

Research Paper

Inclusion of water quality testing in the Afghanistan Living Conditions Survey and status of bacteriological contamination of drinking water in 10 provinces of Afghanistan

Abdus Saboor, Ahmad Khalid Amarkhel, Esmatullah Hakimi, Robert Bain and Rolf Luyendijk

ABSTRACT

The UNICEF Multiple Indicator Cluster Survey module for water testing was included in the 2016/2017 Afghanistan Living Conditions Survey (ALCS) for 10 of the 34 provinces. The module's impact on the survey implementation was assessed through interviews and focus group discussions with survey teams. To assess the level of fecal contamination, drinking water from the source and at the point of consumption was tested for *Escherichia coli* using on-site membrane filtration. On-site testing of water generated significant interest from community members to receive water test results and understand how to keep their drinking water safe from contamination. The inclusion of the module in the ALCS facilitated access of the enumerators to both communities and households. Only 21.0% of households used safely managed drinking water services. A majority of households (58.2%) used water sources contaminated with *E. coli*, while *E. coli* contamination at the point of consumption was found in 77.0% of households. *E. coli* were more frequently detected in water sources used by households with unimproved sanitation. Beside improvement and increased protection of the water supply services, water quality deterioration between source and point of consumption calls for the promotion of safe handling and storage of water at the home.

Key words | drinking water quality, household survey, safely managed water services, Sustainable Development Goal

HIGHLIGHTS

- This study suggests that inclusion of water quality module for SDG 6.1 monitoring into household surveys seems highly feasible.
- *E. coli* contamination of drinking water was found higher at point of use than at point of collection particularly in water sources used by households with unimproved sanitation.
- Only 21% of households met SDG criteria of safely managed drinking water services in 10 of the 34 provinces of Afghanistan.

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INTRODUCTION

The indicator for the SDG target 6.1 on access to the supply of safe drinking water is the proportion of the population using 'safely managed drinking water services' (WHO 2017a, 2017b). A safely managed drinking water service is defined as an improved drinking water source that is located on-premises, available when needed, and free of *Escherichia coli* bacteria, an indicator of fecal contamination and priority chemical pollutants – arsenic and fluoride. 'Improved' drinking water sources include: piped water into dwelling, yard or plot; public taps or standpipes; boreholes or tube wells; protected dug wells; protected springs; packaged water; and delivered water and rainwater (WHO 2017a, 2017b). Microbial contamination of drinking water is responsible for the majority of the water-related health burden, and contaminated water can transmit diseases such as diarrhoea, cholera, dysentery, typhoid, and polio (WHO 2019). Evidence from a systematic review suggests that 1.8 billion people use a source of drinking water contaminated with *E. coli* bacteria (Bain *et al.* 2014). In many areas of developing countries and, specifically, in war-affected areas, the ability to conduct microbial testing is challenged by the availability of laboratory facilities, trained personnel, and essential infrastructure, such as electricity supply.

The WHO/UNICEF Joint Monitoring Programme (JMP) for Water Supply, Sanitation and Hygiene monitors and reports on progress toward SDG target 6.1 and 6.2. The UNICEF-supported Multiple Indicator Cluster Survey (MICS) is one of the main global data sources to support countries to collect nationally representative data on the situation of children and women (Khan *et al.* 2017). For monitoring access to safely managed drinking water services, the JMP and UNICEF-MICS teams have developed a water quality module for the direct testing of drinking water in household surveys (Bain *et al.* 2020). The module includes testing of *E. coli* bacteria, the globally recommended indicator for fecal contamination (WHO 2011). The module was introduced in 2012 in Ghana and has since been used in household surveys in >30 countries (WHO/UNICEF-JMP 2020). In addition to sampling the

drinking water source, samples are also taken at the actual point of use. This allows for the identification of a change in water quality between the point of collection and the point of consumption. An advantage of the integration of the water quality module in household surveys is the ability to assess disparities across all the stratifiers of the household survey, including geographic domains, urban and rural areas, and socio-economic groups (Dorea *et al.* 2020).

