outbreak case study

On Wednesday September 12th (week 37), during routine analyses of surveillance data, the principal epidemiologist of the Food and Waterborne Disease (FWD) team of the National Public Health Agency (NPHA) notices a three-fold increase in the number of routine surveillance reports of AGI from the Mountain District of country X for week 36. The number of cases far exceeds that seen in previous years, even accounting for seasonality of infection. The number of cases exceeds the outbreak detection threshold for AGI.

Figure A: Reports of acute gastrointestinal illness, Mountain district, 2016, 2017 and 2018.



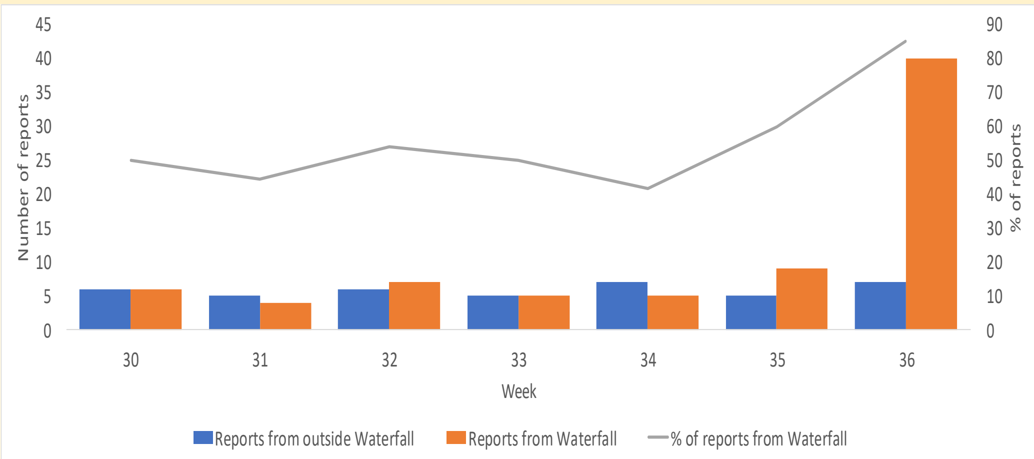
A preliminary analysis reveals that the majority of cases have been reported from the town of Waterfall. Waterfall, the municipal capital of the Mountain District, has a population of 136,000 persons.

The next day (Thursday September 13th) the epidemiologist interviews five cases, including two severely ill cases admitted to the university hospital. The epidemiologist arranges for stool specimens to be taken from all five cases and for these to be priority screened for a full range of enteric pathogens, including viruses and parasites. There are no obvious common exposures or direct link between the cases, such as eating at a particular restaurant or common place of work. Given the clustering of cases in time and place, as well as the common presentation of symptoms among cases, the epidemiologist suspects an outbreak of an enteric pathogen with either a food or water source.

There has been recent heavy rains and flooding in Mountain District (week 34). Given this, and the absence of a direct link between cases, the epidemiologist contacts the municipal water authority to ask if there have been any recent issues with the water system. They report an exceedance of acceptable turbidity levels in two samples taken from the distribution system of the municipal water supply in the western zone of the city on 21 and 23 August. These exceedances were below the alert threshold for reporting under the event-based surveillance system, however given their correlation with the increase in reported cases of AGI, both in time and place, the epidemiologist suspects that the municipal water supply could be a potential source of the outbreak.

Forty cases of AGI were reported from Waterfall in week 36 (Figure B), compared to nine cases in the previous week. Normally reports from Waterfall account for about half of all reports of AGI from the Mountain district. In week 36 they accounted for almost 90% of cases. There was also a slight increase in the number and percentage of reports from Waterfall in the previous week which may have coincided with the start of the outbreak. Syndromic surveillance data for week 37 are not yet available.

Figure B: Number and percentage of AGI reports from Waterfall compared to the rest of the Mountain district, weeks 30 to 36



Of the 12 cases for whom data are available, most report perfuse watery diarrhoea and abdominal cramping, with symptom onset from 27 August onwards.

The district epidemiologist conducts a rapid risk assessment to assess the likelihood of further transmission and the potential consequences to public health. The epidemiologist considers the risk to be high, declares the outbreak and notifies the district Director of Public Health, as well as the FWD team lead at the NPHA, and the municipal water authority.

Step 2: Form outbreak response team

Ideally, a multidisciplinary outbreak response team will be formed to provide the necessary expertise and human resources to investigate the outbreak and to provide a coordinated response.

Special considerations for WRID outbreaks:

- The management of WRID outbreaks often involves a multisectoral and interdisciplinary response, involving public and environmental health agencies, water providers and municipal authorities, as well as clinical, laboratory, epidemiological, environmental, engineering and communication experts among others.
- A multidisciplinary outbreak management team (OMT) will usually be formed and different stakeholders will play distinct and active roles in the investigation, response and management of the outbreak. For instance:
  - Public health agencies will usually lead the overall coordination of the investigation and response to the outbreak. Those working at the subnational level may lead if the outbreak is confined to a single district, while the national level may provide technical support if needed, especially for complex analyses such as analytical epidemiological studies or spatial analyses.
  - Food and water authorities or environment agencies will usually lead and coordinate the environmental investigation and the environmental control activities.
  - Water suppliers will play an active role in the implementation of control measures targeting the water system
  - Health care providers are responsible for identifying and reporting cases and will lead on case management and the implementation of health-related interventions such as vaccination
  - Laboratories support identification and reporting of cases and provide laboratory testing of clinical and environmental samples collected during the outbreak. Expert laboratories such as national reference laboratories may need to either undertake testing, if testing capacity for a particular pathogen is not available at the local level, or they be enlisted to confirm the findings of local laboratories.
- Coordinating activities across different agencies and stakeholders can be complicated, and usually necessitates clearly defining roles and responsibilities and procedures for engagement, as well as developing processes for clear communication and reporting. To support this, it is advisable to develop terms of reference to guide the actions of the OMT, an outbreak plan to guide the conduct of the investigation, a laboratory plan to guide human and environmental specimen collection and testing, and a communications plan.

Outbreak case study
On Friday September 14th, the District Director of Public Health convenes an outbreak management team.

The team meet and agree the objectives of the investigation and the roles and responsibilities of the team members. The OMT develop a plan for the investigation of the outbreak.

The OMT agree the following immediate actions:
1. Implement immediate control measures
2. Start active case finding (step 4) by:
- Enhancing surveillance for AGI by notifying all health facilities in the town and requesting that they report syndromic surveillance data on a daily basis until further notice
- Maintaining a line list of data on all cases of AGI reported from Waterfall in weeks 35 and 36 and until the outbreak is declared over
- Collecting additional epidemiological data on a subset of these cases in order to generate hypotheses on the cause and source of the outbreak

3. Undertake an environmental risk assessment and microbiological investigation of the town water supply (*step 6: additional studies*).

In accordance with emergency preparedness plans, the Director of Public Health and the water authority jointly issue a precautionary boil water notice which is disseminated via mainstream and social media (*step 9: implement control measures*).

Step 3: Define cases

In order to identify persons who are part of the outbreak, it is helpful to define criteria (person, place, time and clinical diagnosis) by which persons who are part of the outbreak can be classified as a case. Cases can be defined as suspect/possible, probable and confirmed.

Special considerations for WRID outbreaks

- For certain diseases such as cholera, standardized case definitions exist, which are detailed in international guidelines for the investigation of outbreaks associated with these diseases [ref].
- It is common to develop a number of case definitions with varying sensitivity and specificity, including definitions for suspect/possible, probable and confirmed cases, to allow for uncertainty in the clinical diagnosis and to provide flexibility, particularly if there is likely to be a delay in obtaining laboratory confirmation of the disease or if laboratory testing of all cases is not warranted.

Outbreak case study continued.

The causative agent of the outbreak is unknown and there is no clearly identifiable index case for the outbreak. There is insufficient information to define the exposure period. Consequently, at this early stage of the investigation, the OMT decides to include a long potential exposure period to maximise case ascertainment.

The OMT agrees the following preliminary possible case definition:

"A person who lives in the town of Waterfall, with diarrhoea (≥3 loose stools in 24 hours) and any one of the following symptoms: abdominal pain, nausea, vomiting, and date of onset of symptoms from 01 August 2018"

Step 4: Identify cases and obtain information

This step involves identifying as many cases affected by the outbreak as possible, in order to:

- Implement control measures to prevent cases, especially asymptomatic cases from further spreading the infection and further propagating the outbreak
- Facilitate the treatment of cases, especially for outbreaks of organisms that are difficult to diagnose but which have severe clinical sequelae
- Assess the size of the outbreak so that adequate resources can be deployed to control it and so that the cost and impact of the outbreak can be estimated.

Active case finding may involve searching for symptomatic people who meet the case definitions for the outbreak, or it may involve contact tracing of well contacts of known cases for testing, or for ongoing follow-up to see if they develop the disease.

Special considerations for WRID outbreaks

- Collect data on cases including clinical and risk factor data, as well as data on their demographic characteristics. For waterborne outbreaks it is especially important to collect geographical data on possible places of exposure to different water sources, such as place of residence, work or study.
- If the causative agent is known, then the questionnaire can include (but not be limited to) exposures and risk factors known to be associated with that particular pathogen.
- The known incubation period for a particular pathogen will enable a likely period of exposure to be calculated. The questionnaire can focus on that exposure period.
- If the causative agent is unknown, but the clinical presentation indicates a short incubation period then the questionnaire can focus on exposures during the 72 hours prior to onset of illness.
- A phone survey of a random sample of the population in different water supply areas can be a quick way to identify cases and estimate attack rates
- Some waterborne pathogens are also easily spread by person-to-person transmission. Consequently, secondary cases, who have been infected by contact with a primary case, rather than with the contaminated water source, are common. These secondary outbreaks can complicate both the containment of the outbreak and the epidemiological investigation. The control measures needed for a secondary outbreak may differ to the primary outbreak.

Cryptosporidium case study continued.
On Saturday September 15th, the district epidemiologist visits all the health facilities in Waterfall that reported cases of AGI in weeks 35 and 36 to collect line list data on the outstanding reported cases. The earliest identified possible case dates from August 27th.

On Sunday September 16th, the regional laboratory confirms that two of the five initially tested cases have tested positive for *Cryptosporidium parvum*. The other three specimens are inconclusive.

Cryptosporidium is a parasitic infection that causes profuse watery diarrhoea. Diarrhoea is associated with cramping and abdominal pain. Transmission is by faecal-oral spread and may include person-to-person transmission, as well as water and foodborne transmission. Cryptosporidium has been associated with a number of large outbreaks in public water supplies. The exact incubation period is unknown but is considered to average seven days and to range from one to twelve days. Oocysts can be shed in stools for several weeks after symptoms resolve and may remain infective in water for two to six months.

The OMT requests that the laboratory characterises the specimens to assess if they are genetically identical (*step 6: additional studies*).

In light of the laboratory data, the OMT considers that cryptosporidium is likely to be the cause of the outbreak. The OMT enhances cryptosporidium laboratory surveillance by requesting that all specimens routinely collected from AGI cases in Waterfall be tested for cryptosporidium until further notice and that the laboratory start daily reporting of cryptosporidium cases (*step 4: active case finding*).

The OMT requests that samples taken as part of the microbiological investigation of the water system be tested for cryptosporidium. The investigators will also endeavour to take specimens from the homes of those interviewed during the epidemiological investigation, such as bottled water and ice specimens for microbiological investigation.

The OMT updates the case definitions for the outbreak (step 3):

Probable case: A person who lives in the town of Waterfall, with diarrhoea (≥3 loose stools in 24 hours) and any one of the following symptoms: abdominal pain, nausea, vomiting, anorexia, and date of onset of symptoms from 15 August 2018

Confirmed case: A person who lives in the town of Waterfall, with laboratory confirmed cryptosporidiosis and onset of symptoms from 15 August 2018.

Step 5: Conduct a descriptive epidemiological investigation (time, place, person)

Data collected during the outbreak should be analysed by time, place and person, as soon as possible after the outbreak is reported, and on an ongoing basis throughout the investigation as more data becomes available. Data are analysed in order to:

- Describe the outbreak in relation to the affected population (person), the geographic distribution of the outbreak (place) and the duration and temporal characteristics of the outbreak (time)

- Identify the population at risk of infection
- Estimate when the initial exposure to the causative pathogen occurred
- Generate and verify hypotheses on the possible source, aetiology and modes of transmission of the outbreak (by examining differences in exposures)
- Identify risk factors for disease and for severe disease
- Identify opportunities for the control of the outbreak

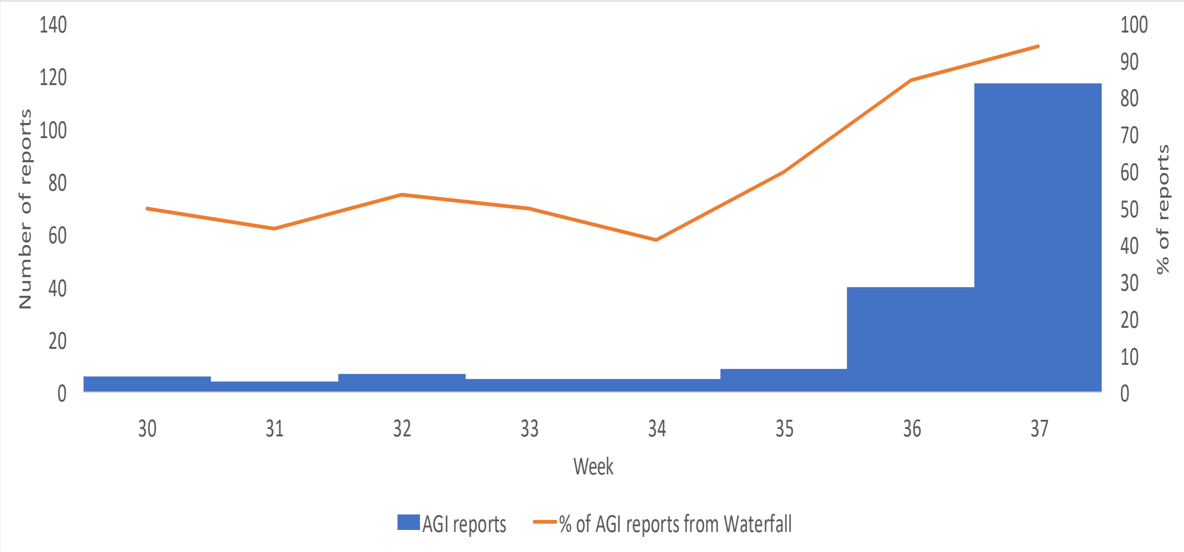
Special considerations for WRID outbreaks

