



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

**Working Group on Water and Health**

Thirteenth meeting

Geneva, 19 and 20 May 2022

Item 5 of the provisional agenda

**Prevention and reduction of water-related diseases**

**INFORMAL DOCUMENT**

**Training module on strengthening drinking-water surveillance using risk-based approaches (draft)**

The Protocol on Water and Health sets several requirements for surveillance of drinking-water, including establishment of the legal and institutional framework for monitoring and surveillance and enforcing standards for quality of drinking-water for protection of water-related diseases.

The development of a training module on drinking-water surveillance is a planned activity under the Protocol's programme of work for 2020-2022. The training module aims to provide a rationale for application of risk-based approaches to drinking-water surveillance and support decision makers, regulators and water professionals to better understand and appreciate the added value of risk-based surveillance approaches and thereby support the building of effective surveillance systems.

The training package is based on the technical guidance provided in the publication *Strengthening drinking-water surveillance using risk-based approaches* (WHO Regional Office for Europe, 2019) that was published under the 2017-2019 programme cycle. It highlights six key messages underlining the main concept of the risk-based approaches of drinking-water surveillance and provides practical examples.

The Working Group on Water and Health is requested to review the draft training package and provide feedback on its technical content by **10 June 2022** to Oliver Schmoll at [schmollo@who.int](mailto:schmollo@who.int).

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

World Health Organization  
REGIONAL OFFICE FOR Europe

UNECE

# STRENGTHENING DRINKING-WATER SURVEILLANCE USING RISK-BASED APPROACHES

1

## MODULE OBJECTIVES

1. To provide a rationale for decision-makers to promote and support uptake of risk-based approaches in regulations and surveillance practice
2. To underline the added value of risk-based drinking-water surveillance and thereby strengthen existing surveillance systems for better protection of public health
3. To provide a strong rationale for the application of risk-based approaches to surveillance and the prioritization of surveillance efforts that consider local hazards and available resources

2

## MODULE CONTENT

- Introduction
  - WHO framework for safe drinking-water
  - Drinking-water surveillance
- Key messages adapted from WHO & UNECE drinking-water surveillance publication
  - Overview of key messages
  - Learning objectives
  - Case studies and expert interviews
  - Knowledge tests
- Further reading

3

## INTRODUCTION

### Purpose of the training programme

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

*"effective surveillance systems have to be ensured for the monitoring of situations likely to result in outbreaks or incidents of water-related disease"*

4

## INTRODUCTION

### What do we mean by the term 'drinking-water surveillance'?

- Defined as the *"continuous and vigilant public health assessment and review of the safety and acceptability of drinking-water supplies"* (WHO, 2011)
- Independent and periodic review of drinking-water quality and public health safety using water-quality monitoring, on-site inspections, hazard identification and risk and trend analysis
- Reflects a shift in focus from overreliance on compliance-testing to promoting a proactive approach to identifying, controlling and monitoring critical risks in water supplies
- Protocol on Water and Health to the 1992 Convention on the Protection and Use of Transboundary Watercourses and International Lakes

5

## INTRODUCTION

### How does surveillance fit into the WHO framework for safe drinking-water?

```

graph TD
    A[Health-based targets] --> B[Water safety plans]
    B --> C[Independent surveillance]
    C --> A
  
```

**Health-based targets**  
Measurable health, drinking-water quality or performance objectives that provide benchmarks for water suppliers and regulators to confirm the adequacy of water supply systems or the need for improvement

**Water safety plans**  
Comprehensive risk-assessment and risk-management approach that encompasses all steps in the drinking-water supply from catchment to consumer, which supports water suppliers with effective management to ensure the safety of the supply system

**Independent surveillance**  
Periodic review, external from the water supplier, of all aspects of drinking-water quality and public health safety, including providing confirmation that water safety plans are effective and that health-based targets are met

6

### What is the purpose of drinking-water surveillance?

- 1) To ensure organized drinking-water supplies do not provide a risk to public health
- 2) To ensure community- and household-managed water supplies do not pose a risk to public health
- 3) To build trust in drinking-water supplies to maximize the benefits of safe and acceptable supplies
- 4) To promote incremental improvement of drinking-water supplies
- 5) To utilise information from different sources to enable understanding of the overall drinking-water supply situation for an entire region or as part of the development of coherent public health-centred policies and practices
- 6) To participate in the investigation, reporting and compilation of outbreaks of waterborne disease

SLIDE 7

7

### KEY MESSAGES

- Key message 1: Surveillance is a core public health function
- Key message 2: Risk-based surveillance is a governmental responsibility
- Key message 3: Risk-based surveillance points at what needs to be looked at
- Key message 4: Microbiological drinking-water quality is a key focus of risk-based surveillance
- Key message 5: Only monitor what is necessary
- Key message 6: Risk-based surveillance aids forward-thinking and anticipation of change

SLIDE 8

8

### KEY MESSAGE 1: Surveillance is a core public health function

#### Learning objectives:

- 1) To be aware of the link between poor water quality and human health
- 2) To understand that risk-based water quality surveillance helps to protect the health of consumers in the most cost-effective way

SLIDE 9

9

### KEY MESSAGE 1: Surveillance is a core public health function

*"Poor water, sanitation and hygiene accounts for 842 000 deaths each year from diarrhoea and limited effective prevention and management of other diseases including malnutrition, neglected tropical diseases and cholera as a result of unsafe drinking-water, sanitation, and hand hygiene."*

Source: Preventing diarrhoea through better water, sanitation and hygiene: exposures and impacts in low- and middle-income countries.

SLIDE 10

10

### KEY MESSAGE 1: Surveillance is a core public health function

#### The link between contaminated water and transmission of disease

Contaminated water and poor sanitation are linked to transmission of diseases such as cholera, diarrhoea, dysentery, hepatitis A, typhoid and polio. Absent, inadequate, or inappropriately managed water (and sanitation) services expose individuals to **preventable** health risks.

Source: WHO drinking-water fact sheet.

SLIDE 11

11

### KEY MESSAGE 1: Surveillance is a core public health function

#### Risks to water quality

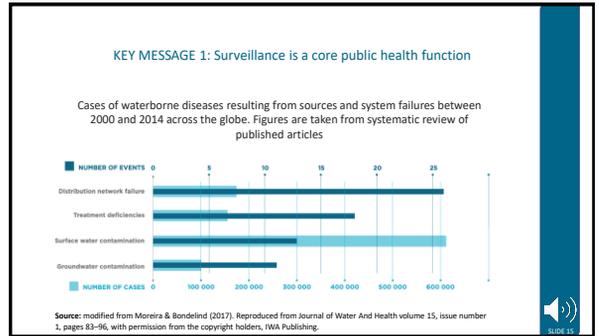
- Can you think of any risk factors or hazards that may lead to contamination of drinking water supplies and disease?
- A sanitary inspection is a visual survey of risk factors that may contribute to the likelihood of fecal contamination in water systems and is considered an effective and low-cost tool for risk assessment (Cronin, 2006).
- This short film will show you how to carry out a sanitary inspection on a small drinking water supply.

