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Perceptions and determinants of households' participation in a randomized evaluation on water quality testing and information in Southern Ghana

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Abstract

In this paper, we analyze perceptions and determinants of households' participation in a randomized experiment on water quality testing and information in southern Ghana. Beneficiary households assessed the components of the intervention including its relevance and adequacy in improving understanding of water quality issues. Motivating and constraining factors to participation in the randomized experiment are also assessed. We also estimate the correlates of participation in the intervention. Social and economic benefits derived from the intervention based on perceptions are compared with impacts of the intervention using an instrumental variable approach. We found evidence that subjective analysis estimates of the effects of the intervention are higher than the objective analysis estimates. Households generally perceived the intervention to be relevant in improving their understanding of water quality issues. However, there are differing opinions based on random assignment into either child or adult treatment groups on most- and least-liked attributes of the intervention, and also motivating and constraining factors affecting participation in the intervention. The factors that statistically and significantly influenced participation in the intervention include educational attainment, ethnicity, religious denomination and marital status of the household heads, in addition to the location of residence.

Keywords: Africa; Determinants; Ghana; Information; Perceptions; Randomized experiment

Introduction

Globally, about 663 million people do not have access to improved drinking water sources (United Nations Children's Fund [UNICEF] & World Health Organization [WHO], 2015) while drinking water sources for 1.8 billion (10^9) people suffer from *Escherichia coli* (*E. coli*) contamination (Bain *et al*., 2014). In recent times, dissemination of information on water quality to households has been

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gaining prominence and this has achieved considerable effects on safe water behaviors and water, sanitation and hygiene investment decisions. Some of these studies on water quality information have addressed arsenic and fecal contamination of water sources. For example, provision of arsenic contamination information leads to households switching to safe water sources (Madajewicz *et al*., 2007). Dissemination of fecal contamination information leads to safe water behaviors including a shift in water source choices and investments in water, sanitation and hygiene-related goods/products (Jalan & Somanathan, 2008; Hamoudi *et al*., 2012).

In the past two decades, development of low-cost in-field water quality testing kits (for instance, aquatest and compartment bag test (CBT)) has been gaining widespread recognition due to increasing interest in water quality issues (see Bain *et al*. (2012) for review of recently developed water quality test kits). However, little is known about end-users or households' perceptions and assessment of these test kits which will eventually lead to the adoption of such technologies. While this study was not structured to review a particular water quality testing technology, it provides some lessons to researchers and policymakers on how to factor in end-users or households' perceptions and assessment into future development of such technologies. In this study, we asked beneficiary households for their opinions on an intervention in water quality testing and information in southern Ghana and some of these views were related to the water testing kits (i.e. CBTs) we relied upon for the intervention. In addition, CBTs have been used in several studies in different settings (see for example Adank *et al*., 2016) and, based on our knowledge, none of the published studies have analyzed end-users or households' perceptions and assessment of this water quality testing technology. This paper fills this lacuna in literature.

Household or individual's perceptions have been studied on a variety of topics including climate change (Haque *et al*., 2012), quality of extension services (Buadi *et al*., 2013), malaria control programs (Brown *et al*., 2016), water use (Attari, 2014) and a national health insurance scheme (Jehu-Appiah *et al*., 2012). However, in the literature on randomized evaluations, few published studies have assessed the relevance of interventions from the beneficiary perspective. Design and implementation of interventions are largely resource based (or top-down) instead of demand driven (or bottom-up). In addition, lessons learnt (including successes or failures) based on beneficiary perspectives are largely undocumented or unpublished. Furthermore, based on our knowledge, no previous published studies on water quality testing and information interventions have evaluated the households' perceptions, which are relevant for stimulating enrollment of these interventions. This study also addresses this gap in the literature. Households' perceptions of randomized experiments could help policymakers and researchers gain insights on how to design effective policies, programs, and projects.

This paper makes other contributions to water quality literature. First, water quality is a major public health policy issue and has received considerable attention in the past years (see Hebert, 1985) and continues to generate a lot of interest as growing evidence suggests that improved water sources based on joint monitoring program (JMP) classifications do not necessarily mean the water is safe for human consumption (see Bain *et al*., 2014). Demand for environmental quality, particularly in terms of the effects of water quality on household behaviors and health outcomes have been studied in more detail in recent times (see for example Madajewicz *et al*., 2007; Jalan & Somanathan, 2008; Kremer *et al*., 2011; Lucas *et al*., 2011; Devoto *et al*., 2012; Hamoudi *et al*., 2012; Brown *et al*., 2014). In addition, determining whether water is safe requires testing for the physicochemical and microbiological properties, and it is least practiced in developing countries including Ghana. Therefore, addressing issues related to dissemination of water quality information, including the perceptions and factors influencing participation in such interventions, are relevant policy studies.

Second, the sustainable development goals (SDGs) have indicators that are related to water quality including those on food and nutrition security, and water, sanitation and hygiene. Therefore, training households on water quality testing and information will help in achieving the SDGs, particularly those related to water quality. Water quality testing and information is also relevant for water management. In addition, water quality monitoring has received international recognition with various frameworks and standards designed including that of the World Health Organization (WHO). For instance, based on WHO standards, water sources have to be tested at least twice per annum. Since previous studies have shown that there is increased water contamination from point-of-source to point-of-use, it is imperative to engage in frequent water testing at the household level. This study contributes to this policy framework by training households in resource-poor settings on how to perform water quality testing using an in-field testing kit.