- Exposure and outcome data reported during the epidemiological investigation can be biased and subject to misclassification. This is especially so if there is a time-gap between the time-period under investigation and the time of the investigation, if the outbreak is widely reported in the media, if outbreak control measures such as boil water notices lead to changes in water consumption patterns and if insufficient consideration has been given to asymptomatic infection. Furthermore, many people consume water from more than one source. For instance, the water source at their place of residence may differ from that at their place of work. This can limit the validity of the results of the epidemiological study.
- Calculate attack rates by exposure to particular water sources and by place. Map the distribution of cases to assess the geographical extent of the outbreak and to identify potential sources. A cluster of cases might suggest exposure to a particular local source such as a well, whereas widely dispersed cases might suggest a widely disseminated source such as a public water supply.
- Undertake spatial analyses using geographical information systems and computer modelling to visualise and explore the spatial distribution of cases in relation to suspect sources, to investigate clusters and to model the spatial dispersion of potential contaminants in a water system.
- The shape of the curve can indicate the type of source (single, continuous or intermittent point source) or the mode of transmission (person-to-person), the time-period of exposure to the causative agent, and the minimum, maximum and mean incubation periods for the disease. Common source outbreaks (with point, continuous or intermittent exposure) are most common for water-related outbreaks associated with water supply systems.
- The epidemic curve can indicate when the outbreak started and if it already has ended or is still ongoing. If the causative agent is known, use the epidemic curve to estimate the likely time-period of exposure and focus the environmental investigation on that time period. Assess if the epidemic curve correlates with events in the water supply system and implementation of control measures.
- Assess whether any cases secondary to the primary outbreak have occurred, as secondary infection by person-to-person transmission or transmission in food can also occur.

Outbreak case study continued.

By the end of week 37, a further 118 cases of AGI have been reported from Waterfall under the routine syndromic surveillance system (Figure C). Of these, 96 meet the probable case definition, and two are confirmed cases (Figure D). Due to media attention, there has been a surge in persons accessing health services with symptoms of AGI.

Figure C: Number and percentage of AGI reports from Waterfall weeks 30 to 37



The first identified case dates from 27 August and so the likely period of exposure is from the 15 to 26 August. The epidemic curve (Figure D) is characteristic of a continuous common source outbreak.

The percentage of cases is slightly higher in women and is highest in those aged 25 to 44 years, followed by those aged 15 to 25 years (Table B). All cases have diarrhoea (as per the case definition), and 80% of cases report abdominal pain. Nine percent of cases have been hospitalised.

Figure D: Probable and confirmed cases of cryptosporidium, Waterfall, by date of onset of symptoms, weeks 35, 36 and 37

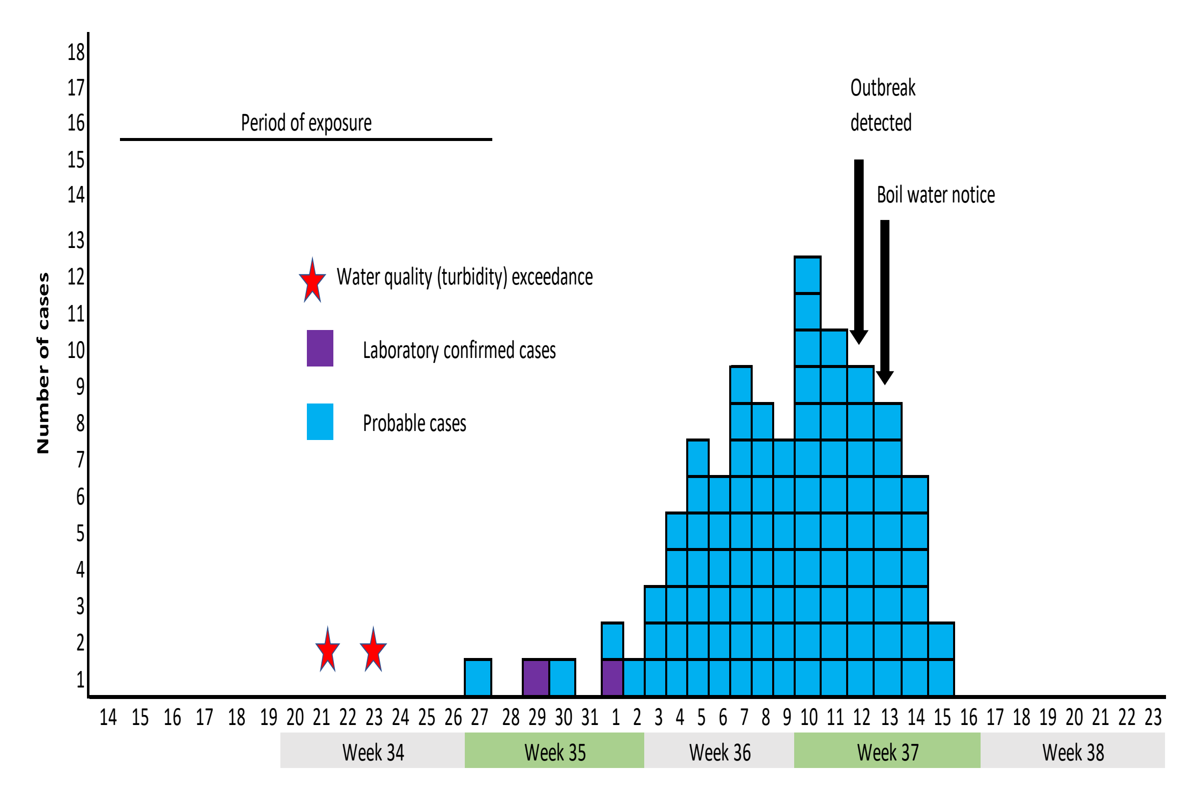
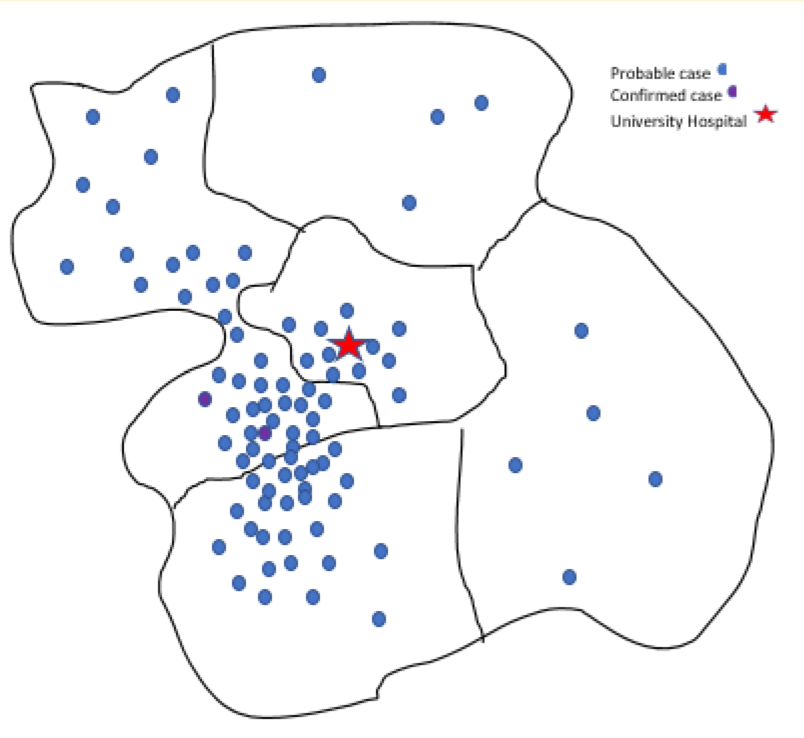


Table B: Characteristics of cases in an outbreak of Cryptosporidium, Waterfall, weeks 35-37

Characteristic		**Number (% of all cases)**
Case classification	Confirmed	2 (2%)
	Probable	96 (98%)
Sex	Female	52 (53%)
	Male	46 (47%)
Age-group	*0-4*	11 (11%)
	5-14	10 (10%)
	15-24	21 (22%)
	25-44	28 (29%)
	45-64	17 (17%)
	≥65	11 (11%)
Symptoms	*Diarrhoea*	98 (100%)
	Abdominal pain	78 (80%)
	Nausea	47 (48%)
	Vomiting	36 (37%)
	Anorexia	43 (44%)
	Hospitalised	14 (9%)

Waterfall is divided into five geographic zones; the city centre and a northern, southern, eastern and western zone. A dot map of cases (Figure E), reveals considerable clustering of cases in the Western and Southern Zone of the city.

Figure E: Map of probable & confirmed cases of cryptosporidiosis, Waterfall, weeks 35, 36 and 37.



Over 50% of all cases are resident in the Western zone, followed by almost 30% in the Southern zone and eleven percent in the city centre. Few cases have been reported from the Northern and Eastern Zones of the city. The attack rate in the Western Zone is 1.6 times higher than in the Southern zone, twice that in the City Centre, eight times that in the Eastern zone and 16 times that in the Northern zone. The Western and Southern zones are the most heavily affected by the outbreak.

Table C: Case distribution and Attack rate by residential zone

Residential zone	**Number of cases**	**% of cases**	**Total population**	**Attack rate (number of cases per 10000 residents)**
City Centre	11	11	13,750	8
Western zone	50	51	32,125	16
Southern zone	28	29	28540	10
Eastern Zone	5	5	24672	2
Northern Zone	4	4	36913	1

Step 6: Conduct additional studies and collect additional information (environmental, laboratory)

In parallel to the epidemiological and clinical laboratory investigations, the OMT will ideally immediately commence investigating any suspected sources of the outbreak or related vehicles of transmission through the conduct of environmental and microbiological investigations.

Based on the preliminary and descriptive epidemiological investigations, as well as the results of the laboratory and the clinical investigations, the OMT may already have identified or have a strong suspicion of the pathogen causing the outbreak, which will in turn inform on possible sources for the outbreak. The characteristics and geographical distribution of cases and the timing of the outbreak may help to narrow the focus of the investigation to specific potential sources and vehicles of transmission.

If the pathogen is known, the investigation should focus on known sources and conditions that allow the pathogen to survive and reproduce. If the outbreak is caused by a pathogen, which may be waterborne, the OMT may start to investigate possible failures in the drinking water supply system that could be the source of the outbreak. Spatial investigations can also help with the identification of potential sources if the preliminary evidence does not point to a particular source.

11.6.1: Environmental Investigation

For the environmental investigation of outbreaks suspected to be associated with drinking water supplies, the OMT in close cooperation with the water service provider will need to launch an investigation of the system to identify and assess any possible incident that may have caused faecal contamination of drinking water. This requires a qualified environmental specialist or engineer to support the investigation.

The objective of the environmental risk assessment is to identify the cause of contamination of the supply system. This includes an evaluation of the appropriateness and effectiveness of the existing control measures along the drinking water supply chain (in source water protection, water treatment, disinfection, storage and distribution), including possible failures and incidents that may have compromised system safety.

In settings where the water service provider has established a functional water safety plan (WSP), the environmental risk assessment should capitalize on its findings. In accordance with the WSP principles[25], the assessment of the water supply system entails the following steps:

1. If not already available, develop a schematic flow diagram of the water system. In describing the water supply system, basic information should be obtained on the water source, abstraction points, treatment processes (if applied), storage tanks and distribution network. An important element of the system description is a characterization of the source of the water, including runoff and recharge processes, and details of the land use in the catchment, such as location of sewage treatment plants, septic tanks, industry and other potential contamination sources. The flow diagram and the system description support the search for system deficiencies and contamination events. If such a system description is not available, undertake a rapid field investigation to describe the system;
2. Undertake a rapid system assessment. For each step in the water supply system, identify any possible hazardous event, which may introduce contamination (see Table XYZ for

examples of such events), and assess whether appropriate control measures are in place. In doing so, consider the following steps:

- Interview water system personnel about any possible deficiencies and events that they may be aware of in the period before the outbreak;
- In non-piped systems, investigate water collection, transport, storage and handling practices by community household members, including hygiene aspects;
- Review the outcomes of sanitary surveys conducted by regulatory agencies and water service providers. If they do not exist, undertake rapid on-site sanitary surveys of key system components to investigate the condition of the system and to identify deficiencies that may compromise the integrity of infrastructure and thus provide contamination pathways;
- Collate and assess water quality information to track unexpected changes to water quality preceding the outbreak. This step enables the identification of hazardous events at different points in the water system. It includes checking data from regulatory compliance monitoring (e.g. on the presence of faecal indicators such as *Escherichia coli*) and from operational parameters (e.g. turbidity, disinfectant levels, pH) that may indicate spikes or rapid changes in source water and/or drinking water quality, which may signal possible contamination events, or suboptimal treatment performance;
- Obtain weather records (such as torrential rains, snow thaw, drought) that could have triggered ingress of faecal matter into the system;
- Analyse operational records to identify possible problems in operations, which may have compromised the functioning and effectiveness of control measures. Treatment failures may also be documented in incident reports and operational logs maintained by the water provider;
- Review customer complaint reports that may provide information on the geographic location and nature of problems;
- Where indicated, and if possible, use additional tools such as computer modelling to model the diffusion of a pathogen through the water system;
- Verify whether any staff working with the suspected water source became ill and, if yes did they have direct contact with the source.

11.6.2: Laboratory investigation

Laboratory (microbiological) investigations of suspected sources and vehicles of transmission, with the aim of isolating the infectious agent from the source or vehicle. Laboratory investigation of the water system can:

1. Provide powerful evidence on the link between the source of the outbreak and cases
2. Help to identify the cause of the outbreak, where this is otherwise unknown
3. Identify the failure in the water system that led to the outbreak.

