Drinking Water Quality in Ethiopia

Results from the 2016 Ethiopia Socioeconomic Survey

A Report by the Central Statistical Agency of Ethiopia
in Collaboration with the
Ministry of Water, Irrigation and Electricity (MOWIE),
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ACRONYMS

CAPI	Computer-assisted personal interviewing
CES-58	Compulsory Ethiopian Standard for Drinking Water Specification
CFU	Colony-forming units
CSA	Central Statistics Agency of Ethiopia
DPD	N,N Diethyl-1,4 Phenylenediamine Sulfate
EA	Enumeration area
EC	Electroconductivity
ESS	Ethiopia Socioeconomic Survey
ESS-WQT	ESS Water Quality Test
GoE	Government of Ethiopia
GPS	Global positioning system
GTP-2	GoE Second Growth and Transformation Plan
HHs	Households
JMP	WHO/UNICEF Joint Monitoring Programme for Water Supply, Sanitation and Hygiene
L	Liter
LSMS	Living Standards Measurement Study
LSMS-ISA	LSMS–Integrated Surveys on Agriculture
MDG	Millennium Development Goals
mg	Milligram
mLs	Milliliter
MoWIE	Ministry of Water, Irrigation and Electricity
NSDS	National Strategy for the Development of Statistics
NTU	Nephelometric Turbidity Unit
RADWQ	Rapid Assessment of Drinking Water Quality
SDGs	Sustainable Development Goals
SNNP	Southern Nations, Nationalities, and Peoples' Region
UNICEF	United Nations Children's Fund
µS/cm	Microsiemens per centimeter
WASH	Water, sanitation, and hygiene
WB	World Bank
WHO	World Health Organization
WQT	Water quality testing

EXECUTIVE SUMMARY

The primary objective of the Ethiopia Socioeconomic Survey's Water Quality Test (ESS-WQT) was to measure the quality, availability, and sufficiency of drinking water in all parts of the country. It is statistically representative at the region level for five specific regions (Addis Ababa, Amhara, Oromiya, SNNP, Tigray) and a sixth "region" comprising all other regions. Drinking water samples were collected from 4,688 households, of which 4,533 also had data collected from their source points.

The survey, conducted in May-July 2016, included tests of the microbial, chemical, and physical characteristics of drinking water samples. The microbial tests investigated contaminations due to *E. coli* and enterococci and were conducted at both source points and points of use (drinking). This made it possible to identify both the extent of contamination of water sources and contamination occurring during water collection, transport, and handling. Chemical and physical characteristics analyzed were fluoride, iron, free chlorine residual, electroconductivity, hardness, and turbidity.

Drinking Water Source Types

The survey collected information on the type of drinking water source used at the time of testing. Sources are classified as improved and unimproved. Improved sources are piped water from any location, tube wells or boreholes, protected dug wells, protected springs, rain water, bottled water, and water delivered by tanker truck or cart. Unimproved sources are water collected from unprotected dug wells, unprotected springs, and surface water.

The survey found that 66 percent of the Ethiopian population uses drinking water from improved sources, with distribution varying by place of residence. In rural areas, 59 percent of the population reported using an improved source, usually protected springs, tube wells, and dug wells. Source type also differs by region; almost all households in Addis Ababa and 72 per cent in Tigray reported using improved sources.

Accessibility and the Collection Burden

Accessibility is measured by the time taken to collect water. Nationally, 74 percent of the population reported taking 30 minutes or less to collect drinking water; 19 per cent use a source located on the premises. The time burden of collection is greater for those using unimproved sources and for residents of rural areas. The burden of collection does not fall equally on all household members – women and younger members of the household spend more time collecting water.

Availability

Two questions assessed whether households have enough water (sufficiency) when needed (availability). Irrespective of region or source type, response patterns for both were similar. The availability and sufficiency of drinking water, regardless of quality, is higher for unimproved sources, and thus for rural areas. In urban areas, over half of households reported that water had been unavailable at some time during the previous two weeks or insufficient during the preceding month.

Quality

E. coli is a recommended indicator of fecal contamination of drinking water. The survey found that E. coli risk varies greatly by drinking water source and location. Nationally, 14 percent of the population gets water from low-risk sources (no detectable E. coli in a 100 mL sample). On the other hand, in Addis Ababa 85 percent of the on-premise piped water is low-risk. Similarly, nationally about 42 percent of on-premise piped water is low-risk. In general E. coli risk is lower for water from improved sources and in urban areas. The survey also found that E. coli levels are more likely to increase than decrease between collection and consumption within the home. E. coli levels were lower in households that reported treating water and in piped water that had medium or high levels of residual chlorine. In addition, fluoride levels exceeding the national standard (1.5 mg/L) affected 3.8 percent of the population.

Safely Managed Drinking Water

Because the Sustainable Development Goal (SDG) indicator "use of safely managed drinking water services" sets a new benchmark for global monitoring, this study sought data to support establishing the baseline for Ethiopia. Safely managed drinking water services consist of improved sources accessible on premises, available when needed, and free from fecal and priority chemical contamination. Using the Joint Monitoring Programme (JMP) methodology, it is estimated from the survey results that, nationally, 13 percent of Ethiopians used safely managed services in 2016.

PREFACE

The Ethiopia Socioeconomic Survey's Water Quality Test (ESS-WQT) was conducted by the Central Statistical Agency (CSA) in collaboration with the Ministry of Water, Irrigation, and Electricity (MoWIE). The survey, the first of its kind in the country, was part of the ESS, which is itself a collaborative project of the CSA and the World Bank team for the Living Standards Measurement Study – Integrated Surveys on Agriculture (LSMS-ISA). ESS is a nationally representative panel survey that began in 2011. In 2016, during the third wave of the panel, the water quality test module was added. The general findings from ESS Wave 3 were published in February 2017. This report details specific findings from the WQT module.

The primary objective of the module was to measure the quality, availability, and sufficiency of drinking water in Ethiopia in order to set a benchmark that can be used to monitor progress toward national and global water and sanitation targets. The data are now available to program managers and researchers, and because the data can be linked to a wide range of socioeconomic and demographic data already included in the ESS, water quality can be studied from a variety of perspectives. The ESS-WQT interviewed a nationally representative population in 4,688 households. Fieldwork took place May-July 2016.

The CSA ensured the success of the ESS-WQT data collection effort by collaborating closely with other government partners and water quality technical experts. The survey received both technical and financial support from the United Nations Children Fund (UNICEF), the World Bank, and the World Health Organization (WHO). Through its Water Supply and Sanitation Directorate, MoWIE provided expertise, oversaw quality assurance, and supervised the WQT laboratory activities. Waterworks Enterprise, guided by the MoWIE, conducted the chemical analyses. The World Bank, WHO, and UNICEF in Ethiopia and the WHO/UNICEF Joint Monitoring Programme for Water Supply, Sanitation, and Hygiene (JMP) made critical contributions to designing and defining the survey, staff training and data collection quality assurance, and interpreting the microbial and chemical water quality tests.

The CSA particularly appreciates the work of staff at both headquarters and branch offices who successfully implemented the field survey and coordinated the complex logistics required to bring the project to completion. Finally, special thanks are extended to the survey respondents, who welcomed our field staff to their homes and generously gave of their time to provide the requested information.

Biratu Yigezu
Director General
Central Statistical Agency


BD Plastipak

Introduction

In 2015, countries throughout the world adopted the Sustainable Development Goals (SDGs), which consist of 17 Global Goals to end poverty, protect the planet, and ensure prosperity for all. Access to safe drinking water is central to Goal 6, Clean Water and Sanitation, the importance of which Ethiopia has underscored by setting national drinking water standards.

The Ethiopia Socioeconomic Survey's Water Quality Test module (ESS-WQT) had two goals: (1) to better understand current access to and the availability and quality of the drinking water Ethiopian households use, in order to establish a baseline for SDG water quality indicators; and (2) to evaluate enhanced methodologies for monitoring household water quality. While self-reporting is the practical standard, direct tests of water quality provide more accurate information, though usually the cost of monitoring is higher. The new field-testing method used for the ESS-WQT, especially when linked to the comprehensive socioeconomic and household health and hygiene information collected in the ESS, allows for greater insights into water quality in Ethiopia.

SDGs and Water Assessment

The 2030 Agenda for Sustainable Development (2030 Agenda) sets out 17 SDGs and 169 targets considered relevant for all countries. The call of the 2030 Agenda for an integrated approach to social, economic, and environmental dimensions is reflected in Goal 6, which sets targets that address all aspects of the water and sanitation cycle. Though exceedingly ambitious, the targets are consistent with the ambitions of the 2030 Agenda to "end poverty in all its forms" and "leave no one behind." It is also recognized that because the SDG targets are highly interdependent, achievement of other SDG goals and targets depends critically on progress toward the water and sanitation targets. SDG Target 6.1 relates specifically to drinking water: *By 2030, achieve universal and equitable access to safe and affordable drinking water for all.* The text, which was carefully formulated, is far more ambitious than the target for the predecessor Millennium Development Goal (MDG):

- Rather than just reducing by half the proportion of the population without access, it calls for universal access.
- It also calls for equitable access, which implies reducing inequities in the delivery of services.
- It specifies that drinking water should be safe, affordable, and accessible to all.

The indicator selected for global monitoring of SDG target 6.1 is the proportion of the population using safely managed drinking water services. Safe management is an ambitious global service norm that is now part of the JMP ladder for global monitoring of household drinking water services (Figure 1). This indicator builds on MDG monitoring by introducing additional criteria: to be considered "safely managed" the source must meet three conditions:

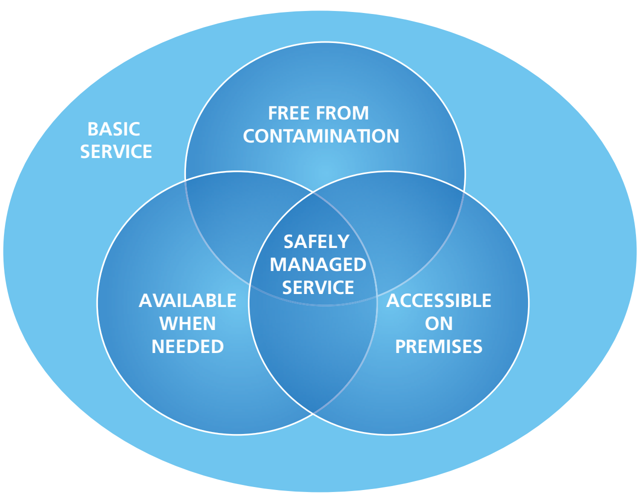
- Accessibility: the source should be on the premises (within the dwelling, yard ,or plot).
- Availability: water should be available as needed.
- Quality: the water supplied should be free from contamination by feces or specified chemicals.

The rungs on the ladder are designed to enable countries at different stages of development to benchmark and compare progress over time.

FIGURE 1. Global Monitoring of Household Drinking Water: JMP Ladder

SERVICE LEVEL	DEFINITION
SAFELY MANAGED	Drinking water from an improved water source that is located on premises, available when needed and free of contamination by feces 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.*



Source: WHO/UNICEF JMP (2017)

The Growth and Transformation Plan and National Water Surveys

In 2015, Ethiopia had achieved the MDG water target with access to water supply at 57 percent. However, the MDG targets spoke of access to improved water supply without mentioning the safety of the sources and possible contamination due to unsafe water handling and storage.

With a distinct water sector goal (SDG 6) that envisions universal, sustainable, affordable, and equitable access to *safe* drinking water, the SDGs set a higher bar, emphasizing universality and safety. The Ethiopian government Second Growth and Transformation Plan (GTP-2) has a similar objective: ensuring the safety of drinking water through a quality monitoring system and safety planning and action. Because both the SDGs and GTP-2 give priority to water safety, new water safety indicators are needed to measure achievements in delivery of water, sanitation, and hygiene (WASH) services.

In a first attempt to quantify the extent to which improved sources provide safe drinking water, in 2004–06 the Rapid Assessment of Drinking Water Quality (RADWQ) was carried out in Ethiopia; it was led by the Federal Ministry of Health with a technical steering committee consisting of representatives from the Federal Ministry of Water Resources, the Ethiopian Health and Nutrition Research Institute, the Quality and Standards Authority of Ethiopia, the Ethiopian Environment Protection Authority, UNICEF, and WHO.[11] The RADWQ project also took place in five other countries. It found that to varying degrees all improved sources contained microbial and chemical contaminants and could not always be relied on to provide safe drinking water. Although the studies provided valuable insight into the quality of the water being provided, the assessment, though extensive, was criticized for not being statistically representative (nationally, by water source, urban/rural, or region) of the quality of water to which people had regular access and could ultimately use.

One general inference was that nationally representative surveys do not capture objective information on water quality and safety, and recent water and sanitation statistics do not provide specific evidence about the quality of water reaching communities, households, and institutions. To obtain a representative sample of the drinking water *regularly used by households*, water quality testing (WQT) is required. Addressing issues of universality necessitates providing WASH services to all equitably—irrespective of residence, geographic location, and socioeconomic status. Linking data on household (HH) socioeconomic status with information on the safety of the water and sanitation services they receive gives critical evidence of the status of HH water quality and safety in Ethiopia.

1 https://washdata.org/report/who-unicef-radwq-ethiopia-report [Accessed on 10/24/2017].

It is fortunate that the ESS-WQT survey coincided with the start of the GTP-2 and SDG period; the information it has generated will be used to establish a reliable baseline and define clear indicators to effectively measure future GTP-2 and SDG achievements. Thus the results of the WQT provide crucial information for making decisions about WASH programs . The water quality data make it possible to monitor not only WASH service coverage but also changes in user behavior related to water safety and quality—information not previously available.

National Water Quality Standards

To ensure access to safe drinking water, the Compulsory Ethiopian Standard for Drinking Water Specification (CES-58) outlines the physical, chemical, and bacteriological requirements for water for drinking and domestic purposes. Aligned with the new SDG targets, it defines quality and safety standards that conform to all the toxic, bacteriological, and organoleptic requirements (see Annex 3 for tables of these minimum requirements).

Moreover, GTP-2, Ethiopia's Second Growth and Transformation National Plan for the Water Supply and Sanitation Sub-Sector (2015/16 – 2019/20), defines the following standards for water accessibility and availability:

- **Goal 1.1.** Provide rural access to water supply that sets a minimum service level of 25 liters per capita per day (l/c/day) within 1 km from the water delivery point for 85 percent of the rural population, 20 percent of whom are reached by a piped system.
- **Goal 1.2.** Provide urban access to water supply with a minimum service level of 100 l/c/day for category-1 towns/cities, 80 l/c/day for category-2, 60 l/c/day for category-3, 50 l/c/day for category-4 up to the premises, and 40 l/c/day for category-5 towns/cities within 250 m, with a piped system for 75 percent of the urban population.

Rationale for ESS-WQT

The objective in undertaking this WQT survey was to generate new data to enhance knowledge of the microbial and chemical quality of the drinking water households are using. Data collection and analysis of water samples from both households and their sources will be used as a baseline to monitor the WASH component of GTP-2 and the SDGs. The survey entailed conducting brief household surveys, carrying out bacteriological testing for all household and source samples, and chemical and turbidity testing and analysis of source water samples.

