Integrating water quality testing into household surveys

WHO/UNICEF JOINT MONITORING PROGRAMME
FOR WATER SUPPLY, SANITATION AND HYGIENE

unicef

WHO UNICEF JMP

World Health Organization

Integrating water quality testing into household surveys
Thematic report on drinking water

ISBN 978-92-806-5167-6 (UNICEF)
ISBN 978-92-4-001402-2 (WHO electronic version)
ISBN 978-92-4-001403-9 (WHO print version)

Suggested citation
United Nations Children's Fund and World Health Organization, *Integrating Water Quality Testing into Household Surveys: Thematic report on drinking water*, UNICEF and WHO, New York, 2020.

Photographs
Page 4: ©UNICEF/UN0229739/Brown; Page 6: ©UNICEF/UNI329722/Haro; Page 7: ©UNICEF/UN0152885/Noorani; Page 8: ©UNICEF/UN054123/Bradley; Page 10: ©UNICEF/ECU/2016/Troppoli; Page 12: ©Osterwalder Kosovo, Lictevout Dominican Republic; Page 13: ©UNICEF/UNI308357/Desjardins; Page 14: ©Lictevout Paraguay; Page 15: ©van Maanen Lebanon; Page 16: ©Lictevout Paraguay; Page 19: ©UNICEF/UN0274937/Panjwani; Page 20: ©Osterwalder Lesotho; Page 21: ©Coskun; Page 22: ©Lictevout Honduras; Page 23: ©Saboor Afghanistan; Page 24: ©UNICEF/UN0311064/Verweij; Page 27: ©van Maanen Lao People's Democratic Republic; Page 28: ©van Maanen Nigeria; Page 29: ©Lictevout Paraguay; Page 30: ©van Maanen Lebanon; Page 31: ©UNICEF/UN0185043/Haro; Page 34: © Osterwalder Malawi; Page 36: ©van Maanen Lebanon; Page 38-39: ©UNICEF/UN0269915/Asselin; Back cover: ©Osterwalder Zimbabwe.

Cover illustration includes vector graphics designed by Freepik.

Edited by Richard Steele. Design and layout by Cecilia Silva Venturini.

Integrating water quality testing into household surveys

WHO/UNICEF JOINT MONITORING PROGRAMME
FOR WATER SUPPLY, SANITATION AND HYGIENE

Table of contents

1

Introduction

Access to safe drinking water is a basic human right and an essential foundation of public health. Obtaining reliable information on the safety of drinking water supplies has historically been a major challenge for national and global monitoring. Since 2017, the World Health Organization (WHO) and United Nations Children's Fund (UNICEF) Joint Monitoring Programme for Water Supply, Sanitation and Hygiene (JMP) reports on progress towards Sustainable Development Goal (SDG) target 6.1 have included estimates on the quality of drinking water supplies[1]. This represents a significant advance in global monitoring of drinking water services.

In many low- and middle-income countries, existing water quality data from regulatory authorities is limited, especially for rural areas and populations using non-piped supplies. To complement the regulator data, an increasing number of low- and middle-income countries are collecting nationally or sub-nationally representative data on drinking water quality through multi-topic household surveys.

Beginning in 2012, a water quality module was developed and standardized by the WHO/UNICEF JMP in collaboration with UNICEF's Multiple Indicator Cluster Survey (MICS) programme. Integration of water quality testing has become a feasible option due to the increased availability of affordable and accurate testing procedures and their adaptation for use by household survey experts. The growing interest in ensuring the implementation of water quality testing in these surveys can, to a large extent, be attributed to the incorporation of drinking water quality in the SDG global indicator for 'safely managed drinking water services'.

This thematic report presents the experience of using the water quality module in representative household surveys.

[1] World Health Organization and the United Nations Children's Fund, *Progress on Drinking Water, Sanitation and Hygiene: 2017 update and SDG baselines*, WHO and UNICEF, Geneva, 2017. <https://washdata.org/report/jmp-2017-report-final>.

2

Summary of findings

The integration of water quality testing into national household surveys has enabled the collection of data representative of the entire population, including those in rural areas and those who are not served by utilities or covered by regulators. Since 2012, the results of 32 nationally or sub-nationally representative household surveys, conducted in 29 countries, have become available.

In the surveys, households selected for water quality testing were asked to provide a glass of drinking water and show interviewers the point where the water was collected (for example, a tap, borehole, dug well, or river). Water samples from both the glass (point of use or PoU) and point of collection (PoC) were analysed for the presence of *Escherichia coli* (*E. coli*), an indicator of faecal contamination. Some surveys tested for additional water quality parameters.

A summary of the 32 survey results is presented in Table 1. The table shows the proportion of the population using drinking water contaminated with *E. coli* at the PoC and PoU, and highlights the large disparities between countries. Water quality testing in household surveys has enabled 26 countries to make their first national baseline for SDG target 6.1.

Section 5.3 provides more detailed findings from each of the surveys, including the degree of contamination using the WHO risk levels for faecal contamination of drinking water.

TABLE 1 **Summary results from 32 representative household survey reports**

Country	Survey◊	Year	Scale	Proportion of population using drinking water contaminated with *E. coli*		Survey enabled first national reporting against SDG 6.1
				Point of collection	Point of use	
Afghanistan	ALCS	2016-17	Sub-national (10 provinces)	58.1	76.9	No
Bangladesh*	MICS	2012-13	National	41.7	61.7	Yes
Bangladesh*	MICS	2019	National	40.3	81.9	No
Congo	MICS	2014-15	National	48.1	77.7	Yes
Côte d'Ivoire	MICS	2016	National	53.6	78.5	Yes
Democratic People's Republic of Korea	MICS	2017	National	23.5	36.6	Yes
Democratic Republic of the Congo∆	MICS	2017-18	National	59.6	74.6	Yes
Ecuador∆	ENEMDU	2016	National	20.7	N/A	Yes
Ecuador∆	ENEMDU	2019	National	20.7	N/A	No
Ethiopia†	ESS	2016	National	86.0	94.4	Yes
Gambia	MICS	2018	National	45.3	73.2	Yes
Georgia	MICS	2018	National	24.9	30.8	Yes
Ghana*	GLSS	2012-13	National	43.5	62.0	Yes
Ghana	MICS	2017-18	National	48.3	76.1	No
Iraq	MICS	2018	National	40.4	50.7	Yes
Kiribati	MICS	2018-19	National	85.1	91.1	Yes
Lao People's Democratic Republic	MICS	2017	National	83.1	86.3	Yes
Lebanon‡	WQS	2016	National	52.0	61.0	Yes
Lesotho	MICS	2018	National	33.0	53.2	Yes
Madagascar	MICS	2018	National	80.9	86.3	Yes
Mongolia	MICS	2018	National	16.0	19.7	Yes
Nepal	MICS	2014	National	71.1	82.2	Yes
Nigeria	MICS	2016-17	National	77.3	90.8	No
Pakistan	MICS	2017-18	Sub-national (Punjab)	36.2	59.6	No
Paraguay	MICS	2016	National	37.5	47.6	Yes
Philippines	APIS	2017	National	51.9	67.3	Yes
Sierra Leone	MICS	2017	National	89.6	97.0	Yes
Suriname	MICS	2018	National	42.5	64.1	Yes
Tonga	MICS	2019	National	70.1	78.1	Yes
Togo	MICS	2017	National	69.1	90.2	Yes
Tunisia	MICS	2018	National	20.5	28.9	Yes
Zimbabwe	MICS	2019	National	59.0	83.7	Yes

Note: Official surveys names may differ but surveys listed as MICS are part of the MICS global programme. For example the Mongolia MICS is known as the Social Indicator Sample Survey.

◊ ALCS – Afghanistan Living Conditions Survey, APIS – Annual Poverty Indicator Survey, ENEMDU – Encuesta Nacional de Empleo, Desempleo y Subempleo, ESS Ethiopia Socio-economic Survey, GLSS – Ghana Living Standard Study, MICS – Multiple Indicator Cluster Survey, WQS – Water Quality Survey
* Survey also included arsenic testing (in the field)
† Survey also included fluoride testing (in the laboratory)
‡ Standalone WASH survey
∞ Follow-up WASH survey (using main ESS sampling frame)
∆ Survey did not use the standardized water quality module for *E. coli*

Drinking water safety and the SDGs

SDG target for drinking water

The SDGs set ambitious new targets for drinking water, sanitation and hygiene (WASH). Target 6.1 under Goal 6 calls for universal access to safe drinking water for all by 2030. This target is measured using a new global indicator, defined as:

Indicator 6.1.1: Proportion of population using safely managed drinking water services

Populations use safely managed drinking water services when the main source of drinking water is an improved source[2] and meets three additional criteria (Figure 1):

- **Accessibility:** the water should be accessible on premises
- **Availability:** the water should be available when needed[3]
- **Quality:** the water should be free from contamination

The JMP has developed a new service ladder to track progress on drinking water services during the SDG period (Figure 2). The new ladder reflects the different levels of service based on the criteria above. The rungs on the ladder enable countries at different stages of development to benchmark and compare their progress over time.

[2] Improved sources include: piped water, boreholes or tubewells, protected dug wells, protected springs, rainwater, and packaged or delivered water.

[3] Household surveys and censuses often ask households whether sufficient quantities of water were 'available when needed' during the past week or month. When data from regulators are available for piped systems, the JMP uses 'availability more than half of the time', meaning a minimum of 12 hours per day or at least four days per week, as a measure of 'availability when needed'.

FIGURE 1 The elements of safely managed drinking water services

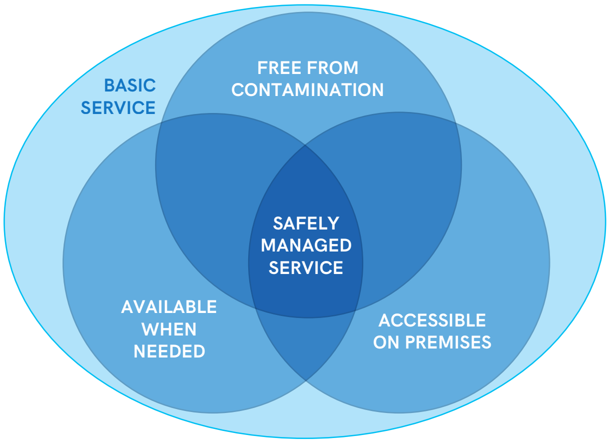


FIGURE 2 The drinking water services ladder

SERVICE LEVEL	DEFINITION
SAFELY MANAGED	Drinking water from an improved source that is located on premises, available when needed and free from faecal and priority chemical contamination
BASIC	Drinking water from an improved source, provided collection time is not more than 30 minutes for a round trip, including queuing
LIMITED	Drinking water from an improved source, for which collection time exceeds 30 minutes for a round trip, including queuing
UNIMPROVED	Drinking water from an unprotected dug well or unprotected spring
SURFACE WATER	Drinking water directly from a river, dam, lake, pond, stream, canal or irrigation canal

Note: Improved sources include: piped water, boreholes or tubewells, protected dug wells, protected springs, rainwater and packaged or delivered water.

A previous thematic report presents more details on how the JMP monitors safely managed drinking water services[4]. The JMP has published core questions for household surveys[5] which provide detailed monitoring definitions and recommended questions to use when collecting information relating to the new SDG WASH indicators.