It is still possible to demonstrate that water is the source of an outbreak, even if the causative agent is not isolated from the water system. However, if resources allow, and if a laboratory investigation can be launched quickly, an attempt should be made to isolate the causative agent from the system.

The scope of the laboratory investigation will depend to a large degree on the availability of qualified personnel and laboratory resources and is likely to require the support of national or regional reference laboratories with expertise in the detection of water-related pathogens.

Guidance on sampling and analysis for microbiological investigations is given in the Guidelines on Drinking Water Quality[19], and in the WHO/OECD document “Assessing Microbial Safety of Drinking Water”[20].

If a water supply is suspected as the source of an outbreak, sampling of the supply may be enhanced in order to identify the system failure that led to the outbreak, as well as to try to isolate the causative agent from the water supply. Isolating the causative agent from the water supply and demonstrating that it is the same pathogen that caused disease in cases provides some of the strongest evidence that the water-system is the source of the outbreak, especially if the two isolates are genetically identical. Enhanced sampling may include:

1. Increasing the frequency of sampling from the normal sampling sites so as to detect temporary changes in water quality. This may be especially useful for small supply systems which are sampled less frequently than larger supplies.
2. Increasing the number of sampling sites in the system in order to detect localised problems within the system, and to increase the chance of detecting temporary changes in water quality. The results of the rapid risk assessment can inform on where to target additional sampling. Sampling can be extended to include:
    a. Suspected sources of pollution within the catchment area, such as livestock or septic tanks
    b. Source water sampling, including sediment from storage reservoirs and decommissioned wells
    c. Critical points in the treatment plant such as backwash from filter beds
    d. Water and sediment from different points in the distribution system, such as service reservoirs, pipelines and consumer taps
    e. Stored water such as water stored in household containers, bottles in customer’s fridges, ice, or filters
3. Extending microbiological analyses beyond those routinely conducted for water quality assessment. These analyses may target evaluation of different parts of the water supply system, as described in section 5.0. Testing for more persistent bacteria such as Clostridium perfringens or aerobic spore-forming bacteria could be conducted to assess the effectiveness of disinfection.

The recovery of pathogens from water supply systems is often unsuccessful, even when there is strong epidemiological evidence implicating the water supply as the source of the outbreak. Pathogens may not be detected from the water system for a number of reasons including:

1. A substantive amount of time may have elapsed between the contamination event, the exposure of cases to the contaminant and the time when samples are actually taken. If the contamination of the system is transient, then the likelihood of detecting the pathogen is very low.
2. Once the water supply is suspected as the source of the outbreak, a super-disinfection of the system may be rapidly performed as a preliminary measure to contain the

outbreak. Any pathogens still circulating in the system will be destroyed, unless they are resistant to the disinfectant.

3. The persistence of the pathogen in the water environment will influence the likelihood of its detection, as will the detection methods that were used.
4. Very large sample volumes of up to 1000 litres may be needed, particularly if trying to isolate enteric viruses or protozoa. Special sampling equipment may be needed.

In the event of contamination of water supply systems with wastewater or sewage, the system may be contaminated with multiple pathogens, and so it may be that the pathogens detected do not correspond to the causative agent identified in the outbreak. In this case there will be evidence of water contamination, but no direct link between that contamination and the disease under investigation.

Molecular techniques, such as PCR and cell culture, can greatly increase the possibility of detecting pathogens, especially viruses, from water. PCR enables rapid detection, whereas cell culture is more sensitive for the detection of viruses when the levels of virus particles in sampled water are low. Ideally these two techniques should be combined. In situ hybridisation and species-specific probes enable the rapid detection and identification of bacteria during field investigations. Microarrays enable the screening of water samples for multiple pathogens, and so may be particularly useful when the causative agent of an outbreak is unknown.

Outbreak case study continued. Step 6: Additional studies; environmental investigation

The district environmental health officer, the sanitation engineer from the municipal water authority, and the water quality and safety officer from the EPA undertake a sanitary inspection, environmental risk assessment and microbiological investigation of the water supply.

The team describe the entire water system including the local hydrogeology, the water source, water treatment plants, and water distribution system using data provided by the municipal water authority and the EPA and using data obtained from site visits, physical investigations and from reviewing the WSP for the system. They identify potential hazards and assess the associated risk, and investigate possible sources of contamination in the catchment area including sewage contamination and contamination from grazing livestock. They review water quality data on turbidity and thermotolerant coliform counts, as well as maintenance records for the system since August 15th. The EPA provided information on rainfall statistics and the municipal authority supplied data on flood warnings during the same time period.

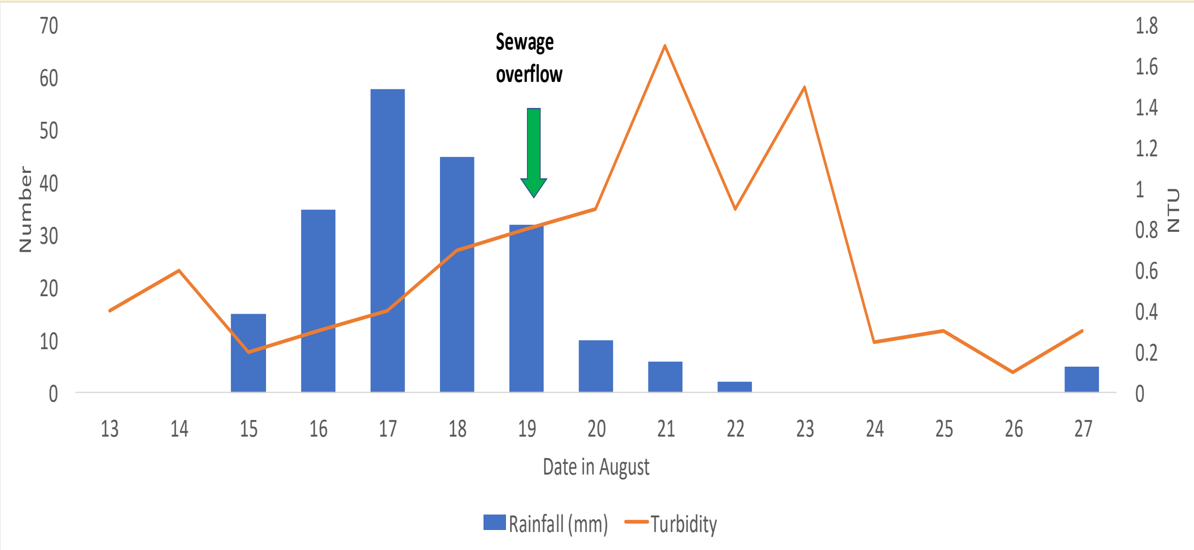
Waterfall is served by two separate water supplies. The Northern and Eastern Zones of the city are served by water from a groundwater source to the north of the city (water supply 1, WS1). The Western and Southern Zones are served by water from Moon Lake to the west of the city (water supply 2, WS2). The city centre is served by both water supplies. The land surrounding both water sources is primarily used for livestock grazing, although there are also some residential developments in these areas. For WS1, water is extracted from an aquifer and piped to a reservoir. The water is chlorinated before entering the distribution system. For WS2, water is extracted from Moon Lake at a depth of 20 meters and is filtered and chlorinated before entering the distribution system. The water distribution system for WS1 has recently been upgraded and the inspection of the system did not identify any hazards. The water distribution system for WS2 is quite old with some parts of the system dating from the 1930s. Some of the pipes are corroded and leakage into the distribution system was identified as a hazard at several points in the system.

Unusually heavy rains had fallen in Waterfall between August 16th and 19th and there had been flood warnings in the city. A sewage overflow was documented by the municipal authorities on August 19th in the Western district of the city (Figure F).

An inspection of the water supply system revealed a number of likely factors that contributed to the outbreak:
1. The heavy rains led to likely contamination of Moon Lake with animal waste runoff from surrounding pasture lands
2. The filtration system at the water treatment plant for WS2 was breached during flooding which likely lead to contamination of the treated water with raw water.

As part of water quality surveillance, there is weekly testing for thermotolerant coliforms and daily monitoring for turbidity in the water distribution system. Thermotolerant coliforms were isolated from the distribution system in a sample taken on August 19th. Turbidity measurements taken on 21 and 23 August exceeded the acceptable limit of 1 nephelometric turbidity unit (NTU) (Figure F).

Figure F: Rainfall (mm), and nephelometric turbidity unit measurements taken from water supply 2 during the likely exposure period (August 15th to 26th), Waterfall.



The OMT took large water samples (2000l) from the source water, water treatment plants, reservoirs and pumping stations, and a series of 10 litre grab samples from the distribution system and fire hydrants (during flushing of the system) from locations with the highest number of cases. They also took samples from the homes of a random sample of the probable and confirmed cases. Samples were taken on Saturday September 15th prior to flushing of the water system.

Cryptosporidium oocysts were isolated from Moon Lake (25 oocysts / 1000l) and from a pumping station in WS2 (65 oocysts/1000L), as well as from a fire hydrant in the western zone (5 oocysts/10L). All other samples, including those taken from the homes of cases were negative. Genotyping revealed that the isolated oocysts were genotype 1

Step 7: Interview cases and generate hypotheses

Collate and review all of the results of the different investigations and analyses and interpret them in order to develop hypotheses. Hypothesis generation can enable the identification of potential sources of the outbreak, or high-risk groups for infection or severe disease that can be immediately targeted with control measures to limit the spread and impact of the outbreak. Depending on the outbreak, hypotheses may address some or all of the following:

- The cause of the outbreak
- The source of the outbreak
- The mode (or vehicle) of transmission
- Risk factors or exposures associated with disease

Considerations for WRID outbreaks

- Review the descriptive epidemiological data, the laboratory and environmental data and the circumstances surrounding the outbreak and assess the plausibility of the hypotheses against these facts
- If water is suspected to be the source, consider it as the target for immediate control measures

Outbreak case study continued.
Based on the results of the epidemiological and environmental investigations the OMT concluded that heavy rains led to contamination of WS2 and that this was the source of the outbreak.

In accordance with this conclusion, the OMT hypothesised that being a case was associated with:
1. Residing in a residential area supplied by WS2
2. Consumption of water from WS2.

Step 8: Evaluate the hypotheses

This step involves evaluating all hypotheses on the cause, source, vehicle of transmission and risk factors for infection against the available evidence to assess their plausibility, and how likely they are to be true.

The OMT must provide strong evidence to support any claims about the source of an outbreak, so as to counter any doubts about the source of the outbreak and to justify targeting control measures at that source. Providing strong evidence is especially important if implicating a particular source will have economic or legal implications for the water provider.

This step involves reviewing the descriptive epidemiological data, the laboratory and environmental data and the circumstances surrounding the outbreak and assessing the hypotheses against these facts. An OMT may choose to undertake an analytical study if the descriptive epidemiological, laboratory, environmental and other available data does not enable the identification of the source. Such a study can be conducted to generate even stronger evidence to support the hypothesis under investigation and to quantify the size and strength of the association between an exposure (such as a water source) and an outcome. The analytical studies usually used in outbreak investigations are cohort studies, case control studies and ecological studies. Guidance on how to conduct such studies are discussed in detail in the documents detailed at the start of this chapter.

Considerations for WRID outbreaks

- The main exposure usually investigated during a WRID outbreak is exposure to a particular water source. Collecting reliable data on water usage during an outbreak period can be challenging, especially if a lot of time has elapsed between the exposure period and the time of the investigation, and particularly if respondents changed their water use in response to publicity surrounding the outbreak, or as part of control procedures for the outbreak. Furthermore, people are often exposed to more than one source of water, for instance the source that supplies their home, and the source that supplies their place of work. Within a household, children may be exposed to different water sources to adults.
- When collecting data on water usage during the outbreak period, the OMT could consider variations in water use at home and outside the home, treatment of water within the home, the use of bottled and filtered water, and both the consumption of water and exposure to water from bathing and recreational activities.
- Ecological studies are useful for investigating outbreaks associated with public water supplies, where defined population groups are exposed to a single water supply and where it is possible to compare attack rates between those exposed to the supply with those not exposed to the supply. These studies may require less expensive and time-consuming data collection, particularly if the water provider can provide readily available data to define the population and to categorise cases by exposure to the water supply. In ecological studies, associations relate to the population level, not to the individual level as the association does not reflect variations in the level of exposure between individuals. Ecological studies include time-series analyses (section 6.1) and spatial analyses (sections 6.2 and 11.6.5).
- Sometimes a primary outbreak can cause a secondary outbreak. For instance, contamination of a municipal water supply may lead to a primary outbreak of *Salmonella typhi* among customers of that supply. One of the cases from that outbreak may prepare food which is subsequently served at a party in an area not served by that supply, this may lead to a secondary outbreak of *Salmonella typhi* at that party which is not associated with the water supply, but which is rather associated with the infected food handler. These secondary cases should be analysed separately to the primary cases as they have not been exposed to the original source of the outbreak. Including them in an investigation of a particular water supply as the source of the outbreak will reduce the power of the study. These cases should be analysed separately to determine the source (or in this case the vehicle) of their infection, which is in fact the food item. Secondary outbreaks of gastrointestinal illness can usually be identified from the epidemic curve as they usually occur at least one incubation period later than the primary outbreak.
- If everyone in the study population is exposed to the suspected water source, it may not be possible to demonstrate an epidemiological association between water and getting ill due to low statistical power. In such instances, an absence of association should be

interpreted as being inconclusive rather than evidence of no association. In such instances, and wherever possible, the analysis could investigate whether the risk of illness increases with consumption of increasing amounts of water. In order to facilitate this, the volume of water consumed daily would need to be quantified. The demonstration of a linear dose-response relationship provides even stronger evidence that water is the source of the outbreak than simply demonstrating an overall increased risk.