Linking a water quality survey with socioeconomic data makes it possible to disaggregate the safety of water used by socioeconomic group, residential area, and geographic location. Measuring water quality at both source points and points of use makes it possible to identify points where water might be contaminated during its collection, transport, and handling between the source and the ultimate user and to inform WASH behavioral change communications and interventions. For example, residual chlorine in household water indicates either that the piped water supply is safe or that the water has been treated within the household.

From a public health perspective, testing at the household level is most important because it reflects the quality of drinking water immediately before consumption. But because source-level[2] assessments were also conducted, the survey provides vital information about which sources are most, and least, reliable. Results from the two levels will yield a representative sample of drinking-water supplies that households are using regularly, which will also provide valuable information about any variation in water quality due to its storage, household treatment, and transport. Moreover, this survey is the first to combine water quality tests at both levels with socioeconomic data from a panel household survey – a combination that can enhance understanding of the linkages between water quality and the many dimensions of wellbeing.

The tests selected for the ESS-WQT project, and the rationale for each, are as follows:

- ***Escherichia coli (E. coli)***: From a public health standpoint, the most important water quality test is a microbiological test that determines the disease risk from recent fecal contamination. *E. coli* is the

2 ESS-WQT source-level information deals with HH water sources. Because a HH sample is used to identify water sources, drinking water sources that are used by more households are more likely to be selected than those used by fewer households.

- main fecal bacterial indicator recommended in the WHO Guidelines for Drinking Water Quality.[3]
- **Intestinal enterococci:** A subset of the fecal streptococci group that is more specific to fecal pollution, was tested because it can survive longer in the environment than E. coli and is more resistant to chlorination.
- **Fluoride**: Drinking water in some parts of Ethiopia is known to contain high levels of fluoride, which can cause dental mottling and, at high concentrations, crippling skeletal deformations.
- **Turbidity**: While turbidity in water does not directly cause health problems, it normally indicates poor quality or treatment failures. It can also interfere with chlorination and consumers can find the visual appearance unacceptable.
- **Free chlorine residual**: This is essential to learn whether water has been chlorinated.
- **Iron**: Dissolved iron, which tends to occur naturally in groundwater, may be unacceptable to consumers.
- **Electroconductivity (EC)**: Water with high dissolved solids or salinity has a high electroconductivity value, which may be unacceptable to consumers.
- **Hardness**: Excessive hardness may not only be unacceptable to consumers but also shortens the lifetime of pipes.

The ESS-WQT collected a wider range of drinking water data than RADWQ (2004-06), which was the last survey to collect extensive data on the subject. The socioeconomic links are another enhancement added by the current effort.

Because the ESS is a recurring panel survey, the same households are revisited after several years. Each wave of data collection covers a 12-month period during which two visits are conducted to capture seasonal variations in productivity, particularly related to agriculture. The first wave, in 2011/12, covered rural and small-town areas. The sample was expanded during the second wave to urban areas (medium and large towns). Implemented by CSA in collaboration with the World Bank Living Standards Measurement Study—Integrated Surveys on Agriculture (LSMS-ISA),[4] ESS is aligned with the National Strategy for the Development of Statistics (NSDS) covering 2009/10-2013/14; the data are available to the public.

The ESS-WQT module was part of the third wave of the parent survey (2015/2016). During ESS household visits, questions were asked about the usual sources for drinking water and other water, sanitation, and health parameters. These data are included in the ESS-WQT data set. Beyond this, the ESS-WQT can be directly linked to all of the multiyear ESS data, making it possible to compare water quality test results with data on health, labor, time-use, etc., as self-reported in the current and previous waves.

3 http://www.who.int/water_sanitation_health/dwq/guidelines/en/.

4 The LSMS-ISA is a regional project funded by the Gates Foundation that supports seven countries in Sub-Saharan Africa to collect multi-topic panel household level data with a special focus on improving agriculture statistics and the link between agriculture and other sectors in the economy. It aims to build capacity, share knowledge across countries, and improve survey methodologies and technology. The project in Ethiopia is implemented by the Central Statistical Agency.

Methods

Survey Design

Sampling and Stratification

To ensure similar representation, the water quality test component (ESS-WQT) was administered to all ESS households. The ESS consists of a probability-based sample of households that are representative of the population of all households in rural, small town, and (as of Wave 2) urban areas of Ethiopia. The current sample size of about 5,200 households is also statistically representative for five specific regions (Addis Ababa, Amhara, Oromiya, SNNP, and Tigray) and a sixth "region" comprising all other regions.[5]

The ESS-WQT sampled water at two levels for each household—one from the household itself and one from the source.

Household samples. The household sample was taken to test the quality of the water actually being consumed by household members. To account for any sterilization or contamination after the water was collected, respondents were asked to provide a cup of drinking water as they would provide it to a child or a guest, on the theory that if the quality of drinking water used by the household varies, it is customary that children and guests would be given the best-quality water available.

Source samples. A separate sample was collected at the source[6] where the household obtains the water. If households accessed the same source of water at different points, such as using different taps of one piped network or different wells from the same aquifer, each tap or location was considered a unique source and was tested. Sources shared by multiple sample households were tested only once, resulting in fewer source than household samples. Source results were linked to all households reporting the same source in order to keep sample weighting consistent across the two sample types.

Because the ESS-WQT data will link directly to the larger ESS data and ESS is in the third round of collecting panel data, household replacements were not considered. The attrition rate from Wave 1 to Wave 3 of the ESS sample was 4.7 percent and between ESS and WQT was 5.4 percent (see Table 1). The attrition rate between household and source samples was even lower (3.2 percent) and was most often due to lack of availability at the time of data collection.

TABLE 1 — Sample Sizes and Attrition

	Initial Sample	Samples Obtained	Attrition Rate (Percent)
ESS-W3	5,200	4,954	4.7
ESS-WQT, household samples	4,954	4,688	5.4
ESS-WQT, source samples	4,688	4,533	3.2

Questionnaire

The WQT questionnaire was intentionally brief. Self-reported ESS questions on drinking water—source type, access, and household treatment—were intentionally repeated but directed this time to the specific water sample provided for testing, rather than sources usually used during rainy and dry seasons. Questions about availability not previously included in ESS surveys were added, as were questions to confirm which tests were conducted and whether source samples were collected for laboratory testing. Results for all field-based tests were recorded at the time of testing. For microbiological tests, results were

5 A more detailed review of the ESS sample design is at http://microdata.worldbank.org/index.php/catalog/2053.

6 For ESS-WQT purposes, source is defined as the point in the water distribution network where a household accesses the water, which is not necessarily where the water originates.

captured twice: calculated and entered by the field team, and then also photographed. The research team used photographs as a data quality verification tool.

Interviews were conducted using Survey Solutions, computer-assisted personal interviewing (CAPI) software that is particularly useful for surveys involving field testing. Scanning bar codes of lab samples, taking photographs of test results and source locations, and capturing GPS points were all integrated into the program and thus directly linked to the correct questionnaires with minimal effort.

This concise water dataset can also be easily linked to the main ESS dataset, which as noted contains a wide range of socioeconomic information. The ESS WASH questions, as well as basic ESS household characteristics, are considered part of the ESS-WQT and incorporated into the findings presented here.

Implementation

For each field test the data collection teams received detailed training from JMP water quality experts, ranging from briefings, demonstrations, and practice tests at the training site to pilot testing in the field and exams to confirm knowledge of correct technique and to ensure that teams were interpreting test scores consistently.

Fieldwork was timed to take place directly after data collection for ESS Wave 3 to ensure the most current information on the sample households. Because the survey was conducted only once, May–July 2016, it did not address seasonality. Water quality is known to have major seasonal variations; testing water quality only during the dry season may introduce systematic bias.[7] Because ESS is a recurring panel survey, future WQT waves could allow for more insights on water quality across years and in different seasons. This would be a major step toward a more complete measure of sustainability than is currently possible.

The fieldwork was undertaken by 18 mobile teams, each consisting of two testers/data collectors and one supervisor, all traveling together in a four-wheel-drive vehicle. The 25 CSA Statistical Branch Offices participated by deploying the field staff and administering the financial and logistical aspects of the survey within the areas where the teams were sent. At the completion of training, all data collectors were supplied with the necessary survey and WQT equipment. To monitor data quality, experts from CSA, WHO, UNICEF, MOWIE, and the World Bank (WB) often accompanied the field teams.

At every stage the project incorporated quality assurance and quality control measures through intensive training, enumerator exams, and field practice; blind second readings for a subsample of water tests; and control tests in both field and laboratory of known contaminant quantities (see Annex 2).

Testing Approaches

Microbiological Analysis

All household and source samples were tested for E. coli and an HH subset (1 per enumeration area) was also tested for enterococci. For every water sample assessed for E. coli or enterococci, two Compact Dry growth plates (produced by Nissui, Japan) were used. One was inoculated with 1 mL of test water, and the other was used with a portable membrane filter (Millipore Microfil®) that contained all the bacteria filtered from a 100 mL sample. The microbiological tests were incubated at 35°C for at least 24 hours using portable MX45 electric incubators (Lynd, UK). After incubation, the visible colonies (or colony-forming units, CFUs) were counted. Each 100 mL test result is thus expected to be about 100 times higher than the 1 mL test result. When teams found more than 100 colonies on a growth plate the results were reported as ">100" (see Annex 2 for full details).

During analysis of microbiological data, the results from the 1 mL and the 100 mL samples were combined using the algorithm shown in Table 2 to produce risk categories. In a minority of cases, no risk category was assigned because test results from the two volumes were inconsistent; for example, the 1 mL test showed 10 colonies but the 100 mL test showed only 5.

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

TABLE 2 — Algorithm for Classifying Risk Based on Test Results

Test Result (100 mL)	Test Result (1 mL)	Risk Category	*E. coli* Range (CFU/100 mL)
0	0	Low	0
1-10	0 or 1	Moderate	1-10
11-100	0 or 1 or 2	High	11-100
> 100	0	High	11-100
11-30	3 or more	Very high	> 100
31-100	2 or more	Very high	> 100
> 100	1 or more	Very high	> 100

Chemical and Physicochemical Analysis

In addition to the microbiological tests, assessments for chlorine residual and turbidity were conducted onsite using photometric methods, and samples were collected for subsequent analysis in Addis Ababa. (Chlorine residual and turbidity photometers were calibrated in advance of the fieldwork.) Chlorine residual was measured using DPD tablets (N,N diethyl-1,4 phenylenediamine sulfate) according to the manufacturer's instructions (Lovibond, UK). A 10 mL vial was first rinsed with water and then filled with 10 mL of sample water to which a tablet was added and then crushed. The intensity of the color change was used to assess the level of residual chlorine. The results were tabulated as either <0.2 mg/mL (low), 0.2-0.5 mg/mL (moderate), or >0.5 mg/mL (high). Turbidity was measured using a turbidimeter (Lovibond, UK) taking care to ensure that vials were cleaned thoroughly and free of fingerprints and other marks. Results were classified as <1 nephelometric turbidity unit NTU (low), 1-5 NTU (moderate), or >5 NTU (high).

For the laboratory testing, water samples were collected from each unique water source in a given cluster and a barcode was affixed to each sample. No household samples were collected for laboratory testing because the values were not expected to be substantially different from those of the sources. Samples were stored in regional offices and then transferred to the central laboratory (Waterworks Enterprise, Addis Ababa), and all analyses were completed within six months of fieldwork. Parameters tested in the laboratory were fluoride, hardness, electrical conductivity, and iron. Fluoride concentrations were assessed using the SPADNS[8] method. Levels of fluoride exceeding the national standard and WHO guideline value of 1.5 mg/L were recorded as high. Given the public health importance of fluoride, additional blinded samples were sent to the central laboratory to complement the internal quality control procedures (see Annex 2). Table 3 shows the classifications for all chemical parameters. Electrical conductivity levels were determined using the potentiometric method. Iron was tested using the 1-10 phenanthroline method with Ferrover Iron Reagent. Hardness was tested using titration methods.

TABLE 3 — Chemical and Physicochemical Risk Categories

Parameter	Risk Categories			
Chlorine residual	Low: <0.2 mg/L	Moderate: 0.2-0.5 mg/L	High: >0.5 mg/L	
Iron*	Low: <0.3 mg/L	Moderate: 0.3-1.0 mg/L	High: >1.0 mg/L	
Turbidity	Low: <1 NTU	Moderate: 1-5 NTU	High: >5 NTU	
Fluoride	Low: <0.5 mg/L	Moderate: 0.5-1.5 mg/L	High: >1.5 mg/L	Very high: >3 mg/L
Hardness	Soft: < 60 mg/L	Moderately hard: 60-180 mg/L	Hard: 180-300 mg/L	Very hard: 300 mg/L
Electrical conductivity	Low: <150 µS	Moderate: 150-500 µS	High: 500-800 µS	Very high: >800 µS

Note: Iron results are not reported due to data issues identified by quality control measures.

Presentation of Results

The analysis[9] that follows is based mainly on data collected by teams during the ESS-WQT, supplemented for comparison purposes by findings from ESS Wave 3, particularly those related to the main source of drinking water; the ESS consumption aggregate and other socioeconomic variables are also used here to stratify the sample by various characteristics. In the tables that follow, values are provided only if there were at least 25 unweighted cases; data that represent fewer than 50 households (25–49) are shown in parentheses.

8 It is a fluoride detection reagent conforming to USEPA and Standard Methods for the Examination of Water and Wastewater.

9 Statistical analysis was conducted in STATA 14 using the svy commands to account for the stratified cluster survey design used in ESS. Household and population weights for the analysis are the same as those used in ESS Wave 3.

Sources Used for Drinking Water

Key Messages

- Over 75 percent of the Ethiopian population reported usually using an improved water source during rainy and dry seasons. This figure drops to 66 percent when asked about the source currently used.
- In rural areas, 59 percent of the population reported using improved drinking water sources, a quarter of which are piped. The most common types of improved sources in rural areas are protected springs, tube wells, and dug wells.
- The use of improved drinking water source varies by region: almost all households in Addis Ababa and 72 per cent in Tigray reported currently using improved sources, compared to the national average of 66 percent.

Table 4 summarizes results for water source data by place of residence, collected in three different scenarios. The first two are the sources that ESS-3 households reported usually using in dry and in rainy seasons; the third is the source actually in use on the day of the ESS-WQT visit. Field teams collected water from and photographed the source at the time of the visit, providing the opportunity for better verification of source type.

Respondents were asked about their usual drinking water sources during dry and rainy seasons, but only 6 percent of households reported that the sources differed, so that the proportion of improved water sources is more or less the same for both seasons. Nationally, then, according to the self-reported usual-use results, about 75 percent of households have access to improved water sources throughout the year, though the proportion slid to 66 percent when respondents were asked about actual use on the day the water sample was collected.

Current use of improved water supplies is 35 percentage points higher in urban areas (94 percent) than in rural areas (about 59 percent). Another major difference is that in urban areas 77 percent of households use piped water, compared to only about 15 percent in rural areas.

Table 5 presents the distribution of population by water supply type, location, and region. The most common sources of drinking water were unprotected springs (20 percent) and piped water on premises (16 percent). A small number of people reported "piped water into the dwelling" (less than 1 percent); these were merged with "piped water into yard/plot" to form "piped water on premises." More than 10 percent of the population collects water from each of public taps or standpipes, boreholes, and protected springs. Nearly 66 percent collects water from improved supply types.