SLIDE 12

12



13



14

KEY MESSAGE 1: Surveillance is a core public health function

Examples of waterborne disease outbreaks, USA

<p>North Battleford, SK, Canada, April 2001</p> <p>1,900 cases of cryptosporidiosis in a chlorinated, filtered surface supply, attributed partly to inadequate filtration performance.</p> <p>Stirling et al.<sup>21</sup></p>	<p>South Bass Island, OH, USA May–September 2004</p> <p>Approximately 1,450 cases of diarrhea with several etiologies occurred, mostly from <i>Campylobacter</i> and norovirus, attributed to “multiple contamination of aquifer from onsite septic systems, land application of sludge, and infiltration of runoff”</p> <p>O’Reilly et al.<sup>22</sup></p>
--	--

15

KEY MESSAGE 1: Surveillance is a core public health function

European Region

- The most commonly reported infectious diseases linked to WASH in the Region are campylobacteriosis (a bacterial gastrointestinal infection), hepatitis A (a viral liver disease) and giardiasis (a parasitic infection of the small intestine, also known as beaver fever).
- Available published data indicate that approximately 18% of reported and investigated outbreaks are linked to water. However, the true extent of water-related diseases in the Region is unknown, and likely to be much higher than data suggest (WHO, 2016)

16

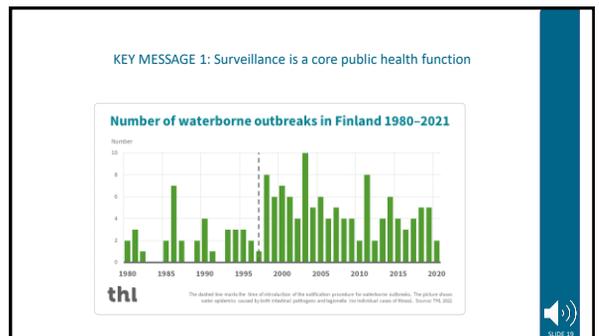
KEY MESSAGE 1: Surveillance is a core public health function

Discussion activity

In groups, discuss the extent of waterborne disease outbreaks in your country/municipality. Think about the following:

- Are there examples of outbreaks where the causes are very obvious (e.g. treatment failure) or examples where the cause is not so clear?
- Was the outbreak from a large municipal supply or small community run supply?
- Was there any action taken as a result of the outbreak to improve management of the supply?
- How might the outbreak have been prevented?
- What were the failings? Consider operations and response.
- How could risk assessment and management have prevented this?

17

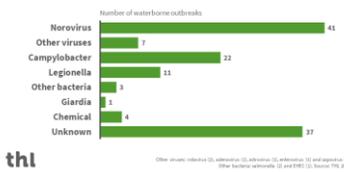


18

## KEY MESSAGE 1: Surveillance is a core public health function

Example of the etiological agents in waterborne disease outbreaks in Finland 1998-2021

## Etiological agents in waterborne outbreaks 1998-2021



SLIDE 19

19

## KEY MESSAGE 1: Surveillance is a core public health function

Small drinking-water supplies are especially vulnerable

In England, private water supplies serve approximately 0.5% of the population, but are responsible for 36% of waterborne disease outbreaks. Major risk factors include animals and agriculture in close proximity to rural small water systems, heavy rains and inadequate treatment (Said *et al.*, 2003).

Further information on small supplies can be found at:  
[https://www.euro.who.int/\\_data/assets/pdf\\_file/0018/140355/e94968.pdf](https://www.euro.who.int/_data/assets/pdf_file/0018/140355/e94968.pdf)



SLIDE 20

20

## KEY MESSAGE 1: Surveillance is a core public health function

Move from compliance monitoring to risk assessment/management

- Protection of public health from outbreaks of waterborne diseases has been the motivation behind changes to the management and operation of drinking-water delivery systems from compliance monitoring to risk assessment/management.
- Some waterborne outbreaks were shown to occur when water quality test results show compliance with standards (Barrell *et al.*, 2000), showing that infrequent testing of parameters may miss critical contamination events and information on potential contamination risks in supply systems.



SLIDE 21

21

## KEY MESSAGE 1: Surveillance is a core public health function

Example of waterborne outbreak despite water quality results complying with standards

- A large waterborne outbreak leading to more than 1,500 cases of campylobacteriosis occurred in Askøy in Norway in June 2019.
- Contamination of drinking water occurred through cracks in a mountain reservoir, probably because of heavy rainfall after an extended dry period.
- There was no indication of contamination with faecal indicator bacteria before the outbreak from routine sampling conducted on 3 June.
- There is a need to focus on proactive water safety planning to protect the water supply from contamination and to conduct risk-based surveillance, rather than reacting to contamination.

Source: <https://www.eurosurveillance.org/content/10.2807/15607917.ES.2020.25.35.2000011>



SLIDE 22

22

## KEY MESSAGE 1: Surveillance is a core public health function

Water Safety Planning

Water safety planning, forms the core of effective water quality management practices with the requirement to put in place barriers to mitigate identified risks to water quality and to monitor the operation of the barriers (operational monitoring) on a continuous basis to ensure that they are working properly.



SLIDE 24

23

## KEY MESSAGE 1: Surveillance is a core public health function

Sanitary inspections

Sanitary inspections are an element of water safety planning and a vital element of drinking-water quality surveillance, particularly for small-scale water supplies.



SLIDE 25

24

### KEY MESSAGE 1: Surveillance is a core public health function

Where does surveillance fit within the WHO Framework for safe drinking water?



SLIDE 26

25

### KEY MESSAGE 1: Surveillance is a core public health function

Case study 1 – Norovirus outbreak in Italy

**Location:** S. Stefano di Quisquina, Sicily, Italy

**Waterborne outbreak:** 156 cases of Norovirus (NoV) genotype GII.4 v2010 with identical genomic sequences between patients

**Surveillance investigation:**

- Epidemiological investigation with regular water sampling and testing was performed
- Detection of a variety of NoV genotypes
- Same NoV clone could not be detected in both patient and environmental samples

Source: taken from Purpari et al. (2012).



SLIDE 27

26

### KEY MESSAGE 1: Surveillance is a core public health function

Case study 1 – Norovirus outbreak in Italy

**Location:** S. Stefano di Quisquina, Sicily, Italy

**Surveillance outcomes:**

- Well supplying the water network was thought to be source of the NoV contamination
- Epidemiological molecular investigations guided outbreak control measures and suggested interventions to prevent future network contaminations
- Use of municipal drinking-water was restricted, and alternative water supplies provided
- Submersible water pump of the municipal well was replaced, and chlorine concentration of the water supply was increased
- Recommendations to local authorities order to prevent similar outbreaks in the future

Source: taken from Purpari et al. (2012).



SLIDE 28

27

### KEY MESSAGE 1: Surveillance is a core public health function

Case study 2 – Legionella outbreak in Germany

**Location:** Cologne, Germany

**Waterborne outbreak:** 9 buildings which had had Legionella spp. occurrences of >100 CFU/100 mL within the last 12 months

**Surveillance investigation:**

collection of 807 drinking water samples from the 9 buildings with Legionella spp. contamination

samples tested for Legionella spp., L. pneumophila, HPC 20 °C and 36 °C (culture-based).

each building was sampled for 6 months under standard operating conditions in the drinking-water plumbing systems

Source: taken from Völker et al. (2016)



SLIDE 29

28

### KEY MESSAGE 1: Surveillance is a core public health function

Case study 2 – Legionella outbreak in Germany

**Location:** Cologne, Germany

**Surveillance outcomes:**

- discovery of high variability (up to 4 log<sub>10</sub> steps) in the presence of Legionella spp. within all buildings over a half year period as well as over the course of a day
- occurrences were significantly correlated with temperature, pipe length measures, and stagnation
- logistic regression modelling revealed three parameters to be the best predictors of Legionella contamination at single outlets

Source: taken from Völker et al. (2016)



SLIDE 30

29

### KEY MESSAGE 1: Surveillance is a core public health function

Conclusion: Surveillance leads to improved health

- Risk assessment/risk management approaches can bring substantial benefits in terms of increased compliance with national standards and reduced microbial and chemical contamination of drinking-water (Setty et al. 2018).
- A direct benefit to public health through a reduction in the incidence of diarrhoeal disease is reported through studies in Iceland (Gunnarsdottir et al. 2012; Jetoo et al. 2015).
- Risk-based water quality surveillance helps to protect the health of consumers in the most cost-effective way by identifying whether the hazards and risks are under proper and continuing control.