The Afghanistan Living Conditions Survey (ALCS), conducted by the Central Statistics Organization of Afghanistan (CSO), is the longest running and most comprehensive source of information about the social and economic situation of people in Afghanistan, and it is the main source for monitoring the implementation of the Sustainable Development Agenda in the country. The 2016/2017 ALCS was the sixth in a series and is carried out by an experienced team of enumerators most of whom have worked for the CSO for many years. The ALCS ran from April 2016 to March 2017. In response to the Sustainable Development Goal (SDG) challenge of reporting against progress toward safely managed drinking water services and with financial and technical support of the UNICEF Afghanistan Country Office (ACO), the Afghanistan CSO agreed to pilot and gain experience with the MICS water quality module during the last five remaining months of the ALCS 2016–2017. If successful, the module would be included in the next round of ALCS and possibly the USAID-funded Demographic and Health Survey – both of which were under preparation at the time.

The main research questions of this study were the following:

1. What lessons can be learned for future surveys implementing water quality testing in Afghanistan?
2. What is the level of fecal contamination of drinking water sources and water collected at the point of consumption in Afghanistan?

The pilot also allowed for the CSO to gain experience with the module to inform a decision whether to include it in future household surveys.

METHODS

Interviews and focus group discussions to record lessons learned from implementing water quality testing in the ALCS household survey

One week after completion of the survey, we conducted interviews with the enumerators responsible for the water quality module of all 11 teams and a focus group discussion (FGD) with all enumerators to determine the impact of the water quality module on the implementation of the ALCS survey. We used a standardized questionnaire for the interviews to document the interactions with the household members regarding the water quality test (interview questionnaire, Supplementary Material, Table 1). We also used a standardized questionnaire to document the enumerators' experience with the new low-cost membrane filtration kit and phase change incubator. Each interview lasted for about 25–35 min. No personal identifiers were documented.

Water quality module

The water quality module was piloted in 10 of the 34 provinces for the last 5 months (November 2016 to March 2017) of the on-going Afghanistan Living Conditions Survey (ALCS 2016/2017). Highly populated provinces were selected for the module, namely Kabul, Kapisa, Nangarhar, Khost, Badakhshan, Samangan, Balkh, Daykundi, Kandahar, and Herat. The two-stage cluster sampling approach was applied with 34 domains defined by the provinces plus one for the Kuchi (nomad) population. Within the province, enumeration areas (EAs) were selected with probability proportional to the number of households per EA. In the final stage of selection, clusters comprising of a fixed number of 10 households per EA were selected and numbered by the CSO cartographer (Central Statistics Organization 2018). Only three households (household number 1, 5, and 9) of the 10 from each cluster were selected for water quality module. From each house, two water samples were tested for *E. coli*, one sample directly from the water source of the house referred to as 'point of collection' and another from a glass or pot from which households usually drink water referred to as 'point of

consumption'. In case of source samples, water was first collected in sterile bags (Whirl-Pak 2020), and for the point of consumption, enumerators asked the household respondent for 'a glass of water that they would give to a child to drink' and directly tested water from the glass or any other vessel provided by the respondent. For quality assurance purposes, each survey team also tested a blank sample once in each cluster. The blank sample was boiled water assumed to have no *E. coli* provided by the supervisor to its team.

The presence of *E. coli* was assessed by filtering 100 mL of water through a 0.45 µm membrane filter using a low-cost filtration apparatus (Supplementary Material). The membrane filter was then placed onto compact dry *E. coli* growth media plates (Nissui 2009). Compact dry *E. coli* growth media plates have been demonstrated to perform favorably compared with laboratory reference methods (Joe *et al.* 2020). These ready-to-use, chromogenic plates for the detection of *E. coli* give results within 22–24 h. Incubation was achieved using specially designed phase-changing incubators to maintain a temperature of ≥ 30 °C even during the night. After 24 h, the number of blue colonies, signifying the presence of *E. coli* colony forming units (cfu), were recorded and classified into the following risk categories: low risk (<1 per 100 mL), contaminated (1–100 per 100 mL), and very high risk (>100 per 100 mL). If there were more than 100 colonies on the plate and in cases where the plate turned blue/green, this would be recorded as '101' to indicate 'too numerous to count' (MICS 2017). An information leaflet in Pashtu or Dari on handwashing and water treatment (English version in Figure 1) was provided to each household where water quality tests were performed. In response to requests from households and community leaders to be provided with the test results, the enumerators agreed to provide their telephone numbers for the households to call them the next day to obtain their test results. Test results were provided to all who contacted the enumerators.