Table 5 also shows regional differences. All sources reported in the capital city of Addis Ababa are improved. Of the four major regions, Tigray has the largest share of improved sources, which are used by about 72 percent of the population. In the SNNP and Oromia, 66 percent reported access to improved sources. Coverage of improved water sources in Amhara is lowest of the regions at 62 percent. Regions also differ by source technology. For example, about 26 percent of water sources in Tigray are piped, compared to 17 percent in Amhara.

TABLE 4 — Drinking Water Sources by Location of Residence, Three Scenarios , Percent

	ESS: Dry Season Usual Source					ESS: Rainy Season Usual Source					ESS-WQT: Current Use				
Water Source:	Country	Rural	Urban (small town)	Urban (large town)	Urban (all)	Country	Rural	Urban (small town)	Urban (large town)	Urban (all)	Country	Rural	Urban (small town)	Urban (large town)	Urban (all)
Piped water into dwelling	2.4	(*)	(*)	10.7	9.2	2.3	(*)	(*)	10.6	9.1	(0.4)	(*)	(*)	(2.4)	(1.9)
Piped water into yard or plot	13.9	2.7	37.3	61.8	55.2	13.2	1.7	37.2	62.2	55.4	15.7	3.0	46.0	69.4	63.7
Piped water, public tap or standpipe	30.3	33.6	36.5	11.8	18.5	29.5	32.5	36.0	11.9	18.4	12.4	12.0	17.1	9.6	11.4
Piped water kiosk or retailer	2.4	(1.0)	(6.0)	8.4	7.8	2.2	0.9	(*)	8.1	6.8	1.9	(*)	(*)	6.6	6.5
Tube well or borehole	6.2	7.7	(*)	(*)	(*)	5.0	6.1	(*)	(*)	(*)	13.9	17.7	(7.0)	(*)	(3.2)
Protected dug well	7.8	9.5	(*)	(*)	(1.6)	7.5	8.9	9.3	(*)	(2.7)	4.6	4.7	(*)	(*)	(2.0)
Protected spring	12.5	15.6	(*)	(*)	(*)	13.2	16.4	(*)	(*)	(*)	14.3	17.9	(*)	(*)	(*)
Rain water	(0.4)	(*)	(*)	(*)	(*)	0.8	1.0	(*)	(*)	(*)	(1.1)	1.3	(*)	(*)	(*)
Bottled water	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(0.4)	(*)	(*)	(2.4)	(2.0)
Tanker truck or cart with small tank	(0.5)	(*)	(*)	(*)	(*)	(0.4)	(*)	(*)	(1.6)	(1.1)	1.3	1.2	(*)	(*)	(1.5)
Total improved	***76.6***	***71.3***	***94.9***	***96.6***	***96.1***	***74.1***	***68.1***	***95.3***	***96.3***	***96.0***	***66.0***	***58.9***	***90.0***	***95.4***	***94.1***
Unprotected dug well	3.7	4.5	(*)	(*)	(*)	3.7	4.5	(*)	(*)	(*)	3.0	3.0	(*)	(*)	(2.2)
Unprotected spring	11.7	14.7	(*)	(*)	(*)	12.8	16.0	(*)	(*)	(*)	20.1	25.2	(*)	(*)	(*)
Surface water	7.2	8.9	(*)	(*)	(*)	8.7	10.8	(*)	(*)	(*)	9.9	11.8	(*)	(*)	(*)
Other	(0.8)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	1.1	1.1	(*)	(*)	(*)
Total unimproved	***23.4***	***28.7***	***5.1***	***3.4***	***3.9***	***25.9***	***31.9***	***4.7***	***3.7***	***4.0***	***34.0***	***41.1***	***10.0***	***4.6***	***5.9***

Note: Values in brackets are estimates from small observations (number of unweighted cases less than 50 but greater than 24). The symbol, (*), denotes suppressed values for unweighted cases of less than 25 observations.

Table 6 summarizes drinking water sources used currently by consumption quintile. As expected, those in the poorest quintile (Q1) have much less access to improved water sources than the richest (Q5); use of an improved source is about 27 percentage points higher among those in Q5 than in Q1. There are also differences in the composition of improved sources. Piped water is the predominant improved source among those in the richest households. For the poorest, improved sources are more likely to be non-piped, such as protected wells and springs.

TABLE 5 — Drinking Water Source by Region, Current Use Sources, Percent

	Country	Tigray	Amhara	Oromia	SNNP	Addis Ababa	Others
Piped water into dwelling	(0.4)	(*)	(*)	(*)	(*)	(*)	(*)
Piped water into yard or plot	15.7	20.8	12.4	12.2	12.8	87.4	12.4
Piped water, public tap or standpipe	12.4	(5.5)	4.7	16.3	15.3	5.3	18.4
Piped water kiosk or retailer	1.9	(*)	(2.0)	(1.8)	(*)	(*)	(*)
Tube well borehole	13.9	29.2	19.3	10.9	13.4	(*)	7.5
Protected dug well	4.6	(6.9)	(4.0)	(6.6)	(*)	(*)	4.2
Protected spring	14.3	(*)	16.9	13.8	20.1	(*)	(4.7)
Rain water	(1.1)	(*)	(*)	(*)	(*)	(*)	(*)
Bottled water	(0.4)	(*)	(*)	(*)	(*)	(*)	(*)
Tanker truck or cart with small tank	1.3	(*)	(*)	(*)	(*)	(*)	(2.2)
Total improved	***66.0***	***72.1***	***61.7***	***66.0***	***65.9***	***100.0***	***55.4***
Unprotected dug well	3.0	(5.7)	(*)	2.4	(*)	(*)	13.5
Unprotected spring	20.1	(11.2)	25.1	21.4	22.2	(*)	5.4
Surface water	9.9	(11.0)	10.8	8.8	10.3	(*)	17.0
Other	1.1	(*)	(*)	(*)	(*)	(*)	8.6
Total unimproved	***34.0***	***27.9***	***38.3***	***34.0***	***34.1***	***(*)***	***44.6***

Note: Values in brackets are estimates from small observations (number of unweighted cases less than 50 but greater than 24). The symbol, (*), denotes suppressed values for less than 25 observations.

TABLE 6 — Drinking Water Source, Current Use, by Consumption Quintile, Percent

Water Source	Q1 (Poorest)	Q2	Q3	Q4	Q5 (Richest)
Piped water into dwelling	(*)	(*)	(*)	(*)	(*)
Piped water into yard or plot	(3.7)	6.6	12.4	18.4	44.3
Piped water, public tap or standpipe	10.1	12.8	12.1	11.8	10.8
Piped water kiosk/ retailer	(*)	(*)	(*)	(3.1)	(3.1)
Tube well / borehole	13.0	19.1	18.0	14.3	9.1
Protected dug well	(2.9)	7.1	(5.2)	(2.7)	3.1
Protected spring	21.5	19.0	14.7	11.5	6.3
Rain water	(*)	(*)	(*)	(*)	(*)
Bottled water	(*)	(*)	(*)	(*)	(1.5)
Tanker truck or cart with small tank	(*)	(*)	(*)	(*)	(*)
Total improved	***55.4***	***67.6***	***67.3***	***65.5***	***82.4***
Unprotected dug well	(3.8)	(3.3)	(2.3)	(2.8)	(2.4)
Unprotected spring	28.0	20.6	19.7	19.6	9.9
Surface water	11.6	7.6	9.6	11.5	4.1
Other	(*)	(*)	(*)	(*)	(*)
Total unimproved	***44.6***	***32.4***	***32.7***	***34.5***	***17.6***

Note: Values in brackets are estimates from small observations (number of unweighted cases less than 50 but greater than 24). The symbol, (*), denotes suppressed values for less than 25 observations.

Accessibility

Key Messages

- Nationally, 74 percent of the population reported that it takes 30 minutes or less to collect drinking water.
- The time burden of collection is greater for those using unimproved sources, female and younger members of the household and residents of rural areas.

Accessibility is a criterion for both "basic" and "safely managed" drinking water services. Because the JMP uses travel time as an indicator of accessibility, it is collected routinely in national household surveys and censuses. Typically, survey teams ask respondents to estimate the amount of time required to travel to the water source, queue if necessary, fill containers, and return. While self-reported journey times are not always precise, they do provide a useful indicator of the relative time burden of water collection.

To meet the *safely managed drinking water services* indicator, the water should be collected from a point on premises—that is, within the dwelling, yard, or plot. Water collected from neighbors or from nearby communal water points is not considered on premises.

In the ESS-WQT, households reporting "Piped water into dwelling" or "Piped water into yard or plot" are classified as having supplies that are on premises. Households reporting use of other water sources were asked how much time is required for round-trip travel to the water collection point and queuing. Those who reported that the total effort takes 30 minutes or less are classified as having at least basic services; those using improved sources that require more than 30 minutes are classified as having limited services.

Table 7 shows the time needed to collect water by source type, place of residence, region, and consumption quintile. Results are presented for the dry season because it lasts more than twice as long as the rainy season. Nationally, for 19 percent of the population the water supply is on premises, 55 percent spend 1 to 30 minutes, and 26 percent must spend over 30 minutes to fetch water.

In general, less time is spent collecting water from improved sources, although sometimes unimproved sources are on premises or nearby. The time burden also varies by residence and region. On average, rural residents spend more time than urban residents in collecting water. Time taken is less for predominantly urban regions or those with a large proportion of improved sources. For example, in Addis Ababa, 97 percent of the population have on-premises drinking water sources. The water collection burden is also higher for households from the poorest than for the richest quintile.

TABLE 7 — Time Burden, Collecting Drinking Water, Dry Season, Percent

	On premises	1- 30 minutes	31- 60 minutes	Over 60 minutes	Total
Total	**18.4**	**56.8**	**17.2**	**7.5**	**100.0**
Source of drinking water					
Piped water into dwelling	100.0	0.0	0.0	0.0	100.0
Piped water into yard	100.0	0.0	0.0	0.0	100.0
Public tap / standpip	(*)	70.3	22.3	7.3	100.0
Piped water kiosk/ret	(*)	82.1	(*)	(*)	100.0
Tubewell / borehole	(*)	65.7	25.0	6.3	100.0
Protected dug well	11.1	60.1	17.0	11.8	100.0
Protected spring	0.8	75.7	19.2	4.2	100.0
Rainwater	(*)	(*)	(*)	(*)	(100.0)
Bottled water	(*)	(*)	(*)	(*)	(*)
Tanker truck / cart with small tank	(*)	(*)	(*)	(*)	100.0
Unprotected dug well	6.5	46.2	15.0	(32.3)	100.0
Unprotected spring	(*)	63.6	24.0	(8.6)	100.0
Surface water	(*)	74.0	17.8	(6.8)	100.0
Other	(*)	(*)	(*)	(*)	(100.0)
Type of drinking water source					
Improved	23.1	54.7	16.3	5.9	100.0
Unimproved	(3.4)	63.7	19.9	13.0	100.0
Place of residence					
Rural	5.7	64.0	21.1	9.2	100.0
Small town	44.0	48.0	(*)	(*)	100.0
Large town	74.3	23.2	(*)	(*)	100.0
Urban all	66.0	30.0	(2.6)	(1.3)	100.0
Region					
Tigray	24.8	53.2	21.0	(*)	100.0
Amhara	17.3	58.6	19.7	(4.4)	100.0
Omoria	14.4	58.8	17.1	9.8	100.0
SNNP	11.6	63.9	15.5	9.0	100.0
Addis Ababa	93.3	(*)	(*)	(*)	100.0
Other region	18.6	49.5	20.5	11.3	100.0
Consumption Quintile					
Q1 (Poorest)	6.4	61.6	22.1	9.9	100.0
Q2	7.7	66.8	20.6	(4.9)	100.0
Q3	15.3	60.2	16.1	8.4	100.0
Q4	20.3	56.3	16.0	7.5	100.0
Q5 (Richest)	46.6	37.3	10.3	5.8	100.0

Note: Values in brackets are estimates from small observations (number of unweighted cases less than 50 but greater than 24). The symbol, (*), denotes suppressed values for less than 25 observations.

Person Responsible for Collecting Water

The burden of water collection does not fall equally on all household members. Table 8 summarizes the characteristics of those responsible for collecting water. Of those household members who collected water on the day preceding the interview, 75 percent are female and 25 percent male. This gender breakdown is consistent for both urban and rural areas. Looking at the burden by relationships within the household, the responsibility of collecting water primarily falls on sons or daughters of the household head. By age, younger household members are more likely to collect water, but this differs by place of residence; while only 22 percent of those who collect water in urban areas are children (ages 7 – 14), in rural areas, nearly 37 percent of water collectors are children.

TABLE 8 — Person Responsible for Collecting Water, Percent

	Country	Rural	Urban
Sex			
Male	24.8	25.2	22.8
Female	75.2	74.8	77.2
Total	100.0	100.0	100.0
Relation to Head			
Head	9.0	7.3	18.9
Spouse	30.0	30.9	25.1
Son or daughter	51.5	53.8	38.2
Grandchild	2.8	2.9	(2.3)
Father or mother	(0.6)	(0.6)	(*)
Sister or brother	0.8	(0.5)	(2.8)
Niece or nephew	0.7	(0.3)	(2.7)
Uncle or aunt	(*)	(*)	(*)
Son- or daughter-in-law	1.5	1.6	(*)
Father- or mother-in-law	(*)	(*)	(*)
Brother- or sister-in-Law	(*)	(*)	(*)
Grandparent	(*)	(*)	(*)
Other relative	1.1	(0.8)	(3.2)
Servant	(0.5)	(*)	(2.8)
Nonrelative	(0.7)	(*)	(*)
Total	100.0	100.0	100.0
Age (Years)			
7–14	34.7	36.8	21.8
15–24	25.4	24.2	32.4
25–35	19.6	19.0	22.9
36–50	14.8	14.5	16.5
51+	5.6	5.4	6.3
Total	100.0	100.0	100.0

Note: Values in brackets are estimates from small observations (number of unweighted cases less than 50 but greater than 24). The symbol, (*), denotes suppressed values for less than 25 observations.

Availability

Key Messages

- Two questions were used to assess whether households have enough water when needed; both had similar response patterns irrespective of water source or region.
- The availability and sufficiency of drinking water is higher in rural areas and for unimproved sources.
- In urban areas, over half of households reported water being unavailable during the previous two weeks or insufficient during the preceding month.

The human right to water specifies that water should be "available continuously and in a sufficient quantity to meet the requirements of drinking and personal hygiene, as well as of further personal and domestic uses, such as cooking and food preparation, dish and laundry washing and cleaning… Supply needs to be continuous enough to allow for the collection of sufficient amounts to satisfy all needs, without compromising the quality of the water."[10]

While drinking water should be available in sufficient quantities at all times, it is unlikely that in the short term all countries can attain that level of service. Where services are unreliable or intermittent, households typically store water to ensure that it is available when needed. They may also restrict their consumption when water sources are far away, available only for a few hours a day or at certain times of the year, or out of service.

The ESS-WQT had two questions about the availability and sufficiency of water:

1. In the past two weeks, was the water from this source unavailable for at least one full day?
2. Has there been any time in the last month when you did not have water in sufficient quantities?
    a. If the answer to the second question was "Yes," the respondent was asked the main reason for the shortage.