From a normative perspective, 'free from contamination' means that drinking water should be free from pathogens and elevated levels of harmful substances at all times. However, for global monitoring purposes it is not currently feasible to compile data on many contaminants. The JMP focuses on three priority parameters based on the WHO Guidelines for Drinking Water Quality[6] and expert taskforces on the monitoring of drinking water quality[7].

The highest priority water quality concern globally, and in most countries, is contamination of drinking water with faecal matter. Faecal contamination of drinking water is usually identified through the detection of indicator bacteria, such as *E. coli*, in a 100 mL sample[6]. In addition to faecal contamination, high-priority chemical parameters at a global level are arsenic and fluoride, because these can occur naturally, affect large populations, and have serious health impacts. Arsenic and fluoride contamination of groundwater is widespread and there are several regions where the levels of contamination in drinking water exceed the WHO guideline values[8]. High levels of contamination often occur in sub-national regions of specific countries and testing can be informed by groundwater risk maps[9].

'Free from contamination' implies that drinking water meets with the following WHO guidelines:

Faecal contamination (priority for all countries)
- No *E. coli* (or alternatively thermotolerant coliforms) detected in a 100 mL sample

Chemical contamination (where relevant)
- Arsenic: a concentration of arsenic not exceeding the WHO provisional guideline value of 10 µg/L (10 micrograms per litre), equivalent to 10 ppb (parts per billion)
- Fluoride: a concentration of fluoride not exceeding the WHO guideline value of 1.5 mg/L (1,500 micrograms per litre), equivalent to 1.5 ppm (parts per million)

[4] World Health Organization, *Safely Managed Drinking Water: Thematic report on drinking water 2017,* WHO, Geneva, 2017. <https://washdata.org/sites/default/files/documents/reports/2017-07/JMP-2017-tr-smdw.pdf>

[5] United Nations Children's Fund and World Health Organization, *Core Questions on Drinking Water, Sanitation and Hygiene for Household Surveys: 2018 update*, UNICEF and WHO, New York, 2018. <https://washdata.org/report/jmp-2018-core-questions-household-surveys.pdf>

[6] World Health Organization, *Guidelines for Drinking-water Quality: Fourth edition incorporating the first addendum*, WHO, Geneva, 2017. <www.who.int/water_sanitation_health/publications/drinking-water-quality-guidelines-4-including-1st-addendum/en>

[7] See the Second Meeting of the WHO/UNICEF JMP Task Force on Monitoring Drinking-water Quality, 2013. <https://washdata.org/report/jmp-2013-tf-water-quality>

[8] It is recognized that at least 140 million people in 50 countries have been drinking water containing arsenic at levels above the WHO provisional guideline value of 10 µg/L (see www.who.int/en/news-room/fact-sheets/detail/arsenic). While the global prevalence of dental and skeletal fluorosis is not known, it is estimated that excessive fluoride concentrations in drinking water have caused tens of millions of dental and skeletal fluorosis cases worldwide over a range of years (www.who.int/ipcs/assessment/public_health/fluoride/en).

[9] The MICS in Bangladesh (2012-13 and 2019) and Nepal (2019) as well as the Ghana LSS (2012-13) have included arsenic testing. Fluoride testing was included in the Ethiopia 2016 ESS water quality survey. More information on the populations at risk for high levels of arsenic or fluoride in their drinking water can be found at <www.gapeawag.com> and <www.unicef.org/wash/files/UNICEF_WHO_Arsenic_Primer.pdf>.

BOX 1

Linking household testing with water safety plans and routine surveillance

Testing for *E. coli* in nationally representative household surveys is an efficient way to fill data gaps and draw attention to problems related to water quality. Household surveys alone, however, are insufficient to ensure water safety. The two most important limitations of household surveys relate to the long time between surveys and the restricted number of water quality parameters that can be included:

- Surveys like the MICS are typically carried out every three to five years. As contamination can be highly variable over time, specific contamination events can escape detection in a household survey but still have serious public health outcomes. Household surveys can therefore overestimate water safety by underestimating the prevalence of contamination.

- While *E. coli* is an essential drinking water quality parameter, monitoring *E. coli* alone is insufficient. There are additional parameters that could and should be monitored to achieve a more comprehensive assessment of water quality[10].

To ensure water safety 'at all times', water suppliers should practise proactive risk management, such as water safety planning[11]. Water safety plans (WSPs) help to identify the greatest risks to water safety and put in place measures to mitigate them. Independent water quality surveillance by the regulatory authority or other entity is also important to ensure water safety. Surveillance should confirm adequate risk management by water suppliers, e.g. through WSP auditing, and confirm compliance with all relevant water quality targets. Surveillance findings should also inform the development of water safely policies and programmes[12].

[10] Refer to the *WHO Guidelines for Drinking-water Quality* for a comprehensive list of water quality parameters and *Developing Drinking-water Quality Regulations and Standards* for guidance on prioritizing water quality parameters that reflect local circumstances.

[11] WSPs are a systematic risk assessment and risk management approach encompassing all steps in the water supply system, from the catchment through to the consumer. Further WHO resources on WSPs can be accessed at <www.who.int/water_sanitation_health/publications/wsp-roadmap.pdf>.

[12] WHO and UNICEF promote the Framework for Safe Drinking-water. This comprises drinking-water quality regulations with water quality targets, water safety plans and independent surveillance. The framework is described in the *WHO Guidelines for Drinking-water Quality*.

4

A new module for household surveys

4.1 Integrating water quality testing into household surveys

Integrating water quality testing into household surveys has several advantages, including:

A. Representative data
National-level data on water quality can be incomplete and not representative of the whole population. The surveillance performed by regulators in low- and middle-income countries is often oriented towards urban areas and piped networks, and excludes large parts of the population, including those with the lowest levels of service. Even in high-income countries it can be challenging to regulate small-scale supplies, especially where these are privately managed.

An additional challenge of available data sets concerns the selection of water sources. Testing is often carried out on a random sample of supplies (usually only public supplies) within a given geographic area, which may not be representative of the sources actually used for drinking. Surveys like the MICS ask household members what their 'main source of drinking water' is and a sample of water is collected for testing regardless of whether the source is a public tap, a private borehole or a river.

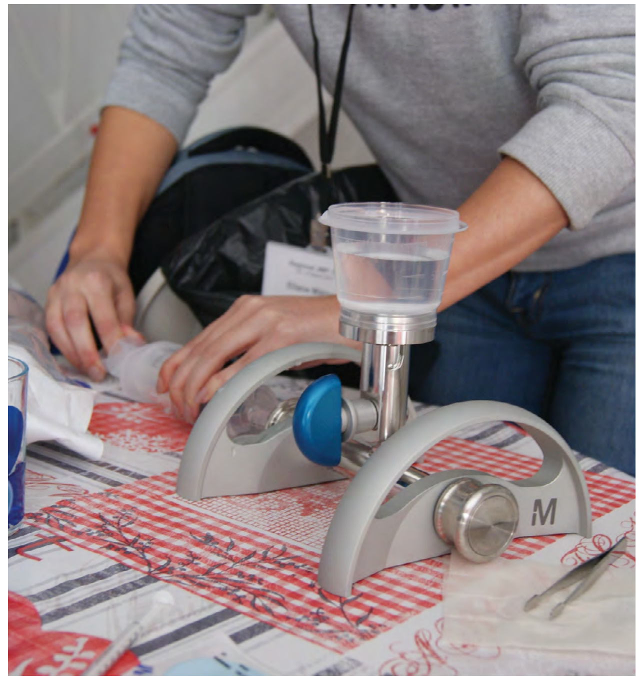
B. Inequalities
Under the SDGs, governments are expected to focus on progressively reducing inequalities in services. To track progress in reducing inequalities, the 2030 Agenda

specifies that 'SDG indicators should be disaggregated, where relevant, by income, sex, age, race, ethnicity, migratory status, disability and geographic location or other characteristics'.

Household surveys such as the MICS include multiple questionnaires that generate data on a large range of household and individual characteristics, permitting such disaggregation. With the water quality module integrated into household surveys, testing results can be disaggregated to highlight disparities between population groups and identify contamination risk factors.

Integrating water quality testing into household surveys can be used to draw attention to common disparities in the use of safe drinking water supplies, such as the differences between populations:

- in rural and urban areas.
- in sub-national areas (regions or provinces).
- with different levels of education (of the household head).
- with different levels of income (wealth quintiles).



C. Risk factors for contamination

'Improved' water sources are designed to protect against contamination, especially faecal contamination, and are less likely to be contaminated than unimproved sources. Nevertheless, when sources are protected, faecal matter may be present at the PoC due to, for example, intermittent water supplies, leaking distribution systems, infiltration of surface water into wells, leaks in septic tanks and latrine pits, and agricultural runoff.

Even when water is free from faecal contamination at the PoC, it can become contaminated before it is consumed. Water that is transported from a source in a storage container and stored in the household may be exposed to faecal contamination through the use of unhygienic or uncovered storage containers, dirty ladles or cups, and contaminated fingers. Water quality may also improve as a result of treatment at household level. The water quality module therefore includes tests at both the PoC and the PoU. This information can be used to identify changes in the level of contamination due to either unsafe handling and storage or water treatment (for example, boiling or filtering) by the household members.

By linking data on water quality at the PoC or PoU to other information collected in the survey, risk factors for contamination can be identified and prioritized. The MICS also includes questions on the type of drinking water source, household water treatment and storage practices, and the time taken to collect water from the source. Together with the results of the tests at the PoC and PoU, these questions enable risk factors for contamination to be analysed.

D. Cost-effectiveness

The collection of reliable and representative data through a standalone water quality survey can be costly. Integrating water quality testing in existing multi-topic household surveys is a much more cost-effective solution.

The general expenses – largely covered by the agency carrying out the survey – include the design and preparation for the survey, listing of households in each cluster, interviewer salaries and daily allowances, transportation of field teams, general supervision, data analysis and report writing. When adding water quality testing, three additional costs are incurred:

- Procuring testing materials (international and local)
- Training field teams (typically for four or five days)
- Support from laboratory technicians from the national regulator or agency responsible for water quality testing (supervision during training and at the start of the survey)

The responsibility for testing water samples in the field is normally added to the responsibilities of an existing member of each field team. Experience shows that survey teams can generally take on this additional task without the need for additional personnel.

The costs of the water quality module are dominated by the consumables and equipment needed to carry out the tests (Box 2). The costs of these materials are relatively low compared with the overall cost of a household survey or carrying out a standalone survey.

BOX 2

Costs of the standard water quality testing module

The standard water quality testing method that has been selected for household surveys is described in Section 5.1. It uses consumables that cost around US$2.50 per test. Because two tests are carried out per household (at the PoU and PoC) the costs are US$5 per household selected for water quality testing. For a typical national survey, conducting water quality testing in 2,500 households, the consumables cost US$12,500. In addition, around 25% extra consumables are recommended for training and any loss or waste, leading to a total cost for consumables of around US$16,000.

The equipment needed to carry out the tests costs around US$1,100 per team in 2020. Therefore, for a typical survey setup with 20 teams the equipment costs are US$22,000. However, a laboratory-grade filtration stand (of US$1,000) represents a large proportion of the equipment costs. By reusing the filtration stands in subsequent surveys, or in other countries, or by making use of lower-cost filtration options, the overall cost of integrating the water quality module can be substantially reduced.