Data analysis

Data analysis was conducted in Stata 16 and used svy to account for survey design. We calculated the proportion of samples in each *E. coli* risk level and reported 95% confidence intervals for the proportion of households where any *E. coli* were detected in the source of drinking water



یونیسف
د ماشومانو لپاره سره یو شی
برای اطفال متحد شوید

Handwashing with soap

When to wash your hands?



After coughing or sneezing



Before breastfeeding and feeding children



After touching people with contagious diseases (diarrhea, scabies, cholera)



Before preparing food



After using the bathroom



After cleaning children (diapering)

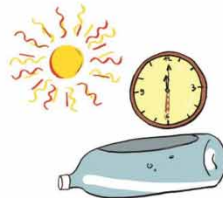
How to wash your hands?



Methods for treating water at home



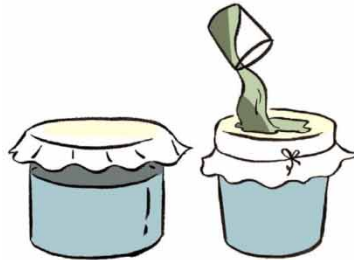
Boil water until the appearance of the first large bubbles for some minutes



Solar disinfection (6 hours)



Chlorination



Filter the water through clean cloth



Always store water in close and covered containers

Figure 1 | Information leaflet on handwashing and water treatment.

(point of collection) and glass of drinking water (point of consumption) and the proportion where over 100 *E. coli* per 100 mL were detected. Safely managed drinking water services were calculated based on households meeting all criteria set out by the WHO/UNICEF JMP, namely households reporting the use of improved drinking water sources, located on-premises, available when needed, and free from *E. coli* at the point of collection (UNICEF 2018). Water quality results and estimates for safely managed drinking water services for the 10 province pilot were disaggregated by the type of residence (urban and rural or Kuchi), the type of water source (piped, boreholes, protected wells and springs, unprotected wells and spring, surface water, and other), and sanitation facility used by households (improved, unimproved) and wealth quintiles. The wealth quintile analysis followed standard procedures outlined by the Demographic and Health Surveys but excluded WASH variables in order to mitigate potential tautology between the outcome (water quality) and asset index (Rutstein & Johnson 2004). The CSO teams from central and regional offices conducted field monitoring visits as part of the quality assurance for the water quality module.

Ethics statement

The CSO provided ethical oversight and approved interview protocols for the ALCS survey, and the interviews conducted following the pilot and provided microdata for the secondary analysis of the water quality findings. Survey teams were informed of the voluntary nature of the interviews and FGDs following the main survey. Written informed consent was acquired from all respondents before beginning the interviews and the FGDs.

RESULTS

Lessons learned from implementing water quality testing in the ALCS household survey

None of the households refused water quality testing. The enumerators reported that the water quality test was, in fact, considered an incentive by households to participate in the survey. All households asked to be provided with

the test results. Enumerators ($n = 10$) reported being asked for their telephone number – and in the absence of guidance to the contrary provided these to the survey respondents. In most cases, enumerators were called back the next day to communicate the test results. Half of the respondents (50%) asked how to solve the contamination problem if their drinking water was contaminated. Almost without exception, households asked for chlorine to disinfect their drinking water. Ten of the 11 enumerator teams responded to the questionnaire regarding provision of chlorine tablets. Four of the 10 enumerators (40%) mentioned that it would be good to provide chlorine tablets/sachet as gifts to the households where they tested the water. The information leaflet on handwashing and water treatment was considered useful by enumerators and was well liked by the community. Most enumerators (80%) advised improving the leaflet with photos, instead of plain text, and adding information on how to protect a water source from becoming contaminated – a common question that the enumerators could not readily answer. Almost all enumerators indicated that the leaflet was an essential item to provide to the households and community leaders (Malik and Imam). Many Imams indicated that they wanted to put the leaflets on the walls to remind people about ways to treat drinking water.

Often, the male enumerators tasked with conducting the water quality test were refused entry into the homes and they had to conduct the water quality testing outside of the home or even the compound on the street or sometimes in their guesthouses. The enumerators suggested that in the future, the CSO also trains female enumerators on conducting the water quality tests. Women, in Afghanistan, usually have much better access into the homes than men, and this would allow the enumerators to observe where the water for testing is actually taken from. Due to the interaction with the community members about the water quality testing, enumerators reported that they felt more at ease and safer conducting the ALCS survey than they did before the inclusion of the water quality module into the survey.