Responses to the two questions were similar (Table 9), with 78 percent reporting no problems with availability and 76 percent reporting no problems with sufficiency.

Availability and sufficiency were higher in rural areas and for unimproved sources. Piped water supplies were less available and less sufficient, as were kiosks and water delivered by small carts. Availability and sufficiency were similar in all regions except for Addis Ababa, where sufficiency was low (52 percent) and availability lower (30 percent).

The second question will be used for calculating the safely managed drinking water indicator for the sub-element "available when needed."

For respondents who had not had sufficient water during the previous month, the main reason reported was that "water was not available from the source" (81 percent for all sources and 83 percent for improved sources). Few households reported that the water was too expensive or inaccessible.

10 United Nations General Assembly, Report of the independent expert on the issue of human rights obligations related to access to safe drinking water and sanitation, Catarina de Albuquerque on 1 July 2010: A/HRC/15/31/Add.1', <http://daccess-ods.un.org/access.nsf/Get?Open&DS=A/HRC/15/31/Add.1&Lang=E >.

TABLE 9 — Availability and Sufficiency of Water, Percent

	Available		Sufficient	
	Proportion	Population (millions)	Proportion	Population (millions)
Total	77.6	93.5	75.6	93.6
Water sample source				
Piped on premises	32.6	15.2	42.3	15.2
Piped water public tap or standpipe	68.6	11.7	73.5	11.7
Tube well or borehole	91.0	12.9	84.7	12.9
Protected dug well	95.0	4.2	84.7	4.2
Unprotected dug well	90.0	2.8	83.1	2.8
Protected spring	96.5	13.4	94.9	13.4
Unprotected spring	94.0	18.7	87.8	18.7
Rainwater collection	(55.9)	1.0	(65.5)	1.0
Piped water kiosk or retailer	30.0	1.8	34.0	1.8
Bottled water	(88.2)	0.4	(76.2)	0.4
Cart with small tank or drum	12.3	1.2	7.7	1.2
Surface water	93.9	9.2	82.7	9.2
Other	57.2	1.0	43.7	1.0
Source type				
Unimproved	92.4	31.8	84.5	31.8
Improved	70.0	61.7	71.1	61.8
Location				
Rural	87.2	74.2	83.4	74.2
Urban (small town)	55.2	5.4	50.6	5.4
Urban (large town)	35.3	14.0	44.0	14.0
Urban (all)	40.8	19.3	45.8	19.4
Region				
Addis Ababa	30.4	3.6	51.6	3.6
Amhara	82.1	22.1	75.2	22.1
Oromia	76.4	37.1	76.4	37.1
SNNP	84.2	19.6	80.6	19.7
Tigray	77.8	5.5	72.2	5.5
All other	75.2	5.7	73.4	5.7
Water collection time burden, dry season				
On premises	39.6	17.8	48.3	17.9
1–30 minutes	88.3	48.9	84.3	48.9
31–60 minutes	82.8	15.8	79.6	15.8
Over 60 minutes	87.6	7.2	77.3	7.2

TABLE 10 — Reasons for Insufficient Water

	Unimproved Sources	Improved Sources	Total
Water not available from source	72.2	83.1	80.7
Water too expensive	(*)	(*)	(*)
Source not accessible or too far away	(14.8)	(*)	4.8
Other	(10.8)	14.3	13.5
Total	100.0	100.0	100.0

Note: Values in brackets are estimates from small observations (number of unweighted cases less than 50 but greater than 24). The symbol, (*), denotes suppressed values for less than 25 observations.

Quality

Key Messages

- With respect to *E. coli,* 14 percent of ESS respondents collected water from low-risk supplies and 36.6 percent from very-high-risk supplies. However, percentages vary by type of source and location.
- The majority of the very-high-risk water (68.7 percent) was from unimproved sources, particularly unprotected springs and surface water.
- Residual chlorine was rarely found in piped water supplies, except in Addis Ababa.
- Almost 90 percent of households whose drinking water had high turbidity levels also had high *E. coli* risk.
- Fluoride levels exceeding the national standard (1.5 mg/L) affected 3.8 percent of the population. Fluoride occurrence is very concentrated, pinpointing areas that warrant attention.

To be considered safe, drinking water must be free at all times from pathogens and elevated levels of harmful substances. Because drinking water quality is an important measure of safety, most countries have national standards, often based on the WHO Guidelines for Drinking Water Quality. In most countries, contamination of drinking water with fecal matter is the worst water quality problem.

E. coli and Enterococci as Indicators of Fecal Contamination

Fecal contamination is usually identified by detection in a 100 mL water sample of an indicator bacteria such as *E. coli*. However, contamination can vary considerably over time; brief contamination events that can escape detection with routine surveillance still lead to severe public health outcomes. Furthermore, the preferred measure of fecal contamination, *E. coli*, is more easily inactivated in treatment than some other pathogens, such as *Cryptosporidium parvum*. While the presence of *E. coli* indicates that drinking water is fecally contaminated and unsafe, its absence does not signify safety.

The JMP recognizes that the best way to ensure water safety is through a holistic risk management approach, such as a water safety plan. However, very few countries currently have data on the proportion of people using systems covered by a verified plan. Data on the proportion of people using water supplies that are chlorinated or the extent to which residual chlorine persists at the household level are, however, available for some countries and can be useful service indicators for national monitoring. However, for purposes of global monitoring, for the JMP the principal indicator of water safety is the absence of fecal indicator bacteria in a 100 mL sample.

For each household in the survey, two samples were tested for *E. coli,* one at the point of collection (the source), and one directly from a glass used for drinking. In one randomly selected household per enumeration area, enterococci tests were also conducted.

Source Water Quality

Of the 4,533 tests conducted at water sources, 4,513 results (over 99 percent) could be classified into risk categories (low, moderate, high, or very high risk.)

The most common source of low-risk water was piped water on premises (45 percent); most of the very-high-risk water was from unimproved sources (64 percent), particularly unprotected springs (34 percent) and surface water (23 percent). Nearly 95 percent of the population accessing low-risk water were using improved water supplies.

TABLE 11 — *E. coli* Risk at Point of Collection, Percent

	Low Risk: *E. coli* < 1 CFU/100 mL	Moderate Risk: *E. coli* 1-10 CFU/100 mL	High Risk: *E. coli* 11-100 CFU/100 mL	Very High Risk: *E. coli* >100 CFU/100 mL
Water sample source				
Piped on premises	44.9	21.9	9.5	3.5
Piped water public tap/standpipe	20.4	22.0	13.6	3.1
Tube well or borehole	14.9	20.1	11.1	11.9
Protected dug well	(*)	(3.3)	8.4	4.0
Unprotected dug well	(*)	(*)	(2.2)	6.3
Protected spring	(8.0)	16.8	23.9	9.9
Unprotected spring	(*)	6.2	22.2	34.0
Rainwater collection	(*)	(*)	(*)	(*)
Piped water kiosk or retailer	(3.4)	(2.2)	(*)	(*)
Bottled water	(1.6)	(*)	(*)	(*)
Cart with small tank or drum	(*)	(*)	(*)	(*)
Surface water	(*)	(*)	5.3	23.1
Other	(1.5)	(*)	(*)	(*)
Total	100.0	100.0	100.0	100.0
Source type				
Unimproved	(5.4)	8.8	30.4	64.4
Improved	94.6	91.2	69.6	35.6
Total	100.0	100.0	100.0	100.0
Location				
Rural	48.3	77.2	85.7	91.6
Urban (small town)	(5.4)	6.6	6.1	4.0
Urban (large town)	46.3	16.2	8.2	4.4
Urban (all)	51.7	22.8	14.3	8.4
Total	100.0	100.0	100.0	100.0
Region				
Addis Ababa	22.1	(2.0)	(*)	(*)
Amhara	18.8	18.2	24.5	29.5
Oromia	31.5	41.6	39.2	39.3
SNNP	10.9	28.2	24.5	18.7
Tigray	10.2	5.0	5.9	5.1
All other	6.5	5.0	5.7	7.2
Total	100.0	100.0	100.0	100.0

Note: Values in brackets are estimates from small observations (number of unweighted cases less than 50 but greater than 24). The symbol, (*), denotes suppressed values for less than 25 observations.

TABLE 12 — *E. coli* Risk at Point of Collection by Water Supply Type, Location, and Region, Percent

	Low Risk: *E. coli* < 1 CFU/100 mL	Moderate Risk: *E. coli* 1-10 CFU/100 mL	High Risk: *E. coli* 11-100 CFU/100 mL	Very High Risk: *E. coli* >100 CFU/100 mL	Total	Population (millions)	Count
Total	**14.0**	**23.2**	**26.2**	**36.6**	**100.0**	**90.2**	**4,402**
Water sample source							
Piped on premises	41.5	33.6	16.3	8.6	100.0	13.7	1,004
Piped water public tap or stand-pipe	22.6	40.3	28.1	9.1	100.0	11.4	475
Tube well or borehole	14.9	33.2	20.8	31.1	100.0	12.6	554
Protected dug well	(*)	(16.8)	48.1	32.0	100.0	4.1	230
Unprotected dug well	(*)	(*)	(18.9)	75.7	100.0	2.8	217
Protected spring	(7.5)	26.2	42.1	24.3	100.0	13.4	477
Unprotected spring	(*)	7.1	28.7	61.6	100.0	18.2	641
Rainwater collection	(*)	(*)	(*)	(*)	(100.0)	0.8	36
Piped water kiosk or retailer	(27.0)	(29.8)	(*)	(*)	100.0	1.6	115
Bottled water	(53.4)	(*)	(*)	(*)	(100.0)	0.4	40
Cart with small tank or drum	(*)	(*)	(*)	(*)	(100.0)	1.2	46
Surface water	(*)	(*)	14.0	85.0	100.0	9.0	481
Other	(18.3)	(*)	(*)	(*)	100.0	1.0	86
Source type							
Unimproved	(2.2)	5.9	23.2	68.7	100.0	31.0	1,425
Improved	20.2	32.2	27.7	19.9	100.0	59.2	2,977
Location							
Rural	8.4	22.2	27.8	41.6	100.0	72.7	3,019
Urban (small town)	14.1	28.7	29.6	27.7	100.0	4.8	345
Urban (large town)	46.4	26.8	15.4	11.4	100.0	12.6	1,038
Urban (all)	37.4	27.3	19.3	15.9	100.0	17.5	1,383
Region							
Addis Ababa	84.8	12.8	(*)	(*)	100.0	3.3	195
Amhara	10.9	17.5	26.6	45.0	100.0	21.7	905
Oromia	11.4	24.9	26.5	37.2	100.0	34.9	844
SNNP	7.2	30.6	30.1	32.1	100.0	19.3	1,025
Tigray	23.8	19.4	25.7	31.2	100.0	5.4	542
All other	14.7	18.7	24.2	42.4	100.0	5.6	891

Note: Values in brackets are estimates from small observations (number of unweighted cases less than 50 but greater than 24). The symbol, (*), denotes suppressed values for less than 25 observations.

Table 12 shows that 14 percent of the population collected water from low-risk sources (no detectable *E. coli*), but 37 percent collected water from very-high-risk supplies.

Water from improved sources had about 10 times better quality (20 percent low-risk) than that collected from unimproved sources (2.2 percent low-risk). Water quality was better in large towns (46 percent low-risk) and worse in rural areas (8.4 percent low-risk). The best water quality was in the Addis Ababa region (85 percent low-risk), and the worst in SNNPR (7.2 percent low-risk).

Water quality was best in bottled water (53 percent low-risk), but this was reported as the main source of drinking water by less than 1 percent of the population. Piped water on premises, used by 14 percent of the population (Table 12), had relatively good water quality, with 42 percent low-risk, and just 8.6 percent very-high-risk. Water collected from kiosks or retailers was typically of good quality (27 percent low-risk) but not widely used.

Very-high-risk water was most commonly collected from unimproved sources (69 percent), especially surface water (85 percent) and unprotected dug wells (76 percent).

Table 13 demonstrates the close association between water quality and wealth as measured by consumption quintile. Over 32 percent of the richest people used

TABLE 13 — *E. coli* Risk at Point of Collection by Social Stratifiers, Behaviors, and Risk Factors

	Low Risk: *E. coli* < 1 CFU/100 mL	Moderate Risk: *E. coli* 1-10 CFU/100 mL	High Risk: *E. coli* 11-100 CFU/100 mL	Very High Risk: *E. coli* >100 CFU/100 mL	Total	Population (millions)	Count
Total	**14.0**	**23.2**	**26.2**	**36.6**	**100.0**	**90.2**	**4,402**
Consumption quintile							
Poorest	8.6	20.7	33.1	37.5	100.0	17.4	677
Poor	9.7	22.0	29.8	38.5	100.0	17.6	721
Middle	10.1	25.3	25.5	39.1	100.0	17.2	753
Rich	14.1	24.1	24.4	37.3	100.0	16.9	846
Richest	32.4	21.9	20.0	25.8	100.0	16.0	1,198
Water collection time burden (dry season)							
On premises	36.6	30.1	18.4	14.9	100.0	16.1	1,131
1–30 minutes	8.5	19.8	30.4	41.2	100.0	47.7	2,151
31–60 minutes	9.2	24.6	26.7	39.5	100.0	15.7	639
Over 60 minutes	(*)	(28.3)	12.4	51.8	100.0	6.9	259
Use of an improved sanitation facility*							
Unimproved	8.6	21.5	26.2	43.8	100.0	45.4	2,153
Improved	19.5	25.0	26.1	29.4	100.0	44.7	2,249
Soap and water handwashing*							
No handwashing place reported	11.1	24.6	26.1	38.1	100.0	75.1	3,562
Handwashing place reported	21.3	13.5	29.1	36.1	100.0	8.3	433
Handwashing place reported with water and soap	36.6	19.0	23.7	20.6	100.0	6.8	407
Has it rained in the past two days?							
Yes	15.8	19.6	27.3	37.3	100.0	59.5	2,873
No	10.5	30.1	24.0	35.4	100.0	30.7	1,529

* Sanitation and handwashing data from ESS Wave 3.

TABLE 14 — ***E. coli*** **Risk at Point of Collection for Piped Water on Premises by Region, Percent**

	Low Risk: *E. coli* < 1 CFU/100 mL	Moderate Risk: *E. coli* 1-10 CFU/100 mL	High Risk: *E. coli* 11-100 CFU/100 mL	Very High Risk: *E. coli* >100 CFU/100 mL	Total	Population (millions)	Count
Total	**33.2**	**36.4**	**21.6**	**8.8**	**100.0**	**25.5**	**1519**
Region							
Addis Ababa	85.0	(13.0)	(*)	(*)	100.0	3.3	193
Amhara	24.6	41.3	(20.2)	(13.8)	100.0	3.7	235
Oromia	27.8	40.2	28.5	(*)	100.0	9.7	317
SNNP	17.4	46.0	20.7	(15.9)	100.0	5.5	283
Tigray	44.8	31.4	(11.7)	(*)	100.0	1.5	237
All other	24.2	23.6	36.3	15.9	100.0	1.8	254

Note: Values in brackets are estimates from small observations (number of unweighted cases less than 50 but greater than 24). The symbol, (*), denotes suppressed values for less than 25 observations.

drinking water from low-risk sources, compared to only 8.6 percent of the poorest. However, the trend for highly contaminated water was not as clear: the richest Ethiopians used only somewhat less water from high-risk and very-high-risk sources.