Finally, this paper is similar to Heckman & Smith's (2003) study of the determinants of participation in social programs which identified factors faced by disadvantaged groups in the various stages of the participation process, including awareness, eligibility, and enrollment, among others. It is essential to understand the factors affecting participation in water quality testing and information in resource-poor settings. Furthermore, the study contributes to the literature on the role of intrahousehold allocation, how to employ group-based training approaches and assessing the effects of water quality testing and information. By disentangling the factors affecting school children and adult household members' participation, respectively, researchers and policymakers will be able to channel resources to ensure enrollment in interventions on water quality testing and information.

The main objective of this paper was to assess households' perceptions of a randomized evaluation on water quality testing and information undertaken in southern Ghana between 2014 and 2015. In addition, motivating and constraining factors affecting households' participation in the intervention are discussed. We also assessed households' perceptions of whether social and economic effects have taken place in the household or community due to participation in the experiment, and this is compared with an objective analysis based on the randomized evaluation design. We also formally analyzed baseline household correlates of participation in the randomized evaluation on water quality testing and information.

The main finding is that perceptions of households related to motivating and constraining factors are important in voluntary participation in water quality testing and information interventions. In addition, school children and adults have different perceptions of benefits/uses, most and least valued attributes, and motivating and constraining factors to participation in the intervention. We also find that participation in the intervention is influenced by educational attainment, ethnicity, religious denomination, and marital status of the household heads. Households' residence location also affects participation in the intervention. The study recommends that researchers and policymakers need to incorporate households' perceptions and assessment in the design of water quality interventions to stimulate participation.

Materials and methods

This section presents the materials and methods used for the study. The section starts with the description of the study sites, followed by research design and survey implementation which includes sampling and sample description, and ends with data analysis techniques.

Description of study areas

Ghana had a population of about 25 million based on the 2010 Population and Housing Census (PHC) and the Greater Accra region is one of the 10 administrative regions. Based on the 2010 PHC, the Greater Accra region is the second most populous region with about 4.01 million people (representing about 16.3 percent of Ghana's population). The Greater Accra region has 16 municipal, metropolitan and district assemblies (Ghana Statistical Service [GSS], 2012). The study was undertaken in Shai-Osudoku district and Ga South Municipal.

The capital of the Shai-Osudoku district is Dodowa. In 2010, the district had a population of 51,913 with the majority (76.7 percent) of its population residing in rural communities. About 48.7 percent of the population was male. Agriculture, forestry and fishing industry employed about 46.4 percent of the economically active population. The main drinking water source in the district was pipe-borne water, which accounted for 70.7 percent of all water sources with only 8.8 percent of households relying on sachet water. Sanitation is low, as 30 percent of the households relied on public toilets, followed by pit latrines (21.1 percent) and only 8.9 percent of the households relied on a water closet (WC). About 31.2 percent of the households defecate in the open including bushes (GSS, 2014a).

Weija is the capital of Ga South Municipal. Based on the 2010 PHC, it had a population of 411,377 of which 48.9 percent were males. The population residing in urban communities was 88.7 percent. In 2010, only 8.6 percent of the employed population was in agriculture, forestry and the fishery industry. About 65.5 percent of the households relied on pipe-borne water while 22.1 percent used sachet water. In terms of sanitation facilities, about 26.6 percent of the households used a WC, followed by those using pit latrines (24 percent) and public latrines (22 percent) (GSS, 2014b).

Research design, survey implementation, and data

The detailed research design, survey implementation, and data are described in an earlier publication (Okyere, 2017).

The water quality testing and information experiment was based on a cluster-randomized controlled design where the unit of randomization was at the public basic school level. Treatment assignment was undertaken by a third party who had no prior knowledge about the study sites. Randomization took place before we conducted the baseline data collection in April/May 2014.

In all, 16 public basic schools in the two districts were selected. From the public basic schools, a total of 512 random draw students from grade five to eight using STATA version 12.1 was undertaken. Thirty-two school children (representing 32 households) were randomly selected from each public basic school. Each child, therefore, represented one household. In order to generate unique households, selected siblings were replaced with students from our randomly selected replacement list. The sampling procedure took into consideration grade level and gender of the students.

Four public basic schools were randomly allocated into the child treatment group and four more were randomly allocated into the adult treatment group with the remaining eight public basic schools serving as the comparison group. The 512 households were apportioned into the treatment groups as follows: 128 households for the child treatment group, 128 households for the adult treatment group and 256 households for the comparison group. The treatment group was separated into the child treatment group and adult treatment group to identify the role of intra-household decision-making in the dissemination of water quality information. As the names suggest, the child treatment group had school children

as the participants in the intervention while the adult treatment group had adult household members such as parents or guardians as the participants for the intervention.

The intervention was rolled-out in three phases. In July 2014 (the first phase), hired community health nurses trained participants on how to undertake water quality testing using a CBT. The CBT kits test for *E. coli* in a given water sample. The training exercise was undertaken using designed training protocol (available upon request). This was a group-based training conducted with the selected public basic school serving as the venue. Then in October 2014 (second phase), procured CBTs were distributed to the participants to undertake their own water quality testing. In addition, handouts containing nine water quality improvement messages (information) were also distributed to the participants. In the third phase of the intervention undertaken in March 2015, the same handouts containing the water quality improvement messages were distributed to the participants. In the child treatment group, hired field assistants visited them in their schools to deliver the handouts while in the adult treatment group, hired field assistants visited their households (individualized delivery) to deliver the handouts.