During the survey, Maliks (community leaders) and community elders usually asked for their drinking water to be tested as well. Enumerators strongly felt that they had to give in to at least some of these requests and in every cluster 1–2 water tests were conducted outside of the survey.

Similarly, prior to the survey, all enumerators also received requests for water testing from their friends, relatives, and neighbors, and most gave in to these requests.

Water quality results

The water quality module was implemented in 307 clusters. In total, 896 samples from point of consumption and 816 samples from water source (point of collection) of households were tested for *E. coli* bacteria. Overall, 58.2% of drinking water sources at point of collection and 77.0% at point of consumption were found to be contaminated with *E. coli* (Table 1). About half (45.5%) of the households in

urban areas and two out of three rural and Kuchi households (67.0%) in the 10 provinces used water from a source that was contaminated with *E. coli*.

Households using improved drinking water sources, including piped water and boreholes, were most likely to use a water source that was free from contamination. Fecal contamination was found in about half (48.9%) of the improved water sources. The results also indicate that access to water free of *E. coli* contamination is concentrated among the wealthier households and increases with increasing wealth quintiles. It is higher in urban areas than rural and Kuchi areas.

In many households, water quality was found to deteriorate between collection from the water source and at point

Table 1 | Percentage of households in selected provinces, by selected background variables, and by the risk level of fecal contamination based on the number of *E. coli* detected in drinking water

Background variables	Contamination at the point of collection % (95% CI)			Contamination at the point of consumption % (95% CI)		
	Contaminated (≥ 1 <i>E. coli</i> per 100 mL)	Very high risk (> 100 <i>E. coli</i> per 100 mL) ^a	N	Contaminated (≥ 1 <i>E. coli</i> per 100 mL)	Very high risk (> 100 <i>E. coli</i> per 100 mL) ^a	N
Total (10 provinces)	58.2 (52.7, 63.6)	7.0 (5.0, 9.7)	816	77.0 (72.6, 80.8)	9.6 (7.4, 12.5)	896
Residence						
Urban	45.5 (36.4, 54.9)	4.1 (1.9, 8.7)	237	67.1 (59.0, 74.3)	6.5 (3.7, 11.1)	268
Rural and Kuchi	67.0 (60.8, 72.8)	9.0 (6.3, 12.8)	579	84.2 (80.1, 87.6)	11.9 (8.9, 15.8)	628
Type of drinking water source						
Piped	38.9 (27.9, 51.2)	1.1 (0.2, 5.6)	151	61.7 (52.4, 70.2)	5.2 (2.5, 10.5)	173
Boreholes	49.2 (40.7, 57.8)	3.3 (1.4, 7.8)	299	74.6 (66.7, 81.2)	5.7 (3.1, 10.0)	311
Protected wells and springs	66.5 (51.0, 79.1)	3.1 (0.8, 11.6)	85	86.0 (77.3, 91.7)	9.6 (4.0, 21.5)	88
Unprotected wells and springs	78.7 (69.4, 85.8)	10.6 (6.0, 18.0)	160	85.0 (77.0, 90.6)	12.3 (7.1, 20.5)	176
Surface water	98.2 (92.7, 99.6)	40.4 (26.1, 56.5)	89	100.0	36.4 (24.5, 50.2)	106
Other	86.7 (66.2, 95.6)	10.9 (3.2, 30.9)	29	90.0 (72.7, 96.8)	9.1 (2.8, 25.8)	39
Drinking water source						
Unimproved	84.2 (77.8, 89.0)	19.2 (13.4, 26.8)	271	89.0 (83.5, 92.8)	19.6 (14.3, 26.3)	308
Improved	48.9 (42.5, 55.4)	2.5 (1.3, 5.0)	542	72.5 (67.1, 77.3)	5.8 (3.8, 8.8)	585
Sanitation facility						
Unimproved	71.7 (64.3, 78.1)	6.5 (3.9, 10.4)	347	87.9 (83.4, 91.3)	11.6 (8.2, 16.2)	382
Improved	51.3 (44.7, 57.9)	7.3 (4.8, 11.1)	469	71.3 (65.6, 76.5)	8.6 (5.9, 12.4)	514
Wealth quintiles						
Poorest	66.8 (55.4, 76.5)	16.1 (8.9, 27.5)	114	89.1 (79.9, 94.4)	17.7 (10.8, 27.6)	137
Poor	70.6 (61.7, 78.2)	11.9 (6.9, 19.9)	204	86.3 (80.3, 90.7)	12.3 (7.7, 19.1)	222
Middle	66.8 (55.5, 76.3)	6.7 (3.2, 13.8)	170	80.8 (72.4, 87.0)	10.9 (6.5, 17.7)	177
Rich	66.1 (54.6, 76.1)	4.8 (2.2, 10.4)	133	74.9 (64.7, 83.0)	7.2 (3.7, 13.5)	141
Richest	41.3 (32.1, 51.1)	2.6 (0.8, 8.1)	195	67.6 (59.0, 75.1)	6.2 (3.3, 11.2)	219