Water quality was best in households with the source on premises and worst among those that had to spend an hour collecting water. (Recent rainfall showed no clear pattern.) Water quality was better in households that had improved sanitation and a place in the home to wash hands with soap and water.

Because it is the main source of low-risk water (45 percent,) piped water on premises was further analyzed (Table 14); piped water on premises is of markedly better quality in Addis Ababa than in other regions.

Household Water Quality in Terms of *E. coli*

Of the 4,686 tests conducted in households on “a glass of water you would give a child or guest to drink,” the risk in 4,666 (99 percent) could be classified.

As with source samples, household samples classified as low-risk were usually collected (Table 15) from water piped on premises (69 percent) and high-risk samples were most often from unprotected springs (29 percent). However, whereas very-high-risk source samples are more than twice as likely to come from unimproved sources (74 percent) than from improved (34 percent), very-high-risk household samples are only slightly more likely to come from unimproved sources (53 percent versus 47 percent).

Although low-risk samples were most often found in drinking water piped on premises, overall only 45 percent of household drinking water from such sources had only a low (24 percent) or moderate (21 percent) risk (Table 16).

Table 16 also shows that while only 5.6 percent of the population has access to low-risk household drinking water, for almost half (48 percent) the drinking water in their homes is very-high-risk. This suggests a general deterioration in the safety of water from when it is collected to when it is consumed. By the time drinking water is consumed, effectively no water that originated from an unimproved source is low-risk (<1 percent). In rural areas household drinking water is most often very-high-risk (55 percent); however in urban areas, over 20 percent of people also consume drinking water that is very-high-risk.

As is shown in Table 17, 16 percent of those in the richest quintile drink low-risk water but virtually none (<1 percent) of those in the two poorest quintiles do. For both groups, water at the source was more likely to be low-risk than water from a glass within the home. The relative disparity in access to low-risk water increased from four times at the water source (Table 13: 32 to 8.6 percent) to nearly ten times within the home (Table 15: 16.3 to 1.6 percent). Even though the richest usually collect water from low-risk sources, by the time they drink it the quality has deteriorated to the point that it has usually become high-

TABLE 15 — *E. coli* Risk in a Glass of Household Drinking Water, by Source (Percent)

	Low Risk: *E. coli* < 1 CFU/100 mL	Moderate Risk: *E. coli* 1-10 CFU/100 mL	High Risk: *E. coli* 11-100 CFU/100 mL	Very High Risk: *E. coli* >100 CFU/100 mL
Water sample source				
Piped on premises	69.3	35.1	16.5	5.7
Piped water public tap or stand-pipe	(13.1)	16.5	16.7	8.4
Tube well or borehole	(*)	(12.8)	16.8	13.0
Protected dug well	(*)	(*)	5.1	5.0
Unprotected dug well	(*)	(*)	1.8	4.7
Protected spring	(*)	(13.2)	19.5	11.8
Unprotected spring	(*)	(7.1)	14.2	29.4
Rainwater collection	(*)	(*)	(*)	(*)
Piped water kiosk or retailer	(*)	(4.3)	2.0	(1.2)
Bottled water	(*)	(*)	(*)	(*)
Cart with small tank or drum	(*)	(*)	(*)	(1.3)
Surface water	(*)	(*)	4.2	17.2
Other	(*)	(*)	(0.9)	(1.2)
Total	100.0	100.0	100.0	100.0
Source type				
Unimproved	(*)	10.8	21.1	52.6
Improved	97.5	89.2	78.9	47.4
Total	100.0	100.0	100.0	100.0
Location				
Rural	20.7	57.0	78.9	91.1
Urban (small town)	(7.4)	10.4	7.6	3.1
Urban (large town)	71.9	32.6	13.5	5.9
Urban (all)	79.3	43.0	21.1	8.9
Total	100.0	100.0	100.0	100.0
Region				
Addis Ababa	45.5	(6.8)	(1.5)	(*)
Amhara	(13.4)	21.4	22.2	26.7
Oromia	20.6	42.4	42.3	38.9
SNNP	6.6	11.9	23.3	22.8
Tigray	8.3	6.3	6.1	5.2
All other	5.6	11.2	4.6	6.3
Total	100.0	100.0	100.0	100.0

Note: Values in brackets are estimates from small observations (number of unweighted cases less than 50 but greater than 24). The symbol, (*), denotes suppressed values for less than 25 observations.

TABLE 16 — Household *E. coli* Risk by Collection Point Type, Location, and Region (Percent)

	Low Risk: *E. coli* < 1 CFU/100 mL	Moderate Risk: *E. coli* 1-10 CFU/100 mL	High Risk: *E. coli* 11-100 CFU/100 mL	Very High Risk: *E. coli* >100 CFU/100 mL	Total	Population (millions)	Count
Total	**5.6**	**9.7**	**37.1**	**47.6**	**100.0**	**93.1**	**4,569**
Water sample source							
Piped on premises	24.2	21.0	37.9	16.9	100.0	15.1	1,098
Piped water public tap or standpipe	(5.9)	12.8	49.6	31.8	100.0	11.7	494
Tube well and borehole	(*)	(9.0)	45.1	44.8	100.0	12.9	562
Protected dug well	(*)	(*)	41.8	53.2	100.0	4.2	232
Unprotected dug well	(*)	(*)	22.0	75.9	100.0	2.8	219
Protected spring	(*)	(9.0)	50.6	39.2	100.0	13.3	474
Unprotected spring	(*)	(3.4)	26.3	69.8	100.0	18.7	655
Rainwater collection	(*)	(*)	(*)	(*)	(100.0)	1.0	45
Piped water kiosk or retailer	(*)	(22.4)	39.3	(31.6)	100.0	1.7	126
Bottled water	(*)	(*)	(*)	(*)	(100.0)	0.4	40
Cart with small tank or drum	(*)	(*)	(*)	(49.8)	(100.0)	1.2	48
Surface water	(*)	(*)	15.9	82.7	100.0	9.2	489
Other	(*)	(*)	(29.6)	(51.5)	100.0	1.0	87
Source type							
Unimproved	(*)	3.1	23.0	73.5	100.0	31.7	1,450
Improved	8.3	13.1	44.3	34.2	100.0	61.4	3,119
Location							
Rural	1.5	7.0	36.9	54.7	100.0	73.8	3,061
Urban (small town)	(7.3)	17.7	49.5	25.6	100.0	5.3	380
Urban (large town)	27.0	21.0	33.3	18.7	100.0	14.0	1,128
Urban (all)	21.6	20.1	37.8	20.6	100.0	19.3	1,508
Region							
Addis Ababa	67.4	(17.3)	(14.4)	(*)	100.0	3.5	213
Amhara	(3.2)	8.7	34.7	53.4	100.0	22.1	937
Oromia	2.9	10.4	39.7	47.0	100.0	36.7	926
SNNP	1.8	5.5	41.1	51.7	100.0	19.6	1,048
Tigray	8.0	10.5	39.0	42.5	100.0	5.4	543
All other	5.2	17.9	27.8	49.1	100.0	5.7	902

Note: Values in brackets are estimates from small observations (number of unweighted cases less than 50 but greater than 24). The symbol, (*), denotes suppressed values for less than 25 observations.

TABLE 17 — Household *E. coli* Risk by Social Stratifiers, Behaviors, and Risk Factors, Percent

	Low Risk: *E. coli* < 1 CFU/100 mL	Moderate Risk: *E. coli* 1-10 CFU/100 mL	High Risk: *E. coli* 11-100 CFU/100 mL	Very High Risk: *E. coli* >100 CFU/100 mL	Tot	Population (millions)	Count
Total	**5.6**	**9.7**	**37.1**	**47.6**	**100.0**	**93.1**	**4569**
Consumption quintile							
Poorest	(*)	(8.1)	37.4	53.0	100.0	17.7	687
Poor	(*)	6.0	37.3	54.0	100.0	17.9	740
Middle	(3.1)	9.4	36.1	51.5	100.0	17.6	777
Rich	6.0	10.6	38.4	44.9	100.0	17.4	875
Richest	16.3	15.2	36.0	32.5	100.0	17.4	1,277
Water collection time burden (dry season)							
On premises	22.4	19.5	36.1	22.0	100.0	17.7	1,234
1–30 minutes	1.9	7.4	37.1	53.7	100.0	48.6	2,194
31–60 minutes	(*)	(6.6)	38.5	54.2	100.0	15.8	642
Over 60 minutes	(*)	(*)	33.7	58.8	100.0	7.1	270
Use of a sanitation facility							
Unimproved	3.1	6.7	35.0	55.2	100.0	46.1	2,199
Improved	8.2	12.6	39.1	40.2	100.0	47.0	2,370
Soap and water handwashing							
No handwashing place reported	3.7	9.2	37.3	49.8	100.0	76.9	3,675
Handwashing place reported	9.0	11.2	35.3	44.5	100.0	8.9	459
Handwashing place reported with water and soap	21.3	13.4	36.4	29.0	100.0	7.4	435
Has it rained in the past two days?							
Yes	6.7	9.7	37.2	46.3	100.0	61.3	2,977
No	3.5	9.6	36.8	50.1	100.0	31.7	1,592
Does household treat water?							
Yes	18.7	(12.0)	24.5	44.8	100.0	5.4	232
No	4.8	9.5	37.8	47.8	100.0	87.7	4,337

Note: Values in brackets are estimates from small observations (number of unweighted cases less than 50 but greater than 24). The symbol, (*), denotes suppressed values for less than 25 observations.

risk (36 percent). For all other quintiles the drinking water they actually consume was most likely to be very-high-risk (45–54 percent for each quintile). Households that report treating their drinking water have a higher proportion of low-risk water than households that do not (18.7 vs 4.8 percent). However, only 5 percent reported treating their water.

Deterioration in Quality Between Source and Household

It is well-known that microbiological contamination tends to increase when water is stored after collection. However, in some cases, particularly when the quality of water at the source is poor or when water is treated within the household, fecal indicator bacteria may decrease between source and household.

Table 18 compares *E. coli* risk at the source to the risk in consuming a glass of water within the household. The cells on the diagonal, shaded yellow, represent households where the risk was the same at both testing points, as it was for 50 percent of the population.

In a few cases (10 percent, shaded green or dark green) *E. coli* levels decreased between collection and consumption, but it was more common that they increased either moderately (26 percent) or substantially (14 percent).

Unimproved sources, which are more contaminated in general, were more likely than improved sources to see risk decrease after collection (Table 19). This is especially true of surface water, which is the most highly contaminated source. Households that reported treating their own water were more likely to see *E. coli* levels decrease (19 percent) than households that did not treat it (9.7 percent).

TABLE 18 — *E. coli* Risk at the Source and in the Household, Percent

		E. coli at the collection point				
		<1	1_10	11_100	>100	Total
E. coli in the glass	<1	3.7	0.8	(0.5)	(*)	5.3
	1-10	3.2	4.1	1.7	(0.9)	9.9
	11-100	5.2	12.3	13.3	6.2	37.0
	>100	1.7	6.5	10.5	29.0	47.8
	Total	13.9	23.8	25.9	36.4	100.0

Large decrease	1.7
Slight decrease	8.7
No change	50.1
Slight increase	26.0
Large increase	13.5

Note: Values in brackets are estimates from small observations (number of unweighted cases less than 50 but greater than 24). The symbol, (*), denotes suppressed values for less than 25 observations.

TABLE 19 — *E. coli* Risk at the Source and in the Household, Percent

	Household Risk Lower than Source	Household Risk Same as Source	Household Risk Higher than Source	Total	Population (millions)	Count
Total	**10.2**	**50.5**	**39.3**	**100.0**	**89.7**	**4,377**
Water sample source						
Piped on premises	12.1	40.2	47.6	100.0	13.5	999
Piped water public tap or standpipe	8.3	27.7	64.0	100.0	11.3	469
Tube well or borehole	(10.6)	35.9	53.5	100.0	12.6	550
Protected dug well	(6.7)	57.2	36.1	100.0	4.1	229
Unprotected dug well	(16.5)	67.4	(16.1)	100.0	2.8	217
Protected spring	(7.5)	49.9	42.6	100.0	13.3	472
Unprotected spring	11.1	65.2	23.7	100.0	18.2	640
Rainwater collection	(*)	(68.5)	(*)	100.0	0.8	36
Piped water kiosk or retailer	(*)	(50.4)	41.4	100.0	1.5	114
Bottled water	(*)	(*)	(*)	100.0	0.4	40
Cart with small tank or drum	(*)	(*)	(*)	100.0	1.2	46
Surface water	11.7	79.0	9.4	100.0	9.0	480
Other	(*)	(43.6)	(46.5)	100.0	1.0	85
Source type						
Unimproved	11.7	68.7	19.6	100.0	30.9	1,422
Improved	9.4	41.0	49.6	100.0	58.8	2,955
Location						
Rural	9.6	51.7	38.7	100.0	72.4	3,003
Urban (small town)	19.4	44.6	35.9	100.0	4.8	341
Urban (large town)	10.1	46.1	43.8	100.0	12.6	1,033
Urban (all)	12.7	45.7	41.6	100.0	17.3	1,374
Region						
Addis Ababa	(*)	66.9	26.2	100.0	3.3	195
Amhara	10.6	55.5	33.9	100.0	21.7	905
Oromia	11.2	49.6	39.2	100.0	34.6	836
SNNP	7.3	43.0	49.7	100.0	19.2	1,020
Tigray	9.1	47.9	43.0	100.0	5.4	538
All other	15.3	55.4	29.2	100.0	5.6	883
Soap and water handwashing						
No handwashing place reported	10.2	50.0	39.8	100.0	74.6	3,540
Handwashing place reported	(10.3)	54.6	35.1	100.0	8.3	433
Handwashing place reported with water and soap	(10.5)	50.6	38.9	100.0	6.7	404
Has it rained in the past two days?						
Yes	10.5	52.5	37.0	100.0	59.3	2,859
No	9.6	46.6	43.8	100.0	30.4	1,518
Does household treat water?						
Yes	(19.0)	63.8	17.2	100.0	5.2	218
No	9.7	49.7	40.7	100.0	84.5	4,159

Note: Values in brackets are estimates from small observations (number of unweighted cases less than 50 but greater than 24). The symbol, (*), denotes suppressed values for less than 25 observations.

Household Water Quality (Enterococci)

As noted, one household per enumeration area was randomly selected for testing for enterococci, also an indicator of fecal contamination. Because so few tests were conducted, the enterococci results should not be considered nationally representative; for illustrative purposes they are shown (Table 20) for a few domains.

The *E. coli* household patterns are also evident for enterococci, though the latter are considerably higher. Table 21 compares household enterococci and *E. coli* levels using a glass of water provided for drinking. The cells on the diagonal, shaded yellow, represent households where the levels for both were similar (within the same log class), as was true for 55 percent of the population.

In many cases (39 percent, shaded orange and red) contamination levels were notably greater for enterococci than for *E. coli*.