SLIDE 31

30

## KEY MESSAGE 1: Surveillance is a core public health function

## Transparency

- Surveillance activities allow for the quantification of water safety, to an extent. In England and Wales, the Drinking-water Inspectorate publish annual drinking-water reports for both public and private supplies. In each report, metrics such as compliance with standards, water supply events, and water supplier cautions and prosecutions are all presented to the public to maintain transparency and trust.
- In Estonia, the Water and Health Information System was launched in 2012. Each year, over 140 water suppliers provide some 70 000 analyses of drinking-water from 1085 waterworks directly to a centralized database. That yields benefits for the Health Board (ease of overview and production of annual reports), water suppliers (ease of sharing of data, all analyses accessible in one database) and consumers (availability of information).



SLIDE 31

31

## KEY MESSAGE 1: Surveillance is a core public health function

## Discussion

- Which authority is responsible for surveillance in your country?
- Are you aware of their responsibilities?



SLIDE 32

32

## KEY MESSAGE 1: Surveillance is a core public health function

Placeholder for video with expert(s) discussing the core functions of drinking-water surveillance.

SLIDE 34

33

## KEY MESSAGE 1: Surveillance is a core public health function

## Portugal success story

- Twenty years ago, the Portuguese legal framework for drinking water quality could only guarantee 50% of safe water, with the remaining supply being beyond authorities' control or in violation of national standards.
- To improve this, a new regulatory model for drinking water quality was established based on the European Drinking Water Directive 98/83/CE.
- Ten years after its implementation, safe water coverage in Portugal reached 98% and water safety plans were implemented to achieve 99% coverage.

Further information can be found at: [https://www.iwa-network.org/filemanager-uploads/WQ\\_Compendum/Cases/Portugal%20Drinking%20Water.pdf](https://www.iwa-network.org/filemanager/uploads/WQ_Compendum/Cases/Portugal%20Drinking%20Water.pdf)

SLIDE 35

34

## KEY MESSAGE 1: Surveillance is a core public health function

## KNOWLEDGE TEST

1. What is surveillance?
2. What is the key aim of water quality surveillance?
3. Waterborne disease outbreaks only occur in low-income countries. True or False?
4. Compliance monitoring of water is a fail-safe way of ensuring drinking water is safe. True or False?
5. Risk based management of drinking water allows hazards and risks to the supply to be identified and acted upon. True or False?

SLIDE 36

35

## KEY MESSAGE 2: Risk-based surveillance is a governmental responsibility

*It is a responsibility of the government to establish legal and regulatory requirements for implementation of risk-based drinking-water surveillance that adequately protect public health.*

SLIDE 37

36

KEY MESSAGE 2: Risk-based surveillance is a governmental responsibility

Learning objectives:

- 1) To understand that water suppliers are responsible for protecting the health of consumers by ensuring water supplies are safe
- 2) To understand that legislation and regulation are inextricably linked with management by establishing the requirements for effective surveillance
- 3) To understand that the supplier requires an appropriate regulatory framework within which to operate and adequate resources to carry out their work

SLIDE 38

37

KEY MESSAGE 2: Risk-based surveillance is a governmental responsibility

Learning objectives:

- 1) To understand that water suppliers are responsible for protecting the health of consumers by ensuring water supplies are safe
- 2) To understand that legislation and regulation are inextricably linked with management by establishing the requirements for effective surveillance
- 3) To understand that the supplier requires an appropriate regulatory framework within which to operate and adequate resources to carry out their work

SLIDE 39

38

KEY MESSAGE 2: Risk-based surveillance is a governmental responsibility

Responsibility

- 1) Water suppliers are responsible for ensuring their water supplies do not pose a risk to public health.
- 2) The supplier requires an appropriate regulatory framework within which to operate and the resources it needs to carry out the work effectively.
- 3) The supplier is NOT the surveillance agency.
- 4) The approach towards risk assessment and management should be flexible to ensure that it is successful and to allow water suppliers to develop approaches that work well for them.
- 5) The risk assessment and management approach (Water Safety Planning) allows the regulator to gain insight into how well the supplier understands and protects the system by looking at the hazard assessment and control measures. Where there is a regulatory requirement, the regulator can become the external auditor.

SLIDE 40

39

KEY MESSAGE 2: Risk-based surveillance is a governmental responsibility

Case study 5: Recognition of the value and need for risk-based approaches in surveillance.

- The EU Drinking Water Directive requires application of risk-based approaches in water supplies in all countries in the EU.
- In many countries in the EU there is a strong belief that drinking water supplies are good and reliable.
- All Nordic countries, except Greenland have requirements for preventive management of water supplies in their regulations, and these requirements meet the requirements in the EU DWD for the supply system.
- Implementation of risk-based approaches is still on-going. Around 40% of all regulated water supplies are to implement a risk-based approach according to national legislation already in place.

SLIDE 41

40

KEY MESSAGE 2: Risk-based surveillance is a governmental responsibility

Evidence that regulatory requirements help surveillance succeed

Across the world, including from high-income countries, experience has shown that key success factors for WSP implementation include regulatory requirements for a risk-based approach amongst other factors.

Examples:

- Schmiege et al., 2020
- Kayser et al., 2019
- Ferrero et al., 2019
- Baum and Bartram, 2018
- Amjad et al., 2016
- Baum et al., 2016
- Gumarsdottir et al., 2012a & 2012b).

SLIDE 42

41

KEY MESSAGE 2: Risk-based surveillance is a governmental responsibility

How is government involved in surveillance?

Example 1: England and Wales

- Water Safety Plans in large supplies are audited by Drinking-water Inspectorate
- Risk assessment of small supplies are undertaken by local authorities, with results sent to Drinking-water Inspectorate
- Water quality testing requirements based on supply characteristics
- Potential to reduce water quality testing frequencies based on risk assessment results

SLIDE 43

42

KEY MESSAGE 2: Risk-based surveillance is a governmental responsibility

Example 2: Norway

- Drinking-water surveillance overseen by the Food Safety Authority comprises annual and five-year inspections, regular auditing and one-off campaigns
- A risk-based local water sampling scheme is in place, sampling for *E. coli* is mandatory, and there is a list of minimum parameters
- Sampling data on water quality and quantity are reported using a web-based system
- Based on risk assessments, the Authority can grant dispensations from meeting the standards laid down in the Regulations
- Different checklists for large and small supplies, and for different treatment methods

SLIDE 44

43

KEY MESSAGE 2: Risk-based surveillance is a governmental responsibility

Example 3: Belarus

- Ministry of Health has overall responsibility for setting government sanitary and epidemiological standards and for carrying out government sanitary surveillance
- Ministry of the Environment is responsible for surveillance of water resources
- Government sanitary surveillance takes two forms: preventive and operational
- Lists of parameters and frequencies of testing are determined for each water supply system based on the environmental situation, water treatment methods used, etc.
- Non-compliance with regulations and standards gives rise to the issuance of notices and recommendations to owners of water supply systems

SLIDE 45

44

KEY MESSAGE 2: Risk-based surveillance is a governmental responsibility

Example 3: Belarus

- Risk assessment is carried out regarding both end products (drinking-water, treatment materials and technologies) and utilities
- Data collected on the characteristics of water sources and utilities using hazard assessment and critical control points (HACCP) methodology
- Some parameters are obligatory, while others (chemical criteria only) may be waived or dropped, if justified by risk assessment

SLIDE 46

45

KEY MESSAGE 2: Risk-based surveillance is a governmental responsibility

Example 4: Portugal

- Water supplies operating under a WSP cover 32% of the population
- Water suppliers must submit an annual water-quality control plan to the Water and Waste Services Regulatory Authority for approval
- The plan includes details of parameters, frequency of sampling and sampling points in the supply chain from source to consumer
- Since 2019, national legislation has required the implementation of a risk-based approach to establishing water-quality control plans
- Once the plan is approved, monitoring data are submitted online and can be assessed by drinking-water and health authorities

SLIDE 47

46

KEY MESSAGE 2: Risk-based surveillance is a governmental responsibility

Example 4: Portugal continued

- If noncompliance is observed, the water supplier must inform the local public health authority, which then carries out a risk assessment to analyse the parameters, exposure time and susceptibility of exposed populations
- The authority can then restrict water use, make recommendations to the public and call on the water supplier to introduce changes to treatment processes
- Health authorities also assess drinking-water supply systems, with a special focus on small supplies
- The country has a mandatory disease-notification system (including for water-related infectious diseases) and a national epidemiological surveillance system

SLIDE 48

47

KEY MESSAGE 2: Risk-based surveillance is a governmental responsibility

Example 4: Norway

- Around 4.6 million people (90% of the population) are provided with drinking water from approximately 1500 regulated water-supply utilities
- Most of supplies are in public ownership, but some smaller water supplies are private
- The Norwegian Food Safety Authority (NFSA) provides oversight to water utilities that produce more than 10 m<sup>3</sup> of drinking-water per day
- Drinking-water legislation is regularly updated and now requires an assessment and management of hazards from catchment to consumer.
- Water utilities are obliged to manage the risks relevant to their water-supply system systematically in terms of long-term planning and in day-to-day operation.