Four waves of data were collected between April 2014 and June 2015. During the baseline survey (wave I) in April/May 2014, we successfully enumerated 505 households comprising of 125 child treatment households, 127 adult treatment households, and 253 comparison households. In the first follow-up survey (wave II) in November/December 2014, we collected data for 486 households which were made up of 115 child treatment households, 127 adult treatment households, and 244 comparison households. During the second follow-up survey (wave III) in January/February 2015, we enumerated 478 households comprising of 118 child treatment households, 115 adult treatment households, and 245 comparison households. In the endline survey (wave IV) undertaken in May/June 2015, we conducted interviews with 437 households which were made up of 109 child treatment households, 108 adult treatment households, and 220 comparison households.

We, therefore, relied on three wave panel data (excluding the baseline survey) which questioned participants in the intervention on their perceptions and assessment. As the comparison households never participated in the intervention, we dropped all samples in this category. In total, 692 household follow-up surveys were carried out comprising of 342 child treatment household surveys and 350 adult treatment household surveys.

The surveys collected detailed household socio-economic characteristics. In addition, participants provided responses on a wide range of variables regarding the operational performance of the intervention. The respondents were the participants in the intervention. For example, the relevance of the intervention in improving participants' understanding of water quality issues was assessed on a five-point Likert scale ranging from 1 'very useful', 2 'useful', 3 'somewhat useful', 4 'not useful' and 5 'not useful at all'. Furthermore, adequacy of the intervention in aiding participants to perform water quality testing was also assessed on a five-point Likert scale. Here, 1 represents 'strongly agree', 2 'agree', 3 'neither agree nor disagree', 4 'disagree' and 5 'strongly disagree'.

Data analysis

Descriptive statistics including means and standard deviations of variables linked to households' perceptions and assessment were computed. Pearson Chi-squared analysis was also undertaken to test the statistically significant differences between the two treatment groups on some of the variables related to perceptions and assessment. We also formally estimated the relationship between baseline covariates and household participation in the intervention using a linear probability model (LPM), and Logit

and Probit regressions. The data collected were analyzed using STATA version 14.0 (STATA Corp., 2015).

Results and discussion

Descriptive statistics

Table 1 presents the descriptive statistics of socio-economic characteristics of the households at the baseline survey. The majority of the households (75 percent) were headed by males. The mean age of the household heads was 48.1 years. Educational attainment of the household heads was generally low, as 63.9 percent had no formal qualification, followed by 26.9 percent with middle school leaving certificate/basic education certificate examination (MSLC/BECE), while only 9.2 percent completed senior secondary school or above. About 74.9 percent of the household heads were Christians reflecting the religious composition of the population in Ghana. About 41.6 percent of the household heads belonged to Ga/Adanbge ethnic group which is the native ethnicity in the study area. The majority of the household heads (74.2 percent) were married. About one-half (51.2 percent) of the household heads had farming as their primary occupation.

Table 1. Baseline summary characteristics of households.

Item	Both Treatment Groups	Child Treatment Households	Adult Treatment Households
A: Household Head Characteristics			
Gender of household head was male	0.750	0.696	0.803
Age of household (years)	48.067	47.816	48.315
Educational attainment of household head			
None	0.639	0.613	0.664
MLSC/BECE	0.269	0.290	0.248
SSSCE and above	0.092	0.097	0.088
Household head is a Christian	0.749	0.760	0.738
Ethnicity of household was Ga/Adangbe	0.416	0.488	0.344
Household head was married	0.742	0.720	0.764
Primary occupation of household head was farming	0.512	0.472	0.551
B: Household Socio-economic Characteristics			
Household lived in Ga South Municipal	0.496	0.496	0.496
Dwelling type was rooms/compound house	0.687	0.632	0.740
Occupancy was owner occupied	0.797	0.704	0.890
Household had access to internet	0.135	0.184	0.087
Household used improved sanitation	0.494	0.540	0.448
Household used improved drinking water sources	0.683	0.696	0.669
Main source of lighting was electricity	0.804	0.832	0.776
Household used charcoal or firewood as main fuel for cooking	0.925	0.888	0.961

Notes: SSSCE represents Senior Secondary School Certificate Examination.

The socio-economic characteristics of households reveal that 49.6 percent resided in an urban district (Ga South Municipal), 68.7 percent had dwelling type of rooms/compound house, 79.7 percent resided in their own buildings as owners, 13.5 percent had access to internet facilities, 49.4 percent used improved sanitation based on JMP classification, 68.3 percent used improved drinking water sources also based on JMP classification, 80.4 percent used electricity as their main lighting source and 92.5 percent relied on charcoal or firewood for cooking. Overall, household head and socio-economic characteristics were largely even among the two treatment groups.

Participation in water quality testing and information experiment

We used two datasets for this subsection: (1) survey data and (2) administrative data. During the training exercise, we collated the list of participants in the intervention. Therefore the administrative data is used to corroborate the survey data on participation in the intervention. In addressing ethical issues, field data enumerators were not presented with the list of participants. This was to avoid giving field data enumerators first-hand information concerning participation in the intervention which might influence the responses on some of the outcome variables. In addition, participation in the training exercise was a prerequisite for receiving the water testing kits and handouts on water quality improvement.

The majority of the households (81.1 percent) in both treatment groups received information to participate in the intervention on water quality self-testing (Table 2). Specifically, households in the child treatment group were more likely to be informed of their eligibility to participate in the intervention (87 percent versus 76 percent). This is not surprising as the delivery of information was through a project contact person (School Health Education Program (SHEP) coordinator) at the various public basic schools and school children had direct contact with these people who were teachers at the schools. The adult treatment group received the eligibility information through the selected student in the public basic school. This could explain the lapse in conveying the eligibility information to this treatment group. Similarly, there were more participants in the intervention in the child treatment group than the adult treatment group. Fewer males than females participated in the training exercise. The two

Table 2. Participation in water quality testing and information experiment.