TABLE 20 — Household Enterococci Levels by Water Supply Type, Location, and Region, Percent

	Enterococci < 1 CFU/100 mL	Enterococci 1-10 CFU/100 mL	Enterococci 11-100 CFU/100 mL	Enterococci >100 CFU/100 mL	Total	Population (millions)	Count
Total	**(*)**	**(*)**	**16.3**	**78.0**	**100.0**	**7.7**	**382**
Water sample source							
Piped on premises	(*)	(*)	(25.9)	(51.5)	100.0	1.3	93
Piped water public tap or standpipe	(*)	(*)	(*)	(76.0)	(100.0)	0.7	31
Tube well or borehole	(*)	(*)	(*)	(88.7)	(100.0)	1.0	45
Protected spring	(*)	(*)	(*)	(77.0)	(100.0)	1.0	38
Unprotected spring	(*)	(*)	(*)	90.3	100.0	1.8	59
Surface water	(*)	(*)	(*)	(87.5)	(100.0)	1.0	48
Source type							
Unimproved	(*)	(*)	(*)	89.3	100.0	3.1	134
Improved	(*)	(*)	21.6	70.3	100.0	4.6	248
Location							
Rural	(*)	(*)	(14.3)	83.9	100.0	6.2	262
Urban (large town)	(*)	(*)	(*)	(46.3)	100.0	1.0	84
Urban (all)	(*)	(*)	(24.6)	53.6	100.0	1.5	120
Region							
Amhara	(*)	(*)	(*)	83.6	100.0	1.9	79
Oromia	(*)	(*)	(*)	77.0	100.0	3.0	78
SNNP	(*)	(*)	(*)	83.1	100.0	1.6	85
Tigray	(*)	(*)	(*)	(71.7)	(100.0)	0.4	44
All other	(*)	(*)	(*)	80.4	100.0	0.5	80

Note: Values in brackets are estimates from small observations (number of unweighted cases less than 50 but greater than 24). The symbol, (*), denotes suppressed values for less than 25 observations.

TABLE 21 — *E. coli* and enterococci Levels in a glass of Household Drinking Water, Percent

		E. coli in the glass				
		<1	1_10	11_100	>100	Total
Enterococci in the glass	<1	1.4	0.8	0.1	0.0	2.3
	1_10	2.1	0.3	1.0	0.0	3.4
	11_100	0.9	5.3	5.9	4.2	16.3
	>100	1.1	2.6	26.8	47.4	78.0
	Total	5.5	9.1	33.8	51.6	100.0

Enterococci much less than *E. coli*	0.1
Enterococci less than *E. coli*	6.0
Enterococci similar to *E. coli*	55.1
Enterococci greater than *E. coli*	34.3
Enterococci much greater than *E. coli*	4.6

Chemical and Physical Characteristics

In addition to microbial water quality, a number of chemical and physicochemical water quality parameters were measured at the water source. Turbidity and chlorine residual were assessed onsite by field teams, enabling comparison with levels of *E. coli*. Samples were also tested centrally for fluoride, iron, hardness, and electroconductivity.

Chlorine Residual

Free chlorine residual was tested for water samples from piped supplies; moderate to high levels usually indicate that water has been adequately treated. Drinking water used by 14 percent of the households with piped water had moderate or high levels of residual chlorine. It was most common in Addis Ababa (28 percent with moderate levels), while no other region had enough moderate or high observations for adequate reporting. Households that had piped water on premises had higher chlorine residual (18 percent combined moderate and high) than other piped water sources.

Conversely, an absence of chlorine could reflect water that has never been treated. Almost all household water from piped sources had low residual chlorine (82-97 percent by piped type), as was true for piped water in rural areas (98 percent) and small towns (92 percent).

The study showed a reasonably high correlation between moderate to high chlorine levels and low *E. coli* risk (Table 23): 75 percent of households using water with moderate and high residual chlorine were also classified as at low risk for *E. coli* compared to only 33 percent of households with low residual chlorine. Piped water samples with low residual chlorine were about evenly classified as at low, moderate, and high (combining both high and very high) *E. coli* risk.

Turbidity

As might be expected, high turbidity (over 5 NTU) occurred most often in surface water and unprotected dug wells (Table 24). Over 80 percent of the samples from bottled water had low turbidity (but note that this was the least used source). Aside from this, piped water, both on premises (42 percent) and in public taps and standpipes (45 percent), had the least turbidity.

Almost 90 percent of households collecting drinking water from sources with high turbidity (89 percent) were classified as high or very high *E. coli* risk (Table 25). Though low turbidity samples had the least *E. coli* risk—31 percent, compared with 25 percent at moderate and 5.5 percent at high turbidity—they were still generally considered moderate risk (43 percent).

TABLE 22 — Residual Chlorine in Piped Water Used in Households, Percent

	Low: <0.2 mg/L	Moderate: 0.2-0.5 mg/L	High: >0.5 mg/L	Total	Population (millions)	Count
Total	**86.3**	**9.6**	**4.1**	**100.0**	**18.7**	**1297**
Water sample source						
Piped on premises	82.4	12.5	5.0	100.0	13.0	983
Piped water public tap or standpipe	96.9	(*)	(*)	100.0	4.4	219
Piped water kiosk or retailer	89.3	(*)	(*)	100.0	1.3	95
Location						
Rural	97.9	(*)	(*)	100.0	5.2	205
Urban (small town)	92.0	(*)	(*)	100.0	2.9	212
Urban (large town)	79.0	14.6	6.4	100.0	10.5	880
Urban (all)	81.8	13.0	5.2	100.0	13.5	1,092
Region						
Addis Ababa	63.5	28.4	(*)	100.0	3.2	187
Amhara	94.1	(*)	(*)	100.0	3.6	240
Oromia	92.2	(*)	(*)	100.0	5.8	253
SNNP	89.9	(*)	(*)	100.0	3.4	216
Tigray	82.3	(*)	(*)	100.0	1.5	222
All other	89.9	(*)	(*)	100.0	1.2	179

TABLE 23 — Residual Chlorine in Piped Water Used in Households and *E. coli* Risk, Percent

	Low Risk: *E. coli* < 1 CFU/100 mL	Moderate Risk: *E. coli* 1-10 CFU/100 mL	High Risk: *E. coli* 11-100 CFU/100 mL	Very High Risk: *E. coli* >100 CFU/100 mL	Total	Population (millions)	Count
Total	**38.7**	**32.8**	**20.0**	**8.4**	**100.0**	**18.6**	**1,318**
Residual chlorine (mg/L)							
Low: < 0.2	32.9	35.4	22.1	9.7	100.0	16.0	1,099
Medium: 0.2 - 0.5	75.3	(*)	(*)	(*)	100.0	1.8	145
High: > 0.5	75.4	(*)	(*)	(*)	100.0	0.8	74

Note: Values in brackets are estimates from small observations (number of unweighted cases less than 50 but greater than 24). The symbol, (*), denotes suppressed values for less than 25 observations.

TABLE 24 — Drinking Water Turbidity at Source, Percent

	1 NTU	1-5 NTU	>5 NTU	Average (NTU)	Total	Population (millions)	Count
Total	**22.6**	**36.0**	**41.5**	**22.4**	**100.0**	**52.5**	**2,728**
Water sample source							
Piped on premises	42.0	42.1	15.9	5.3	100.0	13.0	983
Piped water public tap or standpipe	44.8	39.5	(15.7)	4.6	100.0	4.4	219
Tube well or borehole	27.0	46.5	26.5	21.7	100.0	5.6	227
Protected dug well	12.4	39.8	(47.8)	11.1	100.0	2.4	120
Unprotected dug well	(*)	(*)	82.8	72.1	100.0	1.5	96
Protected spring	(16.1)	43.5	40.4	10.1	100.0	5.8	204
Unprotected spring	(*)	32.3	63.8	22.9	100.0	11.5	395
Rainwater collection	(*)	(*)	(*)	(14.0)	(100.0)	0.8	34
Piped water kiosk or retailer	(32.9)	(48.3)	18.9	11.6	100.0	1.3	95
Bottled water	(83.4)	(*)	(*)	1.6	100.0	0.4	39
Cart with small tank or drum	(*)	(*)	(*)	16.9	100.0	0.3	27
Surface water	(*)	(*)	88.0	89.5	100.0	5.0	249
Other	(*)	(*)	(*)	51.8	100.0	0.6	40
Source type							
Unimproved	(4.8)	24.4	70.8	45.8	100.0	18.6	780
Improved	32.3	42.3	25.4	9.7	100.0	33.9	1,948
Location							
Rural	16.3	33.9	49.8	28.4	100.0	37.0	1,483
Urban (small town)	30.2	41.5	28.3	10.0	100.0	3.8	277
Urban (large town)	39.9	40.7	19.4	7.6	100.0	11.7	968
Urban (all)	37.5	40.9	21.6	8.1	100.0	15.5	1,245
Region							
Addis Ababa	41.1	53.8	(*)	2.0	100.0	3.2	192
Amhara	21.0	35.2	43.7	22.6	100.0	14.9	615
Oromia	16.5	38.5	45.1	21.3	100.0	19.2	546
SNNP	25.4	27.7	47.0	22.3	100.0	9.2	559
Tigray	39.6	37.4	22.9	12.2	100.0	3.3	355
All other	21.9	27.7	50.4	64.9	100.0	2.8	461

Notes: NTU refers to nephelometric turbidity units. Values in brackets are estimates from small observations (number of unweighted cases less than 50 but greater than 24). The symbol, (*), denotes supressed values for less than 25 observations.

TABLE 25 — Drinking Water Turbidity at Source and *E. coli* Risk, Percent

	Low Risk: *E. coli* < 1 CFU/100 mL	Moderate Risk: *E. coli* 1-10 CFU/100 mL	High Risk: *E. coli* 11-100 CFU/100 mL	Very High Risk: *E. coli* >100 CFU/100 mL	Total
Total	**18.2**	**20.5**	**26.6**	**34.7**	**100.0**
Turbidity (NTU)					
< 1	31.3	42.7	22.1	3.8	100.0
1 - 5	24.6	24.1	31.6	19.7	100.0
> 5	5.5	5.3	24.8	64.4	100.0

Note: NTU refers to nephelometric turbidity units.

Fluoride

The Ethiopian national standard for fluoride in drinking water is a maximum of 1.5 mg/L, the WHO Guideline Value. The ESS-WQT found that the fluoride concentrations in the water available to 96 percent of the population meet that standard (Table 26). Although high fluoride levels do affect a small portion of the population, its occurrence is very concentrated, so remedies can be targeted effectively. Of the 3.8 percent of the population whose water sources have 1.5 mg/L or more of fluoride, 26 percent were found to use water that was twice the guideline value (>3 mg/L).

Hardness

Hardness in water primarily affects consumer preferences and the condition of water pipes. The Ethiopian national standard for hardness in drinking water is 300 mg/L (as $CaCO_3$). There is no relevant WHO Guideline Value, and the WHO Guidelines note that public acceptability of hardness in drinking water may vary considerably.

Though hardness varied a bit by the source of water collected, the share of the population whose water is hard or very hard did not vary much by source type or location. Of the regions, markedly more people in Tigray accessed hard and very hard drinking water (68 percent); most residents of SNNP (92 percent) had soft or only moderately hard water (Table 27).

Electroconductivity

There is neither an Ethiopian national standard nor a WHO Guideline Value for electroconductivity[11] in drinking water. However, the Australian standard considers electrical conductivity of <800 μS/cm to indicate good quality. Electroconductivity is closely linked to total dissolved solids, salinity, and hardness, but conversion factors can vary depending on both the composition and the temperature of the water.

Nationally, only 6.4 percent of Ethiopia's drinking water sources had very high electroconductivity (Table 28), but some regions appear to be more at risk for very high levels, as was true for 22 percent of water sources in Tigray and 30 percent in 'all other' regions

11 Electroconductivity, a measure of the conductivity of water, is a proxy indicator of total dissolved solids, and therefore an indicator of the taste or salinity of the water. Although this parameter does not provide information about specific chemicals in water, it acts as a useful indicator of water-quality problems, particularly when it changes with time. High conductivity water, for example, can cause excessive scaling in water pipes, heaters, boilers, and household appliances.

TABLE 26 — Fluoride in Drinking Water at Source, Percent

	Low Fluoride: < 0.5 mg/L	Moderate Fluoride: 0.5 to 1.5 mg/L	High Fluoride: 1.5 to 3 mg/L	Very High Fluoride: >3 mg/L	Total
Total	**59.8**	**36.5**	**2.8**	**(1.0)**	**100.0**
Water sample source					
Piped on premises	44.8	50.7	(3.2)	(*)	100.0
Piped water public tap or standpipe	42.4	44.5	(*)	(*)	100.0
Tube well or borehole	57.4	38.5	(*)	(*)	100.0
Protected dug well	61.7	(34.9)	(*)	(*)	100.0
Unprotected dug well	65.8	(33.4)	(*)	(*)	100.0
Protected spring	71.6	27.9	(*)	(*)	100.0
Unprotected spring	74.7	24.5	(*)	(*)	100.0
Rainwater collection	(88.0)	(*)	(*)	(*)	(100.0)
Piped water kiosk or retailer	62.6	(28.7)	(*)	(*)	100.0
Bottled water	(71.4)	(*)	(*)	(*)	(100.0)
Cart with small tank or drum	(*)	(*)	(*)	(*)	(100.0)
Surface water	62.7	33.7	(*)	(*)	100.0
Other	(*)	(52.7)	(*)	(*)	(100.0)
Source type					
Unimproved	69.8	28.6	(*)	(*)	100.0
Improved	54.3	40.7	3.6	(*)	100.0
Location					
Rural	63.9	32.3	(2.7)	(*)	100.0
Urban (small town)	53.4	43.6	(*)	(*)	100.0
Urban (large town)	48.7	47.4	(3.2)	(*)	100.0
Urban (all)	49.8	46.4	(3.0)	(*)	100.0
Region					
Addis Ababa	47.2	52.1	(*)	(*)	100.0
Amhara	69.6	28.9	(*)	(*)	100.0
Oromia	58.9	35.4	(4.3)	(*)	100.0
SNNP	64.0	32.6	(*)	(*)	100.0
Tigray	41.8	53.8	(*)	(*)	100.0
All other	35.4	57.9	(*)	(*)	100.0

Note: Values in brackets are estimates from small observations (number of unweighted cases less than 50 but greater than 24). The symbol, (*), denotes supressed values for less than 25 observations.

TABLE 27 — Hardness in Drinking Water at Source, Percent

	Soft: < 60 mg/L	Moderately Hard: 60-180 mg/L	Hard: 180-300 mg/L	Very Hard: >300 mg/L	Total
Total	**31.4**	**40.7**	**16.7**	**11.2**	**100.0**
Water sample source					
Piped on premises	21.7	49.0	18.4	10.9	100.0
Piped water public tap or standpipe	(29.6	37.6	(22.1)	(10.7)	100.0
Tube well or borehole	(*)	43.0	29.8	19.2	100.0
Protected dug well	(*)	(32.7)	(13.2)	(16.0)	100.0
Unprotected dug well	(*)	50.1	(22.9)	(*)	100.0
Protected spring	42.3	39.9	(*)	(*)	100.0
Unprotected spring	36.1	40.3	(12.4)	(11.2)	100.0
Rainwater collection	(85.7)	(*)	(*)	(*)	(100.0)
Piped water kiosk or retailer	(31.9)	41.1	(*)	(*)	100.0
Bottled water	(89.9)	(*)	(*)	(*)	(100.0)
Cart with small tank or drum	(*)	(*)	(*)	(*)	(100.0)
Surface water	48.8	30.3	13.1	(*)	100.0
Other	(*)	(*)	(*)	(*)	(100.0)
Source type					
Unimproved	38.5	38.0	13.4	10.1	100.0
Improved	27.6	42.1	18.4	11.9	100.0
Location					
Rural	33.4	38.7	16.3	11.7	100.0
Urban (small town)	34.6	35.6	24.2	(5.6)	100.0
Urban (large town)	24.1	48.7	15.4	11.8	100.0
Urban (all)	26.7	45.5	17.6	10.3	100.0
Region					
Addis Ababa	(13.2)	50.8	33.0	(*)	100.0
Amhara	12.9	53.8	21.1	12.2	100.0
Oromia	41.6	34.9	13.7	(9.8)	100.0
SNNP	57.4	34.9	(6.3)	(*)	100.0
Tigray	(8.4)	23.3	26.8	41.5	100.0
All other	23.1	37.7	16.7	22.6	100.0

Note: Values in brackets are estimates from small observations (number of unweighted cases less than 50 but greater than 24). The symbol, (*), denotes supressed values for less than 25 observations.