SLIDE 49

48

## KEY MESSAGE 2: Risk-based surveillance is a governmental responsibility

### Example 4: Norway

- Water utilities shall also establish a risk-based routine monitoring plan based on the assessment of local hazards.
- Analysis for *Escherichia coli* is mandatory, and water utilities that produce more than 10 m<sup>3</sup> of drinking-water per day have a minimum requirement to monitor for intestinal enterococci, colour, turbidity and acceptable aesthetic appearance (free from taste/odour).
- If a risk assessment demonstrates that a substance does not represent a health risk, the water utility may reduce the frequency of sampling if all representative results from drinking-water quality analysis in a three-year period are below 60% of the standard value
- NFSA receives yearly reports with data on water quality and system information from the water utilities.
- These data are used by the NFSA to perform risk-based inspections and audits.

SLIDE 49

49

## KEY MESSAGE 2: Risk-based surveillance is a governmental responsibility

### Example 5: Serbia

- A study by WHO found that one third of rural water systems inspected in Serbia did not meet standards for microbiological drinking-water quality, and more than 60% were exposed to possible contamination from latrines, sewers, animal breeding, cultivation, roads, industry, rubbish and other sources of pollution placed nearby.
- The findings informed specific recommendations for national authorities, which led to revised regulations. The country made 2 key interventions to improve small-scale water supplies. First, it added a new provision in the draft law on drinking-water that stipulates the introduction and implementation of mandatory Water Safety Plans to ensure safe drinking-water supply management. Second, it is increasingly enforcing regulation on the foundation and ownership of water supply systems (regardless of size) to ensure their management by authorized legal entities.

Additional information:  
[https://www.euro.who.int/\\_data/assets/pdf\\_file/0019/340561/Serbia\\_waterWeb.pdf](https://www.euro.who.int/_data/assets/pdf_file/0019/340561/Serbia_waterWeb.pdf)

SLIDE 50

50

## KEY MESSAGE 2: Risk-based surveillance is a governmental responsibility

### Discussion

- Can you identify the regulations that exist in your country within which the water supplier works?
- Who is responsible for implementation and enforcement of the regulations?
- Since the introduction of that legislation, is there evidence that water quality has improved? What changes have occurred?
- Are risk-based assessments of the water supply system carried out? Who does this?

SLIDE 51

51

## KEY MESSAGE 2: Risk-based surveillance is a governmental responsibility

### Main activities of surveillance agencies

- Investigate waterborne disease in the population, including waterborne outbreaks, and assess whether health targets are being met
- Check compliance with drinking-water quality standards through direct water-quality testing and review of water suppliers' monitoring records
- Audit WSPs and verify their effectiveness
- Conduct on-site sanitary inspections
- Provide advice and support to water suppliers, particularly for small supplies that may have only limited resources
- Analyse water-quality trends and the outcomes from sanitary inspections and/or WSP audits locally and nationally to inform local remedial measures and wider policy for protection of water resources and drinking-water.

SLIDE 52

52

## KEY MESSAGE 2: Risk-based surveillance is a governmental responsibility

### Factors to ensure an effective surveillance system

- Establish an enabling legal framework and legal support for drinking-water surveillance
- Establish a legislative and institutional basis for effective drinking-water surveillance that promotes local risk assessments as the basis for prioritizing surveillance and responses
- Review and update national drinking-water quality standards by integrating a risk-based approach
- Ensure that surveillance covers the whole of the drinking-water system, from the sources to the point of consumption
- Take into account the particular circumstances of small drinking-water supplies and establish the surveillance agency's specific responsibility for supporting small systems

SLIDE 53

53

## KEY MESSAGE 2: Risk-based surveillance is a governmental responsibility

### Factors to ensure an effective surveillance system

- Provide clear definitions of water suppliers' and surveillance agencies' roles and responsibilities
- Promote effective coordination and collaboration between the water supplier and the public health surveillance agency and any other agencies that might play a role
- Assess human-resource and institutional capacity and identify needs for strengthening surveillance of the drinking-water supply
- Secure adequate human resource and financing for drinking-water surveillance programmes
- Implement capacity-building at different levels, including training programmes for public health officers, inspectors and water operators

SLIDE 54

54

**KEY MESSAGE 2: Risk-based surveillance is a governmental responsibility**

Factors to ensure an effective surveillance system

- Build and sustain an inventory/information system that supports effective surveillance
- Ensure adequate reporting and flow of water-quality data among responsible parties
- Analyse and use surveillance data in improving water-quality regulations and to inform improvements by the water supplier
- Create an enabling environment to ensure the exchange of information to support the water supplier's responsibilities and the surveillance agency's operations

SLIDE 54

55

**KEY MESSAGE 3: Risk-based surveillance points at what needs to be looked at**

*Risk-based drinking-water surveillance identifies the hazards that pose the greatest risks to the population and supports the development of appropriate and efficient monitoring programmes for individual supplies.*

SLIDE 57

56

**KEY MESSAGE 3: Risk-based surveillance points at what needs to be looked at**

Learning objectives:

- 1) To appreciate that risk-based drinking-water quality surveillance is an important part of a proactive approach to identification and control of hazards and risks in drinking-water systems
- 2) To appreciate that the identification of hazards and assessment of the risks in the system will provide a rationale for prioritizing strategies and improvement actions to control critical hazards.

SLIDE 58

57

**KEY MESSAGE 3: Risk-based surveillance points at what needs to be looked at**

- Surveillance should cover the whole drinking water system, including the sources and activities in the catchment, abstraction, treatment, storage, distribution system and the point of consumption
- Surveillance of drinking-water requires a systematic programme of data collection and surveys that may include water sampling, analysis and sanitary inspection of the supply system. Hence, water quality monitoring and sanitary inspections are integral components of surveillance, not independent activities
- The identification of hazards and assessment of the risks in the system will provide a rationale for prioritizing strategies and improvement actions to control the hazards

SLIDE 59

58

**KEY MESSAGE 3: Risk-based surveillance points at what needs to be looked at**

The role of risk-based surveillance

SLIDE 60

59

**KEY MESSAGE 3: Risk-based surveillance points at what needs to be looked at**

**\*\* KEY POINT \*\***

The safe and effective operation of a water supply system requires a full understanding of the system. This understanding develops with the implementation of a water safety plan and is refined by risk-based water quality surveillance.

SLIDE 61

60

KEY MESSAGE 3: Risk-based surveillance points at what needs to be looked at

What hazards and risks can you spot here?