- An assessment of the evidence implicating a water source must consider all evidence from all steps of the investigation including:
  - The circumstances surrounding the identification of the outbreak, for instance if there was an increase in cases of cryptosporidium following flooding or after a cluster of customer complaints to the water provider
  - Descriptive epidemiological data linking cases to a potential source by person, place or time, such as clustering of cases close to a particular water source or a temporal association between an increase in cases and a known exceedance of water quality indicators monitored through routine water quality surveillance
  - Environmental data such as the results of the risk assessment demonstrating a failure in integrity of the distribution system that corresponds to the time of the outbreak
  - A temporal association between the introduction of a control measure and a decline in the number of cases.
  - Laboratory data such as the isolation of a genetically identical organism from the water supply and cases
  - Data from the analytical epidemiological study on the statistical probability of an association between illness and the source
- In WRID outbreaks, some of the strongest evidence on the source of an outbreak is gained by securing laboratory confirmation of the pathogen isolated from cases (supported by clinical and epidemiological data), and by linking this pathogen to an identical laboratory confirmed agent isolated from the suspected source of the outbreak. In the absence of laboratory confirmation from either cases or the source, clinical and epidemiological data can be used, although the strength of the evidence will be less.
- It is not always possible to isolate the causative agent in an outbreak from the suspected source of the outbreak[18]. Failure to isolate the causative agent from the suspected water source does not rule out the possibility that it is a water-related disease outbreak. It has been proposed that investigations of water-related diseases focus on collecting water quality data, rather than on detecting pathogens, as water quality information can help to identify possible sources of faecal contamination of water[ref].
- Tillett et al[51] have proposed a classification system for assessing the strength of the evidence that an outbreak is associated with water (Figure x). This system ranks epidemiological data higher than water-quality or engineering data when assessing the strength of the evidence. An epidemiological association, paired with microbiological and environmental evidence provides the strongest evidence that the outbreak is water-related; however, outbreaks can be classified as water-related, based on epidemiological evidence alone, or based on isolation from the environment alone. Such a system can help to systematise the way in which outbreaks are classified as water-related, which can

be particularly useful when trying to combine evidence from many different sources to demonstrate an association, especially given the challenges in definitively demonstrating water as the source in many outbreaks.

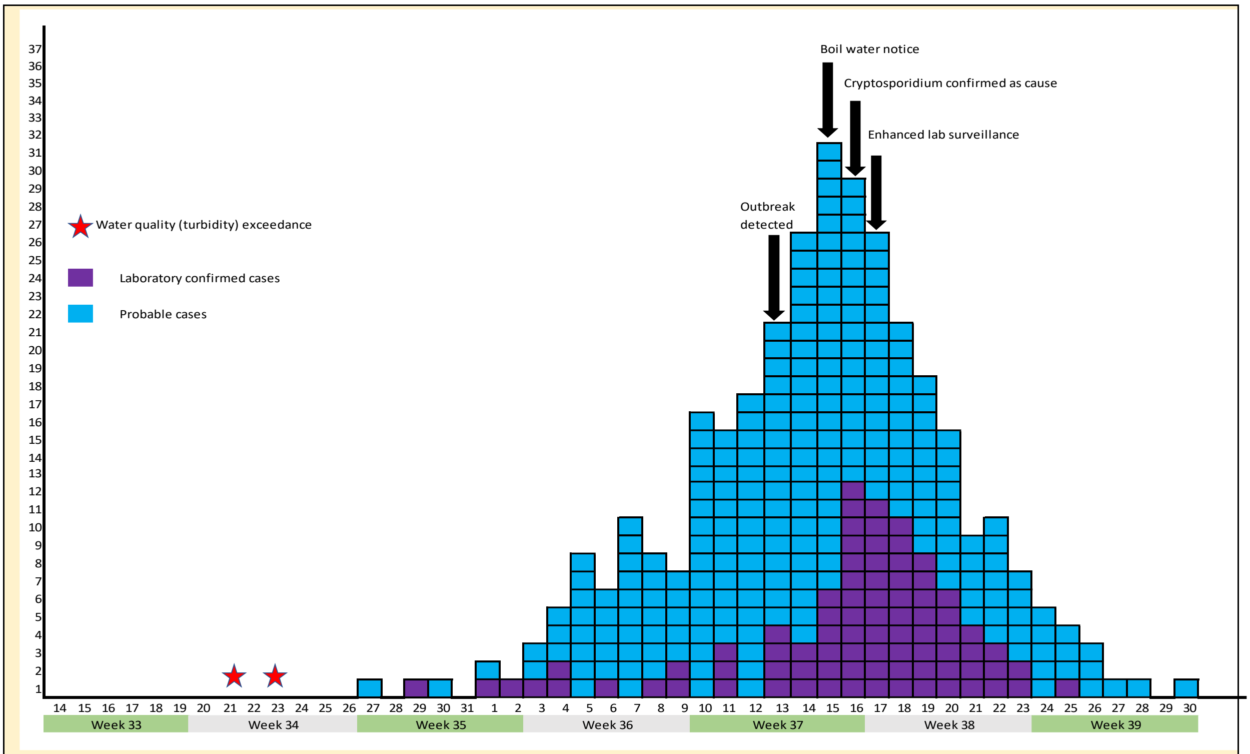
Figure X: Classification system for assessing the strength of the evidence linking an outbreak to water

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 suggest 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, Epidemiology and Infection (1998), 120, 37-42.

Outbreak case study continued. Step 8. Evaluate the hypothesis
By the end of week 39 a total of 330 cases have been identified as part of the outbreak. After week 39 no further cases associated with the outbreak are reported. Usually there is an approximate one month turn around on the receipt of reports from laboratory surveillance however daily reporting was introduced at the start of week 38. By the end of week 41 all laboratory results have been received.

0f the 330 cases identified during the outbreak, 83 are laboratory confirmed as cryptosporidium. A subset of these have been genotyped and confirmed to be genetically identical to the cryptosporidium isolated from the water system.



The OMT decides to conduct a case control study to test the hypothesis the exposure to WS2 was associated with getting sick with cryptosporidium and to identify factors associated with cryptosporidium infection.

For the purposes of the case control study, cases are those who meet the confirmed case definition for the outbreak investigation. Possible secondary cases (those who became ill between 1 and 14 days after another case in the same household) will be excluded.

Controls are randomly selected from the population register for Waterfall and are matched by sex, age and water supply system. Two controls are interviewed for each case.

The OMT administers a standardised telephone questionnaire to 80 confirmed cases and 160 controls. The questionnaire collects data on water consumption and other risk factors for cryptosporidium infection such as diet, contact with farm animals and pets and use of a swimming pool. Data are collected on exposures from 15 August when the outbreak was announced and the boil water notice issued, until the outbreak is declared over.

The results of the case control study indicated that residing in the Western or Southern Zones and consumption of water from WS2 were associated with being a case (Table D). A dose-response relationship was also found between the volume of water consumed daily, and illness. No other factors were associated with illness.

Table D: Factors associated with cryptosporidium infection

Variable	**Adjusted Odds Ratio**	**95%CI**
Residential zone		
Northern	ref	
Eastern	1.24	0.52-1.95
Central	3.13	2.12-4.58
Southern	7.58	4.93-9.17

Western	10.44	7.84-13.58
Consumption of water from WS2 *No* *Yes*	 ref 6.53	 4.95-8.16
Daily water consumption *< 1 glass* *1-2 glasses* *3-4 glasses* *≥ 5 glasses*	 ref 2.11 4.34 8.42	 0.67-9.2 0.96-18.10 1.95-27.34

In addition to the case-control study, the OMT calculated population-based risk ratios for cryptosporidiosis by water supply zone (Table E).

Table E: Factors associated with cryptosporidium infection

Variable	**Risk ratio**	**95%CI**
Water supply zone *WS1* *WS1+2* *WS2*	 ref 6.31 24.25	 3.28-11.01 17.31-28.52

There is robust evidence that residing in the Western and Southern zones is strong associated with cryptosporidium infection. Those in the Western zones are over 10 times more likely, and those in the Southern zone are almost 8 times more likely to be infected than those in the Northern zone. Consumption of water from WS2 is associated with an almost 7-fold increased risk of infection. Those who consume a higher volume of water daily are more likely to get sick. Finally, those living in areas supplied solely by WS2 have an almost 24-fold increased risk of infection than those living in areas supplied by WS1 only.

There is strong evidence to support the hypothesis that the outbreak of cryptosporidiosis that occurred in Waterfall during weeks 35 to 39 was associated with contamination of WS2 in the town, and that WS2 was the source of the outbreak. The causative agent has been isolated from both cases and the water source. The environmental investigation has revealed weaknesses in the integrity of the water system that coincides with heavy rainfall and flooding. There is evidence of poor water quality in the days prior to the onset of symptoms in the earliest cases. The implementation of control measures is followed by a decline in cases.

Step 9: Implement control measures

Control measures are usually implemented immediately at the start of the outbreak, in order to stop the spread of the outbreak and to prevent further cases. Ideally control measures will be evaluated continuously throughout the outbreak and adjusted as needed. These measures will typically target different steps on the chain of transmission, such as the causative agent, the source of the outbreak, the mode of transmission, the portal of entry or the host.

Considerations for WRID outbreaks

- In most WRID outbreaks, water serves as a vehicle for the transmission of the infectious agent between a human or animal reservoir and the population. For certain organisms such as *Legionella* or species of vibrio cholerae, water itself serves as the reservoir.
- Control measures during WRID outbreaks will typically target:
  - The water supply system (catchment, treatment, storage, distribution) so as to remove the source of contamination by securing the system or by sanitising the environment to prevent the growth of pathogens or by limiting access to the water
  - Secondary vehicles of transmission such as food items prepared with the contaminated water
  - Secondary spread via person-to-person transmission
- Control measures may target more than one mode of transmission. For instance, an outbreak of hepatitis A suspected to be associated with a contaminated water supply should ideally prompt control measures targeting the water supply, as well as vaccination of the contacts of cases. An explanation of the different steps in the chain as they relate to WRID and examples of control measures targeting these steps is given in Table 14**.**
- Control measures should not only target the immediate cause of the outbreak (such as contamination of the water supply or hazardous events leading to the outbreak), but also the underlying causes of the outbreak (such as insufficient policy or tools or inadequate investment in the training of waterworks personnel or maintenance of the water distribution system).
- The outbreak may highlight issues that will need to be addressed in the water safety plan, such as measures to protect source waters or extension of treatment processes to include treatments targeting protozoa such as cryptosporidium.
- Similarly, the findings of an outbreak may prompt policy changes, such as changes to the location of industrial cooling towers, or extension of surveillance to include the surveillance of pathogens that are newly emerging in the country, such as giardia, legionella and cryptosporidium.

Table 14: Overview of the components of the chain of transmission and examples of associated target control measures for WRID.

Component	Description	Example of Targeted Control Measures
Portal of exit	The way by which the infectious agent leaves the reservoir, for example cracks in distribution pipes enabling infiltration of raw sewage, pigeons breaching water storage tanks and defecating into the treated water supply	Securing the water source against contamination by animal waste Repairing distribution systems Securing water storage tanks against invasion by rodents or birds
Mode of transmission	The mechanism by which the infectious agent is transmitted to people, for example indirect spread through consumption of contaminated water or inhalation of aerosolised legionella	Super-chlorination of the water distribution system Temporary closure of a suspected industrial cooling tower or spa facility
Portal of entry	How the infectious agent gets into the human body; for example, consumption of contaminated water or inhalation of legionella	Water avoidance notices & provision of alternative water supply

Susceptible host	A person who is not immune to the disease as they have never had the disease or they have not been vaccinated	Vaccination to stop a hepatitis A or cholera outbreak
Causative agent	The microorganism that causes the illness	Increase treatment and disinfection of source water, following treatment or during distribution Boil water notices
Reservoir	Where the causative agent is able to grow and multiply for example, biofilms for legionella	Disinfection of distribution systems Optimisation of temperature control in hot or cold-water distribution system in buildings (keep the water temperature outside the range of 20–50°C, if possible)

Cryptosporidium case study continued. Step 9: Implement control measures
In addition to the boil water notice issued on September 15th, a number of additional control measures were implemented:
1. Advice on hand hygiene and infection control measures were issued to the public to prevent secondary transmission within households. Cases were also provided with this information individually
2. The entire water system, including the pumping station, was flushed to eliminate oocysts from the distribution system
3. The filtration system was repaired and flushed to eliminate oocysts
4. The leaking and corroded pipes in the water-distribution system were repaired or replaced as needed
5. The sewage system pipes were repaired and improved to enhance their capacity to cope with increased volumes during flooding events

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

It is good practice to communicate with stakeholders, including the public, at regular intervals throughout the outbreak, and also at the end of the outbreak, in order to keep stakeholders informed on i) what is happening during the outbreak, ii) the progress and findings of the investigation and iii) the recommendations for the control of the outbreak. It is also important to evaluate the outbreak response to document lessons learned and to identify needed improvements to outbreak response capacity and to inform the updating of emergency response plans. A number of guidance documents for after action reviews of public health events can be used to inform the conduct of the evaluations [ref].

Interim and final reporting is best informed by a communications strategy which can be agreed at the start of the outbreak. Communications with the public are best informed by risk communications principles, as discussed in section xx. A final written outbreak report is important to document the investigation, its findings, the lessons learned, and the recommendations for control and other public health measures. The recipients for the final report will vary depending on the outbreak and is usually decided by the OMT.

Considerations for WRID outbreaks
- Communicate immediate control measures relating to the water-system in interim reports released frequently throughout the outbreak

- Vary the frequency of interim reporting as needed throughout the outbreak in response to the needs of the outbreak. For instance, for a large outbreak in a municipal water supply, the OMT may decide on the release of weekly situation reports throughout the outbreak, but they may decide to release additional ad hoc reports as new information becomes available, or if they want to make urgent recommendations on community control strategies during the outbreak.
- Communicate regularly to the public about the outbreak and preventive measures
- Make recommendations for long-term improvements to the water-supply system in the final outbreak report and update the water-safety plan with these recommendations as needed.
- If serious problems with the water system are identified during the outbreak, it may be necessary to recommend in the final report that the water provider undertake a full systematic water system risk assessment in accordance with WSP principles, so as to identify potential additional long-term improvements to the system.
- After-action reviews of the outbreak response would ideally include an assessment of the process of outbreak detection and alert, the conduct of the investigation, the suitability and speed of implementation of control measures and a review of the process of outbreak reporting and communication. It would evaluate what worked well in the outbreak and what could be improved in future outbreak investigations, with a view to identifying the lessons to be learned from the outbreak.