Understanding of the Intervention	Both Treatment Groups	Child Treatment Households	Adult Treatment Households	*P-Value* of Pearson Chi-square Comparing Child Treatment with Adult Treatment
Household informed to participate in the intervention	0.811	0.865	0.758	0.000
Household had a participant in the intervention	0.712	0.854	0.574	0.000
Gender of participants (=male)	0.465	0.456	0.479	0.637
Number of days participants attended the training exercise				
Only Day 1	0.118	0.062	0.212	0.000
Only Day 2	0.065	0.054	0.083	0.246
Both Day 1 and Day 2	0.816	0.884	0.705	0.000

treatment groups had equal gender representation as the Pearson Chi-square analysis was not statistically significant at the traditional confidence intervals.

In terms of the number of days the participants attended the training sessions, the majority of the participants (about 82 percent) attended both day one and day two, followed by only day one (11.8 percent) and about 6.5 percent of the participants attended only day two. Attendance for only day one, and both day one and two differs across the treatment groups, with participants in the adult treatment group having less attendance for both day one and two, and being more likely to attend only day one of the training sessions. The results on participation are in line with those obtained in previous studies (Okyere, 2017). The motivations and constraints to participation in the intervention are examined next in Table 3.

Table 3. Motivating and constraining factors affecting participation in the intervention.

Reasons	Both Treatment Groups	Child Treatment Households	Adult Treatment Households	*P-Value* of Pearson Chi-square Comparing Child Treatment with Adult Treatment
Reasons for not attending both day 1 and day 2 (N = 55)				
Venue was too far from my house	0.036	0.000	0.049	0.400
Too busy with business or school activity	0.345	0.214	0.390	0.232
I was sick	0.200	0.429	0.122	0.013
The invitation or notice came very late	0.073	0.000	0.098	0.225
Other	0.345	0.357	0.341	0.915
Reasons for not attending training exercise after having been informed to participate (N = 31)				
Venue was too far from my house	0.097	0.000	0.107	0.551
Too busy with business or school activity	0.290	0.000	0.321	0.244
I was sick	0.065	0.333	0.036	0.046
The invitation or notice came very late	0.065	0.000	0.071	0.632
Other	0.484	0.667	0.464	0.505
Motivating factors for attending the training exercise				
Acquire skills in water testing	0.313	0.292	0.348	0.230
Compelled by school teacher to attend	0.099	0.113	0.076	0.221
Saw others going and decided to participate	0.019	0.012	0.032	0.151
To obtain knowledge on water quality	0.537	0.572	0.481	0.071
Other	0.031	0.012	0.063	0.003

Motivating and constraining factors affecting participation in the intervention

We proceed to analyze the motivating and constraining factors affecting participation in the intervention and the results are presented in Table 3. The main reasons for not attending both day one and two training sessions include being too busy with business or school activity (35 percent) and other reasons such as traveling, not aware or did not know of the training exercise, was not given test kits for personal use during training, and raining on the day of the exercise (35 percent). Sickness was reported by about 20 percent, 7.3 percent indicated that the invitation came late and 3.6 percent reported that the venue for the training exercise was far from their homes. Far venue and late invitation were only indicated by participants in the adult treatment group. Sickness was largely reported by participants in the child treatment group. The 'other' reasons for not participating in both day one and two of the training exercise were equally reported among the two treatment groups.

Reasons for not attending the training exercise after having been informed to participate were also assessed. In most cases, households cited other reasons such as traveling, did not know time and venue, visiting relatives and taking care of children (about 48.4 percent) followed by too busy with business or school activity (29 percent), then venue far from home (9.7 percent) with the least reason being sickness and late invitation (both at 6.5 percent). Sickness was largely reported by school children rather than adult household members. Far venue, late invitation and busy with business activity were only reported by adult household members.

Participants were asked about the motivating factors for their attendance in the training sessions. The major motivating factors cited by the participants were to obtain knowledge on water quality (53.7 percent), to acquire skills in water quality testing (31.3 percent), and compelled by school authority to attend (9.9 percent). The least motivating factor was related to peer effects where participants saw others going and decided to participate (1.9 percent).

Table 4 presents participants' perceived relevance and adequacy of the training exercise. The participants generally agreed and ranked the training exercise as adequate in improving their understanding of

Table 4. Perceptions of the relevance and adequacy of the training exercise.

Item	*N*	Mean (SD)	CV
Panel A: Both Treatment Groups			
Adequacy of training exercise in understanding how to perform water testing	418	1.610 (0.678)	42.083
Usefulness of training exercise in improving knowledge on water quality issues	416	1.577 (0.654)	41.477
Panel B: Child Treatment Households			
Adequacy of training exercise in understanding how to perform water testing	261	1.621 (0.695)	42.859
Usefulness of training exercise in improving knowledge on water quality issues	258	1.570 (0.664)	42.287
Panel C: Adult Treatment Households			
Adequacy of training exercise in understanding how to perform water testing	157	1.592 (0.650)	40.820
Usefulness of training exercise in improving knowledge on water quality issues	158	1.589 (0.640)	40.272