SLIDE 61

61

KEY MESSAGE 3: Risk-based surveillance points at what needs to be looked at

Activity: Fill in the gaps

Process step	Hazardous event	Microbial or chemical?	Prioritization
Source	Cattle defaecation close to unfenced wellhead		
Source	Pesticides from agriculture		
Distribution	Leaks on trunk main and distribution system		
Treatment	No back-up power supply		

SLIDE 61

62

KEY MESSAGE 3: Risk-based surveillance points at what needs to be looked at

Case study 6: Walkerton, Canada

- An estimated 2,300 people became seriously ill and seven died from exposure to microbially-contaminated drinking water in the town of Walkerton in May 2000
- The most serious of many waterborne outbreaks that could have potentially been prevented had the principles of risk management been implemented
- Operators were unaware of the overall risks of contamination of the supply and the need for continuous vigilance to ensure treatment was optimised all of the time.

SLIDE 64

63

KEY MESSAGE 3: Risk-based surveillance points at what needs to be looked at

Case study 7: Prague, Czech Republic

- From May - June 2015, Prague experienced its largest waterborne outbreak since the 1950s caused by cross contamination resulting from breakages of water and sewerage pipes.
- A total of 5,150 persons with acute gastric illness from this area sought official medical treatment by the end of June and it was estimated there were about 11,000 to 12,000 cases of norovirus infection in this outbreak.
- Understanding the distribution system with its vulnerabilities along with appropriate operational monitoring would have provided an early warning of an incident so that appropriate early action could have been implemented.

SLIDE 65

64

KEY MESSAGE 3: Risk-based surveillance points at what needs to be looked at

Case study 8: Lithuania

- The PHC specialist has to send a copy of this letter to the primary health-care institution that provided the information in the first place
- At least every six months, the PHC informs the municipality in which the pregnant woman or infant resides about water quality in terms of concentration of nitrate and nitrite in drinking-water so the municipality can plan long-term prevention measures for residents

SLIDE 66

65

KEY MESSAGE 3: Risk-based surveillance points at what needs to be looked at

Knowledge Test

SLIDE 67

66

KEY MESSAGE 4: Microbiological drinking-water quality is a key focus of risk-based surveillance

*"Every year, on a global basis, billions of cases of illness result from ingestion of microorganisms in drinking water."*  
(Yates, 2019)

67

MESSAGE 4: Microbiological drinking-water quality is a key focus of risk-based surveillance

Learning objectives:

- 1) To understand that the main recognised risks to human health from poorly-managed water supplies, relate to microbiological contamination causing infectious gastrointestinal disease, and chemical contamination where chronic disease is more of a risk.
- 2) To appreciate the role of fecal indicators and their limitations
- 3) To understand how operational monitoring and surveillance help minimize the risk from microbiological pathogens

68

MESSAGE 4: Microbiological drinking-water quality is a key focus of risk-based surveillance

Primary sources of drinking-water contamination

Inorganic	Organic	Biological	Radiological
Fluoride	Trihalomethanes	Algae	Alpha Particles
Arsenic	Volatile Organic Chemicals	Bacteria	Beta Particles and Photon Emitters
Lead	Dyes	Protozoan	Radium 226 and Radium 228 (combined)
Mercury	Emerging Organic Contaminants	Viruses	Uranium

69

MESSAGE 4: Microbiological drinking-water quality is a key focus of risk-based surveillance

Microbiological pathogens and chemicals

- Over 500 waterborne enteric and non-fecal pathogens may cause illness and even death in humans, sometimes by a single exposure
- Only a small number of chemicals – arsenic, fluoride, nitrate/ nitrite and lead – are known to cause disease through drinking-water, almost invariably following long-term exposure
- Microbial water quality often varies rapidly and may result in swift and widespread simultaneous infection within a population
- Pathogens and chemical contaminants can arise in source waters, treatment, distribution and in plumbing systems in buildings (such as for Legionella and lead)
- EU Drinking-water Directive allows derogation from certain chemical parameters and sampling frequencies. This is not permitted for microbiological parameters

70

MESSAGE 4: Microbiological drinking-water quality is a key focus of risk-based surveillance

Enteric and non-fecal microorganisms

- The most common route of infection with a waterborne pathogen is the "fecal-oral" route
- Nonfecal pathogenic microorganisms may take various pathways such as aerosols (e.g., Legionella) or sediments (e.g., Naegleria fowleri)
- Enteric microorganisms can be mitigated against via the implementation of relatively simple interventions such as handwashing and other sanitation measures
- Both sets of microorganism may cause contamination pre- and post-water treatment
- Indicator bacteria typically used to determine the presence of pathogens of fecal origin

71

MESSAGE 4: Microbiological drinking-water quality is a key focus of risk-based surveillance

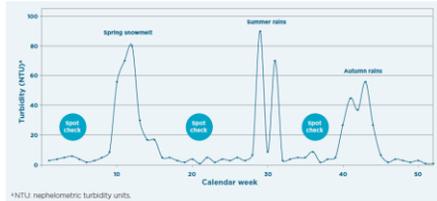
Bacterial faecal indicators and their limitations

- Used to indicate the presence of faecal contamination
- Identification of fecal indicators does not guarantee the presence of pathogens
- The sample size is small in relation to the volume of water supplied
- Samples are relatively infrequent – numbers of pathogens vary in time and are not evenly dispersed
- Viruses and protozoa are often more resistant in the environment and to disinfection than faecal indicator bacteria
- Spot checks may miss critical contamination events, such as wet-weather events that affect source-water quality and possibly drinking-water quality

72

MESSAGE 4: Microbiological drinking-water quality is a key focus of risk-based surveillance

Bacterial faecal indicators and their limitations



SLIDE 74

73

MESSAGE 4: Microbiological drinking-water quality is a key focus of risk-based surveillance

Location: Havelock North, New Zealand

**Waterborne outbreak:** largest recorded outbreak of water-borne disease in New Zealand (and probably for water-borne campylobacteriosis in the world) resulting in an estimated 5500 cases, 45 hospitalisations and three deaths

Cause of outbreak and outcomes:

- Very heavy rainfall resulting in overflow of surface water bodies into boreholes
- Post-contamination surveillance identified the serving aquifer to be vulnerable to surface water intrusion
- Poor relationships between stakeholders were identified
- Events such as extreme weather noted as being important warning signs of potential contamination

Source: taken from NZ Department of Internal Affairs (2017).



SLIDE 75

74

MESSAGE 4: Microbiological drinking-water quality is a key focus of risk-based surveillance

Location: Milwaukee, USA

**Waterborne outbreak:** an estimated 403,000 people had watery diarrhoea attributable to an outbreak of cryptosporidium oocysts

Cause of outbreak and outcomes:

- rates of isolation of other enteric pathogens remained stable, but there was more than a 100-fold increase in the rate of isolation of cryptosporidium
- cryptosporidium oocysts passed through the filtration system of one of the city's water-treatment plants
- water-quality standards and the testing of patients for cryptosporidium were not adequate to detect this outbreak

Source: taken from Mac Kenzie et al. (1994).