Outbreak case study continued. Step 10: Outbreak reporting

Throughout the course of the outbreak daily interim reports were sent to the municipal authorities, Ministry of Health, Director of the NPHA and Director of the Water Provider to update them on the status of the investigation.

Daily updates were posted on the NPHA website and announced and linked to on social media.

The OMT published an outbreak report within one month of declaring the outbreak over which made a number of recommendations including:

1. To introduce ozonation of the raw water to deactivate cryptosporidium in the source water prior to treatment.
2. To upgrade (by replacing piping) parts of the distribution system
3. Undertake work to protect the water filtration system from future flooding
4. Introduce a protection zone around Moon lake, within which livestock grazing will be protected, so as to minimise runoff into the source water
5. Increase the frequency of inspection of the water system, including the filtration system, after extreme weather events
6. Increase the frequency of water testing at all stages of the system after extreme weather events.

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

12.0: Risk communication

Outbreaks are emergencies requiring rapid action in order to 1) care for cases, 2) prevent spread and 3) control the outbreak. This requires rapid decision-making and action, often with cooperation from the public.

Risk communication is a key component of risk management[55,56]. It is used in WRID outbreak management to guide public participation to support the rapid control of the outbreak, to alleviate public concern and to mitigate the social and economic consequences of the outbreak. Risk communication opportunities exist at different steps throughout an outbreak investigation and skilled communication is critical, especially if using the media to engage the public in outbreak containment measures.

Under the Protocol on Water and Health, Article 8 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." Furthermore, emergency risk communications capacity is a core requirement for countries within the framework of the International Health Regulations.

WRID outbreaks, particularly those associated with public water supplies, can potentially cause considerable social and economic disruption and are likely to attract considerable political and media attention.

Human behaviour often contributes to the spread of outbreaks, and so communications to the public can and should form a key component of outbreak control measures. The ultimate purpose of effective risk communication is to enable people at risk to take informed decisions to protect themselves and those around them. Consider what risk communication opportunities exist at the different steps of an outbreak investigation. Risk communication is not limited to 'notification' in the investigation process, and needs to be integrated throughout the decision-making processes, offering an opportunity for control of the outbreak and its response.

Effective risk communication and planning can mitigate complications during outbreaks that may be caused by a number of factors, including:

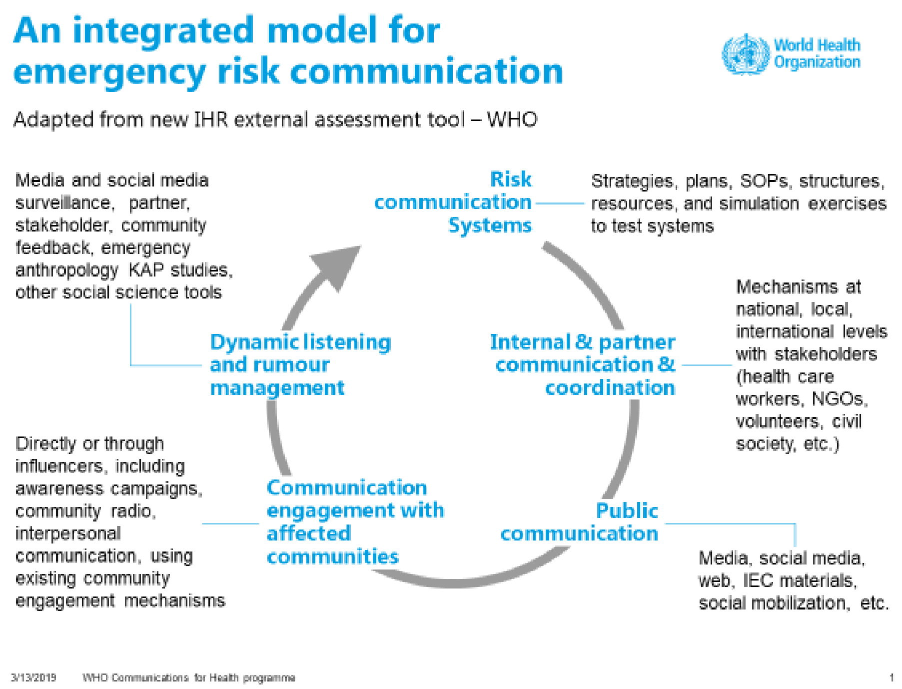
1. Outbreaks are often characterised by uncertainty, confusion and a sense of urgency. They can be unpredictable and alarming to the general public, with a potential to cause social disruption and economic losses beyond their direct health care costs and disproportionate to the severity of the risk.
2. Outbreaks may have a high political profile, beyond the MoH. This can mobilise political commitment to outbreak management but if political authorities are motivated by economic rather than public health concerns, it can impede outbreak management.
3. Outbreaks are often newsworthy and OMTs frequently have to communicate through the media. However, engagement with the media also puts the OMT under public scrutiny and it creates pressure for them to act rapidly and decisively.

Exaggerated media coverage can exacerbate public anxiety, a scenario that is more likely to occur in the absence of trustworthy official information. The flow of official information from the OMT may need to be rapid to meet the increasingly rapid media cycle, especially since rumours may be used to stem any void in official information.

4. Communication failures during outbreaks can impede outbreak control measures, can undermine public trust and engagement and can exacerbate and prolong social, economic and political turmoil.

Given these factors, communication expertise is as essential to WRID outbreak management as epidemiological, environmental and laboratory expertise. In-depth guidelines for outbreak communication are listed in **Annex 3**. Figure X presents an overall framework for risk communication.

Figure X: Integrated model for risk communication



12.1: Key elements of risk communication

There are a number of best practices for risk communication during an outbreak including:

1. Trust

- Communicate in ways that build, maintain or restore trust. A lack of trust leads to fear and reduced engagement with outbreak control measures
- Keep to the facts whilst acknowledging uncertainty and avoid excessive reassurance.
- Trust that the public will not automatically panic if given incomplete and sometimes worrying information
- Work to build trust between those leading on communication and both policy makers and other members of the OMT who may see communication with the public as a diversion from the task of outbreak response.

- Build consensus among the members of multisectoral OMTs and key stakeholders, especially when these include different ministries, agencies and perhaps even private commercial organisations, and especially if these various partners have conflicting interests.
- Work to ensure accountability and transparency for instance by allowing high-profile critics to observe and possibly even participate in decision making.
- Listen to and be aware of public concerns

2. Announce the outbreak early

- Early announcement of an outbreak helps to build public trust that the authorities are not withholding information and sets expectations that information will not be concealed.
- The first to announce an outbreak is often what people remember and whom they will turn to for further information.
- To prevent rumours and misinformation spreading, especially on social media, announce the outbreak early
- Avoid withholding information to “protect” the public. This may make the information seem more frightening, especially if it is revealed by an outside source.
- Always announce early if:
    - The containment of the outbreak is dependent on public behaviour change
    - There is a defined risk group, such as residents served by a particular water supply; alert them to the risk and explain ways to reduce it
    - If neighbouring countries are at risk; warn them to be alert to imported cases
    - If the country can benefit from international support and experience
- The size of the outbreak, or a lack of information are not always justifications for delaying the announcement of an outbreak. For some outbreaks, such as cholera, even one case can justify an early announcement.
- Publicly acknowledge that the announcement is based on preliminary information that may be incomplete or incorrect, and so the situation may change as further information emerges.
- Ensure that there are clear communication channels between key stakeholders so that they are aware in advance of the announcement, especially if they disagree with the initial assessment. Test these communication channels as part of preparedness planning (section 10.0).
- Take particular care with the first communication about an outbreak as it is likely to be newsworthy, to come as a surprise, to capture the attention of the media and public and it could potentially cause alarm. How this initial announcement is handled may impact on the reception to all subsequent communication.
- Late detection of the outbreak will lead to late reporting. This is a particular issue for WRID outbreaks, as the outbreak may not come to the attention of the authorities until it is suddenly conspicuous.
- Outbreaks should not be announced based on rumours alone; rather they should only be announced following verification of at least some of the facts, and most typically following verification of the outbreak itself.

3. Transparency

Greater transparency leads to greater trust.

- Communication must be frank, easily understood, complete and factually accurate.
- Keep the public informed about the activities of the investigation, including the information-gathering, risk assessment and decision-making process of the outbreak management. Focus on what is being done and the next steps, rather than what is not being done.
- Transparency allows the public to see that the OMT are systematically investigating and responding to the outbreak, and it promotes deliberate and accountable decision-making.
- Note that protecting public health is a higher priority than economic concerns, and that economic recovery is usually faster when governments are transparent and effectively manage the outbreak.
- Be aware that pride, embarrassment, fear of revealing weaknesses and fear of being blamed can lead to a lack of candour. Develop strategies to address these issues as part of preparedness planning, so as to promote transparency.
- The decision on what information to reveal to the public, and what to withhold should be based on an assessment of what will help the public and what is likely to cause harm within the limits of transparency.
- Unverified rumours, information that has no public health benefits, confidential data on patients, and information that could lead to the discrimination of patients, their families or particular minority groups should not be revealed.

4. Understand the public

The public is entitled to information relating to their health. Knowing who the public is, and what they think, is essential in developing effective public health messages.

- Crisis communication is a dialogue
- Make sure you understand the public's beliefs, opinions and knowledge about specific risks
- If possible, involve representatives of the public in the decision-making process. If this is not possible, the communication lead will need to understand and represent the public's views in the decision-making process.
- Respect the public's concern, regardless of their validity, then address this concern in any policies developed in response to the outbreaks. Publicly acknowledge and correct mistaken concerns.
- In risk communication messages include information on how the public can protect themselves, as it enables the public to take control over their own well-being which in turn will encourage a more reasoned public response to the risk. Share also information on the symptoms of infection, who is at risk and how and when to seek medical care if necessary.

5. Planning and preparedness

Public trust and risk perception are more influenced by the decisions and actions of public health officials than by communication. Ideally integrate risk communication with risk analysis and risk management, and incorporate it into preparedness planning (section 10.0) for major events and outbreak response.

- Ensure that the relevant members of the OMT have received media training as part of preparedness planning (section 10.0) and that they have practiced delivering bad news and discussing uncertainty.

- Consider having a daily press conference rather than answering multiple media enquiries throughout the day.
- Prepare in advance pre-approved public health messages that can be adapted for the outbreak, as part of preparedness planning.
- Develop the risk communication plan as part of the outbreak management plan from the start of the outbreak. This can be an adapted version of the template plan developed as part of preparedness planning.
- Brief senior management from the outset of the need to acknowledge uncertainty and to empathise with the public's beliefs and fears, as these principles may be counter to their approach to dealing with the public.
- Agree the first announcements, limits of transparency and other communication factors with senior management, key stakeholders, and if necessary political leaders early on. Specifically agree: What needs to be done? Who needs to know? Who is the communications lead (agency and individual)? Who needs to act? Link these steps to the activities of other ministries and agencies as needed.

Generally, technical staff must understand the need for clear jargon-free communication; communicators must understand the need for scientific and medical accuracy, as well as for framing scientific knowledge within the local political context; and decision makers must accept the need to inform the public, so that communicators are not left to face an expectant audience without a response.

12.2: Preparing public health messages

It is important to provide clear information and advice to the public during the outbreak. This is best done through prepared communication messages, containing clear public health advice. When writing these messages, consider the following:

1. 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?
2. Keep action messages short, simple and memorable and clearly describe what needs to be done, by whom, when it needs to be done, how it needs to be done and for how long.
3. Ensure these messages can be understood by and are accessible to different groups such as people with disabilities, those with different language and literacy skill and those with various access to media.
4. The target audience can only absorb a limited amount of information and they may not understand the data
5. What is the single overriding communication objective and the key message that needs to be understood by the audience?
6. When developing the key message, consider what is important to the target audience, and what the target audience needs to know
7. Ensure that the key message is simple, accurate, credible, relevant, consistent and timely. Avoid technical language.
8. Ensure that the key message is supported by a small number of facts that you want the audience to remember.
9. Seek input from medical experts to ensure that both the public health messages and medical guidance are complementary.

12.3: Partnership with stakeholders

As with all aspects of outbreak management, coordination and collaboration with partners and stakeholders is key to ensuring effective risk communication. ***Relationships with stakeholders should be developed and the processes for communication agreed upon when developing the communication plan as part of preparedness planning.*** Engagement of stakeholders and communication planning is discussed further in section 10.0.

12.4: Engaging with social media and the community

Social media can be an important tool for directly and immediately communicating with the public. It enables peer-to-peer communication. It can raise awareness about the outbreak and it can be used to communicate about and support control and response measures in the community. It gives the public a voice, and it enables those who use it to become involved in the response to the outbreak, through commentary and the provision of information on the outbreak, especially the community's response to the outbreak. It is also useful for monitoring response and public concerns about the outbreak, including community resistance, and it can be used to monitor and counter rumours about the outbreak.

Integrate the use of social media within the overall communications strategy for the outbreak. It is important to apply the same criteria regarding transparency, accuracy and timing, as explained above, in developing social media messaging. For larger outbreaks or those causing a lot of public concern it may be prudent to appoint a dedicated social media officer to manage the social media response.

Community engagement can be crucial in outbreak response. In addition to use of social media, or in areas of poor social media uptake or connectivity, public meetings can be used to establish dialogue and to build trust with the affected community.

Guidance documents[58] on using social media for outbreak communications are listed in **Annex 3**.

13.0: International frameworks for managing transboundary events & outbreaks

Outbreaks associated with transboundary waters, that are likely to affect multiple countries may require close coordination and cooperation between Member States, in order to manage the outbreak and to protect public health.

There are several international agreements and regulations aiming to strengthen collaboration on cross-border health threats, including threats linked to shared water resources. These include:

The Protocol on Water and Health: Article 13 of the Protocol requires that Parties that border common transboundary waters work together to prevent and control water-related disease outbreaks by sharing information on risks and by establishing coordinated surveillance, early warning systems and contingency plans so that they can respond to outbreaks, especially those due to water-pollution and extreme weather events.

- ***The European Union decision on cross border health threats***

Decision 1082/2013/EU on serious cross-border threats to health) gives a framework for crisis management and coordination of cross border health threats (which is implemented with the assistance of the European Centre for Disease Prevention and Control (ECDC) and the European Food Safety Authority.