Notes: (1) SD indicates standard deviation. (2) CV represents the coefficient of variation. (3) *N* represents valid responses across the three follow-up survey waves. The five-point Likert scale used in assessing the adequacy of the training exercise in understanding how to perform water testing was as follows: 1 = strongly agree, 2 = agree, 3 = neither agree nor disagree, 4 = disagree, 5 = strongly disagree. The five-point Likert scale used in assessing the usefulness of the training exercise in improving knowledge on water quality issues was as follows: 1 = very useful, 2 = useful, 3 = somewhat useful, 4 = not useful and 5 = not useful at all.

how to perform water quality testing. Similarly, there was a high regard for the usefulness of the training exercise in improving knowledge on water quality issues. The average agreement of the adequacy of the training exercise was 1.61 with a standard deviation of 0.68 and coefficient of variation (CV) of 42.08. The usefulness of the training exercise in improving knowledge on water quality issues had a mean of 1.58 with a standard deviation of 0.65 and CV of 41.48. Overall, the mean ranks for the two indicators on the perceived relevance and adequacy of the training exercise were very similar across the two treatment groups. The relatively high CVs mean that participants generally agreed on the relevance and adequacy of the training exercise.

In Table 5, we analyzed perceptions on the most and least valued attributes of the intervention, and also asked participants to give opinions on how to improve upon the intervention. The two most-liked attributes of the intervention were all related to the test kits such as color changes of the tested water samples indicating the level of fecal contamination (23.9 percent) and the CBT (16 percent). Other most-liked attributes of intervention were the ability to differentiate between 'good' and 'bad' water (12.9 percent), ability to perform water quality self-testing (9.4 percent), everything concerning the intervention (11.3 percent) and training procedure (8.1 percent). About 9.2 percent of the participants could not indicate one particular attribute they liked most about the intervention. In general, the treatment groups differ in their most-liked attributes of the intervention for four indicators which are: ability to differentiate between 'good' and 'bad' water, ability to perform water quality self-testing, color changes of tested water samples indicating the level of fecal contamination, and nothing/do not know.

In terms of least-liked attributes of the intervention, about 52.7 percent of the participants could not cite anything negative concerning the intervention. About 26.2 percent of the participants cited bad scent/odor of the water samples after testing, followed by bad scent/odor of the growth medium (8.5 percent) and training and operational related issues, such as far venue from homes, did not like the size of the gloves, timing and duration of the training exercise, accounted for 6 percent. Time taken to get results was reported by about 0.9 percent while 2.6 percent of the participants reported perceived poisonous nature of the growth medium as their least-liked attributes of the intervention. Comparing the responses for the two treatment groups indicates that the least-liked attributes of the intervention differ among four indicators which are: bad scent/odor of water samples after testing, nothing/do not know, other test kit related issues, and time taken to get results.

Participants were also asked for their opinion on how to improve the intervention. About one-half of the participants could not give an opinion on how to improve the intervention. Among those that expressed their opinions, the key issues include the intervention should involve the whole students/community (16.8 percent), more test kits should be distributed (12.5 percent), and training and operational related issues, including inform participants early, increase the content of the training manual, more instructors needed, and training should be done on weekends, among others, (9.7 percent). In addition, 3.7 percent of the participants felt the intervention should be done regularly while 3.1 percent of the participants wanted test kits that produce 'less' scent/odor. Only 2.5 percent felt there was the need for some form of compensation/reward for participating in the intervention. When comparing the two treatment groups, the opinions expressed differ in terms of need pipe/water treatment equipment, nothing/do not know and use test kits that produce less 'bad' scent/odor.

Almost all the participants indicated their willingness to participate in the intervention in the near future and about one-quarter (23.2 percent) of the participants indicated that the timing of the intervention interfered with their business or work or school activities. These factors were equally reported among the two treatment groups.

Table 5. Perceptions on most and least valued attributes, and how to improve the intervention.

Item	Both Treatment Groups	Child Treatment Households	Adult Treatment Households	*P-Value* of Pearson Chi-square Comparing Child Treatment with Adult Treatment
Most-liked attributes				
Ability to differentiate between 'good' and 'bad' water	0.129	0.095	0.181	0.014
Ability to perform water quality self-testing	0.094	0.116	0.060	0.068
Colour changes indicating level of contamination	0.239	0.289	0.161	0.004
Everything	0.113	0.103	0.128	0.469
Information on water quality issues	0.092	0.073	0.121	0.117
Nothing/do not know	0.092	0.060	0.141	0.008
The CBT kit	0.160	0.177	0.134	0.270
Training procedure	0.081	0.086	0.074	0.666
Least-liked attributes				
Bad scent/odor of *E. coli* test bud/ growth medium	0.085	0.098	0.066	0.304
Bad scent/odor of water samples after testing	0.262	0.307	0.191	0.016
Growth medium perceived to be poisonous	0.026	0.019	0.037	0.294
Nothing/do not know	0.527	0.474	0.610	0.013
Other test kit related issues	0.031	0.047	0.007	0.040
Time taken to get results	0.009	0.000	0.022	0.029
Training and operational related issues	0.060	0.056	0.066	0.690
View/opinion on how to improve the intervention				
Involve the whole students/ community	0.168	0.144	0.206	0.142
More test kits should be distributed	0.125	0.128	0.119	0.808
Need pipe/water treatment equipment	0.025	0.005	0.056	0.005
Nothing/do not know	0.492	0.533	0.429	0.067
Should be done regularly	0.037	0.026	0.056	0.168
Should be rewarded/compensated	0.025	0.031	0.016	0.403
Training and operational related issues	0.097	0.087	0.111	0.478
Use test kits that produce less bad scent/odor	0.031	0.046	0.008	0.054
Perceptions on future participation and timing of the intervention				
Household would like to participate in the intervention in the near future	0.974	0.967	0.985	0.239
Timing of the intervention conflicted with business or work or income generating or school activities	0.232	0.220	0.253	0.435