SLIDE 76

75

MESSAGE 4: Microbiological drinking-water quality is a key focus of risk-based surveillance

Waterborne outbreaks can occur at all stages of a network

**Study:** review on drinking waterborne outbreaks from raw water contamination, treatment deficiencies and distribution network failures during 2000-2014

Main causes of contamination:

- in groundwater was intrusion of animal faeces or wastewater due to heavy rain
- in surface water was discharge of wastewater into the water source and increased turbidity and colour
- in treatment plants were malfunctioning of the disinfection equipment
- in distribution systems were, cross-connections, pipe breaks and wastewater intrusion into the network



SLIDE 77

76

MESSAGE 4: Microbiological drinking-water quality is a key focus of risk-based surveillance

Waterborne outbreaks can occur at all stages of a network

**Study:** review on drinking waterborne outbreaks from raw water contamination, treatment deficiencies and distribution network failures during 2000-2014

- pathogens causing the largest number of affected consumers were *Cryptosporidium*, norovirus, *Giardia*, *Campylobacter*, and rotavirus
- largest number of different pathogens was found for the treatment works and the distribution network
- largest number of affected consumers with gastrointestinal illness was for contamination events from a surface water source
- largest number of individual events occurred for the distribution network



SLIDE 78

77

MESSAGE 4: Microbiological drinking-water quality is a key focus of risk-based surveillance

Operational monitoring and surveillance of microbiological drinking-water quality

- Operational monitoring is the conduct of planned observations or measurements to assess whether the control measures in a drinking-water system are operating properly
- Surveillance is the independent (external) and periodic review of all aspects of quality and public health safety
- Operational monitoring set limits for control measures, monitors those limits and takes corrective action in response to a detected deviation before the water becomes unsafe
- Surveillance agencies should investigate and compel action to rectify incidents of contamination caused by outbreaks of waterborne disease or other threats to public health

SLIDE 79

78

MESSAGE 4: Microbiological drinking-water quality is a key focus of risk-based surveillance

Operational monitoring and surveillance of microbiological drinking-water quality

- Operational monitoring is usually carried out through simple observations and tests, in order to rapidly confirm that control measures are continuing to work
- Surveillance requires a systematic program of data collection and surveys that may include auditing of WSPs, analysis, sanitary inspection and institutional and community aspects
- Surveillance should cover the whole of the drinking-water system, including sources and activities in the catchment, transmission infrastructure, whether piped or unpiped, treatment plants, storage reservoirs and distribution systems
- The frequency of operational monitoring varies with the nature of the control measure—for example, checking structural integrity monthly to yearly, monitoring turbidity online or very frequently and monitoring disinfectant residual continuously online

SLIDE 79

79

MESSAGE 4: Microbiological drinking-water quality is a key focus of risk-based surveillance

Knowledge Test

SLIDE 80

80

MESSAGE 4: Microbiological drinking-water quality is a key focus of risk-based surveillance

Video

SLIDE 81

81

MESSAGE 5: Only monitor what is necessary

*"Most chemicals arising in drinking-water are of health concern only after extended exposure of years, rather than months, with the principal exception of nitrates."*  
(WHO, 2017)

SLIDE 82

82

MESSAGE 5: Only monitor what is necessary

Learning objectives:

- 1) To understand why it is necessary to prioritize core parameters for monitoring.
- 2) To be able to select those parameters that are of public health significance and system performance.

SLIDE 83

83

MESSAGE 5: Only monitor what is necessary

What are the core parameters?

EU Directive, 2020

Key Message 4 outlined the importance of monitoring for microbiological pathogens.

*Escherichia coli (E. coli)* and intestinal enterococci are considered 'core parameters' and their monitoring frequencies shall not be the subject of a reduction due to a risk assessment of the supply system in accordance. They shall always be monitored at least at the frequencies set out in the Directive.

SLIDE 84

84

## MESSAGE 5: Only monitor what is necessary

What are the core parameters?

EU Directive, 2020

The list of core parameters in the Directive may be added to under specific circumstances, e.g.:

- (a) ammonium and nitrite, if chloramination is used; or
- (b) aluminium and iron, if used as water treatment chemicals.

SLIDE 85

85

## MESSAGE 5: Only monitor what is necessary

Common sources of chemicals in drinking-water

- Naturally occurring in source water and are released from rocks and soils and algal toxins in surface water
- Industrial activities released to source waters from manufacturing, processing and mining
- Agricultural activities reaching source waters as a result of application of manure, fertilizer and pesticides
- Human settlements resulting in source-water contamination from sewage, waste disposal, urban runoff and fuel leakage
- Drinking-water treatment and disinfection processes
- Contact with materials during distribution, such as from storage tanks and pipes, including domestic plumbing

SLIDE 86

86

## MESSAGE 5: Only monitor what is necessary

*Monitoring of chemicals needs to be selective. Risk-based drinking-water surveillance directs water-quality monitoring towards the most important, relevant parameters for system performance and public health protection.*

SLIDE 87

87

## MESSAGE 5: Only monitor what is necessary

EU Directive, 2020

- WHO recommended that chemical parameters for inclusion in the Directive should be prioritized to avoid reducing the impact of standards with largely redundant parameters
- They should be either of particular health significance and should occur across the Member States at significant concentrations
- The concept of local hazard analysis and risk assessment is a key part of the WSP approach and may identify additional substances that are of local concern
- The requirement in the Directive that no substance should be present at concentrations which constitute a potential danger to health should be emphasized

SLIDE 88

88

## MESSAGE 5: Only monitor what is necessary

How to select which parameters to monitor?

EU Directive, 2020

As a result of a risk assessment of the supply system, the list of parameters considered in the monitoring and the sampling frequencies ... may be reduced provided that all of the following conditions are met:

- (a) the location and frequency of sampling is determined in relation to the parameter's origin, as well as the variability of its concentration
- (b) as regards reducing the minimum sampling frequency of a parameter, the results obtained from samples collected at regular intervals over a period of at least three years, from sampling points representative of the whole supply zone, are all less than 60 % of the parametric value;

SLIDE 89

89

## MESSAGE 5: Only monitor what is necessary

How to select which parameters to monitor?

EU Directive, 2020

- c) as regards removing a parameter from the list of parameters to be monitored, the results obtained from samples collected at regular intervals over a period of at least three years, from sampling points representative of the whole supply zone, are all less than 30 % of the parametric value;
- d) as regards removing a parameter from the list of parameters to be monitored, the decision is based on the outcome of the risk assessment that takes into account the results of monitoring of sources of water intended for human consumption and confirms that human health is protected from the adverse effects of any contamination of water intended for human consumption, as laid down in Article 1;

Source: EU (2020).

SLIDE 91

90

MESSAGE 5: Only monitor what is necessary

How to select which parameters to monitor?

EU Directive, 2020

e) as regards reducing the sampling frequency of a parameter or removing a parameter from the list of parameters to be monitored, the risk assessment confirms that no factor that can be reasonably anticipated is likely to cause deterioration of the quality of the water intended for human consumption.

Source: EU (2020). SLIDE 91

91

MESSAGE 5: Only monitor what is necessary

Risk-based thinking leads to targeted and resource-effective surveillance and thus to better protection of public health. Sensible standard-setting is important: priority parameters of public health significance in a country should be carefully selected on the basis of occurrence and health risks.

The WSP approach is the public health benchmark for providing safe drinking-water. WSP outcomes inform local decision-making in terms of priority risks and direct the scope of surveillance efforts.

SLIDE 91

92

MESSAGE 5: Only monitor what is necessary

Microbiological parameters	
E. coli	3.9%
Coliform Bacteria	10.4%
Enterococci	5.5%
Chloridium perfringens	4.8%
Chemical Parameters	
Odour	23.4%
Taste	18.0%
Manganese	5.0%
Iron	5.1%
Aluminium	1.5%
Turbidity	1.2%
Colour	1.3%
Lead	3.1%
Nickel	3.1%
Nitrate	7.7%
Fluoride	3.5%
Pesticides	0.3%
Others	1.2% (including pesticides)
	1.6% (not including pesticides)

Source: DWI (2021). SLIDE 94

93

MESSAGE 5: Only monitor what is necessary

**Arsenic**

WHO Guideline value	0.01 mg/l (provisional A TL)
Number of countries and territories setting a regulatory / guideline value	102 (out of 104)
Number of countries and territories setting a regulatory / guideline value greater than WHO Guideline	22
Number of countries and territories setting the WHO Guideline	79
Number of countries and territories setting a regulatory / guideline value less than WHO Guideline	1
Maximum value set	0.5 mg/l
Minimum value set	0.007 mg/l
Median value	0.01 mg/l

SLIDE 95

94

MESSAGE 5: Only monitor what is necessary

**Bentazone**

WHO Guideline value	None specified
WHO health-based value	0.3 mg/l
Number of countries and territories setting a regulatory / guideline value	11 (out of 104)
Number of countries and territories setting a regulatory / guideline value greater than WHO Health-based value	2
Number of countries and territories setting the WHO Health-based value	4
Number of countries and territories setting a regulatory / guideline value less than WHO Health-based value	5
Maximum value set	0.4 mg/l
Minimum value set	0.03 mg/l
Median value	0.03 mg/l

SLIDE 96

95

MESSAGE 5: Only monitor what is necessary

Case study XX – prioritization of chemicals for various water types

**Location:** Germany

**Surveillance approach:**

- In the suspect screening, data were screened for the presence of a large set of anthropogenic chemicals
- 700 detected compounds from LC-HRMS screening data were linked to one or multiple suspects
- From over 5200 chemicals 174 were prioritized for their health relevance for drinking water.
- The prioritized suspects are relevant for detailed future risk assessment.
- The relatively fast approach shows to be complementary to currently used target-based approaches.