^aSecond column (very high risk (> 100 *E. coli* per 100 mL)) in Table 1 is subset of the first column (contaminated (≥ 1 *E. coli* per 100 mL)).

of consumption within the home. Table 1 shows that the proportion of households with *E. coli* detected in their drinking water increased between water source (58.2%) and the glass within the home (77.0%) and likely reflects contamination that occurred during household water storage and handling. The extent of water quality deterioration between water source and point of consumption is higher in urban households (from 45.5 to 67.1%) than in rural and Kuchi areas (67.0–84.2%). Households using improved drinking water sources, including piped water and boreholes, were most likely to use a water source that was free from contamination. Results also highlight the likely impact of unimproved sanitation on the quality of the water source. About 71.7% of the households having *E. coli* in their water source were also using unimproved sanitation facilities compared with those using improved sanitation facilities where *E. coli* was detected in 51.3% of their water sources.

Overall, only 13.0% of households in the selected 10 provinces were found to have water free of *E. coli* at the point of consumption. About half (51.1%) of the improved water sources were found contaminated with *E. coli* at the point of collection, and by the time it is used within the home,

more than one-third (72.5%) of the samples has *E. coli* contamination. The majority of rural and Kuchi households (84.2%) and around two-thirds of urban households (67.1%) were found to drink water that contains *E. coli*. A similar trend of impact of unimproved sanitation on water source was also identified in households with unimproved sanitation facilities which have a higher number of drinking water at the point of consumption to be contaminated with *E. coli*.

It is evident from Figures 2 and 3 that the proportion of samples with *E. coli* contamination increases at the point of consumption in all types of water supplies signifying unhygienic handling of water. The increase in contamination is highest at the point of consumption for drinking water collected from a borehole (27.8% pt.), followed by a piped water supply (26.9% pt.) and protected wells/springs (26.0% pt.).

Safely managed water services

Households with improved sources accessible on-premises, with sufficient quantities of water available when needed and free from *E. coli* contamination, meet the SDG criteria for 'safely managed' drinking water services. Table 2 shows

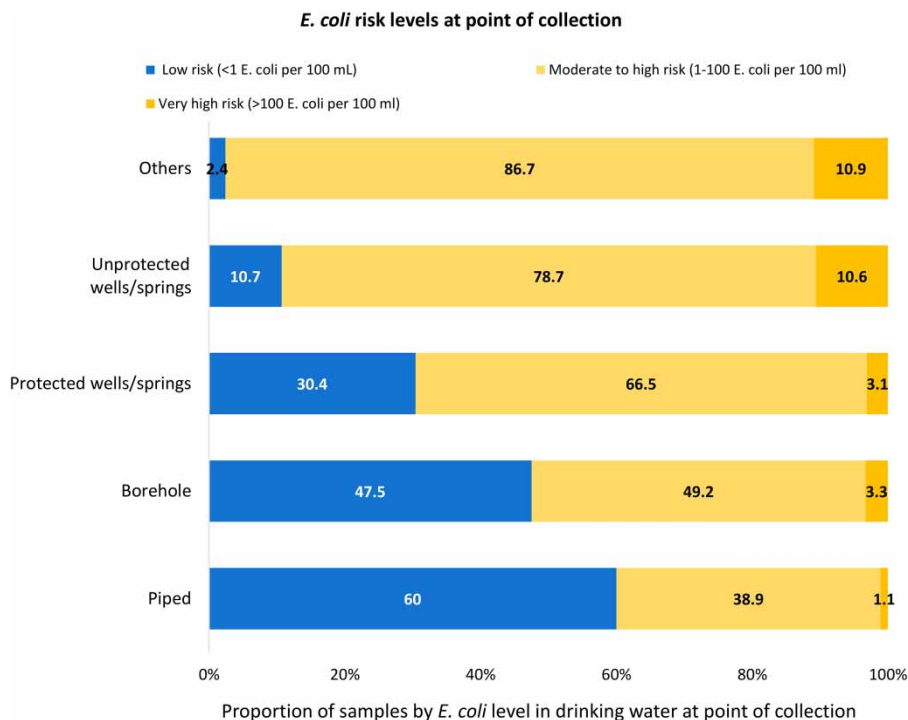


Figure 2 | Water quality by water source at point collection.