Baseline correlates of households' participation in water quality testing and information

In this subsection, we formally estimate the baseline correlates of participation in the intervention on water quality testing and information. We present the results from three random effects regressions using data from the three follow-up surveys conducted in 2014 and 2015: LPM, i.e. coefficient estimated using OLS regressions, Logit and Probit models. The dependent variable is an indicator variable measured as 1 if household had a participant in the intervention and 0 otherwise. We run two regressions for each model: (1) a regression with treatment assignment, a dummy variable of household ever received WASH information at baseline survey, and the interaction of these two variables and, (2) a regression including baseline controls in addition to treatment assignment variable, ever received WASH information variable and its interaction. We report robust standard errors. All the estimated regressions passed the measure of goodness of fit as the p-values of the F-tests of joint significance were less than 5 percent; indicating that the regressors jointly and statistically significantly explain the variations in the regressand (i.e. participation in the intervention). Interestingly, treatment assignment into either child or adult group affects participation. In the LPM (i.e. the preferred model) we found that participation in the intervention on water quality testing and information is high in the child treatment group compared with the adult treatment group (Table 6, column (1)). This result is robust to regression specifications including additional baseline household and household head covariates (column (2)) and also using Logit and Probit models (columns (3)–(6)). This corroborates previous results which showed high participation in the child treatment group compared with adult treatment group.

The other baseline covariates met the *a priori* expectation. Households resident in urban district at baseline (by contrast to those residing in a rural district) were statistically significantly more likely to participate in the intervention, and a household head who belonged to the native ethnicity of the study area (Ga/Adanbge) significantly increased take-up. Household ever received WASH information at baseline does not explain participation, but household heads who were Christians (in comparison with non-Christians) significantly increased the likelihood of take-up of the intervention. This suggests that social groups are key determinants of participation in interventions. Married household heads, who apparently have more duties to perform at the household level, including child care, were less likely to participate in the intervention. Educational attainment of household heads to senior secondary school level and above (in comparison with those with no formal education qualification) increased the likelihood of participation. The results obtained from the LPM corroborated those obtained from the Logit and Probit models.

Effects of the intervention: comparing subjective versus objective analyses

This subsection compares subjective analysis using frequency analysis to objective analysis using instrumental variable (IV) estimation. The subjective analysis is based on respondents' self-report of the benefits/uses of the intervention rather than relying on actual information on water, sanitation and hygiene practices, and health outcomes. In comparing the results from the subjective analysis to that of the IV estimation (objective analysis), we found that subjective analysis should capture the self-report measure of potential benefits/uses of the intervention and thus should be higher than the actual benefits/uses estimates obtained by the IV estimation.

Table 6. Baseline correlates of participation in the intervention.

	(1)	(2)	(3)	(4)	(5)	(6)
	Participation in the Intervention (1 = Yes, 0 = No)					
Variables	LPM		Logit		Probit	
Child treatment	0.226** (0.105)	0.196* (0.112)	5.805*** (0.766)	6.677*** (1.357)	2.555*** (0.494)	3.076*** (0.827)
Households had ever received WASH information	0.011 (0.107)	−0.029 (0.107)	0.093 (0.975)	−0.494 (1.752)	0.296 (0.867)	−0.489 (1.311)
Child treatment* Households had ever received WASH information	0.136 (0.137)	0.160 (0.147)	1.527 (2.842)	3.088 (4.363)	1.319 (2.160)	2.309 (3.206)
Male headed households		− 0.002 (0.068)		− 0.155 (1.604)		−0.093 (1.049)
Head's age		0.019 (0.014)		0.477* (0.254)		0.305 (0.233)
Square of head's age		−0.000 (0.000)		−0.005** (0.002)		−0.003 (0.002)
Household head was married		−0.129* (0.066)		−4.496*** (1.485)		−2.432** (1.105)
Ethnicity of household head was Ga/Adanbge		0.156*** (0.059)		5.414*** (1.542)		2.967*** (1.107)
Household head was a Christian		0.125* (0.067)		3.771** (1.603)		1.920* (0.993)
Reference: Household head had no formal education						
MLSC/BECE		0.017 (0.038)		1.809 (1.208)		1.059 (0.717)
SSCE and above		0.076* (0.041)		6.566** (2.973)		3.553** (1.763)
Household size		−0.017 (0.031)		−0.733 (0.678)		−0.352 (0.500)
Square of household size		0.001 (0.002)		0.040 (0.036)		0.020 (0.026)
Household resided in Ga South Municipal		0.116* (0.064)		3.344* (1.752)		2.089* (1.160)
Dwelling type was rooms/compound house		0.052 (0.056)		1.949 (1.424)		1.109 (0.847)
Household had access to internet		0.044 (0.068)		−0.080 (2.073)		0.151 (1.584)
Household used improved sanitation		0.009 (0.056)		−0.378 (1.356)		−0.038 (0.864)
Household used improved drinking water sources		−0.088 (0.057)		−2.773* (1.633)		−1.435 (0.932)
Household main lighting was electricity		0.029 (0.070)		0.894 (1.693)		0.366 (1.055)
Constant	0.612*** (0.070)	0.140 (0.350)	3.500*** (0.529)	−8.938 (6.211)	2.822*** (0.425)	−5.829 (5.344)
Wave fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations (household-wave)	671	641	671	641	671	641
Number of households	242	233	242	233	242	233
Prob > chi^2	0.000	8.42×10^{-10}	0.000	4.71×10^{-9}	3.69×10^{-7}	0.00494

Notes: Robust standard errors in parentheses.
***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

Estimated subjective analysis of the effects of the intervention is higher than the objective analysis estimate. Table 7 presents households' perceptions on the benefits/uses of the knowledge from the water quality testing and information and this is compared with results from previous studies (Okyere, 2017; Okyere & Asante (undated)) which relied on IV regressions (Table 8). The perceptions

Table 7. Perceptions on the benefits/uses of the knowledge from the intervention.