- ***The International Health regulations***

Requires all WHO member states to report and collaborate to detect and response to health threats with potential for international spread. The countries may also request, technical assistance from the WHO

Under the IHR outbreaks of cholera, as well as any outbreak or event that could have a serious public health impact, that is unexpected and that is likely to spread internationally, or that could result in travel or trade restrictions must be notified to the WHO. Similarly, IHR regulations relating to the inspection of ships and to the issuing of ship sanitation certificates may be of relevance to outbreaks of legionellosis or other WRID occurring on ships.

Annex 1: Classification Systems for Water Related Diseases

The most widely used classification system for water-related diseases is one proposed by Bradley in 1974 comprising five categories and subsequently revised down to four categories (Table A1) in 1977[14,15,60]. This classification, which is still widely used today, can be summarised as follows:

Table A1: Classification of water-related diseases

Category	Description	Example diseases
Waterborne disease	Enteric infections spread through faecal contamination of drinking water	Typhoid, campylobacter, giardia, cryptosporidium, cholera, enterohaemorrhagic & enterotoxigenic E. coli, norovirus
Water-washed diseases (including water scarce diseases)	Diseases occur due to the lack of adequate water supply for washing, bathing and cleaning. Pathogens are transmitted from person to person or by contact with contaminated surfaces. Eye and skin infections as well as diarrhoeal illnesses occur under these circumstances.	Trachoma, scabies, shigella Waterborne pathogens include bacteria, viruses, protozoa and helminths.
Water-based diseases	Diseases where the causative organism requires part of its lifecycle to be spent in water	Schistosomiasis, dracunculiasis
Water-related diseases	Vector-borne diseases where the insect requires access to water	Malaria, onchocerciasis, trypanosomiasis

Cotruvo et al (2004)[4] further expanded the Bradley classification system to define water-related zoonotic diseases, based on the transmission route (Table A2).

Table A2: Classification of water-related zoonotic diseases[4]

Category	Definition	Example diseases
Waterborne via drinking water	Enteric infections spread through faecal contamination of drinking water	Salmonellosis, E. coli 0157:H7, cryptosporidiosis, giardiasis, camplyobacteriosis
Waterborne via recreational water contact	Enteric infections spread through faecal contamination of recreational water	Leptospirosis, cryptosporidiosis, giardiasis
Water-washed	Diseases caused by poor personal and/or domestic hygiene, due to a lack of readily accessible water which limits the washing of contaminated hands and utensils	Cryptosporidiosis, giardiasis, hepatitis E virus, trachoma, scabies

Water-based	Worm infections in which the pathogen spends part of its life in the aquatic environment. Transmission can be via ingestion or contact with water.	Schistosomiasis
Water-related insect vectors	Diseases transmitted by insects that breed in water	West Nile virus, yellow fever, dengue, malaria
Inhalation of water/wastewater aerosols	Disease is transmitted by inhaling water aerosols	Mycobacteria, Legionella
Aquatic food	Disease transmitted by bivalve molluscan shellfish cultivated in faecally contaminated water which have concentrated enteric organisms in their tissues	Hepatitis A and E, human caliciviruses, Shigella

The Cotruvo classification was further refined by Yang et al, 2012[3] (Table A3) who described a general framework for the classification of water associated infectious disease which included six categories.

Table A3: Classification of water related infectious diseases (adapted from Yang et al, 2012[16])

Category	**Description**	**Example diseases**
Waterborne	Caused by enteric microorganisms, which enter water sources through faecal contamination and cause infections in humans through ingestion of contaminated water	Typhoid, cholera
Water carried (a subset of waterborne)	Transmission can be through accidental ingestion of, or exposure to, contaminated water	*Cryptosporidium, Giardia*
Water-based	Diseases caused by infections of worms which must spend parts of their life cycles in the aquatic environment	Schistosomiasis
Water-related	Need water for breeding of insect vectors to fulfil the transmission cycle	Malaria, trypanosomiasis
Water-washed	Transmission is due to poor personal and/or domestic hygiene as a result of lack of appropriate water	*Shigella*
Water-dispersed	Infections of agents which proliferate in fresh water and enter the human body through the respiratory tract	*Legionella*

Annex 2: Useful Resources

1. Water system guidance documents

- WHO (1999) Protocol on Water and Health to the 1992 Convention on the Protection and Use of Transboundary Watercourses and International Lakes. http://www.euro.who.int/en/publications/policy-documents/protocol-on-water-and-health-to-the-1992-convention-on-the-protection-and-use-of-transboundary-watercourses-and-international-lakes

- WHO (2011) Guidelines for drinking water quality, 4th ed. https://www.who.int/water_sanitation_health/publications/2011/dwq_guidelines/en/

- WHO (2001) Water quality: Guidelines, standards and health: Assessment of risk and risk management for water-related infectious disease. https://www.who.int/water_sanitation_health/publications/whoiwa/en/

- WHO and OECD (2003). Assessing Microbial Safety of Drinking Water; improving approaches and methods. https://www.who.int/water_sanitation_health/publications/9241546301/en/

- WHO (2011). Water safety plans. In: Guidelines for drinking-water quality – fourth edition. Geneva: World Health Organization http://www.who.int/water_sanitation_health/publications/2011/dwq_guidelines/en

- WHO and IWA (2009). Water safety plan manual: step-by-step risk management for drinking-water suppliers. Geneva: World Health Organization http://www.who.int/water_sanitation_health/publication_9789241562638/en/

- WHO (2012). Water safety planning for small community water supplies: step-by-step risk management guidance for drinking-water supplies in small communities. Geneva: World Health Organization http://www.who.int/water_sanitation_health/publications/2012/water_supplies/en/index.html

- WHO (2014). Water safety plan: a field guide to improving drinking-water safety in small communities. Copenhagen: WHO Regional Office for Europe http://www.euro.who.int/en/health-topics/environment-and-health/water-and-sanitation/publications/2014/water-safety-plan-a-field-guideto-improving-drinking-water-safety-in-smallcommunities

- WHO and IWA (2012). Water safety plan training package. Geneva: World Health Organization http://www.who.int/water_sanitation_health/publications/wsp_training_package/en

- WHO (2011). Water safety in buildings. Geneva: World Health Organization http://www.who.int/water_sanitation_health/publications/2011/9789241548106/en

- WHO (2004) Waterborne zoonoses; identification, causes and control. https://www.who.int/water_sanitation_health/publications/zoonoses/en/

- WHO (2009) Water safety plan manual: step-by-step risk management for drinking water suppliers. https://www.who.int/water_sanitation_health/publications/publication_9789241562638/en/

- WHO (2014). Water safety in distribution systems. Geneva: World Health Organization http://www.who.int/water_sanitation_health/publications/Water_Safety_in_Distribution_System/en/

- WHO (2017) Water quality and health. Review of turbidity: Information for regulators and water suppliers. Technical brief. https://www.who.int/water_sanitation_health/publications/turbidity-technical-brief/en/

- WHO (2017). Water quality and health. Boil Water. Technical Brief. https://apps.who.int/iris/handle/10665/155821

- WHO (2012) Rapid assessment of drinking-water quality; A handbook for implementation. https://www.who.int/water_sanitation_health/publications/rapid_assessment/en/

- United States Environmental Protection Agency. Online water quality monitoring resources https://www.epa.gov/waterqualitysurveillance/online-water-quality-monitoring-resources

2. Surveillance Guidelines and Tools

- World Health Organization, Regional Office for Europe (2011). Technical guidance on water-related disease surveillance. http://www.euro.who.int/en/publications/abstracts/technical-guidance-on-water-related-disease-surveillance-2011

- World Health Organization, Regional Office for Europe (2011). Policy guidance on water-related disease surveillance. http://www.euro.who.int/en/publications/abstracts/policy-guidance-on-water-related-disease-surveillance-2011

- WHO (2014). Early detection, assessment and response to acute public health events; implementation of early warning and response with a focus on event-based surveillance. https://www.who.int/ihr/publications/WHO_HSE_GCR_LYO_2014.4/en/

- World Health Organization. (2017). Strengthening surveillance of and response to foodborne diseases: a practical manual. Stage 1: using indicator- and event-based surveillance to detect foodborne events. http://www.who.int/iris/handle/10665/259471.

- World Health Organization. (2017). Strengthening surveillance of and response to foodborne diseases: a practical manual. Stage 2: strengthening indicator-based surveillance. https://apps.who.int/iris/handle/10665/259472

- World Health Organization Regional Office for Europe (2001). Waterborne Disease Surveillance: Goals and Strategies. www.euro.who.int/_data/assets/pdf_file/0010/239275/E74635.pdf

- WHO (1999). WHO recommended surveillance standards, 2nd ed. https://www.who.int/csr/resources/publications/surveillance/WHO_CDS_CSR_ISR_99_2_EN/en

- WHO (2006). Communicable disease surveillance and response systems. Guide to monitoring and evaluating. https://www.who.int/csr/resources/publications/surveillance/WHO_CDS_EPR_LYO_2006_2/en/

- WHO (1997). Protocol for the evaluation of epidemiological surveillance systems. https://apps.who.int/iris/handle/10665/63639

- Andersson and Bohan (2001). Disease surveillance and waterborne outbreaks. In Water quality: Guidelines, standards and health: Assessment of risk and risk management for water-related infectious disease. World Health Organisation, 2001. https://www.who.int/water_sanitation_health/publications/whoiwa/en/

- Centers for Disease Control and Prevention (2012). Lesson 5: Public Health Surveillance. In: Priniciples of Epidemiology in Public Health Practice, 3rd ed. An Introduction to Applied Epidemiology and Biostatistics. https://www.cdc.gov/ophss/csels/dsepd/ss1978/lesson5/index.html

- ECDC (2012). Toolkit for investigation and response to Food and Waterborne Disease Outbreaks with an EU dimension. https://ecdc.europa.eu/en/publications-data/toolkit-investigation-and-response-food-and-waterborne-disease-outbreaks-eu

- ECDC (2014). Data quality monitoring and surveillance system evaluation – A handbook of methods and applications. Stockholm: ECDC; 2014. https://ecdc.europa.eu/en/publications-data/data-quality-monitoring-and-surveillance-system-evaluation-handbook-methods-and

- European Union (2018) surveillance case definitions. Commission Implementing Decision (EU) 2018/945 of 22 June 2018 on the communicable diseases and related special health issues to be covered by epidemiological surveillance as well as relevant case definitions. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv%3AOJ.L_.2018.170.01.0001.01.ENG

3. Outbreak Guidelines and Tools

- WHO (2017). Strengthening surveillance of and response to foodborne diseases: a practical manual. Stage 1: investigating foodborne disease outbreaks. World Health Organization. https://www.who.int/foodsafety/publications/foodborne_disease/surveillancemanual/en/

- WHO (2008). Foodborne disease outbreaks; guidelines for investigation and control http://www.who.int/foodsafety/publications/foodborne_disease/outbreak_guidelines.pdf

- CDC (2012). Lesson 6: Investigating an Outbreak. In: Principles of Epidemiology in Public Health Practice, 3rd ed. An Introduction to Applied Epidemiology and Biostatistics. https://www.cdc.gov/ophss/csels/dsepd/ss1978/lesson6/index.html

- ECDC / European Programme for Intervention Epidemiology Training (2019). Field Epidemiology Manual. https://wiki.ecdc.europa.eu/

- Public Health England (2014). Communicable Disease Outbreak Management; Operational Guidance. https://www.gov.uk/government/publications/communicable-disease-outbreak-management-operational-guidance

- WHO (2012). Guideline for rapid risk assessment of acute public health events http://www.who.int/csr/resources/publications/HSE_GAR_ARO_2012_1/en/

- CDC (2017). Water, sanitation & Hygiene (WASH)-related Emergencies & Outbreaks. https://www.cdc.gov/healthywater/emergency/index.html

- WHO (2000) Guidelines for the collection of clinical specimens during field investigations of outbreaks http://www.who.int/ihr/publications/WHO_CDS_CSR_EDC_2000_4/en/

- WHO (2017). Guidance on regulations for the transport of infectious substances 2017-2018. https://www.who.int/ihr/publications/WHO-WHE-CPI-2017.8/en/

- WHO (2008). Early warning and response to outbreaks and other public health events; a guide. http://www.searo.who.int/entity/emerging_diseases/documents/SEA_CD_178/en/

- WHO (2008). WHO Event Management for International Public Health Security Operational Procedures. http://www.who.int/csr/HSE_EPR_ARO_2008_1.pdf

- WHO (2003). First steps for managing an outbreak of acute diarrhoea http://apps.who.int/iris/bitstream/10665/70538/1/WHO_CDS_CSR_NCS_2003.7_Rev.2_eng.pdf

- WHO (2004). Cholera outbreak: assessing the outbreak response and improving preparedness http://apps.who.int/iris/bitstream/10665/43017/1/WHO_CDS_CPE_ZFk_2004.4_eng.pdf

- WHO (1997). Cholera and other Epidemic Diarrhoeal Diseases Control. Technical Cards on Environmental Sanitation http://apps.who.int/iris/bitstream/10665/65505/1/WHO_EMC_DIS_97.6.pdf

4. Outbreak and risk communication

- WHO (2018) Communicating Risk in Public Health Emergencies: a WHO Guideline for Emergency Risk Communication (ERC) policy and practice https://www.who.int/risk-communication/guidance/download/en/

- WHO (2005). WHO Outbreak Communication Planning Guide http://www.who.int/ihr/elibrary/WHOOutbreakCommsPlanngGuide.pdf

- WHO (2005). WHO Outbreak communication guidelines http://www.who.int/csr/resources/publications/WHO_CDS_2005_28/en/

- WHO (2012). Communications for behavioural impact https://www.who.int/ihr/publications/combi_toolkit_outbreaks/en/

- CDC (2018). Crisis and Emergency Risk Communication (CERC). https://emergency.cdc.gov/cerc/

- ECDC (2016). Social media strategy development – A guide for using social media for public health communication. https://ecdc.europa.eu/en/publications-data/social-media-strategy-development-guide-using-social-media-public-health

- CDC (2017). Drinking water advisory communication toolbox. https://www.cdc.gov/healthywater/emergency/dwa-comm-toolbox/index.html

5. Data management and analysis

- http://www.epidata.dk/
- http://www.cdc.gov/epiinfo/
- https://www.openepi.com/

Annex 3: Template boil water notice

Annex 4: Legionella Resources

Legionnaires disease is an acute bacterial infection characterised by anorexia, malaise, myalgia and headache. Fever, commonly of 39.0-40.5^{0}C, usually manifests within one day, and is frequently accompanied by chills. Other common symptoms are non-productive cough, diarrhoea and abdominal pain. Pneumonia and respiratory failure may occur. Case fatality rates of up to 39% have been reported in hospitalised patients. Mortality is highest in the immunocompromised. Most cases and outbreaks occur in summer and autumn. Attack rates of 0.1-5% in the at-risk population have been reported. Hot water systems, air conditioning cooling towers, evaporative condensers, humidifiers, whirlpool spas, fountains and respiratory therapy devices have all been associated with outbreaks. Legionella can survive for months in tap water. Airborne transmission is the most common route of infection. Person-to-person transmission has not been documented. The incubation period averages five to six days but can range from two to ten days. Risk factors for infection include increasing age, smoking and underlying comorbidities including cancer, chronic lung disease, diabetes, renal disease and immunocompromise. Males are more than twice as likely to develop Legionnaires disease as women.