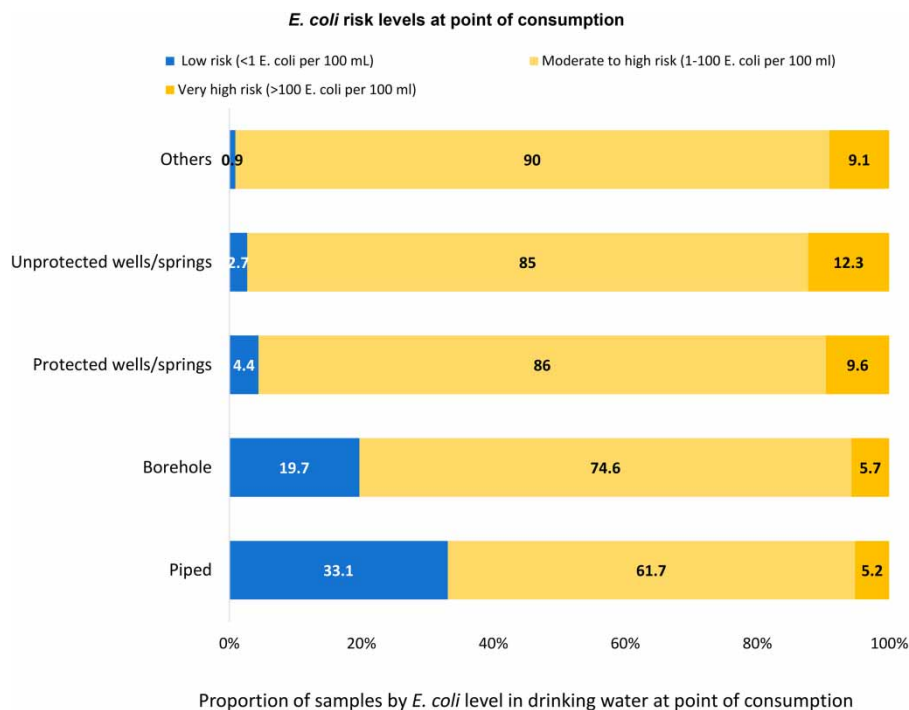


Figure 3 | Water quality by water source at point consumption.

Table 2 | Percentage of households in selected provinces that meet criteria of drinking water that is (a) improved, (b) accessible on-premises, (c) available when needed, (d) free from fecal contamination, and (e) safely managed, by residence and wealth quintile

Residence	a. Improved % (95% CI)	b. Accessible on-premises % (95% CI)	c. Available when needed % (95% CI)	d. Free from Contamination % (95% CI)	e. Safely Managed % (95% CI)	Number of households with data on safely managed services
Total (10 provinces)	73.9 (69.0, 78.2)	54.0 (48.5, 59.3)	68.0 (62.9, 72.8)	41.8 (36.4, 47.3)	21.0 (16.8, 25.9)	811
<i>Residence</i>						
Urban	91.8 (86.1, 95.3)	84.4 (77.5, 89.5)	73.3 (64.9, 80.3)	54.5 (45.1, 63.6)	36.7 (28.5, 45.7)	237
Rural and Kuchi	61.5 (55.0, 67.6)	32.8 (27.3, 38.9)	64.4 (57.7, 70.5)	33.0 (27.2, 39.2)	10.1 (7.0, 14.3)	574
<i>Type of improved drinking water source</i>						
Piped	100.0	78.7 (67.7, 86.7)	55.6 (44.5, 66.3)	61.1 (48.8, 72.1)	30.4 (21.0, 41.9)	151
Boreholes	100.0	61.5 (53.3, 69.2)	82.3 (75.4, 87.6)	50.8 (42.2, 59.3)	32.5 (25.1, 41.0)	299
Protected wells and springs	100.0	50.7 (36.6, 64.7)	70.7 (55.4, 82.4)	33.5 (20.9, 49.0)	8.3 (3.8, 17.2)	85
<i>Wealth quintiles</i>						
Poorest	59.3 (46.0, 71.4)	13.2 (7.7, 21.9)	61.5 (47.8, 73.6)	33.2 (23.5, 44.6)	4.4 (1.7, 11.2)	113
Poor	57.1 (47.0, 66.6)	30.5 (23.1, 39.0)	67.4 (57.1, 76.2)	29.4 (21.8, 38.5)	6.7 (3.4, 12.8)	202
Middle	66.5 (56.2, 75.4)	44.3 (34.8, 54.2)	62.0 (51.6, 71.5)	33.2 (23.7, 44.5)	12.7 (6.7, 22.6)	168
Rich	65.3 (53.9, 75.2)	49.5 (37.4, 61.6)	68.8 (58.2, 77.7)	33.9 (23.9, 45.4)	15.3 (9.4, 23.8)	133
Richest	94.9 (89.9, 97.5)	86.0 (79.1, 90.9)	72.8 (63.7, 80.3)	58.7 (48.9, 67.9)	40.3 (31.5, 49.7)	195