The overall cost, including involving national laboratory technicians and a JMP trainer, can range from US$50,000 to US$80,000, depending on the scale of the survey and the number of teams. This represents a small fraction of the overall costs of implementing nationally representative household surveys, which can range from US$500,000 to well over US$5 million.

TABLE 2

Approximate costs of the equipment and consumables of the standard approach

Equipment (per team)	Cost (USD)	Consumables (per 100 tests)	Cost (USD)
Filtration stand	1,000	Membranes and funnels	100
Metal forceps*	50	Disposable sterile syringe (1 mL)	8
Reusable syringe (100 mL)*	4	Alcohol swabs	9
Incubation belt*	10	Dehydrated media plates	100
Water quality testing bag	2	Sample collection bags	10
Water quality storage bag	2	Chlorine tablets	4
Permanent marker*	2	Hand sanitizer	4
		Trash bags	1
		Bottled water	5
		Paper towels	1
Costs per team	**1,070**	**Costs per 100 tests**	**242**

* Teams have a spare of these items, which is included in the estimates.

4.2 How is the water quality testing module integrated into MICS surveys?

MICS data are collected by teams of interviewers in face-to-face interviews with respondents, based on a large set of globally-recommended questionnaires[13]. Because household surveys such as the MICS are not specifically designed for water quality testing, the water quality module must be adapted to the household survey into which it will be integrated. That means the water quality module must suit the existing sampling approach, the training calendar and the modalities for fieldwork.

How are households selected for water quality testing?
The primary objective of the sample design of the MICS is to produce statistically reliable estimates. The surveys are usually designed to have a sufficient sample size to be representative for a set of priority indicators at the national level and first sub-national level (for example, region or province), and urban and rural areas.

The required sample size differs by indicator and is considered in conjunction with several additional factors related to implementation, such as the costs, length of fieldwork, workload, and amount of time available to work on the MICS survey[14]. A subset of households interviewed in the MICS is selected for water quality testing to minimize workload and cost and due to the high intra-cluster correlation, which means testing all households would only marginally increase the precision of the water quality estimates. Using a randomly selected sub-sample of households in a cluster, reliable estimates can be produced on the quality of drinking water at the PoC and PoU.

For example, a very common application of this sampling approach involves the selection of 500 clusters at national level using stratification and random selection. Within each cluster, 25 households are randomly selected for household interviews and five of these are randomly selected for water quality testing. The water quality testing sub-sample in this example size is therefore 500x5=2,500 households compared with 12,500 households selected for the entire MICS. Because water samples within a cluster are likely to have similar contamination levels, testing more than about five households per cluster does not provide much additional statistical power.

The 25 households in each cluster and the 5 households selected for water quality testing are identified before the field teams are deployed. When the field teams enter a cluster, the supervisors help the interviewers locate the five households that have been selected for water quality testing. Finally, within each of these households, a knowledgeable respondent, 18 years of age or older, responds to the water quality questionnaire, provides the cup of water for the PoU test, and shows the location of the water source so the field tester can collect a water sample for the PoC test.

Who does the testing?
Field teams in the MICS typically consist of a supervisor, three or four interviewers and a measurer. A measurer is a member of the team who is responsible for anthropometry. As part of this questionnaire, all children under the age of five in selected households are measured using a measuring board (height) and scale (weight).

In most cases, water quality testing is added to the responsibilities of the measurer. Measuring children is a task that demands a high level of precision and accuracy. Reliable water quality testing also requires these skills. In addition, measurers often have enough spare time to carry out water quality testing.

In a small number of surveys, another team member has been selected for water quality testing or the responsibility has been shared between all team members. The choice of tester should consider the team composition, time management, workload and capacity.

How are field testers trained?
Field testers are trained by a team of national laboratory technicians together with an international water quality expert supplied by the JMP team. Collaboration with laboratory technicians or other national water quality specialists ensures every field tester is adequately trained and supervised during the practice sessions. Each trainee should have the opportunity to practise the testing procedure at least 15 times, to build confidence and to allow for the trainers to observe their technique.

Laboratory technicians are well suited to support the training, provided they are knowledgeable about microbial water quality, familiar with testing for coliform bacteria, and motivated to train and supervise the teams. Ideally, one trainer would be responsible for five to eight trainees. Their role includes demonstrating the water test, moderating sessions and supervising participants. As recognized authorities on water quality, laboratory technicians are well placed to respond to questions from participants, especially those related to the national context[15].

[13] The questionnaires are customized at the country level to meet specific needs. Country customization can include question deletion or addition along with language customization.

[14] The MICS approach to sampling is that countries define a set of key indicators for the survey, reporting domains and the desired level of precision, and then determine sample sizes to achieve these parameters.

[15] It is essential to plan for a two-hour briefing and demonstration of the water testing procedure with national water quality experts before the training.

How can we be confident the data are reliable?
The reliability of the results depends on the quality of the implementation of the water quality module. The following quality assurance and quality control measures increase the reliability of the results:

- Involvement of laboratory technicians or other national water quality specialists during training
- High quality practice-based training (four or five days), including fieldwork
- Supervision by laboratory technicians at the start of the survey
- Supervision by supervisors throughout the survey
- Procurement of standard testing equipment and consumables (for example, through UNICEF's Supply Division in Copenhagen[16])
- Regular blank testing throughout the survey

Regular blank testing is an essential quality control measure, used to verify if interviewers have respected the testing protocol in the field. At specific intervals (usually after approximately 10 actual tests), the interviewer tests a 'blank' water sample that is expected to be free from *E. coli*. Bottled water or distilled water can be used for this test[17]. The blank test must be carried out under normal field conditions. When the testing protocol is respected, the results of a blank test will be 'negative', meaning zero colonies of *E. coli* are detected. A positive test result shows one or more colonies of *E. coli*. Such a result is evidence of errors made during the testing procedure. For example, an interviewer may not have disinfected the materials properly, or the water sample may have been contaminated by the hands of the field tester. In this case, the interviewer should review the testing protocol together with the supervisor. During the training, if an interviewer continues to have positive results on blank tests, a survey coordinator needs to be informed. Results of blank tests from the most recent MICS in each country are shown in Table 3 and demonstrate that a small proportion of blanks tested positive (<5%), except in Côte d'Ivoire and Gambia. In these two surveys, few of the positive blanks exceeded 10 *E. coli* per 100 mL. This implies that positive results in PoC and PoU samples represent real contamination of the drinking water, and not poor hygiene of the field tester.

[16] UNICEF's Supply Catalogue includes a product list for water quality testing. <https://supply.unicef.org/all-materials/water-sanitation.html>

[17] The bottled or distilled water should be tested before the start of the fieldwork to guarantee it is free from contamination.

TABLE 3 Results of blank testing by the interviewers in selected MICS

Survey	% Blank tests positive for *E. coli*	Total number of blank tests for *E. coli* carried out
Bangladesh 2019	1.9	602
Congo 2014-15	2.5	240
Côte d'Ivoire 2016	8.2	473
Democratic People's Republic of Korea 2017	1.1	336
Democratic Republic of the Congo 2017-18	0.8	649
Gambia 2018	6.2	373
Georgia 2018	0.0	536
Ghana 2017-18	1.0	558
Iraq 2018	0.8	1,668
Kiribati 2018-19	1.3	150
Lao People's Democratic Republic 2017	2.1	1,034
Lesotho 2018	0.6	327
Madagascar 2018	0.9	674
Mongolia 2018	1.4	500
Nepal 2014	0.0	164
Nigeria 2016-17	1.2	1,018
Pakistan (Punjab) 2017-18	2.1	2,527
Paraguay 2016	0.0	371
Sierra Leone 2017	2.4	591
Suriname 2018	1.1	272
Togo 2017	2.1	380
Tunisia 2018	1.2	497
Zimbabwe 2019	1.2	434

5

Experiences to date

5.1 What testing approaches have been used in the MICS?

Faecal contamination

The standard approach for integrating water quality testing in the MICS is based on an adapted portable membrane filtration kit (Figure 3). This kit, assembled by the JMP by combining equipment from different manufacturers, allows testing for *E. coli* to detect faecal contamination in a field setting.

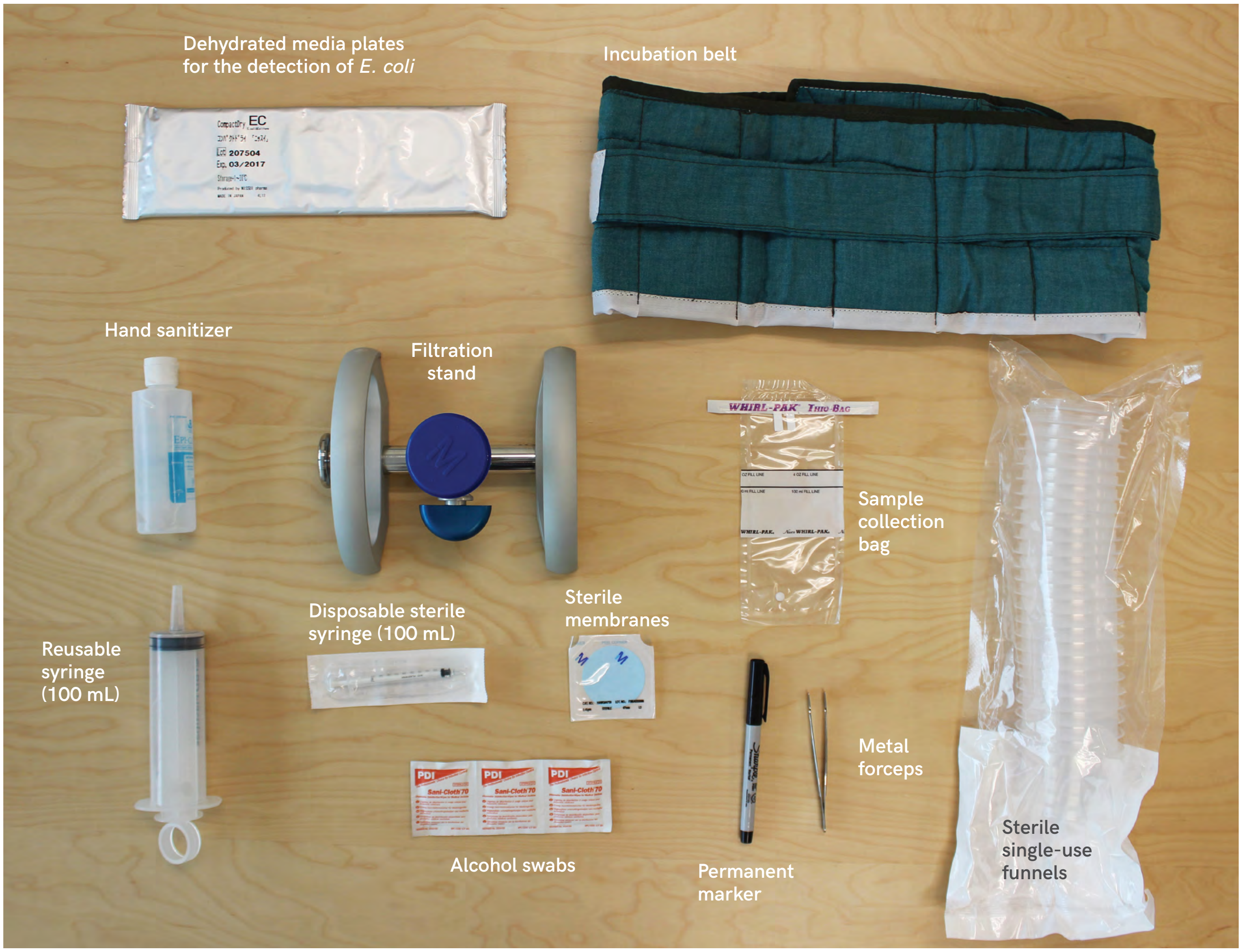
The key components of the portable kit are a membrane filtration kit, dehydrated media plates, and an incubator. Key features of the portable kit are:

- A laboratory-grade filtration stand in combination with a syringe to draw the sample through the membrane filter (to filter 100 mL of sample water)
- Dehydrated media plates for the detection of *E. coli*
- Disposable sterile funnels in combination with standard paper membranes (45 µm)
- Alcohol wipes to disinfect the filter support and forceps, and a sterile 1 mL syringe (to rehydrate the media on the dehydrated media plates)

For further details of the portable kit, see *MICS Manual for Water Quality Testing*[18]. Alternative approaches that have been used in a small number of surveys are described in Box 3.