Source: taken from Sjerps et al. (2016). SLIDE 97

96

**MESSAGE 5: Only monitor what is necessary**

- National standards for drinking-water quality should provide affordable protection of public health, serving as benchmarks for water supply operators and to give reassurance to consumers.
- Standards should reflect the priorities for water quality and public health, listing only important parameters, chosen on the basis of a substance's risk (presence, significance for public health and acceptability) and relevance in the area.
- Standards should be tailored to take into account types of supply and available resources.
- Monitoring of compliance with standards is vital but needs to be flexible, resource effective and concentrate on important risks to public health, and to be undertaken at a sensible frequency for a particular supply.

SLIDE 97

97

**MESSAGE 5: Only monitor what is necessary**

- Surveillance of drinking-water quality should provide an understanding of hazards, hazardous events and efficacy of control measures throughout the water supply system, from catchment/source through treatment and distribution to the consumer, based on sanitary inspections and drinking-water quality monitoring.
- End-product testing for faecal indicator bacteria (E. coli or enterococci) alone has been recognized as a case of "too little, too late": it provides little information about the system and outbreaks have been reported even though drinking-water was in compliance with standards.
- Priority chemical parameters should be identified on the basis of health concerns. They may include arsenic, fluoride and nitrate in source water (unlikely to change in distribution); manganese and iron in source water (potential problems for distribution); trihalomethanes and cadmium (change in distribution); and lead and copper from pipework in buildings.

SLIDE 98

98

**MESSAGE 5: Only monitor what is necessary**

- Indicators of operations and acceptability (turbidity, taste and odour, conductivity and discolouration) should be monitored, as should pH and chlorine residual.
- The choice of parameters should take account of variations in occurrence and concentration, as well as circumstances such as the use of chlorine and extraction of groundwater or surface water.
- Frequency of monitoring should reflect the risk of a breach of a standard or guideline value (i.e., a health target).
- Mitigation may reduce the need for monitoring.
- All decisions concerning choice of parameters and frequency of monitoring should be justified and documented.

SLIDE 99

99

**MESSAGE 5: Only monitor what is necessary**

	RISK	SCENARIO	RESPONSE
ASSESSMENT PHASE	<b>Low Risk</b>	<ul style="list-style-type: none"> <li>No previous evidence of arsenic in groundwater</li> <li>No contamination risk on <a href="http://www.gpmpa.net">www.gpmpa.net</a></li> </ul>	<ul style="list-style-type: none"> <li>Laboratory testing of priority natural contaminants (i.e. As, F, Li, Cl, Cd, Pb) in c.1% of wells at different depths</li> </ul>
	<b>Suspected Risk</b>	<ul style="list-style-type: none"> <li>No previous evidence of arsenic in groundwater</li> <li>Some contamination risk on <a href="http://www.gpmpa.net">www.gpmpa.net</a></li> </ul>	<ul style="list-style-type: none"> <li>Laboratory testing for priority natural contaminants (i.e. As, F, Li, Cl, Cd, Pb) in c.1% of wells in areas identified by <a href="http://www.gpmpa.net">www.gpmpa.net</a></li> </ul>
	<b>Identified Risk</b>	<ul style="list-style-type: none"> <li>Some reports of arsenic in groundwater, not yet confirmed</li> </ul>	<ul style="list-style-type: none"> <li>Establish a multi-disciplinary team to undertake arsenic contamination validation testing &amp; analysis exercises</li> </ul>
MANAGEMENT PHASE	<b>Confirmed Risk</b>	<ul style="list-style-type: none"> <li>Sample surveys have confirmed the presence of arsenic in the ground or surface water</li> </ul>	<ul style="list-style-type: none"> <li>Set health-based targets (including arsenic standards)</li> <li>Prepare arsenic testing, marking and monitoring plans</li> <li>Develop communication strategy based on RAMP analysis</li> <li>Identify priority arsenic mitigation options</li> </ul>
	<b>Quantified Risk</b>	<ul style="list-style-type: none"> <li>Data on the nature and scale of the problem has been presented in detailed maps</li> </ul>	<ul style="list-style-type: none"> <li>Undertake blanket survey of wells in high-risk areas</li> <li>Upgrade capacities for field testing &amp; lab verification</li> <li>Introduce unique coding system for all wells</li> <li>Initiate priority arsenic mitigation options</li> </ul>
	<b>Mitigated Risk</b>	<ul style="list-style-type: none"> <li>Blanket surveys have identified all the safe and contaminated wells (public &amp; private)</li> <li>Alternative sources have been identified/developed for at risk populations</li> </ul>	<ul style="list-style-type: none"> <li>Establish health/epidemiology surveillance system</li> <li>Support public/private arsenic mitigation at scale</li> <li>Enhance O&amp;M processes for all mitigation options (incl. arsenic testing &amp; coding standards for all new wells)</li> <li>Research arsenic in health/hydrogeology data</li> </ul>
	<b>Secondary Risk</b>	<ul style="list-style-type: none"> <li>Anomalies in arsenic exposure and health impacts have been identified</li> </ul>	<ul style="list-style-type: none"> <li>Test/mark arsenic contamination of ingestion wells</li> <li>Open access databases on arsenic contamination</li> <li>Support academic research to address anomalies</li> </ul>
	<b>Prospective Risk</b>	<ul style="list-style-type: none"> <li>Foreseen yet unquantified risk of exposure to arsenic</li> </ul>	<ul style="list-style-type: none"> <li>Research identification of disease, intergenerational effects, arsenic mobilisation/migration, consequences on food &amp; water security, trust in public agencies</li> </ul>

SLIDE 100

100

**MESSAGE 5: Only monitor what is necessary**

Placeholder for video with expert(s) discussing the choice of parameters to monitor.

SLIDE 101

101

**MESSAGE 5: Only monitor what is necessary**

KNOWLEDGE TEST

SLIDE 102

102

MESSAGE 6: Risk-based surveillance aids forward-thinking and anticipation of change

*Hazards and risks change over time. Surveillance agencies have an important supporting role in predicting, identifying and tracking long-term changes and associated risks for drinking-water supply.*

103

MESSAGE 6: Risk-based surveillance aids forward-thinking and anticipation of change

Learning objectives:

- 1) To identify emerging sources of drinking-water supply strain
- 2) To understand the role of surveillance agencies in responding to long-term change

104

MESSAGE 6: Risk-based surveillance aids forward-thinking and anticipation of change

Emerging sources of drinking-water supply strain include:

- Climate change
- Urbanization
- Pressures from agriculture, population growth
- Aging infrastructure

105

MESSAGE 6: Risk-based surveillance aids forward-thinking and anticipation of change

“Climate change is disrupting weather patterns, leading to extreme weather events, unpredictable water availability, exacerbating water scarcity and contaminating water supplies. Such impacts can drastically affect the quantity and quality of water...”  
(UNICEF, 2021)

106

MESSAGE 6: Risk-based surveillance aids forward-thinking and anticipation of change

Examples of climate change impacts on drinking-water supply	
Event	Potential Impacts
Increased temperatures	<ul style="list-style-type: none"> <li>• Increased formation of cyanobacterial blooms in freshwater</li> <li>• Increased risk of wildfires degrading water quality in moorland and forested and peaty catchments</li> <li>• Proliferation of opportunist pathogens (such as Legionella) and heterotrophic bacteria within water-storage and distribution systems</li> <li>• Reduced stability of chlorine residual in distribution</li> <li>• Increased formation of some disinfection by-products</li> <li>• Higher water demand</li> </ul>

Sources: WHO (2017c); WHO Regional Office for Europe (2011).