the proportion of the household with improved water sources located on-premises, available when needed, and free from contamination. It combines this information to provide estimates of safely managed drinking water services.

In the 10 provinces, 73.9% of households have access to improved water sources, 54% used a water service that was located within the dwelling or in the household's yard or plot ('accessible on-premises'), and 68% used a water service that was available in sufficient quantities during the last month ('available when needed'). Similar to other countries (WHO/UNICEF-JMP 2020), water quality was the major limiting factor for safely managed services as only 34.8% of households used a water source in which *E. coli* were not detected ('free from contamination'). Taken together, the findings from the ALCS pilot show that just two out of 10 households (21.0%) used safely managed services. Households in urban areas (36.7%) were more likely to use a water service that is safely managed compared with those in rural and Kuchi areas (10.1%), due to insufficient drinking water or water found to be contaminated with *E. coli*. Access to a safely managed water service is higher in the richest households (40.3%) and decreases with wealth quintile as only 4.4% of the poorest households have access to safely managed water service.

DISCUSSION

This study sought to document the findings from a pilot integrating water quality testing in the ALCS in Afghanistan, examining the impact of the implementation of the survey and the findings related to levels of fecal contamination in 10 selected provinces. The study was part of a wider initiative to support countries to integrate water quality testing in household surveys and address data gaps on safely managed drinking water services.

Lessons learned from implementing water quality testing in the ALCS household survey

The overall experience suggests that both survey teams and communities have shown a high level of interest in the water quality module and that its inclusion in the ALCS has

facilitated access to the survey teams to enter communities which, particularly in war-torn areas, is not always a given. Specific changes to the materials and the enumerator training are recommended to include training of female enumerators on the water quality module, provision of water disinfection materials, and redesigning the information leaflet. Sufficient time needs to be allocated in the workload of the survey teams, as our findings suggest that about 25 min are needed to administer the module. Out-of-survey water tests requested by community leaders or elders are sometimes hard to reject, suggesting that extra consumables may be provided to each team to enable them to do one or two additional tests per cluster. Capacity building consistent with the local context of the survey teams on the purpose of the module and how to communicate water results, information on water source disinfection, and protection from contamination is highly recommended for future surveys. Although none of the enumerators reported having reservations about providing their personal telephone numbers to survey respondents to obtain the water quality test results, this issue requires further consideration and exploration of alternatives as it constitutes an infringement on the right of privacy of the enumerators. The leaflet on handwashing and water treatment turned out to be helpful to respond to common questions raised by the communities. Communities appreciated photo-based information more than text, and instead of normal paper, laminated paper with color print was suggested as communities paste it onto the walls of community places. Discussions between survey teams and communities do provide an opportunity for raising awareness about water quality, but this falls beyond the mandate of survey field teams and is better addressed by other actors such as community health workers or local district health centers. However, enumerators should be provided with clear instructions and supporting materials on how to respond to, and engage in discussions with community members about the issue of drinking water quality. Based on the strongly expressed desire by households and community leaders to receive the results of the water quality tests, we suggest that survey authorities consider communicating the results of the water quality tests back to the households – when these households specifically request the results.