TABLE 28 — Electroconductivity in Drinking Water at Source, Percent

	Low: < 150 µS/cm	Moderate: 150-500 µS/cm	High: 500-800 µS/cm	Very High: >800 µS/cm	Total
Total	**33.3**	**44.3**	**16.0**	**6.4**	**100.0**
Water sample source					
Piped on premises	16.0	54.6	21.9	7.5	100.0
Piped water public tap or standpipe	(15.4)	49.8	(27.1)	(7.8)	100.0
Tube well or borehole	(13.7)	51.4	24.7	(10.2)	100.0
Protected dug well	(48.8)	(27.9)	(*)	(7.8)	100.0
Unprotected dug well	(*)	(41.1)	(*)	(*)	100.0
Protected spring	49.2	38.7	(*)	(*)	100.0
Unprotected spring	47.6	37.4	(9.5)	(*)	100.0
Rainwater collection	(85.7)	(*)	(*)	(*)	(100.0)
Piped water kiosk or retailer	(*)	60.4	(*)	(*)	100.0
Bottled water	(66.3)	(*)	(*)	(*)	(100.0)
Cart with small tank or drum	(*)	(*)	(*)	(*)	(100.0)
Surface water	48.6	40.2	(7.0)	(*)	100.0
Other	(*)	(*)	(*)	(*)	(100.0)
Source type					
Unimproved	47.2	38.1	9.2	5.6	100.0
Improved	25.6	47.8	19.8	6.8	100.0
Location					
Rural	37.9	40.8	15.6	5.8	100.0
Urban (small town)	22.5	60.6	(10.5)	(6.4)	100.0
Urban (large town)	22.2	50.1	19.4	8.3	100.0
Urban (all)	22.3	52.7	17.2	7.8	100.0
Region					
Addis Ababa	34.1	30.5	35.5	(*)	100.0
Amhara	23.8	58.6	13.8	(*)	100.0
Oromia	38.4	39.1	16.8	(5.7)	100.0
SNNP	47.7	44.5	6.4	(*)	100.0
Tigray	(10.7)	32.9	34.5	22.0	100.0
All other	26.2	33.1	10.7	29.9	100.0

Note: Values in brackets are estimates from small observations (number of unweighted cases less than 50 but greater than 24). The symbol, (*), denotes supressed values for less than 25 observations.

Safely Managed Drinking Water

Key Messages

- Because the SDG indicator "use of safely managed drinking water services" sets a new benchmark for global monitoring, this study sought support for setting the baseline for Ethiopia.
- Safely managed drinking water services are improved sources accessible on premises, available when needed, and free from fecal and specified chemical contamination.
- Using the JMP methodology, nationally 13 percent of the population is considered to be using safely managed services.
- Services available to one in five (20 percent) of those using improved sources can be considered safely managed.

Together, the four sub-indicators—improved, on premises, available (sufficient), and low *E. coli* risk—constitute the safely managed drinking water services indicator. The four sub-indicators can be integrated at different scales ranging from national level to calculating the safely managed indicator for each household. Combined at the household level, the ESS-WQT found that only 3.4 percent of households in Ethiopia are accessing safely managed services.

However, because the sub-indicators sometimes come from different data sources and therefore cannot always be combined at the household level, the JMP estimates the safely managed indicator by combining sub-indicators according to the domain for which estimates are being made, and the safely managed indicator will be the lowest of the sub-indicator elements for that domain. For example, for Ethiopia as a whole, of the sub-indicators, *E. coli* risk has the lowest value (13 percent), so that based on the ESS-WQT data the proportion of safely managed drinking water services would be an estimated 13 percent.

Table 29 shows the four sub-indicators by category (sources, locations, regions, and wealth quintiles), with the lowest for each category—the safely managed indicator for that category—highlighted in pink. In most cases the quality sub-indicator is the limiting factor, but in rural areas and for some technologies it is "on premises." In large towns and in the Addis Ababa region, the "availability" sub-indicator drives the safely managed indicator.

TABLE 29 — Safely Managed Drinking Water Services, Percent

	Improved	On Premises and improved	Sufficient and Improved	Quality and Improved	Safely Managed (Household)	Safely Managed (Domain)
Total	**66.0**	**18.2**	**46.9**	**13.2**	**3.4**	**13.2**
Water sample source						
Piped on premises	100.0	100.0	42.3	41.5	21.4	41.5
Piped water public tap or standpipe	100.0	0.0	73.5	22.6	0.0	0.0
Tube well or borehole	100.0	1.3	84.7	14.9	0.0	1.3
Protected dug well	100.0	9.3	84.7	3.1	0.0	3.1
Protected spring	100.0	0.0	94.9	7.5	0.0	0.0
Rainwater collection	(100.0)	(88.3)	(65.5)	(1.0)	(0.0)	(1.0)
Piped water kiosk or retailer	100.0	0.0	(34.0)	27.0	0.0	0.0
Bottled water	(100.0)	(100.0)	(76.2)	(53.4)	(44.0)	(53.4)
Cart with small tank or drum	100.0	(*)	(*)	(*)	(*)	(*)
Location						
Rural	58.8	4.7	48.2	7.4	0.1	4.7
Urban (small town)	89.3	49.2	44.9	14.0	5.3	14.0
Urban (large town)	95.5	77.6	41.0	46.4	21.7	41.0
Urban (all)	93.8	69.8	42.1	37.4	17.1	37.4
Region						
Addis Ababa	99.7	93.7	51.3	84.8	45.6	51.3
Amhara	61.4	14.7	45.4	10.6	2.0	10.6
Oromia	66.1	14.8	45.9	10.4	0.9	10.4
SNNP	66.4	14.1	50.3	6.7	1.6	6.7
Tigray	71.9	22.8	53.7	23.8	7.1	22.8
All other	56.1	16.5	38.9	11.2	0.7	11.2
Consumption quintile						
Poorest	56.1	(3.8)	44.7	7.5	0.3	3.8
Poor	67.9	7.6	52.2	8.1	0.8	7.6
Middle	66.8	13.5	50.4	9.6	1.3	9.6
Rich	64.1	21.4	42.3	13.9	3.6	13.9
Richest	80.7	48.2	47.1	31.9	12.7	31.9

Notes: "Household" refers to an estimate for safely managed services where the indicator is calculated for each individual household. "Domain" refers to a simplified calculation whereby the lowest value for accessible, available and quality for the population in question (e.g. urban and rural areas, or users of different types of water sources) is used to estimate safely managed services. This second approach is based on the method used by the JMP. Values in brackets are estimates from small observations (number of unweighted cases less than 50 but greater than 24). The symbol, (*), denotes suppressed values for less than 25 observations.

Table 30 shows information similar to that in Table 29 but restricted to improved sources. It is identical to Table 29 in the "source of drinking water sample" section but shows generally higher numbers in other rows because improved sources are more likely to be on premises, sufficient, and free from *E. coli*. Thus, from this analysis 20 percent of the national population using improved sources would be classified as having safely managed drinking water.

For the official estimate of the safely managed indicator the JMP will draw on multiple data sources for each sub-

TABLE 30 — Safely Managed Drinking Water Services, Users of Improved Sources, Percent

	On Premises among Improved	Sufficient among Improved	Quality among Improved	Safely Managed among Improved (Household)	Safely Managed among Improved (Domain)
Total	**27.6**	**71.1**	**20.0**	**5.2**	**20.0**
Water sample sources					
Piped on premises	100.0	42.3	41.5	21.4	41.5
Piped water public tap and standpipe	0.0	73.5	22.6	0.0	0.0
Tube well or borehole	1.3	84.7	14.9	0.0	1.3
Protected dug well	9.3	84.7	3.1	0.0	3.1
Protected spring	0.0	94.9	7.5	0.0	0.0
Rainwater collection	(88.3)	(65.5)	(1.0)	(0.0)	(1.0)
Piped water kiosk or retailer	0.0	(34.0)	27.0	0.0	0.0
Bottled water	(100.0)	(76.2)	(53.4)	(44.0)	(53.4)
Cart with small tank or drum	0.0	(*)	(*)	(*)	(*)
Location					
Rural	8.1	82.0	12.7	0.2	8.1
Urban (small town)	55.1	50.3	15.7	5.9	15.7
Urban (large town)	81.2	42.9	48.5	22.7	42.9
Urban (all)	74.4	44.9	39.8	18.2	39.8
Region					
Addis Ababa	94.0	51.5	85.1	45.7	51.5
Amhara	24.0	74.1	17.3	3.2	17.3
Oromia	22.5	69.5	15.7	1.4	15.7
SNNP	21.2	75.7	10.1	2.4	10.1
Tigray	31.7	74.7	33.0	9.9	31.7
All other	29.4	69.4	20.1	4.9	20.1
Consumption quintile					
Poorest	(6.8)	79.7	13.4	0.5	6.8
Poor	11.2	76.9	12.0	1.1	11.2
Middle	20.2	75.5	14.3	1.9	14.3
Rich	33.4	66.0	21.6	5.6	21.6
Richest	59.7	58.3	39.5	15.8	39.5

Notes: "Household" refers to an estimate for safely managed services where the indicator is calculated for each household. "Domain" refers to a simplified calculation whereby the lowest value for accessible, available, and quality for the population in question (e.g. urban and rural areas, or users of different types of water sources) is used to estimate safely managed services. This second approach is based on the method used by the JMP. Values in brackets are estimates from small observations (number of unweighted cases less than 50 but greater than 24). The symbol, (*), denotes suppressed values for less than 25 observations.

indicator, so the 13 percent estimate based on the ESS-WQT data alone might not carry through to the formal SDG estimate. At present, however, because the ESS-WQT is the only nationally representative source of water quality data available for SDG reporting purpose, the finding that 20 percent of water collected from improved sources is low-risk will be combined with any other data sources that emerge to produce an official estimate, and will likely be the determining factor.

Annex 1: Questionnaire

Form ESS-WQT (2016)

CENTRAL STATISTICAL AGENCY

2015/16 ETHIOPIAN SOCIOECONOMIC SURVEY

WATER QUALITY TESTING MODULE

COVER

1	2	3	4	6	7
Region	Zone	Woreda	Geographic Status	Kebele	EA
Code	Code	Code	Code	Code	Code

8	9	10	11	12
Household ID	Village name where the HH lives	WATER ID	Household Head Name	RESPONDENT Name
Code		Code		

	FIRST VISIT	SECOND VISIT
15. DATE: DD/MM/YY	(Recorded by the survey solution program)	
16. TIME STARTED (hh:mm)		
17 TIME ENDED (hh:mm)		
18 Questionnaire Status (CODE)		

Questionnaire Status (CODE)
1.Complete
2.Partially Complete
3.The respondant is not at home
4.The respondant refused
5.Household Not Located
6.Household Moved Away

TEAM DETAILS	NAME	ID	Date DD	MM	YY
20. Enumerator	(Recorded by the survey solutions program)				
21. Coordinator					
22. HQ review					

19. GPS COORDINATES OF THE DWELLING (UTM READING).

LATITUDE (N)						
__	__	__	__	__	__	__

LONGITUDE (E)						
__	__	__	__	__	__	__

COMMENTS DURING FIELDWORK

(In survey solutions, remarks can be entered under each individual question)

HH INTERVIEW DAY

1	2	3	4	4b	5	6
Please provide me with a glass of water that you would give to a child to drink.	REASON WHY WATER SAMPLE NOT COLLECTED. FILL AND END SURVEY	Did you or anyone in your household do anything to **this** water to make it safer to drink? NOTE: REFERS TO GLASS OF WATER THEY GAVE YOU.	What did you/household member do to make this water safe for drinking?	When did you fetch this water?	What is the source of **this** glass of water?	Where is the source mentioned in Q5 located?
Water sample PROVIDED….1 >>3 Water sample NOT PROVIDED... 2	NO DRINKING WATER CURRENTLY IN HOUSE ...1 REFUSDE ...2 HH NOT HOME....3 HH NOT LOCATED...4 HH MOVED AWAY...5 OTHER, SPECIFY...6	Yes…. 1 No …. 2 >> 4b	BOIL...............1 ADD CHLORINE/ OTHER CHEMICLAS..2 USE A WATER FILTER.3 SOLAR DISINFECTION.4 LET IT STAND AND SETTLE......5 STRAIN IT THROUGH A CLOTH ......6 OTHER, SPECIFY.....7	TODAY ......1 YESTERDAY ....2 LESS THAN A WEEK AGO ....3 OVER 1 WEEK AGO……. …4	PIPED WATER INTO DWELLING.........1 ►6b PIPED WATER INTO YARD/PLOT........2 PIPED WATER PUBLIC TAP/STANDPIPE..3 ►6b TUBEWELL/BOREHOLE.......4 PROTECTED DUG WELL......5 UNPROTECTED DUGWELL.....6 PROTECTED SPRING........7 UNPROTECTED SPRING......8 RAINWATER COLLECTION....9 PIPED WATER KIOSK/RETAILER..10 ►6b BOTTLED WATER...............11 ►6b CART WITH SMALL TANK/DRUM............12 ►6b TANKER-TRUCK.........13 ►6b SURFACE WATER (RIVER, DAM, LAKE, POND, STREAM, CANAL, IRRIGATION CHANNELS).............14 OTHER,SPECIFY.........15	IN THE DWELLING......1 PRIVATE YARD/PLOT.....2 NEIGHBOR'S YARD/SHARED COMPOUND......3 PUBLIC SPACE..4

6b	7	8a	8b	9	10	10b
Has it rained in the past TWO days?	In the past **two weeks**, was the water from this source not available for at least one full day?	Has there been any time in the **last month** when you did not have water in sufficient quantities?	What was the main reason that you did not have water in sufficient quantities?	THE HOUSEHOLD SAMPLE IS BEING TESTED …	COLLECT DRINKING WATER SAMPLE FOR **HOUSEHOLD EC** TEST IF Q9=1:POUR SAMPLE DIRECTLY FROM DRINKING GLASS IF Q9=2:LABEL WHIRL-PAK WITH CODE: **H+WATER ID** AND THEN FILL WITH WATER	COLLECT DRINKING WATER SAMPLE E FOR **HOUSEHOLD ETC** TEST IF Q9=1:POUR THE SAMPLE DIRECTLY FROM DRINKING GLASS IF Q9=2:LABEL WHIRL-PAK WITH CODE: **H+**WATER ID AND THEN FILL WITH WATER
Yes …..1 No …..2	Yes…. 1 No …. 2 DK… 8	Yes…. 1 No …. 2 >>9	WATER NOT AVAILABLE FROM SOURCE …….1 WATER TOO EXPENSIVE ….2 SOURCE NOT ACCESSIBLE/TO FAR…...3 OTHER, SPECIFY …4	NOW AT HH …1 LATER, AT FIELD BASE (TEAM'S TEMPORARLY SITE) ……..…2	DONE..1 NOT DONE…2 >>15	DONE..1 NOT DONE…2