107

MESSAGE 6: Risk-based surveillance aids forward-thinking and anticipation of change

Examples of climate change impacts on drinking-water supply	
Event	Potential Impacts
Drought	<ul style="list-style-type: none"> <li>• Increased competition for scarce water resources, potentially leading to lower water availability</li> <li>• Reduced groundwater tables causing wells to dry up, increasing travel distances to collect water</li> <li>• Decreased dilution in source waters and increased concentration of pollutants and nutrients</li> <li>• Release of contaminants from reservoir sediments into waterbody, such as benthic nutrients and metals</li> </ul>

Sources: WHO (2017c); WHO Regional Office for Europe (2011).

108

MESSAGE 6: Risk-based surveillance aids forward-thinking and anticipation of change

Examples of climate change impacts on drinking-water supply	
Event	Potential impacts
Sea-level rise	<ul style="list-style-type: none"> <li>Increased saline ingress of coastal aquifers</li> <li>Intrusion of seawater into distribution networks</li> <li>Inundation of water-supply infrastructures</li> </ul>
Precipitation and flooding	<ul style="list-style-type: none"> <li>Flood damage to water and sanitation infrastructure</li> <li>Overwhelmed containment systems discharging untreated storm- and wastewater into source waters</li> <li>Heavier rainfall events and storm runoff causing increased loading of pathogens and suspended sediment in surface waters</li> <li>Overwhelmed drinking-water treatment systems becoming less effective</li> </ul>

Sources: WHO (2017); WHO Regional Office for Europe (2011).

SLIDE 109

109

MESSAGE 6: Risk-based surveillance aids forward-thinking and anticipation of change

Surveillance agency responses to long-term change

- Advocating and proactively participating in long-term planning processes to:
  - ensure continuing access to freshwater sources for drinking-water purposes;
  - manage water demand among competing needs
  - review the resilience of supply systems and
  - implement control measures to maintain water quality.
- Promoting consideration of the hazards and health risks resulting from long-term changes in the local WSPs of water suppliers

SLIDE 110

110

MESSAGE 6: Risk-based surveillance aids forward-thinking and anticipation of change

Surveillance agency responses to long-term change

- Engaging with other sectors and agencies (including environment, water resource management, meteorology and agriculture) and supporting collation and analysis of data over time to:
  - identify possible new hazards, trends and peaks in concentrations, and
  - inform water suppliers accordingly (other sectors may already have data available that the water-supply sector can access);
- Advising policy-makers and regulators if regulations and water-quality standards merit updates in response to observed changes in terms of, for example, additional parameters or parametric values.

SLIDE 111

111

MESSAGE 6: Risk-based surveillance aids forward-thinking and anticipation of change

Case study XX – Impact of climate change on trihalomethanes formation in drinking-water treatment

Location: Scotland

Surveillance approach:

- monitoring data from 5 drinking-water treatment plants (DWTPs) showed significant correlations exist between conditionally carcinogenic trihalomethanes (THMs) levels, water temperature and dissolved organic carbon (DOC)
- the strong seasonality of these parameters demonstrated how climate can influence THMs formation
- laboratory experiments quantified the sensitivity of THMs formation to changes in water temperature and DOC concentration, reproducing real-world THM formation in the DWTPs

Source: taken from Valdivia-Garcia et al. (2019).

SLIDE 112

112

MESSAGE 6: Risk-based surveillance aids forward-thinking and anticipation of change

Case study XX – Impact of climate change on trihalomethanes formation in drinking-water treatment

Location: Scotland

Surveillance outcomes:

- validated relationships were combined with literature about future trends in summer temperatures and surface water DOC in the British Isles, to estimate future global warming impacts on THMs formation in DWTPs that use chlorine for disinfection
- an increase in mean summer temperatures will likely increase THM formation, with a 1.8 °C temperature increase and 39% THMs increase by 2050 representing a mid-range scenario.
- projected increases have major implications to potable water around the world, either an increased health risk or increased water treatment costs to maintain an equivalent quality potable supply

Source: taken from Valdivia-Garcia et al. (2019).

SLIDE 113

113

MESSAGE 6: Risk-based surveillance aids forward-thinking and anticipation of change

Case study XX – Impact of climate resilient water safety planning

Location: Ethiopia

Surveillance approach:

- climate-resilient water safety planning was implemented in the water supplies of Addis Ababa and Adama, which supply 5 million and 500,000 people, respectively
- based on the risks identified, water quality monitoring can be optimized by prioritizing parameters and events which pose a higher risk for contaminating the drinking-water

Surveillance outcomes:

- water quality monitoring was improved at both drinking-water utilities to provide relevant data used as input for climate-resilient water safety planning
- by continuously linking water quality monitoring and climate-resilient water safety planning, utilization of information was optimized

Source: taken from van den Berg et al. (2019).

SLIDE 114

114

MESSAGE 6: Risk-based surveillance aids forward-thinking and anticipation of change

Increases in some extreme weather events and storm surges will increase the risk that infrastructure for drinking water, wastewater, and stormwater will fail due to either damage or exceedance of system capacity, especially in areas with aging infrastructure. As a result, the risk of exposure to water-related pathogens, chemicals, and algal toxins will increase in recreational and shellfish harvesting waters and in drinking-water where treatment barriers break down.

SLIDE 115

115

MESSAGE 6: Risk-based surveillance aids forward-thinking and anticipation of change

Case study: Greece

Demands on water supply:

- Agriculture highly dependent on irrigation Seasonality of demand Tourism, peaks in the summer
- Agriculture, peak demand in the dry season
- Uneven distribution of resources
- Uneven distribution of population
- Overexploitation and salinization of underground aquifers
- Dependence on transboundary waters flowing from northern regions 30% of total average annual water resources originates outside the country
- Increasing frequency of droughts and torrential rains in recent years

SLIDE 116

116

MESSAGE 6: Risk-based surveillance aids forward-thinking and anticipation of change

Case study: USA

Demands on infrastructure:

- Water main failures are a common occurrence in the United States with the total number of failures of all size pipe estimated at more than 500,000 per year.
- As the buried infrastructure continues to age and deteriorate without repair or replacement, such failures can be expected to increase with time.
- Water main breaks and flooded valve chambers not only disrupt communities and affect their citizens and businesses but also pose an increased health risk.
- Many older buried water mains can be leaking undetected for months, experience sudden water demands, such as automatic lawn watering or intermissions at sports events, and fail unexpectedly

SLIDE 117

117

MESSAGE 6: Risk-based surveillance aids forward-thinking and anticipation of change

Case study: USA

Demands on infrastructure:

- These events, as well as firefighting, can depressurize the water system and allow contaminated water to be drawn in and later consumed.
- The chlorine-based disinfectant added during the treatment process can be overwhelmed and any pathogens that are introduced can remain infectious.
- Aging metal pipes are also prone to developing tubercles on the pipe walls that can impede water flow and provide a favourable habitat for bacterial populations to become established and multiply.
- There is also clear evidence that corroded unlined metallic pipe "absorbs" disinfectant residuals.

SLIDE 118

118

MESSAGE 6: Risk-based surveillance aids forward-thinking and anticipation of change

KNOWLEDGE TEST

SLIDE 119

119

MESSAGE 6: Risk-based surveillance aids forward-thinking and anticipation of change

VIDEO

SLIDE 120

120