[18] Multiple Indicator Cluster Surveys, *Manual for Water Quality Testing*, MICS, 2016. < http://mics.unicef.org/tools#data-collection>

FIGURE 3 **The main elements of the portable membrane filtration kit**



Additional items not shown in the photo:			
	• Water quality testing bag • Storage bag	• Chlorine tablets • Trash bags	• Bottled water • Paper towels

The dehydrated media plates have three important features that make them appropriate for use in household surveys:

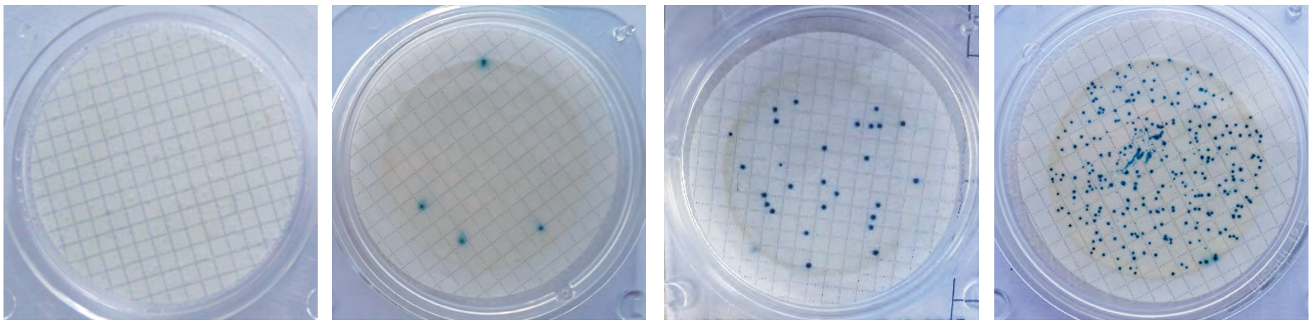
- **Growth media:** The growth media is present in dehydrated form on the plates and can be rehydrated simply by adding 1 mL of sample water using a sterile syringe. This greatly simplifies media preparation and does not require a cold chain. The media contains an enzyme substrate that specifically detects *E. coli*, with individual colonies turning blue during incubation.

- **Quantification:** A standard membrane filter can be placed on top of the hydrated media. This makes it possible to combine the plates with membrane filtration, a quantitative method that provides a high level of precision. After 24 hours of incubation, the level of contamination can easily be measured by counting the number of *E. coli* colonies on the membrane. This makes it easy for the field teams to read the results, which can be compared with the WHO risk levels.

- **Incubation:** Because the plates are compact and can be sealed, they are easy to transport and incubate. The use of enzymatic substrates permits the use of non-standard incubation temperatures and enables the use of low-cost incubation options, such as an 'incubation belt'. An incubation belt is appropriate for contexts where electric incubation is not an option and allows mobile field teams to carry the plates with them for incubation as they proceed with the survey.

Testing results are available after 24 hours of incubation. The enzyme substrate on the plates gives the *E. coli* colonies a blue colour. The field teams record the number of blue colonies on the water quality questionnaire. Examples of plates with different levels of contamination after 24 hours of incubation are displayed in Figure 4. During data analysis, the MICS team classifies the different levels of contamination using the WHO risk levels (listed in Table 4).

FIGURE 4 **Examples for each of the four WHO risk levels, interpreted by the number of *E. coli* colonies on a plate**



LOW RISK (no *E.coli* detected)	MEDIUM RISK	HIGH RISK	VERY HIGH RISK

TABLE 4

WHO risk levels for faecal contamination of drinking water

E. coli per 100 mL of water	WHO risk level
<1	LOW RISK
1-10	MEDIUM RISK
11-100	HIGH RISK
>100	VERY HIGH RISK

BOX 3

Alternatives to the standard portable membrane filtration unit

Using a portable membrane filtration unit usually generates results that have a good degree of precision at a reasonable cost. However, there have been instances where the context of the MICS has demanded a method that requires less training and supervision.

For example, the MICS 2017-18 in the Democratic Republic of the Congo used an unusually large number of teams due to the size of the country. 75 field teams had to be trained in 15 zonal centres and the training was delivered without the presence of national laboratory technicians[19].

For this reason, the JMP recommended the use of an alternative method, which was appropriate for a household survey context but used a simplified testing protocol.

The field teams used two different methods for each water sample:

- 100 mL presence/absence test, using a sterile bottle and X-gluc media[20]. This test detects the presence of *E. coli* in water but does not indicate whether the level of contamination is low or high.
- 1 mL quantitative test using a dehydrated media plate[21]. This test detects how many *E. coli* bacteria are present in 1 mL of sample water. It indicates if the water sample contains very high levels of contamination.

The combination of these methods renders the results semi-quantitative. The interpretation of the results is shown in Table 5.

The ENEMDU 2016 and 2019 surveys[22] in Ecuador also used a presence/absence test. Given relatively low prevalence of faecal contamination anticipated in Ecuador and the number of teams involved in the survey (more than 100 teams), presence/absence testing was considered sufficient for national and SDG monitoring and a more viable option.

[19] Except for four zonal training sessions (in Goma - Nord Kivu, Kindu - Maniema, Mbuji-Mayi - Kasaï and Matadi - Kongo Central). Experts from the Direction Nationale de l'Hygiène of the Ministry of Health supervised the training of field teams in those 4 out of 15 training zones.

[20] Sterile bottles and X-gluc media from HiServe were used. The X-gluc media came in a separate pouch in the form of a bud and needed to be added to the sterile bottle at the start of a test.

[21] A 1 mL syringe was used to draw 1 mL of sample water to re-hydrate the growth media.

[22] Instituto Nacional de Estadistica y Censos, *Medición de los indicadores ODS de Agua, Saneamiento e Higiene (ASH)* en el Ecuador, INEC, 2017. <https://www.ecuadorencifras.gob.ec/indicadores-ods-agua-saneamiento-e-higiene/>

The Afghanistan 2016-17 ALCS[23] used an alternative to the laboratory-grade filtration stand. The presence of *E. coli* in drinking water was assessed by using the same membrane filter and disposable funnel on a new low-cost filtration kit. A small handpump created a vacuum pulling the 100 mL water sample through the membrane filter into a vacuum flask fixed to the filtration support. Building on feedback from the field teams in Afghanistan and Pakistan, the JMP aims to refine this low-cost option.

TABLE 5

Interpretation of results using a combined approach: 100 mL presence/absence and 1 mL dehydrated media plate

Results	WHO risk level	*E. coli* per 100 mL of water
Nothing detected in the bottle and nothing detected on the plate	LOW	<1
Bottle 'positive' and 0 or 1 colonies on the plate	MEDIUM/HIGH	1-100
Bottle 'positive' and 2 or more colonies on the plate	VERY HIGH	>100

[23] The field note *Piloting a Field-based Water Quality Test for E. coli: Lessons from Afghanistan* describes the experiences from the pilot <https://washdata.org/report/piloting-water-quality-testing-afghanistan>

BOX 4

What are the incubation options for microbial water quality testing?

The choice of incubation method depends on the simplicity of the method for the field teams, the ambient temperature in the field, the costs, and the availability of a reliable electricity supply.

Using enzymatic substrates on the dehydrated media plates permits the samples to be incubated at non-standard temperatures, in contrast to the often-used thermotolerant coliform, which requires incubation at around 44 °C to ensure specificity[24].

Experience shows *E. coli* can grow into countable colonies if the temperature is kept between 25 °C and 40 °C for 24 hours. If the temperature is too low for an extended period, the *E. coli* will grow too slowly to be visible. And if the temperature is too high, the *E. coli* might be killed or overtaken by other bacteria suited to hotter conditions.

There are several ways to maintain an adequate incubation temperature. Most JMP-supported surveys have used incubation belts, and this has become the recommended approach. These simple belts are worn around the body and keep the plates close to body temperature. They are low cost, easy to use and do not require electricity. The belts must be worn by the interviewer throughout the day, but at night the interviewers can keep the belts close to their body (underneath their pillow or under their bed covers).

[24] Matthews, Robert L., and Tung, Rosalind, 'Broader incubation temperature tolerances for microbial drinking water testing with enzyme substrate tests', *Journal of Water and Health*, vol.12, no.1, pp.113-21, March 2014. <https://iwaponline.com/jwh/article/12/1/113/7922/Broader-incubation-temperature-tolerances-for>

Alternative incubation methods have included:

- **Electric incubators**
  A few surveys have used electric incubators, which can be plugged into team vehicles or mains electricity. Because the incubation chamber is somewhat insulated, electric incubators can be used even when there are brief interruptions in the electricity supply, otherwise batteries are needed. In the Suriname MICS 2018, for example, battery packs were used to ensure adequate incubation in remote regions of the Amazon.

- **Phase-change incubators**[25]
  This option can be suitable for contexts without a reliable supply of electricity, provided a suitable source of heat is available, for example, boiling water. Prototype phase change incubators were used in the Afghanistan ALCS 2016-17 and in the Nepal MICS 2014.

- **Incubation 'vests'**
  Until 2019, the standard module included incubation belts that covered a large part of an interviewer's waist. That design was not always appropriate in some countries, as the belts could be confused with belts used for terrorism. A solution was introduced in the Afghanistan ALCS 2016-17, where the survey team's uniform was adapted to produce an incubation 'vest'. In 2019, the JMP introduced a more compact belt design.

[25] The phase-change incubator is a low-cost, low-maintenance incubator to help test for microorganisms in water supplies. It uses a chemical compound that, when heated and then kept insulated, will stay at around 37 °C for 24 hours. Boiling water is typically used to heat the phase change material before each incubation cycle.

Arsenic and fluoride

Arsenic and fluoride are the two priority chemical contaminants in the monitoring framework for SDG6.

The relevance of integrating chemical testing in the MICS should be considered together with factors such as the workload for field teams and the costs. For example, where the available information indicates 'high risk' areas in specific parts of a country, it may be preferable to carry out a separate standalone survey. In other cases, the integration of chemical testing in the MICS may be a first opportunity to obtain baseline information on the degree to which populations are exposed to high levels of concentrations of arsenic or fluoride.