Item	Both Treatment Groups	Child Treatment Households	Adult Treatment Households	*P-Value* of Pearson Chi-square Comparing Child Treatment with Adult Treatment
Benefits or uses of the knowledge from the intervention				
Ability to check or monitor water quality	0.282	0.305	0.246	0.234
Avoid or reduction in WASH-related diseases	0.035	0.039	0.029	0.608
Improved water storage and handling techniques	0.029	0.034	0.022	0.494
Increased awareness on water quality issues	0.059	0.044	0.080	0.172
Inform others on water quality issues	0.299	0.320	0.268	0.303
Nothing/do not know	0.070	0.059	0.087	0.324
Use safe or improved water sources	0.126	0.123	0.130	0.842
Water treatment	0.100	0.074	0.138	0.054
Other social and economic benefits of the intervention				
Improved community/ household spirit or involvement for water quality issues	0.245	0.220	0.289	ns
Improved women participation in discussions on water quality issues	0.067	0.049	0.099	ns
Increased awareness and capacity to disseminate water quality information	0.312	0.281	0.366	ns
Increased school attendance	0.085	0.085	0.085	ns
Increased use of improved water sources	0.451	0.443	0.465	ns
Decreased water-related or water-borne diseases	0.224	0.199	0.268	ns
Improved WASH behaviors in terms of water storage, handling and use	0.046	0.033	0.070	ns
Other	0.010	0.012	0.007	ns
None of the above/do not know	0.105	0.111	0.085	ns

Notes: ns denotes not specified as we do not perform Chi-square analysis for the variables under consideration. Percent of cases are reported for other social and economic benefits of the intervention as we are dealing with multiple responses.

Table 8. Impacts of the intervention on water, sanitation and hygiene behaviors, and health outcomes.

Item	Both Treatment Groups	Child Treatment Households	Adult Treatment Households
Improved main drinking water based on JMP	0.049	0.098***	−0.024
Improved secondary drinking water source	0.095**	−0.023	0.261***
Improved main general-purpose water	0.051	0.148***	−0.090
Satisfied with water quality	−0.103***	0.047	−0.321***
Household treat water to make it safer to drink	−0.031	−0.096***	0.063
Drinking water storage container is covered	0.039**	0.049***	0.027
Interior of drinking water storage container is clean	0.027	0.057***	−0.010
Surrounding of household is clean/average	0.030	−0.020	0.103**
Respondent mentioned at least three instances of handwashing yesterday	0.017	0.011	0.026
Household reported at least one diarrhea episode in the past one month	0.037	0.032	0.045
Household reported at least one malaria case in the past one month	−0.019	0.011	−0.064
Child had diarrhea in the past 4 weeks indicator	0.021	0.026	0.011
Child had malaria in the past 4 weeks indicator	0.010	0.037	−0.042
Change in water treatment, storage and handling techniques + ++	0.050**	−0.003	0.102***
Discussions on water quality + ++	0.239***	0.206***	0.271***

Notes: Estimates reported from previous studies (Okyere, 2017; Okyere & Asante (undated)) based on IV regressions. The random assignments to the treatment groups are used as instrument for participation in a similar estimation strategy used by Finkelstein *et al*. (2012) and Devoto *et al*. (2012). The estimates are compared with the non-participating households. The estimates are obtained from regressions without baseline covariates as results in Table 7 are simple means.
***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.
+ ++ The study applied intention-to-treat (ITT) estimation which is based on mean differences between the treatment group (s) and the comparison group as the questions were asked only in the follow-up surveys.

were based on open-ended question which were later coded. The most cited benefits or uses were informing others on water quality issues (29.9 percent), ability to monitor water quality (28.2 percent), use of safe or improved water sources (12.6 percent) and water treatment to make it safer for consumption (10 percent). Avoiding or reduction in WASH-related diseases was mentioned by 3.5 percent of the participants while improvement in water storage and handling techniques was indicated by 2.9 percent. About 5.9 percent of the participants mentioned increased awareness on water quality issues and 7 percent of the participants could not mention any benefits or uses of the knowledge from the water quality testing and information. When we compared the two treatment groups, there was equal understanding of the benefits/uses of the knowledge of the intervention except on water treatment which differs between the treatment arms.

Using structured questions with multiple responses, we wanted to understand if other social and economic benefits have been derived from the intervention. Increased use of improved water sources was the most-derived benefit of the intervention (45.1 percent), followed by increased awareness and capacity to disseminate water quality information (31.2 percent), with the least-mentioned benefit being others, including stopped polluting water sources (1.03 percent). Other perceived benefits/uses of the intervention included improved community/household spirit or involvement of water quality issues (24.5

percent), decreased water-related or water-borne diseases (22.4 percent), improved WASH behaviors in terms of water storage, handling and use (4.6 percent) and increased school attendance (8.5 percent). About one-tenth of the participants did not know or could not provide responses that matched the structured questions.