Environmental microorganisms can grow and form biofilms in the pipes of distribution systems, as well as on outlets, mixing valves and on washers[21,23]. Biofilms can harbour water-dispersed pathogens such as *Legionella, Naegleria fowleri and Mycobacterium* species. Once biofilms have developed in a water system, they are extremely difficult to remove. They are resistant to disinfection. Preventing their growth is an important measure to control water-dispersed diseases. Biofilms are more likely to form when there are nutrients present in the source water and in the system, when there is corrosion or scale in the system, when the temperature of the water is warm, and when the flow rates are low or the water is stagnant for instance in dead ends of the system or storage tanks. Biofilms in water distribution systems can inoculate building water systems where they are associated with *Legionella* outbreaks[21,22,23].

Building water systems can be contaminated in several ways[22,23]. Inadequate storage tanks and cross-connections with wastewater pipes can lead to faecal contamination of water. Stagnation of water in poorly designed plumbing systems can enable the growth of biofilms which provide a niche for the growth of *Legionella*. Of note, backflow from building water systems into the public distribution system can lead to cross contamination of the drinking water supply outside the building.

For instance, when a case of *Legionella* is detected, the case will be investigated to determine the exposure history in the time period corresponding to the incubation period (usually the two weeks prior to onset of illness). Diaries and street maps may be used to help to aid the collection of these data. Based on the exposure history, the case will be classified as community acquired, domestically acquired, nosocomial or travel associated. Cases are usually reported to the national surveillance system after data on the exposure history has been collected and after the case has been classified. Single cases will be investigated for possible links to other cases by time and place. Potential sources of infection for these cases may be identified and a risk assessment of these sources may be launched. For instance, the identification of a nosocomial or domestically acquired infection is likely to instigate the launch of an environmental investigation of the water system in the health-care facility or building associated with infection, with a view to implementing control measures to secure the water system. Clusters of community-acquired cases would usually prompt an investigation of potential sources in the neighbourhoods in the vicinity of cases. Travel associated cases must be investigated in the country of infection in accordance with the guidelines issued by the European Working Group on Legionella Infection (EWGLI) (ref).

Legionella Outbreak Investigation Case Study

Step 1: Receipt of initial report and confirmation of the outbreak

On 06 June the district epidemiologist in the Mountain District received a report of a single case of Legionnaires disease in an elderly man admitted to the university hospital. Additional notifications occurred on 11 and 15 June, by which time there were a total of five cases.

The epidemiologist completed a case investigation form for all cases in accordance with standard procedures. Cases were clustered in the Northern zone of the city. One case died. All cases had onset of symptoms after 01 June. Four of the five cases were male and all were aged greater than 60 years. Four lived in the Northern zone and the remaining case lived outside the city but worked in the Northern zone. All cases had underlying comorbidities or were smokers. All cases had laboratory confirmation of *Legionella pneumophilia* based on either culture from respiratory specimens or urinary antigen testing. None of the cases were considered to be travel or healthcare associated. The epidemiologist started a line list to document key information on the cases.

Rapid public health risk assessment

The epidemiologist conducted a rapid public health risk assessment.

The epidemiologist noted that cases had occurred over a ten-day period indicating that transmission in the community was ongoing. Legionnaires disease can have severe outcomes including death and one case had already died. If action was not taken to contain the outbreak it was likely that more cases would occur and the consequences to public health could be severe. Given this, the epidemiologist classified the outbreak as high-risk.

Report to stakeholders

The epidemiologist declared the outbreak and notified the district Director of Public Health.

Form OMT & prepare for investigation

The district director of public health convened an OMT on 16 June to investigate and control the outbreak. The OMT comprised:

- The district epidemiologist
- The district environmental health officer
- A microbiologist with expertise in legionella from the regional public health laboratory
- A risk manager from the municipal authority
- A legionella expert from the EPA
- A specialist in GIS from the NPHA
- A communications expert

The OMT met to agree the objectives of the outbreak management, to agree on roles and responsibilities and to develop a plan to investigate the outbreak. Having reviewed the data the OMT agreed that this was an outbreak of legionnaires disease with a likely source in the community.

Step 2: Confirm the cause

Four of the five cases were male and all were aged greater than 60 years. Four lived in the Northern zone and the remaining case lived outside the city but worked in the Northern zone. All cases had underlying comorbidities or were smokers. All cases had laboratory confirmation of *Legionella pneumophilia* based on either culture from respiratory specimens or urinary antigen testing. None of the cases were considered to be travel or healthcare associated.

Step 3: Define cases

The OMT agreed the following case definitions for the outbreak:

Confirmed case: A person with community acquired pneumonia, with laboratory confirmation of Legionella pneumophilia, with date of onset of illness from 15 May, who lived in or visited the Northern zone of Waterfall in the two weeks prior to onset of illness

Probable case: A person with community acquired pneumonia, with date of onset of illness from 15 May, who lived in or visited the Northern zone of Waterfall in the two weeks prior to onset of illness

Step 4: Active case finding

The OMT alerted local primary care doctors and hospitals about the outbreak and asked them to consider legionella as a possible cause of community acquired pneumonia and to submit urinary specimens from probable cases for testing. The public health laboratory was asked to notify the OMT on a daily basis about any new laboratory confirmed cases of legionella. The NPHA alerted all districts in the country about the outbreak and asked them to forward the details of any cases that met the case definitions to the OMT and to arrange for testing of these cases.

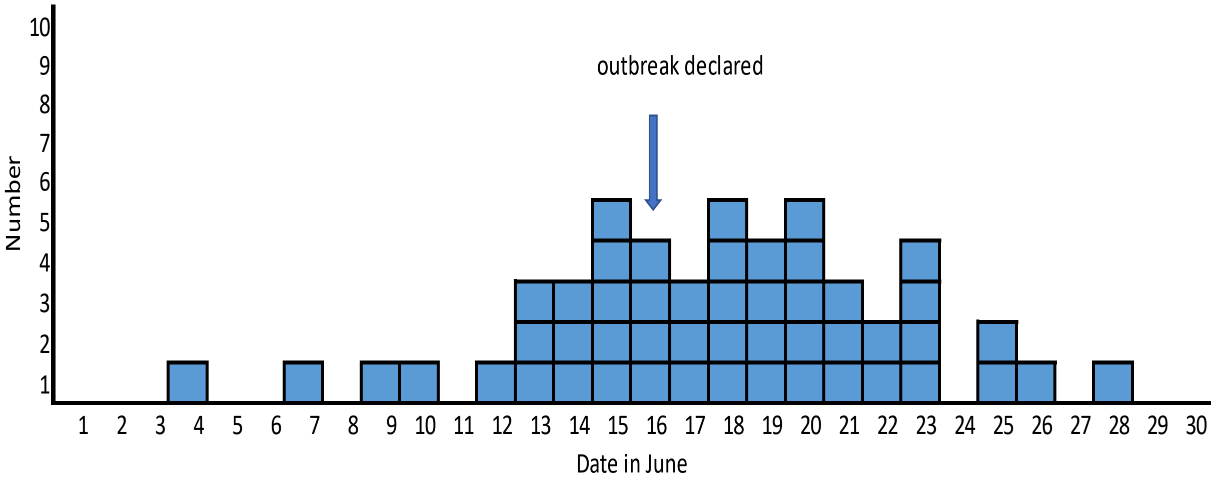
The OMT interviewed all cases about their movements in the two weeks before onset of illness using a standardised questionnaire, taking detailed information on the location of the places that they visited and the timing of their visits. The questionnaire also collected data on where they worked, where they shopped, any recent travel or overnight stays in hotels, and exposure to potential sources such as spa pools or fountains. Lower respiratory tract specimens were taken from all confirmed cases for reference culture and typing at the national reference laboratory.

Step 5: Descriptive epidemiological investigation

Time

By 30 June a total of 50 cases had been notified, all with data of onset between 04 and 28 June (Figure I).

Figure I: Cases of legionellosis, Waterfall, 03-28 June



The shape of the curve was consistent with a continuous point source. The index case had onset of symptoms on 04 June, suggesting a potential exposure period of between 21 May and 03 June.

Place

Thirty-nine cases (78%) were resident in the Northern Zone (Figure II) which corresponded to an attack rate of 16 per 10000 residents of the Northern Zone. There were a further 11 cases who resided outside the Northern Zone but who either worked there or were regular visitors to that part of the city. No cases were reported from outside the Mountain District.

Figure II: Distribution of cases of *Legionella pneumophilia*, Waterfall, June 2018

Person

Table 1 summarises the characteristics of cases. All cases had a positive urinary antigen test for Legionella pneumophilia serogroup 1 (LP1). Five case were culture positive. Forty-five cases (90%) were admitted to hospital; the remaining cases were treated at home. Cases were aged between 56 and 91 years of age (median=63) and 75% (38) were male. Five cases (10%) died. Fifteen cases (30%) had underlying comorbidities including asthma (3 cases), COPD (7 cases), diabetes (3 cases) and immunosuppression (2 cases). Thirty-two cases (64%) smoked, and an additional four were ex-smokers. None of the cases had travelled abroad or been admitted to hospital in the two weeks prior to illness onset.

Table 1: Characteristics of cases of *Legionella pneumophilia*, Waterfall, June 2018

Characteristic	**Number (% of cases)**
Confirmed cases	50 (100)
Status	
Hospitalised	45 (90)
Died	5 (10)
Age-group	
40-49	2 (4)
50-59	5 (10)
60-69	14 (28)
70-79	18 (36)

≥80	11 (22)
Sex	
Male	36 (72)
Female	14 (28)
Underlying	
comorbidities	15 (30)
Any	3 (6)
Asthma	7 (14)
COPD	3 (6)
Diabetes	2 (4)
Immunosuppression	
Smoking status	
Current smoker	32 (64)
Former smoker	4 (8)

Table 2: Attack rate for Legionella pneumophilia among residents of the Northern Zone

Characteristic	Number	Attack rate / 10,000 persons
Overall	39	16
Age-group		
40-49	0	0
50-59	2	4
60-69	10	23
70-79	16	43
≥80	11	45
Sex		
Male	30	26
Female	9	7

Table 2 summarises the attack rates for the 39 cases resident in the Northern zone. Among residents in the Northern Zone, the attack rate was highest for those aged 70 to 79 years and 80 years and over, as well as for males.

Step 6: Additional studies

Environmental investigation

The district environmental health officer, the risk manager from the municipal authority and the representative from the EPA led the environmental investigation. The geographical distribution of cases indicated that the epicentre of the outbreak was in a neighbourhood to the northeast of the Northern Zone. They listed all potential sources within a 500-meter radius of the epicentre and prioritised them for investigation. They consulted the municipal register of industrial cooling towers to identify cooling towers. They also identified additional potential sources in the area such as whirlpool spas, car washes, fountains and supermarket food display units with humidifiers. They visited each site and conducted a risk assessment of the potential source. They reviewed the operation and maintenance procedures and the cleaning and disinfection records for the potential source. They asked the operators about unusual events relating to the potential sources during the previous two months, including periods when the source was not operating and any breakdowns in equipment. They took water samples and swabs from areas where Legionella species were likely to grow, from areas where there was a lot of biofilm growth and from close to the heat source. Samples were sent to the local EPA laboratory for culture and typing.

When all sources within a 500-meter radius were identified and inspected, they repeated this exercise at increasing 500-meter radii to a maximum of two kilometres.

Spatial analyses

The daily movements of cases in the two weeks prior to illness onset, and their place of residence and work were entered into a GIS database, along with details on the location of possible sources of the outbreak and data on meteorological data (specifically data on the prevailing wind direction and speed each day from 15 May).

Given the geographic distribution of cases, information on the prevailing wind directions during the period of exposure and findings from the environmental risk assessments, three cooling towers to the north east of the Northern Zone were identified as the most likely sources of the outbreak. The OMT also modelled the atmospheric dispersion of plumes from these sources during the exposure period to assess the degree to which the likely geographic spread of emissions from these sources matched the spatial distribution of cases.

Step 7: Generate hypotheses

Considering the results of the epidemiological and environmental investigation, the OMT hypothesised that one of the three cooling towers located in the north east of the city was the most likely source of the outbreak.

Step 8: Evaluate hypotheses

Ecological study

The OMT conducted an ecological study to quantify the risk of infection for those living at various distances from each of the suspected sources. The OMT calculated attack rates for those living at distances of 500m, 1000m, 1500m and 2000m from each of the suspected sources. They then calculated rate ratios for each zone compared to those living outside the zone.

Table 3: Attack rates (AR) per 10,000 persons and risk ratios (RR) for legionella pneumophilia infection by proximity to suspected cooling towers, Waterfall, June 2018.