Arsenic testing is typically carried out in the field by interviewers, while fluoride samples are often collected by interviewers but analysed in a laboratory.

Arsenic testing by field teams has been integrated in the MICS in Bangladesh[26], Ghana and Nepal[27]. Two kits have been used: the 'Econo-Quick Kit' and the 'Quick Kit'. The methods are very similar; both are visual field test kits, semi-quantitative[28] and take around 12 minutes to carry out. The test results indicate the concentration of arsenic in parts per billion. The results are obtained by comparing colour change on a test strip with a colour chart. Because arsenic samples can be stored for long periods, it is possible to bring samples to a national laboratory for duplicate testing. Laboratory duplicate testing is a good quality control measure that can help to verify the field results.

The JMP has supported **fluoride** testing in the context of Ethiopia ESS in 2016[29]. The ESS is part of the World Bank Living Standards Measurement Study - Integrated Surveys on Agriculture (LSMS-ISA). After the ESS was completed, a sub-sample of households were revisited as part of a dedicated water quality survey. A range of water quality parameters were analysed in the field. Fluoride samples were collected and then tested in the laboratory.

[26] A thematic report on the WASH-related findings of the Bangladesh MICS 2012-13 is available at: <https://washdata.org/report/bangladesh-mics-2012-2013-water-quality-thematic-report-final>.

[27] Arsenic testing was part of the MICS 2019 in Nepal, not the MICS 2014. Results are not available at the time of publication.

[28] Both kits are manufactured by Industrial Test Systems. The Econo-Quick Kit requires 50 mL of sample water, while the Quick Kit uses 100 mL of sample water.

[29] The full report of the ESS WASH follow-up survey is available at: <https://washdata.org/report/drinking-water-quality-ethiopia-ess-2016>.

In Bangladesh, 1 in 5 people use drinking water sources with levels of arsenic exceeding 10 ppb

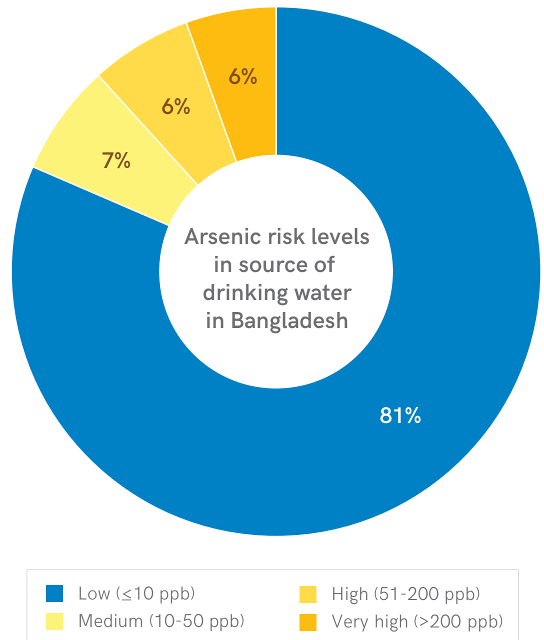


FIGURE 5

Arsenic in household drinking water in Bangladesh, 2019

Source: Bangladesh MICS 2019 report

Other parameters

In a few countries where water quality testing has been carried out as part of a standalone survey, additional water quality parameters have been incorporated alongside the standard *E. coli* module. In Lebanon, a standalone water quality survey was designed using the sampling strategy of the UNICEF Lebanon Country Office Baseline Survey of 2016. Water quality testing was carried out in 2,770 households and included four parameters (*E. coli*, free chlorine, nitrate[30], and turbidity). The Ethiopia ESS 2016 (mentioned above) was also a dedicated water quality survey and included testing at almost 5,000 households. The interviewers used portable kits to test water samples for *E. coli*, enterococci[31], turbidity, and residual chlorine in the field. Interviewers also collected samples for laboratory analysis on fluoride, hardness, electrical conductivity, and iron.

[30] Nitrate testing was only carried out in high risk areas at sub-national level, in Bekaa and Akkar.

[31] Enterococci testing was carried out in a sub-sample of the households selected for water testing.

5.2 Case studies

Lao People's Democratic Republic

The integration of water quality testing in the Lao Social Indicator Survey II (LSIS II) was the first time nationally representative water quality data was collected.

The LSIS II was carried out in 2017 by Lao Statistics Bureau (LSB) in collaboration with the Ministry of Health and Ministry of Education and Sport, as part of the Global MICS Programme. Technical support was provided by UNICEF. The water quality module was implemented with support from the Lao Ministry of Health's Centre for Environmental Health and Water Supply (Nam-Saat).

The LSIS II measured the level of faecal contamination of drinking water using the standard JMP portable kit for *E. coli*. Water quality testing was carried out by 25 teams in a total of 1,170 clusters. In each cluster, 3 households were selected for water quality testing, making a total of 3,510 households. In each case, water was tested at the PoC and PoU by the field testers.

During a pre-test, four Nam-Saat technicians were trained by an international trainer on how to deliver water quality training to the field teams. The field teams were then trained, in the Lao language, by Nam-Saat, with the training supervised by an international trainer. During the fieldwork, Nam-Saat accompanied the LSB on field visits as part of the quality assurance of the water quality module.

The LSIS II included a module on anaemia[32]. This task was also added to the responsibilities of the field testers, so field testers in the LSIS were therefore responsible for three modules (anthropometry, water quality and anaemia). To manage the workload, each field team included two field testers instead of one. Each field tester worked on all three modules[33].

Figure 6 shows the findings of the water quality testing at the PoC and PoU. The LSIS II report presents additional breakdowns of the results (urban vs rural, wealth quintiles, level of education of the head of the household, and so on).

[32] Anaemia testing was carried out on children aged 6 months to 59 months and women of 15 to 49 years of age in 50% of sample households.

[33] Sharing water quality testing responsibilities among members of a single field team is not standard practice in JMP-supported surveys. The most important downsides include: a large increase in the number of interviewers to be trained on water quality testing, less practice/experience with water quality testing per interviewer in the field, a reduced number of blank tests per interviewer, and the logistical implications of sharing a kit within a field team.

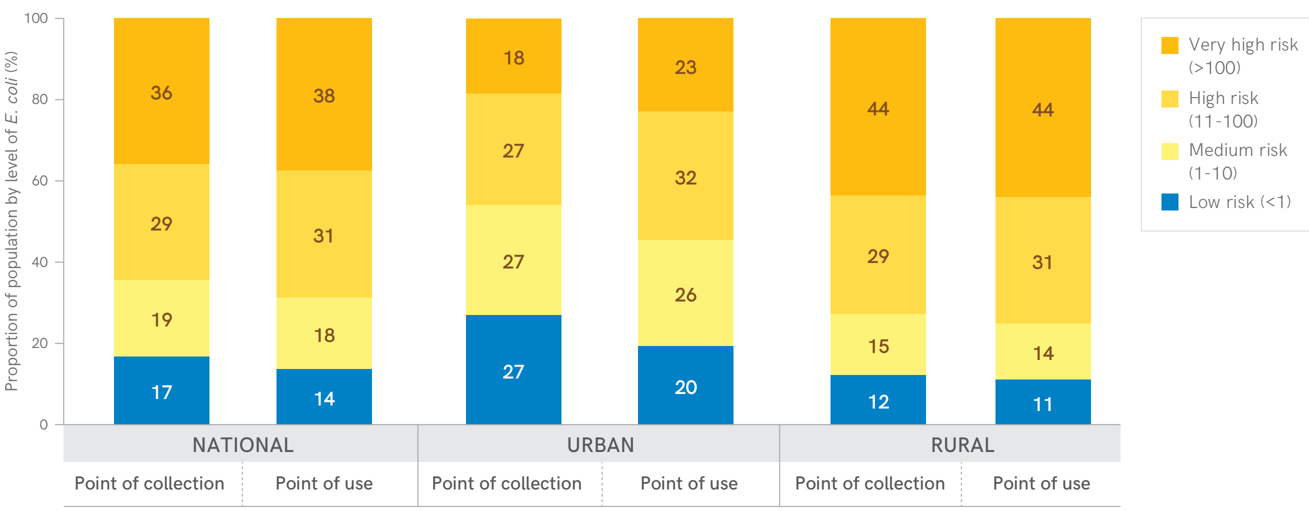


FIGURE 6 Results of water quality testing in the LSIS II 2017 in Lao PDR

Source: Lao PDR LSIS 2017 report


BD Plastipak

Nigeria

The Nigeria MICS was the first time the water quality module was implemented in a decentralized way, through the training of trainers.

The Nigeria MICS 2016-17 was carried out by the National Bureau of Statistics (NBS) in collaboration with UNICEF. The water quality module was implemented with the support of 18 laboratory technicians identified by the Federal Ministry of Water Resources (FMWR).

The Nigeria MICS measured the level of faecal contamination of drinking water using the standard JMP portable kit for *E. coli*. 78 teams carried out water quality testing in 50% of the 2,239 clusters, in which three households were selected for water quality testing. The testing was carried out by the field testers.

During a pre-test, 6 FMWR laboratory technicians were trained by an international JMP trainer on how to deliver the water quality training. The FMWR trainers then assisted 2 international trainers to train a further 18 high-quality FMWR trainers[34]. The final step involved training 78 field teams in six separate regional training zones. In each training zone, supported by the NBS survey coordinators, three FMWR trainers trained around 13 field teams. During the fieldwork, the FMWR trainers accompanied the NBS on field visits as part of the quality assurance of the water quality module. The field testers regularly carried out blank tests.

Figure 7 shows the findings of the water quality testing at the PoC and PoU. The Nigeria MICS report presents additional breakdowns of the results (urban vs rural, wealth quintiles, level of education of the head of the household, and so on).

[34] 24 laboratory technicians took part in the training, and 18 were retained to deliver the training to the field teams. Six NBS survey coordinators also participated in the training of trainers.

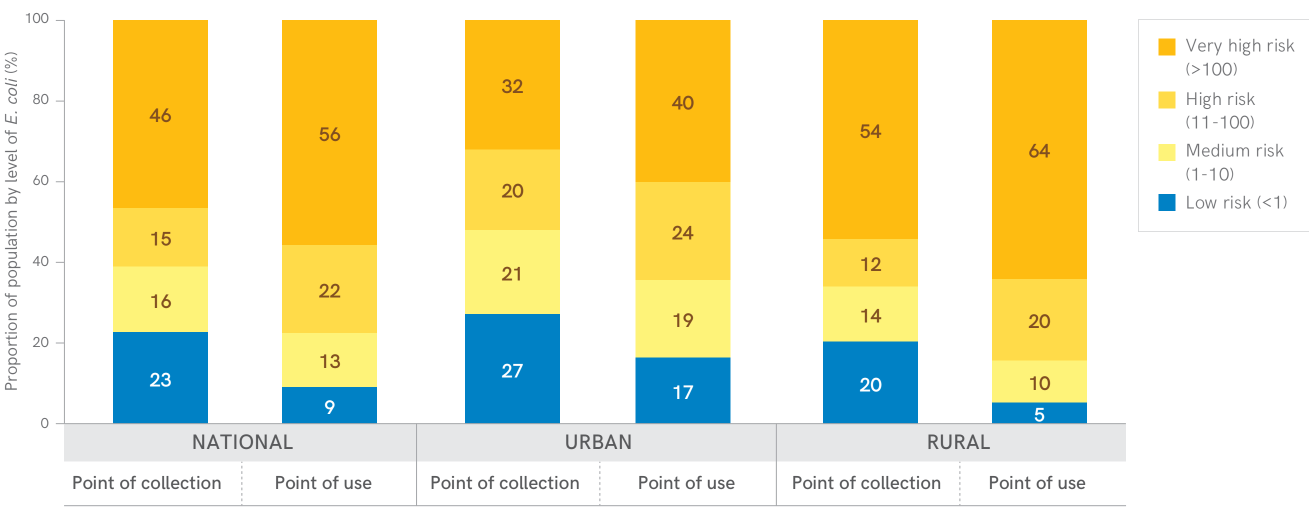


FIGURE 7 **Results of water quality testing in the MICS 2016-17 in Nigeria**

Source: Nigeria MICS 2016-17 report

Paraguay

In 2016, Paraguay carried out a MICS for the first time. It was implemented by the General Directorate of Statistics and Censuses (DGEEC) and supported by the Ministry of Public Health and Social Welfare (MSPBS) and UNICEF.