Water quality results

Similar to other studies (Shields *et al.* 2015), we found that drinking water at the point of consumption was more likely to be contaminated than water collected at the source. Households in urban areas (36.7%) are more likely to use a water service that is safely managed compared with those in rural/Kuchi areas (10.1%). Higher fecal contamination was observed in unimproved water sources (84.2%) than in improved sources (48.9%). The detection of *E. coli* in half of the improved water sources indicates that an 'improved drinking water source' cannot be equated to a safe drinking water source. The highest level of *E. coli* contamination was found in rural households, indicating the urgent need for targeted and effective interventions here. The extent of fecal contamination highlights the fragility and vulnerability of these water sources where current monitoring and maintenance of facilities are often inadequate. Overall, results indicate that just one in five households (21.0%) met SDG 6.1 standards for 'safely managed' drinking water. Drinking water both at source and point of consumption of the households lacking access to improved sanitation facilities is more likely to be contaminated than households having access to improved sanitation facilities as reported earlier by other studies (Palamuleni 2002; Kayembe *et al.* 2018). Not only unhygienic handling of water from the water source to the point of consumption but also unsanitary environmental condition, weak water supply infrastructure, and intermittent supply are likely to be associated with the decline in the quality of water. Significant inequalities between urban and rural and Kuchi areas and between the richest and poorest wealth quintiles across all four elements of the safely managed water service were identified. Households from the richest quintile are most likely to have higher service levels compared with households in the poorest.

CONCLUSIONS

The inclusion of the MICS water quality testing module in the ALCS increased access of the enumerators to both communities and households and generated significant interest from community members in the test results. Overall learning from the pilot suggests that the inclusion of the water quality

module into the future household surveys seems highly feasible and even desirable by both the enumerators and households/communities. Given that all households participating in the water quality testing asked the enumerators for chlorine tablets to disinfect their drinking water, the CSO may consider the provision of such tablets during survey implementation to households selected for the water quality module in future surveys. Guidance on communicating the results of the water quality test to the community needs to be strengthened, and female enumerators should be trained on using the module to increase access to the point of consumption which is usually inside the home and off-limits to male enumerators. The information leaflet about drinking water treatment and safe storage was found to be very useful and recommendations were made to improve it using photographs instead of drawings.

The extent of fecal contamination detected in this ALCS pilot highlights the fragility and vulnerability of these water sources where current monitoring and maintenance of facilities are often inadequate. Beside improvement in water supply services, water quality deterioration between collection from the water source and at the point of consumption calls for programmatic interventions for community education and the promotion of hygienic handling and storage of water to reduce exposure to fecal contamination through drinking water. The substantial inequalities in exposure to fecal contamination by household characteristics including residence and wealth also serve to highlight the importance of targeting interventions to improve water quality.

LIMITATIONS

This study has several limitations. The water quality data with a small sample size (<900) are representative of 10 out of 34 provinces of Afghanistan. The proportion of the population with access to improved water sources in seven of the selected 10 provinces (except three provinces: Kapisa, Diakundi, and Samangan) is better than national estimates (Central Statistics Organization *et al.* 2017), limiting the generalisability of the national water quality status. Several variables that may be associated with contamination in Afghanistan (e.g. handwashing and water treatment practices) were not covered by the ALCS survey. Since household surveys are conducted in a

wide variety of contexts, we may not have identified all challenges in security prone areas. Further work is needed to ensure that the water quality module is appropriate for other contexts and understood by respondents in these contexts. The feedback interviews and focus groups involved only survey teams, and efforts were made to capture community perspectives indirectly from survey teams. With limited numbers, the study may not have reached saturation on every topic explored. Nevertheless, patterns across the various evaluation techniques provided coherent, logical, and explainable patterns. We advocate for a continued agenda of testing survey tools across different settings which would ultimately build a more comprehensive body of evidence on the performance of survey tools.

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COMPETING INTERESTS

R.B. works for the WHO/UNICEF Joint Monitoring Programme, A.K.A. and E.H. work for National Statistic and

Information Authority (NSIA) Afghanistan formerly known as Central Statistic Organization (CSO). A.S. and R.L. worked for UNICEF Afghanistan. The authors' opinions do not reflect positions of NSIA or WHO or UNICEF.

DATA AVAILABILITY STATEMENT

All relevant data are included in the paper or its Supplementary Information.

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