	Cooling tower A		**Cooling tower B**		**Cooling tower C**	
Distance	AR	RR	AR	RR	AR	RR
500m	27	3.1	95	19.1	56	7.2
1000m	20	2.5	72	12.3	39	5.1
1500m	32	3.9	23	2.9	18	3.4
2000m	36	4.1	8	1.5	6	1.2

Assessing the strength of the evidence

The ecological study demonstrated that the risk of legionella infection increased with increasing residential proximity to cooling tower B. This association was not observed for cooling towers A and C. This suggested that cooling tower B was the source of the outbreak.

This finding was supported by data from the environmental and microbiological investigations and from the atmospheric modelling.

The environmental risk assessment revealed that those operating cooling tower B were not complying with regulations for the cleaning and maintenance of the water system in the tower. The water system was found to be heavily contaminated with biofilm. A sample taken from the biofilm tested positive for Legionella pneumophilia and was found to be genetically identical to the organism isolated from cases.

Step 9: Implement control measures

All sources were shut down and subjected to a precautionary decontamination before being permitted to operate again. This was done after the environmental risk assessment and collection of environmental samples.

The owners of cooling tower B were instructed to

a) comply with regulations for the cleaning and maintenance of the water system
b) increase the frequency of disinfecting the system
c) maintain cold water temperatures at $\leq 25^0$C and hot water temperatures at $\geq 55^0$C

Step 10: Communicate findings

Throughout the outbreak the OMT sent daily updates on the progress of the investigation to the NPHA and to the municipal authorities. The outbreak attracted substantial local media attention and so regular reports were also issued to the public and the media and were disseminated by social media. The final report recommended that further resources be allocated to the enforcement of regulations for the maintenance of cooling towers and other potential sources of legionella infection.

Legionella Guidelines and Tools

WHO (2007). Legionella and the prevention of legionellosis.
https://www.who.int/water_sanitation_health/publications/legionella/en/

European Legionnaires' Disease Surveillance Network (ELDSNet) https://ecdc.europa.eu/en/about-us/partnerships-and-networks/disease-and-laboratory-networks/eldsnet
(Includes Legionnaires disease outbreak investigation toolbox and GIS tool)

ECDC (2017). European technical guidelines for the prevention, control and investigation of infections caused by Legionella species. https://ecdc.europa.eu/en/publications-data/european-technical-guidelines-prevention-control-and-investigation-infections

CDC (2018). Legionella Environmental Investigation Resources.
https://www.cdc.gov/legionella/health-depts/environmental-inv-resources.html

References

1 Data and statistics. 2019; published online Feb 16. http://www.euro.who.int/en/health-topics/environment-and-health/water-and-sanitation/data-and-statistics (accessed Feb 16, 2019).

2 Protocol on Water and Health; about The Protocol. Geneva United Nations Econ. Comm. Eur. 2018. 2018. http://www.unece.org/?id=2975 (accessed Sept 10, 2018).

3 Kulinkina A V, Shinee E, Guzman Herrador BR, Nygard K, Schmoll O. The Situation of Water-Related Infectious Diseases in the Pan-European Region. 2016 http://www.euro.who.int/en/publications/abstracts/situation-of-water-related-infectious-diseases-in-the-pan-european-region-the-2016.

4 Cotruvo JA, Dufour A, Rees G, *et al.*, editors. Waterborne Zoonoses Identification, Causes and Control. London: World Health Organization and IWA Publishing, 2004.

5 WHO | Emerging issues in water and infectious diseases. *WHO* 2003.

6 Blasi M, Carere M, Funari E. National surveillance capacity of water-related diseases in the WHO European Region. *J Water Health* 2011; **9**: 752–62.

7 Plutzer J, Lassen B, Jokelainen P, *et al.* Review of Cryptosporidium and Giardia in the eastern part of Europe, 2016. *Eurosurveillance* 2018; **23**. DOI:10.2807/1560-7917.ES.2018.23.4.16-00825.

8 Risebro HL, Hunter PR. Surveillance of waterborne disease in European member states: a qualitative study. *J Water Health* 2007; **5**: 19–38.

9 Mac Kenzie WR, Hoxie NJ, Proctor ME, *et al.* A Massive Outbreak in Milwaukee of Cryptosporidium Infection Transmitted through the Public Water Supply. *N Engl J Med* 1994; **331**: 161–7.

10 Guzman-Herrador B, Carlander A, Ethelberg S, *et al.* Waterborne outbreaks in the Nordic countries, 1998 to 2012. *Euro Surveill* 2015; **20**. http://www.ncbi.nlm.nih.gov/pubmed/26111239 (accessed Nov 5, 2018).

11 Protocol on Water and Health to the 1992 Convention on the Protection and Use of Transboundary Watercourses and International Lakes. Geneva: United Nations Economic Commission for Europe and WHO Regional Office for Europe, 2006 http://www.euro.who.int/en/publicaitons/policy-documents/protocol-on-water-and-health-to-the-1992-convention-on-the-protection-and-use-of-transboundary-watercourses-and-internatonal-lakes, accessed 19 July 2018.

12 World Health Organization. International health regulations (2005). World Health Organization, 2008.

13 Campbell OMR, Benova L, Gon G, Afsana K, Cumming O. Getting the basic rights - the role of water, sanitation and hygiene in maternal and reproductive health: a conceptual framework. *Trop Med Int Health* 2015; **20**: 252–67.

14 Funari E, Kistemann T, Herbst S, Rechenburg A, editors. Technical guidance on water-related disease surveillance. World Health Organisation Regional Office for Europe, 2011 http://www.euro.who.int/en/publications/abstracts/technical-guidance-on-water-related-disease-surveillance-2011.

15 Bartram J, Hunter P. Bradley Classification ofdisease transmission routes for water-related

hazards. 2015; published online Oct 5. DOI:10.4324/9781315693606.ch03.

16 Yang K, LeJeune J, Alsdorf D, Lu B, Shum CK, Liang S. Global distribution of outbreaks of water-associated infectious diseases. *PLoS Negl Trop Dis* 2012; **6**: e1483.

17 Nygard K. Water and Infection. Epidemiological Studies of Epidemic and Endemic Waterborne Disease. 2008. http://urn.nb.no/URN:NBN:no-20138.

18 Craun GF, Frost FJ, Calderon RL, *et al.* Improving waterborne disease outbreak investigations. *Int J Environ Health Res* 2001; **11**: 229–43.

19 Guidelines for Drinking Water Quality, Fourth edi. Geneva: World Health Organization, 2011.

20 Assessing Microbial Safety of Drinking Water. Geneva, 2003.

21 World Health Organization. Water safety in distribution systems. .

22 WHO | Water safety in buildings. *WHO* 2013.

23 WHO | Legionella and the prevention of legionellosis. *WHO* 2016.

24 Water safety plan: a field guide to improving drinking-water safety in small communities. 2017; published online Oct 12. http://www.euro.who.int/en/publications/abstracts/water-safety-plan-a-field-guide-to-improving-drinking-water-safety-in-small-communities (accessed Feb 23, 2019).

25 Bartram J, Corrales L, Davison A, *et al.* Water safety plan manual: step-by-step risk management for drinking water suppliers. Geneva, 2009.

26 Policy guidance on water-related disease surveillance (2011). 2017; published online March 18.

27 WHO | Strengthening surveillance of and response to foodborne diseases. *WHO* 2017. https://www.who.int/foodsafety/publications/foodborne_disease/surveillancemanual/en/ (accessed Feb 20, 2019).

28 WHO | Strengthening surveillance of and response to foodborne diseases. *WHO* 2017. https://www.who.int/foodsafety/publications/foodborne_disease/surveillancemanual/en/ (accessed Feb 23, 2019).

29 Principles of Epidemiology | Lesson 6 | Overview. https://www.cdc.gov/ophss/csels/dsepd/ss1978/lesson6/index.html (accessed Feb 23, 2019).

30 Lecture 03 - Outbreak Investigations - EPIET - Wiki - EPIET - FEM Wiki. https://wiki.ecdc.europa.eu/training/epiet/w/wiki/884.lecture-03-outbreak-investigations (accessed Feb 23, 2019).

31 Bartram J, Fewtrell L, Stenstron TA. Harmonised assessment of risk and risk management for water-related infectious disease: an overview. In: Fewtrell L, Bartram J, eds. Water quality: guidelines, standards and health. London: International Water Association, 2001.

32 Paquet C, Coulombier D, Kaiser R, Ciotti M. Epidemic intelligence: a new framework for strengthening disease surveillance in Europe. *Euro Surveill Bull Eur sur les Mal Transm = Eur Commun Dis Bull* 2006; **11**: 212–4.

33 Bisseux M, Colombet J, Mirand A, *et al.* Monitoring human enteric viruses in wastewater and relevance to infections encountered in the clinical setting: a one-year experiment in central France, 2014 to 2015. *Eurosurveillance* 2018; **23**. DOI:10.2807/1560-7917.ES.2018.23.7.17-00237.

34 Hellmér M, Paxéus N, Magnius L, *et al.* Detection of pathogenic viruses in sewage provided early warnings of hepatitis A virus and norovirus outbreaks. *Appl Environ Microbiol* 2014; **80**: 6771–81.

35 World Health Organization, Early warning and response to outbreaks and other public health events:A guide: 2008. *SEARO* 2017. http://www.searo.who.int/entity/emerging_diseases/documents/SEA_CD_178/en/ (accessed Feb 23, 2019).

36 WHO | Outbreak surveillance and response in humanitarian emergencies. *WHO* 2012. https://www.who.int/diseasecontrol_emergencies/publications/who_hse_epr_dce_2012.1/en/ (accessed Feb 23, 2019).

37 European technical guidelines for the prevention, control and investigation of infections caused by Legionella species. https://ecdc.europa.eu/en/publications-data/european-technical-guidelines-prevention-control-and-investigation-infections (accessed Feb 23, 2019).

38 Zeger SL, Irizarry R, Peng RD. On time series analysis of public health and biomedical data. *Annu Rev Public Health* 2006; **27**: 57–79.

39 Naumova EN, Macneill IB. Signature-forecasting and early outbreak detection system. *Environmetrics* 2005; **16**: 749–66.

40 De Roos AJ, Gurian PL, Robinson LF, Rai A, Zakeri I, Kondo MC. Review of Epidemiological Studies of Drinking-Water Turbidity in Relation to Acute Gastrointestinal Illness. *Environ Health Perspect* 2017; **125**: 086003.

41 Kulinkina A V., Mohan VR, Francis MR, *et al.* Seasonality of water quality and diarrheal disease counts in urban and rural settings in south India. *Sci Rep* 2016; **6**: 20521.

42 Lo Iacono G, Armstrong B, Fleming LE, *et al.* Challenges in developing methods for quantifying the effects of weather and climate on water-associated diseases: A systematic review. *PLoS Negl Trop Dis* 2017; **11**: e0005659.

43 Beaudeau P. A Systematic Review of the Time Series Studies Addressing the Endemic Risk of Acute Gastroenteritis According to Drinking Water Operation Conditions in Urban Areas of Developed Countries. *Int J Environ Res Public Health* 2018; **15**: 867.

44 Bédubourg G, Le Strat Y. Evaluation and comparison of statistical methods for early temporal detection of outbreaks: A simulation-based study. *PLoS One* 2017; **12**: e0181227.

45 Guidelines on the Setting of Targets, Evaluation of Progress and Reporting. Protocol on Water and Health to the Convention on the Protection and Use of Transboundary Watercourses and International Lakes. Geneva and New York, 2010 The meeting was organized by the WHO European Centre for Environment and Health of the WHO%0ARegional Office for Europe in support to the implementation of the Protocol on Water and Health to the%0AConvention on the Protection and Use of Transboundary Wat.

46 Collection of good practices and lessons learned on target setting and reporting under the Protocol on Water and Health. Geneva and New York, 2016 https://www.unece.org/index.php?id=44286.

47 European Working Group for Legionella Infections (2011). EWGLI Technical Guidelines for the Investigation, Control and Prevention of Travel Associated Legionnaires' Disease. .

48 Kluge H, Martín-Moreno JM, Emiroglu N, *et al.* Strengthening global health security by embedding the International Health Regulations requirements into national health systems.

BMJ Glob Heal 2018; **3**: e000656.

49 World Health Organisation Regional Office for Europe (2009). Outbreaks of Waterborne Diseases. Factsheet 1.1. RPG1_WatSan_E1. .

50 Communicable disease outbreak management: operational guidance - GOV.UK. https://www.gov.uk/government/publications/communicable-disease-outbreak-management-operational-guidance (accessed Feb 23, 2019).

51 Tillett HE, de Louvois J, Wall PG. Surveillance of outbreaks of waterborne infectious disease: categorizing levels of evidence. *Epidemiol Infect* 1998; **120**: 37–42.

52 World Health Organization. (2008). Foodborne disease outbreaks : guidelines for investigation and control. Geneva : World Health Organization. .

53 WHO | Rapid risk assessment of acute public health events. *WHO* 2013. https://www.who.int/csr/resources/publications/HSE_GAR_ARO_2012_1/en/ (accessed Feb 22, 2019).

54 Nygård K, Werner-Johansen Ø, Rønsen S, *et al.* An outbreak of legionnaires disease caused by long-distance spread from an industrial air scrubber in Sarpsborg, Norway. *Clin Infect Dis* 2008; **46**: 61–9.

55 Smith CM, Le Comber SC, Fry H, Bull M, Leach S, Hayward AC. Spatial methods for infectious disease outbreak investigations: systematic literature review. *Eurosurveillance* 2015; **20**: 30026.

56 WHO | WHO outbreak communication guidelines. *WHO* 2015. https://www.who.int/csr/resources/publications/WHO_CDS_2005_28/en/ (accessed Feb 23, 2019).

57 WHO | Outbreak Communication. *WHO* 2015. https://www.who.int/csr/resources/publications/WHO_CDS_2005_32/en/ (accessed Feb 23, 2019).

58 Resources | Crisis & Emergency Risk Communication (CERC). https://emergency.cdc.gov/cerc/resources/index.asp (accessed Feb 23, 2019).

59 Social media strategy development – A guide to using social media for public health communication. https://ecdc.europa.eu/en/publications-data/social-media-strategy-development-guide-using-social-media-public-health (accessed Feb 23, 2019).

60 Hunter PR, MacDonald AM, Carter RC. Water Supply and Health. *PLoS Med* 2010; **7**: e1000361.