The MICS 2016 confirmed that over 90% of households in Paraguay use a piped water service as their main source of drinking water. The integration of the water quality module in the MICS provided an opportunity to obtain a first nationally representative picture of the quality of the piped water services.

The water quality module was implemented with support from the Regulatory Body for Sanitary Services (ERSSAN). The MICS measured the level of faecal contamination of drinking water using the standard JMP portable kit for *E. coli*. Water quality testing was carried out by 15 teams in a total of 500 clusters, taking a sub-sample of 4 out of 16 households per cluster, for a total of 2,000 households. In each case, water was tested at the PoC and PoU by the field testers. Each selected household received a brochure with basic information on hand hygiene and how to store and treat water at home.

All teams used portable electric incubators with car-plugs and battery packs. Additional incubation belts were distributed in case teams encountered prolonged power cuts.

ERSSAN technicians participated in the pilot survey and supported the main water quality training. During the fieldwork, ERSSAN carried out monitoring visits to ensure the quality of the work by the field testers. To verify their own work, field testers carried out blank tests in each cluster.

Figure 8 shows the findings of the water quality testing at the PoC and PoU. The MICS report presents additional breakdowns of the results (regions, urban vs rural, wealth quintiles, ethnicity/language, type of water source, type of sanitation facility, level of education of the head of the household, and so on).

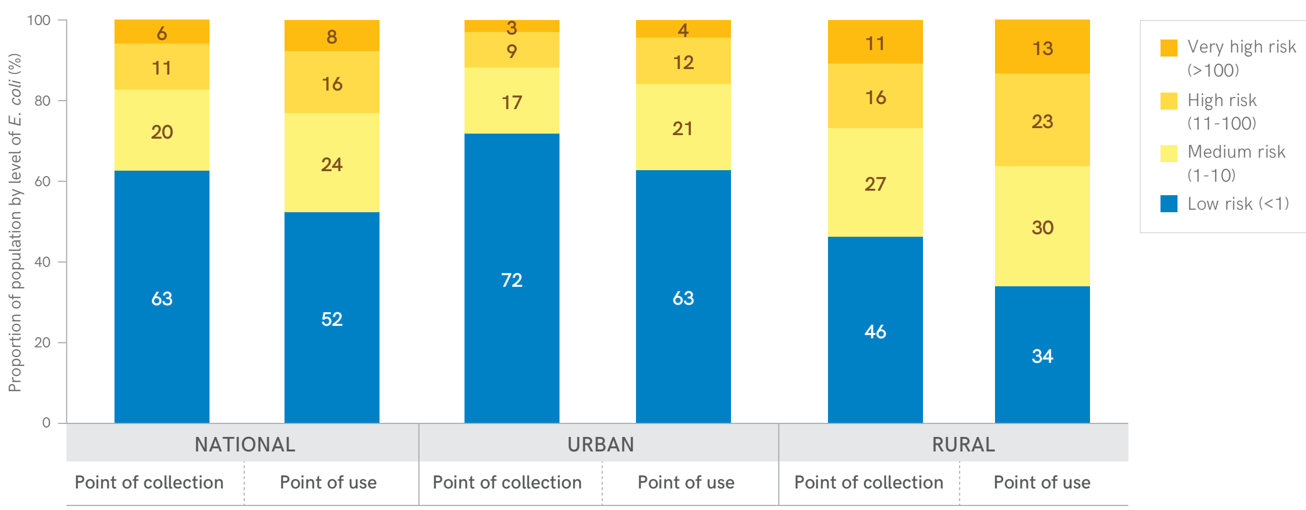


FIGURE 8 **Results of water quality testing in the MICS 2016 in Paraguay**

Source: Paraguay MICS 2016 report

Lebanon (standalone surveys)

In 2016, the JMP supported the first nationwide household water quality survey in Lebanon, called the Lebanon Water Quality Survey (LWQS). Based on the experience of the LWQS 2016, a standalone water, sanitation and hygiene census in institutions (WASHIN) was carried out in 2017[35]. The WASHIN 2017 covered all public schools, primary healthcare centres, social development centres, and childcare centres, totalling 2,425 institutions[36]. The available drinking water sources in these institutions were tested for levels of *E. coli*[37] and residual chlorine.

The Lebanese Red Cross (LRC) carried out the census using 23 small field teams. Their progress was coordinated and overseen by designated LRC area coordinators.

Laboratory technicians from the Ministry of Public Health (MoPH) first trained six LRC staff members, who in turn co-facilitated the training of the 23 field teams. A JMP trainer supervised and coordinated the training.

Blank testing was conducted at 10% of facilities. Monitoring was carried out with trained staff from the supporting institutions, who randomly joined field teams to perform checks and reinforce the training.

Figure 9 presents the findings of the *E. coli* tests of the LWQS 2016 and the WASHIN 2017. The results of the WASHIN only reflect cases where a drinking water point was available (20% to 30% of institutions did not have a source of drinking water available within the institution).

[35] The census was supported by UNICEF, WHO, the Ministry of Education and Higher Education (MEHE), Ministry of Social Affairs (MoSA), Ministry of Public Health (MoPH), and the United Nations Relief and Works Agency for Palestine (UNRWA).

[36] Including public schools and primary healthcare facilities in Palestinian camps under UNWRA.

[37] The standard JMP portable kit was used to measure levels of *E. coli* contamination (membrane filtration in combination with dehydrated media plates). Free chlorine was measured using a digital photometer with DPD 1 tablets (Lovibond MD100) on a 10 mL sample.

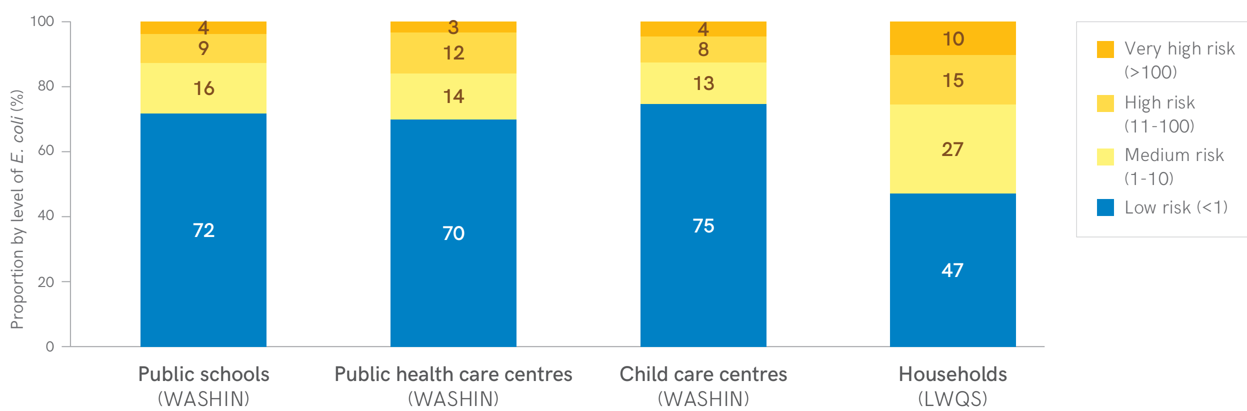


FIGURE 9 **Results of water quality testing in the LWQS 2016 and the WASHIN 2017 in Lebanon**

Source: Lebanon WASHIN 2017 and LWQS 2016 reports

5.3 Key findings

Water quality testing results from more than 30 surveys have been published by national statistical offices and have enabled the establishment of baselines for safely managed drinking water services for many of these countries. The survey results serve to demonstrate the challenge of achieving SDG 6.1 and enable countries to examine inequalities in service levels across population groups.

In many countries, the proportion of the population using safely managed drinking water is considerably lower than the proportion using an improved source of drinking water, the indicator used to track progress on drinking water before the SDGs. For example, in Lao People's Democratic Republic, JMP estimates for 2017, shown in Figure 10, found that most of the population used improved sources of drinking water (83%) and most met the criteria for a basic drinking water service (82%). However, the water services used by just 16% of the population met the criteria for safely managed drinking water, with drinking water contamination being the limiting factor[38].

[38] The JMP calculates urban and rural estimates for safely managed drinking water services that are 'accessible on premises', 'available when needed' and 'free from contamination'. Since these often draw upon different sources (such as regulator and household surveys), it is not always possible to combine them at the household level, so the JMP takes the minimum of the three at the urban and rural level as the estimate for 'safely managed drinking water services'. This may overestimate safely managed services, since some households with uncontaminated water may not have water accessible on premises or available when needed. Urban and rural estimates are then weighted to form national estimates. In household surveys that have integrated water quality testing and asked questions about availability and accessibility, it is also possible to calculate the proportion of the population meeting all three criteria at the household level. In the Lao People's Democratic Republic SIS-MICS 2017 report, 15.3% of the population were found to live in households where all three criteria were met.

Water quality testing in household surveys enables calculation of safely managed drinking water services

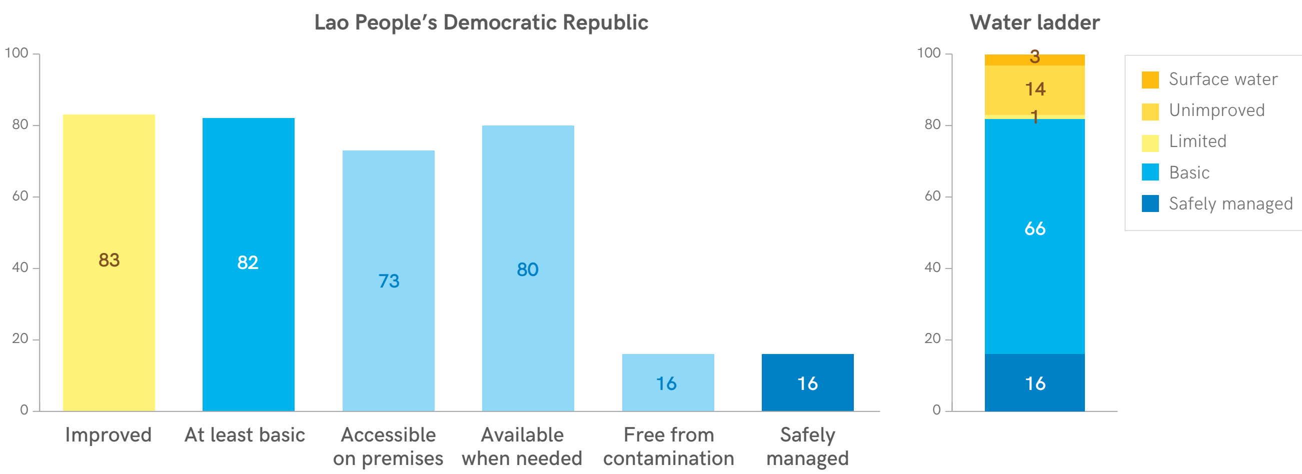


FIGURE 10 Population using drinking water sources meeting SDG criteria for safely managed services, Lao People's Democratic Republic, 2017

Source: WHO/UNICEF JMP 2019

The water quality data also show that there are substantial differences between countries in both the extent and level of contamination. Figure 11 shows *E. coli* risk levels for each country using the WHO classification. The proportion of the population using a drinking water source with detectable *E. coli* ranged from 16% in Mongolia to 90% in Sierra Leone and exceeded 50% in 14 surveys. More than one in three people in eight countries were found to use very high risk drinking water sources.