2

11	12	13	14	15	16	17	18	19
UPON CONDUCTING EC TEST: WHO CONDUCTED THIS HH TEST?	UPON CONDUCT-ING EC TEST: FOR 100 mL TEST, APPROX WHAT PORTION OF WATER WAS FILTERED?	UPON CONDUCT-ING EC TEST: REGSTER INCUBATION START TIME NOTE: TEST SHOULD BE WITHIN 30 MINUTES OF COLLECTION OF WATER SAMPLE	RECORD CHLORINE RESIDUAL RESULT [TEST ONLY IF Q5=1, 2,3, 10] IF Q9=1: POUR SAMPLE DIRECTLY FROM DRINKING GLASS IF Q9=2: USE WATER FROM WHIRL-PAKS	Can you please show me the source of **this glass of water,** so that I can also take a water sample from there?	TAKE PHOTO OF THE WATER SOURCE IF SOURCE IS PRIVATE, REQUEST PERMISSION FROM OWNER	GPS COORDINAT E OF SOURCE [ONLY IF SOURCE IS NOT IN RESPONDENT'S DWELLING OR YARD/PLOT]	THE SOURCE SAMPLE IS BEING TESTED …	COLLECT SAMPLE FOR CENTRAL LAB TESTING WRITE ON LABEL **S**+WATER-ID, THEN FILL BOTTLE
SELF… 1 TEAM MATE… 2	ALL ...... 1 MORE THAN HALF........2 HALF........3 LESS THAN HALF........4	HH:MM Day…1 Night…2 [Amharic time]	__ . __ __	COLLECT SAMPLES.......1 COLLECTED WITH OTHER HH DATA........2>>25 NOT COLLECTED....3>>26			NOW, AT SOURCE WHERE TEAM IS COLLECTING…1 LATER, AT FIELD BASE (AT TEAM'S TEMPORARLY SITE) 2	SCAN BARCODE

20	21	22	23	24	25	26	27
COLLECT WATER SAMPLE FOR **SOURCE EC** TEST IF Q18=1: POUR SAMPLE DIRECTLY FROM SOURCE IF Q18=2: LABEL WHIRL-PAK WITH CODE: **S**+WATER ID AND THEN FILL WITH WATER **BEFORE COLLECTING SOURCE SAMPLES, COORDINATE WITH TEAM TO ENSURE ONLY ONE SAMPLE PER SOURCE**	RECORD CHLORINE RESIDUAL TEST RESULT [NOTE; CHLORINE TEST ONLY IF Q5=1, 2, 3, 10]	RECORD TURBIDITY TEST RESULT IF RESULT IS 'HI' OR OVER 1000 THEN RECORD 999.99	UPON CONDUCTING EC TEST: FOR 100 mL TEST, APPROX WHAT PORTION OF WATER WAS FILTERED?	UPON CONDUCTING EC TEST: REGISTER INCUBATION START TIME. NOTE: EC TEST SHOULD BE WITHIN 30 MINUTES OF COLLECTION OF WATER SAMPLE ANSWER >> 27	ENTER THE WATER-ID UNDER WHICH SOURCE SAMPLES ARE COLLECTED NOTE: S+OTHER HH WATER ID ANSWER >> 27	REASON WHY WATER SAMPLE NOT COLLECTED	CONDUCT BLANK **EC** TEST USING STERILE SAMPLE YOU WERE PROVIDED POUR 100 ml FROM THE STERILE SAMPLE LABEL WITH CODE: **B**+waterID NOTE: ONLY FOR HH SELECTED FOR BLANK TEST WHO CONDUCTED THE TEST:
DONE..1 NOT DONE…2	0.00 - 9.99 __ . __ __		ALL ...... 1 MORE THAN HALF..2 HALF........3 LESS THAN HALF....4	HH:MM Day…1 Night…2	**OTHER** HH WATER-ID	WATER SOURCE TOO FAR ….1 SOURCE LOCATION NOT KNOWN ..2 SOURCE NOT FUNCTIONAL ….3 UNABLE TO ACCESS SOURCE …. 4 OTHER, SPECIFY…5	SELF… 1 TEAM MATE… 2

MICROBIAL RESULTS REGISTER

Following 24-48 hours of incubation the results from the water quality tests should be recorded.

1	2	3	4	5	6	7	8	9	10
HOUSEHOLD E.COLI TEST AND INCUBATION COMPLETED? [ASK IF a10a=1]	TAKE PHOTO OF TEST RESULT	Number of red/pink colonies in **1 mL** sample CONFIRM "EC" ON PLATES. IF MORE THAN 100 REGISTER 101	Number of blue colonies in **1 mL** sample CONFIRM "EC" ON PLATES. IF MORE THAN 100 REGISTER 101	Number of red/pink colonies in **100 mL** sample CONFIRM "EC" ON PLATES. IF MORE THAN 100 REGISTER 101	Number of blue colonies in **100 mL** samplee CONFIRM "EC" ON PLATES. IF MORE THAN 100 REGISTER 101	**HOUSEHOLD ENTEROCOCCI** TEST AND INCUBATION COMPLETED? [ASK if a10b=1]	TAKE PHOTO OF TEST RESULT	Number of blue/green colonies in **1 mL** sample CONFIRM "ETC" ON PLATES. IF MORE THAN 100 REGISTER 101	Number of blue/green colonies in **100 mL** sample CONFIRM "ETC" ON PLATES. IF MORE THAN 100 REGISTER 101
		COUNT 0-101	COUNT 0-101	COUNT 0-101	COUNT 0-101			COUNT 0-101	COUNT 0-101
TESTED AND HAS RESULTS…1 TESTED, RESULTS LOST/ NOT READABLE.... 2>>7 NOT TESTED… 3>>7						TESTED AND HAS RESULTS…1 TESTED, RESULTS LOST/ NOT READABLE.... 2>>11 NOT TESTED… 3>>11			

11	12	13	14	15	16	17	18	19	20	21	22
SOURCE WATER SAMPLE E.COLI TEST AND INCUBATION COMPLETED? [ASK IF a15=1 & a20=1 [ASK if a15=2]	TAKE PHOTO OF TEST RESLUT	Number of red/pink colonies in **1 mL** sample CONFIRM "EC" ON PLATES. IF MORE THAN 100 REGISTER 101	Number of blue colonies in **1 mL** sample CONFIRM "EC" ON PLATES. IF MORE THAN 100 REGISTER 101	Number of red/pink colonies in **100 mL** sample CONFIRM "EC" ON PLATES. IF MORE THAN 100 REGISTER 101	Number of blue colonies in **100 mL** samplee CONFIRM "EC" ON PLATES. IF MORE THAN 100 REGISTER 101	**BLANK E.COLI** TEST AND INCUBATION COMPLETED? [ASK if a27=1or2]	TAKE PHOTO OF TEST RESULT	Number of red/pink colonies in **1 mL** sample CONFIRM "EC" ON PLATES. IF MORE THAN 100 REGISTER 101	Number of blue colonies in **1 mL** sample CONFIRM "EC" ON PLATES. IF MORE THAN 100 REGISTER 101	Number of red/pink colonies in **100 mL** sample CONFIRM "EC" ON PLATES. IF MORE THAN 100 REGISTER 101	Number of blue colonies in **100 mL** samplee CONFIRM "EC" ON PLATES. IF MORE THAN 100 REGISTER 101
		COUNT 0-101	COUNT 0-101	COUNT 0-101	COUNT 0-101			COUNT 0-101	COUNT 0-101	COUNT 0-101	COUNT 0-101
TESTED AND HAS RESULTS…1 TESTED, RESULTS LOST/ NOT READABLE.... 2>>17 NOT TESTED… 3>>17						TESTED AND HAS RESULTS…1 TESTED, RESULTS LOST/ NOT READABLE.... 2>>END NOT TESTED… 3>>END					

4

Annex 2: Quality Assurance

The fieldworkers spent 10 days of intensive training in Hawassa, in which experts from the World Bank covered the material exhaustively. During the training the participants, CSA enumerators and supervisors and water experts from MoWIE, reviewed both the subjective and objective components of fieldwork. The first three days were spent familiarizing them with questionnaire content. Next, experts from UNICEF and WHO gave the fieldworkers rigorous practical training. This segment was exclusively focused on how to perform household and source bacteriological and physical tests; it covered procedures that should be tracked during the fieldwork and how to properly use test kits, count colonies, and record results. The fieldworkers were also trained in Survey Solutions, a CAPI software program. The training concluded with two days of field piloting of both source and household water quality tests.

The survey was conducted using proper fieldwork procedures, particularly the following quality control procedures:

- Blank tests: Blank tests were used to ensure that teams were not inadvertently contaminating microbial samples and that the chemical and physical tests were in line with expected values. Each fieldworker performed one blank household test per enumeration area. A total of 629 blank tests were conducted. In 88 percent of them no E. coli was detected. Of the 77 tests that did show contamination, 49.3 percent (38) found only one colony-forming unit (CFU) , and 88 percent (68) found 1 to 7 CFUs. Only 1 percent of blank tests (9 samples) were found to have over 10 E. coli CFUs.

- Proportion of filtered water: Teams recorded the proportion of the 100 mL water sample that they were able to filter, noting if they were only able to filter half or a quarter of the sample. This is an issue with turbid samples and may influence the colony counts.

- Photo analysis: This analysis counts the colonies on the 1 mL and 100 mL water plates using photos and analyzing consistency between the water plates. The fieldworkers were instructed to take pictures of each plate (1 mL and 100 mL) after the required incubation period for each bacteria test using the Survey Solution template. Every day, the field coordinators re-checked the number of colonies recorded in the data. This practice served two purposes: (1) It flagged the possibility of contamination during the test process, which could contribute to inconsistency between the 1 mL and 100 mL plates. (2) Any discrepancy between the number of colonies in 1 mL and 100 mL suggested that fieldworkers had made a mistake by recording results in the reverse order (the 100 mL for 1 mL and vice versa). Fieldworkers were then informed about these issues and corrected the records accordingly.

- Test timing: This is the bacterial test conducted within an hour after the water sample is collected. The procedure was managed through a daily base communication between team leader and water testers.

- Control sample for chemical lab test: This test was done in a central laboratory in Addis Ababa. The institute that conducted it was provided with control samples as well as the main source samples. The control samples had features of the standard measure for each chemical test. At the end of the lab test, the control sample results from the institute were checked against the original sample results.

- Internal consistency checks: Extensive checks of internal consistency were conducted during and after data collection. Based on the data edit specifications, syntax was written for checking data consistencies. If the enumerator recorded incorrect values, an error message appeared. The supervisor reviewed whether the uploaded data were error-free and qualified the stated points. If errors were recorded in the uploaded data, the supervisor returned the data to the enumerator with comments about the errors. Error-free data was approved by the supervisor.

- Quality assurance practices—central lab test: In addition to the usual central lab quality control procedures, the institute sent randomly selected water samples plus samples with outlier figures to another lab whose techniques the institute had approved. The outcomes from the second lab's analysis were found to be consistent with those from the first lab. Moreover, to ensure that the final outcomes were accurate and sound, the whole process was reviewed and approved by four senior lab experts. They reviewed, e.g., whether the equations applied for each test type were appropriate, which figures were inserted into specific equations, and the system for recording results. Electroconductivity results were recorded directly from the measuring machine onto a hard copy and then transferred to an Excel spreadsheet. Survey coordinators analyzed the possibility of mistakes during data entry by checking the raw data (first hard copy) against the official data (a soft copy). About 3 percent of the total sample was checked; the official and the raw data matched 100 percent.

Annex 3: Compulsory Ethiopian Standard for Drinking Water (CES-58)

The Compulsory Ethiopian Standard for Drinking Water Specification (CES- 58) outlines the physical, chemical, and bacteriological requirements of water for drinking and domestic purposes. Like the new SDG targets, it defines quality and safe water as water intended for drinking and domestic use that conforms to all toxic, bacteriological, and organoleptic requirements outlined in CES-58. CES-58 stipulates the following minimum requirements for drinking water:

Maximum permissible level is a requirement whose nonfulfillment would disqualify water for drinking and domestic use because of its probable hazard to health.

Physical requirements (CES-58): The physical characteristics of drinking water must conform to the levels specified in Table A3-1.

TABLE A3-1 — Physical Characteristics of Drinking Water

Characteristics	Maximum permissible level
Odor	Unobjectionable
Taste	Unobjectionable
Turbidity, NTU	5
Color, TCU	15

Chemical requirements (CES-58):

Palatability properties: characteristics that affect the palatability of water must conform to the levels specified in Table A3-2.

TABLE A3-2 — Characteristics that Affect the Palatability of Drinking Water

Substance or characteristic	Maximum permissible level
Total hardness ($CaCO_3$)	300
Total dissolved solids mg/Ll	1,000
Total Iron (Fe) mg/L	0.3
Manganese (Mn) mg/L	0.5
Ammonia (NH_3+NH_4+) mg/L	1.5
Residual free chlorine mg/L	0.5
Magnesium (Mg) mg/L	50
Calcium (Ca) mg/L	75
Copper (Cu) mg/L	2
Zinc (Zn) mg/L	5
Sulfate (SO_4) mg/L	250
Chloride (Cl) mg/L	250
Total alkalinity ($CaCO_3$) mg/L	200
Sodium (Na) mg/L	200
Potassium(k) mg/L	1.5
pH value, units	6.5 to 8.5 (permissible range)
Aluminum (Al) mg/L	0.2

Content of toxic and/or disease substances: when tested, the characteristics that affect the safety of drinking water must conform to the levels specified in Table A3-3.

TABLE A3-3 — Content of Toxic and/or Disease-causing Substances in Drinking Water

Substance or characteristic[1]	Maximum permissible level
Barium (Ba) mg/L	0.7
Total mercury (Hg) mg/L	0.001
Cadmium (Cd) mg/L	0.003
Arsenic (As) mg/L	0.01
Cyanide (CN) mg/L	0.07
Nitrate (NO_3) mg/L	3
Lead (Pb) mg/L	0.01
Boron (B) mg/L	0.3
Selenium (Se) mg/L	0.01
Fluoride (F) mg/L	1.5
Chromium (Cr) mg/L	0.05

[1]For other parameters, see CES-58, Ethiopian Standards Agency 2013.

Bacteriological requirements: when tested the bacteriological requirements of treated drinking water must not exceed the levels shown in Table A3-4.

TABLE A3-4 — Bacteriological levels

Organism	Maximum permissible level
Total viable organisms, colonies per mL	Must not be detectable
Fecal streptococci per 100 mL	Must not be detectable
Coliform organisms, number per 100 mL	Must not be detectable
E. coli, number per 100 mL	Must not be detectable