In Table 8, we present the results from an IV analysis on the impacts of the intervention on water, sanitation and hygiene behaviors, and health outcomes. Households in the child treatment group were 9.8 percentage points more likely to report using improved drinking water sources. We find no statistically significant result for households in the adult treatment group. Use of improved secondary drinking water sources increased by 9.5 percentage points in both child and adult treatment groups. In the adult treatment households, there was an increment of 26.1 percentage points in comparison with non-participating households, but we do not find a statistically significant result for households in the child treatment group. Use of improved general-purpose water sources increased by 14.8 percentage points in the child treatment households. We do not find a statistically significant result for adult treatment households. Satisfaction with water quality decreased by 10.3 percentage points in both child and adult treatment groups. In the adult treatment group, satisfaction with water quality decreased by 32.1 percentage points.

Water treatment by households to make it safer to drink is 9.6 percentage points lower in the child treatment group. We do not find statistically significant results for households in both child and adult treatment groups and also for those in the adult treatment group. Covering of drinking water storage container was 3.9 percentage points higher in both child and adult treatment groups and also about 4.9 percentage points more in the child treatment group. We find no statistically significant result for households in the adult treatment group. Households in the child treatment group were 5.7 percentage points more likely to have the interior of drinking water storage observed to be clean. There are no statistically significant results for households in the adult treatment group and also for those in both child and adult treatment groups. Households in the adult treatment group were 10.3 percentage points more likely to have clean/average surroundings. We found no statistically significant results for households in both child and adult treatment groups and also those in only the child treatment group. There is an increase of 5 percentage points in changes in water treatment, storage and handling techniques in households in both child and adult treatment groups. We also found an increment of 10.2 percentage points in changes in water treatment, storage and handling techniques in households in the adult treatment group. We do not find a statistically significant effect for households in the child treatment group. Discussions on water quality increased across all the treatment assignment indicators. Finally, we do not find statistically significant effects on either household health outcomes or child health outcomes. Even in some cases we rather found increases in self-reported cases of either diarrhea or malaria. The main conclusion is that the subjective analysis overstates the benefits of the intervention in comparison with the objective analysis.

Conclusions

In this paper, we analyzed households' perceptions of a cluster-randomized controlled experimental design on water quality testing and information in southern Ghana. The intervention involved three phases, where in the first phase participants were trained on water quality self-testing using a group-based approach and the second phase involved households testing their stored water for *E. coli*

contamination using a CBT and also receiving handouts containing water quality improvement messages. The third phase involved the repeat of the dissemination of the water quality improvement messages used during phase two of the intervention. The first phase was completed in July 2014, with the second phase undertaken in October 2014 and the third phase took place in March 2015. There were two categories of participants: (1) school children and (2) adult household members. Hired community health nurses undertook the training exercise using a designed protocol. The training exercise used the various public basic schools as the venue while the water quality testing took place at the various households. Beneficiary households indicated their perceptions on the relevance and adequacy of the training exercise and also benefits/uses of the intervention.

By capitalizing on the group-based training program and dissemination of water quality information, we are able to assess the effects of the intervention based on subjective analysis using participants' perceptions and this is compared with objective analysis using IV estimation. Because of the cluster-randomized experimental research design, the use of the IV estimation is not subject to some of the econometric issues related to the choice of valid instruments and can be used to corroborate the estimates from subjective analysis. By relying on the random assignment into the treatment groups, we are able to isolate the causal effect of participation in the intervention on water, sanitation and hygiene behaviors, and health outcomes. The effects of the intervention based on subjective and objective analysis are at variance with each other. Subjective analysis estimates of the effects of water quality testing and information overstate the effects on water, sanitation and hygiene behaviors, and health outcomes. However, the estimates from the subjective analysis are consistent with those from the objective analysis in terms of the key variables which showed some effects due to the water quality testing and information intervention.

Our study showed that households in southern Ghana are willing to participate in intervention on water quality testing and information and intra-household decision-making affects participation. We found that school children are more willing than adult household members to participate in such interventions and this may be due to a genuine quest to obtain knowledge on water quality issues instead of peer effects.

Baseline correlates of households' participation in the intervention are estimated and the results show that baseline factors that influence participation include educational attainment of the household heads to senior secondary school and beyond, household heads' ethnicity being Ga/Adangbe (the native tribe or ethnic group of the region of study), residence in urban district, married household heads, and household heads who were Christians. Based on traditional/cultural or religious values in many African countries, tribe/ethnic or religious groups as social groups could influence decision-making including voluntary participation in interventions. The results imply that household heads' social status affects participation in water quality testing and information intervention.

We found evidence of obtaining knowledge on water quality issues and acquiring skills on water quality testing as motivating factors affecting participation in intervention on water quality testing and information. We also found evidence of busy with business or school or income generating activities, sickness, late invitation or notice, and traveling as constraining factors affecting participation in the water quality testing and information experiment.

Our result suggests that group-based training programs are adequate in improving households' understanding of water quality issues and existing institutions could be used to disseminate water quality information to households in low resource settings. The results from the study are important inputs into the design of interventions on water quality testing and information, although there is the need for further studies using national representative samples in other geographical locations.

In conclusion, households generally perceived the intervention to be relevant and adequate in improving their understanding of water quality issues. However, the participants (school children versus adult household members) had differing views concerning enrollment in the intervention with respect to benefits/uses, most and least valued attributes, and motivating and constraining factors. The findings from the study suggest that perceptions of motivating and constraining factors are key to voluntary participation in water quality testing and information interventions. Perceptions relating to water test kits, particularly scent/odor and color changes are found to be important. Researchers and policymakers need to incorporate households' perceptions and assessment in the design of interventions to stimulate participation.

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