In many countries, a large proportion of the population uses high risk or very high risk drinking water sources

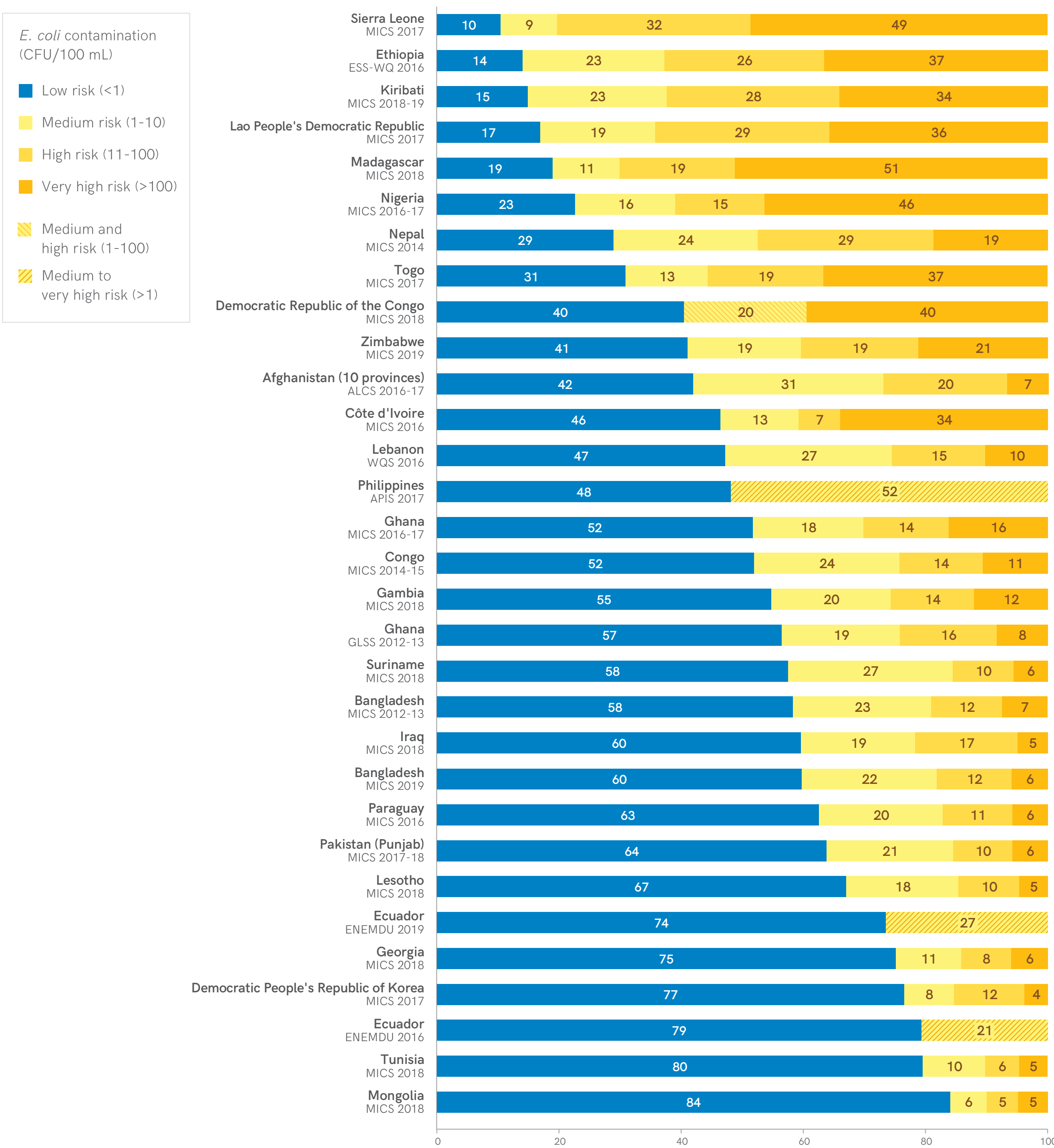


FIGURE 11 *E. coli* risk levels at the point of collection from selected household surveys, 2012-19

Most surveys collected water quality samples at the PoU and PoC in order to understand both the quality of water supplied and the quality of water consumed by household members. Figure 12 shows that in all these countries, water quality deteriorated between these two sampling locations, implying that factors such as unhygienic water handling and storage practices had a greater impact than measures some households report taking to treat their water at home.

The water quality findings can be combined with other information collected in the survey to identify populations at greatest risk of *E. coli* and examine inequalities in drinking water services. For example, Figure 13 shows the proportion of the population with no detectable *E. coli* at PoC and PoU by wealth quintile. In most countries, there is a substantial gap between the richest and poorest quintiles at both sampling locations.

Water quality often deteriorates after collection, but the extent varies greatly between countries

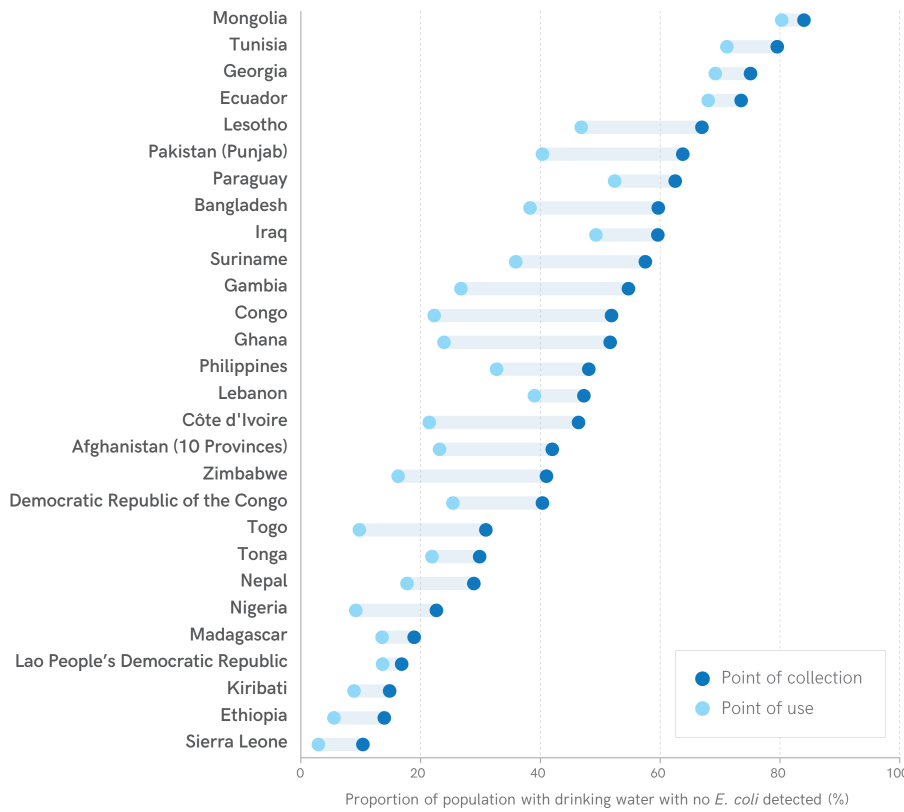


FIGURE 12 **Proportion of the population with water free from *E. coli* at the point of collection and point of use**

Source: Selected household surveys, 2014-19

Wealth quintile data reveals inequalities between rich and poor

FIGURE 13 **Proportion of population with drinking water free from *E. coli* at point of collection and point of use, by wealth quintile**

Source: Latest available MICS, 2014-19

Figure 14 shows that while 75% of the population of Georgia used improved sources free from contamination in 2018, there were significant gaps in service levels between urban (94%) and rural (46%), and between the richest (100%) and poorest (43%) quintiles. There were also large inequalities between sub-national regions: in Guria, just one in three people used sources free from contamination, compared with an estimated 100% of the population in Tbilisi. These data also show that protected wells and springs (used by 9% of the population) were much less likely to be free from contamination than other types of improved sources.

The findings from water quality testing in household surveys have been included in several different types of report targeting different audiences (Box 5). The JMP team has supported in-depth analysis at country level through water quality thematic reports, including in Bangladesh, Ethiopia and Lebanon. The main survey report in MICS is known as the 'Survey Findings Report' and includes a chapter focused on a clean and safe environment for children that includes several tables summarising the key indicators for drinking water, sanitation, hygiene and menstrual hygiene. The survey findings report includes estimates for basic and safely managed drinking water services as well as *E. coli* risk levels at the PoU and PoC for a number of selected disaggregates, typically including wealth quintiles, sub-national regions and types of water source. In addition to the main survey report, the MICS team has developed a dedicated data snapshot visualising the key findings for WASH. Increasingly, these water quality data are also being used in global and thematic reports, such as those produced by the JMP, as well as regional and cross-country analysis.

Water quality data can be used to examine multiple dimensions of inequality

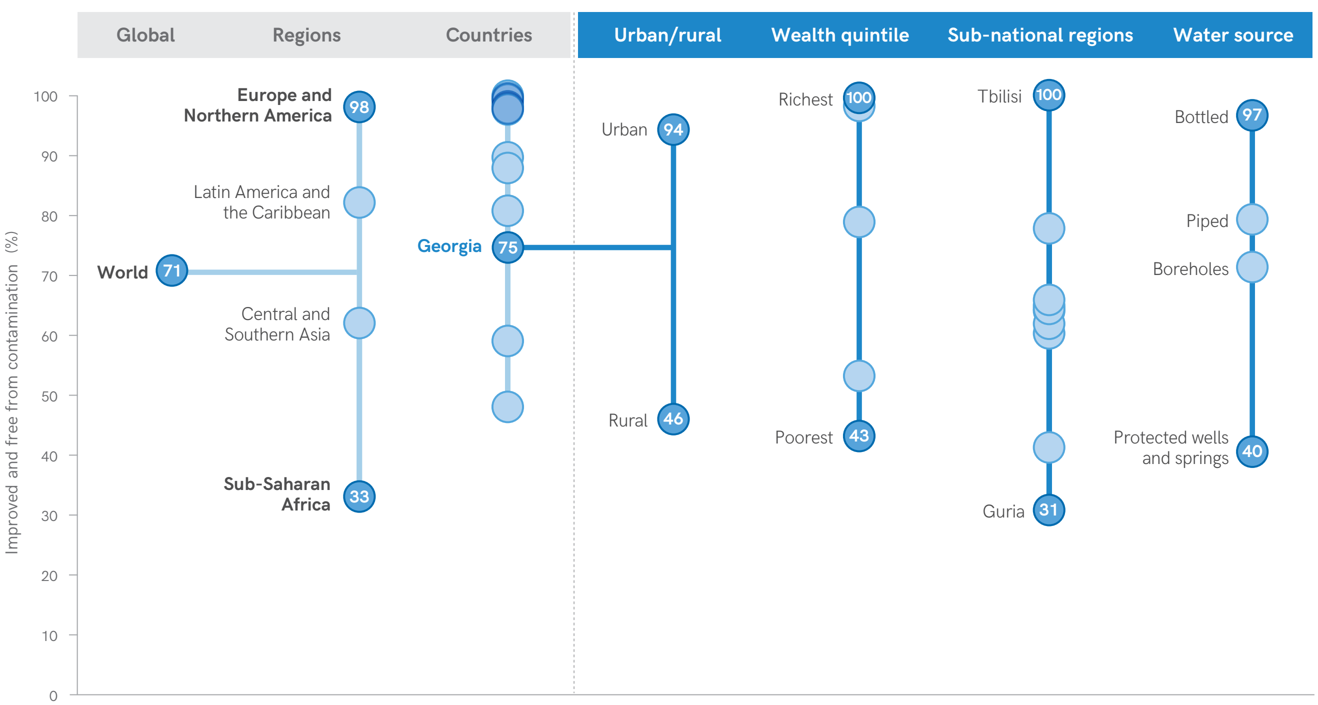


FIGURE 14 **Inequalities in drinking water free from *E. coli* at point of collection, Georgia, 2018**

Source: WHO/UNICEF JMP 2019 and Georgia MICS 2018

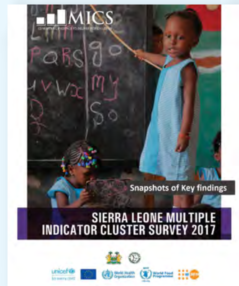
Note: Insufficient data were available to produce a regional estimate for Northern Africa and Western Asia.

BOX 5 Examples of reports on water quality

Water quality thematic reports | **MICS survey findings reports** | **MICS data snapshots** | **JMP global and thematic reports**

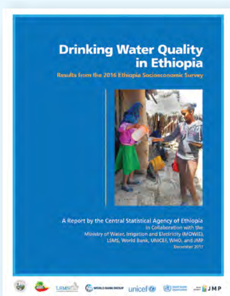
Bangladesh MICS 2012-2013 Water Quality Thematic Report

Democratic People's Republic of Korea MICS 2017

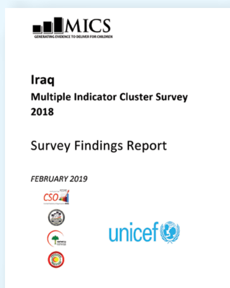


MICS Snapshots of Key Findings: Sierra Leone MICS 2017

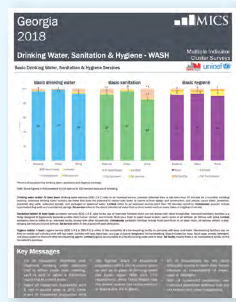
Progress on Drinking Water, Sanitation and Hygiene: 2017 update and SDG baselines



Drinking Water Quality in Ethiopia ESS 2016



Iraq MICS 2018

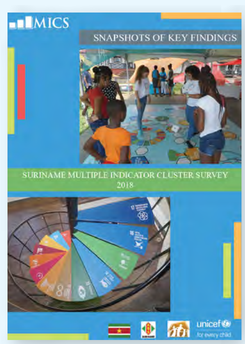


MICS Snapshots of Key Findings: Georgia MICS 2018

Progress on Household Drinking Water, Sanitation and Hygiene 2000-2017: Special focus on inequalities

Lebanon Water Quality Survey 2016

Lesotho MICS 2018



MICS Snapshots of Key Findings: Suriname MICS 2018

Safely Managed Drinking Water: Thematic report on drinking water

More reports and data can be found at **www.washdata.org** and **mics.unicef.org**

6

Lessons learned and recommendations for scaling up

Lessons learned

Household surveys can generate reliable data on drinking water quality for national and global SDG monitoring
The experience of integrating the JMP water quality module in MICS household surveys has demonstrated that national statistical offices can effectively and efficiently integrate water quality testing into national household surveys. The integration of water quality testing into representative household surveys yields reliable water quality data for national and SDG monitoring. The module generates estimates for SDG 6.1 on the household population using safely managed drinking water services.

The portable membrane filtration kit produces results that can be interpreted using the WHO risk levels, making it possible to compare drinking water quality between countries. In addition, the module yields data for the analysis of common risk factors for faecal contamination, such as the type of source and household water treatment and storage practices. The data can be disaggregated to assess inequalities between population groups in terms of geography, wealth and other socio-economic characteristics.

Existing household survey teams can carry out water quality testing in the field
Practical training that includes field work, is supported by national laboratory technicians, and focuses on the aseptic technique ensures interviewers with no prior experience of water testing can perform the portable membrane filtration method in the field and generate reliable results. Quality control measures, especially the analysis of blank tests, show that the data are reliable and any measured contamination is not due to interviewer error.

National teams play a critical role in planning for the inclusion of water quality testing in household surveys, and in implementing and following up the surveys
The national MICS coordination teams play a critical role in the organization and customization of the water quality module, including determining the sample size, adapting and translating the questionnaire, providing support during the water quality testing training and supervision in the field, and analysing data and disseminating results.

WASH sector engagement is key to maximize ownership and use of data collected
The MICS water quality module benefits greatly from the involvement of national WASH sector stakeholders, such as line ministries responsible for water services, regulators, and national water quality experts. WASH sector engagement in the early stages of planning the survey is key to build trust and ownership of data collected. The engagement of national laboratory technicians is fundamental for quality control and quality assurance, and for ensuring the survey results are considered credible for use as official statistics.

Household survey data complements wider efforts to strengthen routine surveillance and regulation of drinking water quality
In many countries where the water quality module has been carried out, it represents the only source of representative information on water quality suitable for SDGs monitoring. The integration of water quality testing into household surveys should complement wider efforts to strengthen surveillance of water quality by regulatory authorities. Where the water quality module is carried out, water quality testing findings can be compared with existing surveillance data to identify gaps and advocate strengthening and expanding national water quality surveillance.

International trainers provide technical advice on designing, planning and implementing water quality testing in household surveys
The quality of the training of the field teams can be assured through the presence of an experienced international trainer. In the lead-up to the survey, the coordination between local MICS teams, national water quality experts and the international trainer is essential for adequate planning and implementation of the survey.

Procurement of water quality testing equipment needs to be planned well in advance
National MICS teams need to allow three months for delivery for international procurement of water quality testing equipment and consumables, and identify suppliers for local items well in advance of the training.

Recommendations for scaling up water quality testing in household surveys

Disseminate the results widely to inform ongoing national efforts to improve water quality
The water quality data collected through MICS household surveys can directly inform national efforts to achieve the SDG target of universal access to safely managed drinking water services. National WASH sector stakeholders should be involved at all stages. Results should be widely disseminated and used to identify populations at greatest risk and develop scalable approaches that address water safety in all countries that have integrated water quality testing into household surveys. Data from subsequent surveys must be used to evaluate progress and critically reflect on WASH sector strategies.

Adapt the module for use in other national and international household survey programmes
In the JMP's most recent household report in 2019, 95 countries[39] did not have baseline estimates available on safely managed drinking water services. To help address this data gap, the water quality module could be integrated into an increasing number of MICS and other household surveys. Efforts are ongoing to integrate water quality testing into household surveys supported by the USAID Demographic and Health Survey (Côte d'Ivoire, Mozambique) and World Bank Living Standards Measurement Study (United Republic of Tanzania), in addition to several other national surveys. To scale up the number of surveys supported each year, the pool of international trainers will be expanded. To facilitate the integration of the module into future surveys, the JMP will continue to refine the available resources, such as the manual, questionnaire, supply list, training materials and guidance notes. The JMP plans to translate all available supporting resources into multiple languages in order to reduce the effort required to adapt the module. Additional supporting resources, such as videos and visualizations, can help new countries discover the module and support new countries in planning the survey.

Support innovations to reduce costs and further simplify the testing protocol
UNICEF and WHO have begun discussions with researchers and the private sector to investigate to what extent the existing methods for water quality testing can be further simplified and made more affordable, and if alternative methods could be adopted. The JMP is currently piloting elements that relate to more practical incubation options and reducing the weight and cost of the filtration stand. In the longer term, it is hoped that novel, rapid tests will replace the culture-based approaches that dominate the water testing market. Such tests have the potential to greatly facilitate water testing in household surveys. Reducing the costs of the testing materials will aid the uptake of the water quality module in more MICS and other household surveys.

[39] The JMP tracks progress for 234 countries, areas and territories, including all 193 United Nations Member States.

Scaling up water quality testing in household surveys

2012-13

- Bangladesh MICS
- Ghana LSS

2014-15

- Congo MICS
- Côte d'Ivoire MICS
- Nepal MICS
- Pakistan Sindh MICS*
- Belize MICS6 Pilot*

2016-17

- Afghanistan ALCS*
- Democratic People's Republic of Korea MICS
- Democratic Republic of the Congo MICS
- Ecuador ENEDMU
- Ethiopia ESS
- Ghana MICS
- Lebanon WQS
- Mongolia MICS*
- Nigeria MICS
- Paraguay MICS
- Philippines APIS
- Senegal WQS
- Sierra Leone MICS

2018

- Algeria MICS
- Central African Republic MICS
- Chad MICS
- Gambia MICS
- Georgia MICS
- Guinea-Bissau MICS
- Iraq MICS
- Kiribati MICS
- Lao People's Democratic Republic MICS
- Lesotho MICS
- Madagascar MICS
- Mongolia MICS
- Suriname MICS
- Togo MICS
- Tunisia MICS

2019+

- Afghanistan IELF
- Bangladesh MICS
- Côte d'Ivoire DHS
- Dominican Republic MICS
- Fiji MICS
- Guyana MICS
- Honduras MICS
- Jamaica MICS
- Kosovo MICS
- Malawi MICS
- Mozambique DHS
- Nauru MICS
- Nepal MICS
- Pakistan Provincial MICSs*
- Palestine MICS
- Saint Lucia MICS
- Samoa MICS
- Sao Tome and Principe MICS
- Sri Lanka HIES
- Tanzania LSMS
- Tonga MICS
- Trinidad and Tobago MICS
- Turks and Caicos MICS
- Tuvalu MICS
- Viet Nam MICS
- Zimbabwe MICS

Note: Surveys listed above include completed, ongoing and planned surveys. Official survey names may differ but surveys listed as MICS are part of the MICS global programme. For example, the Mongolia MICS is known as the Social Indicator Sample Survey.

*Sub-national survey

For a list of published survey reports, visit: https://washdata.org/monitoring/drinking-water/water-quality-monitoring

unicef

WHO UNICEF JMP

World Health Organization

9 789240 014022