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Approaches to Increase Arsenic Awareness in Bangladesh: An Evaluation of an Arsenic Education Program

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Abstract

The objective of this study was to design and evaluate a household-level arsenic education and well water arsenic testing intervention to increase arsenic awareness in Bangladesh. The authors randomly selected 1,000 study respondents located in 20 villages in Singair, Bangladesh. The main outcome was the change in knowledge of arsenic from baseline to follow-up 4 to 6 months after the household received the intervention. This was assessed through a pre- and postintervention quiz concerning knowledge of arsenic. Respondents were between 18 and 102 years of age, with an average age of 37 years; 99.9% were female. The knowledge of arsenic quiz scores for study participants were significantly higher at follow-up compared with baseline. The intervention was effective in increasing awareness of the safe uses of arsenic-contaminated water and dispelling the misconception that boiling water removes arsenic. At follow-up, nearly all respondents were able to correctly identify the meaning of a red (contaminated) and green (arsenic safe) well relative to arsenic (99%). The educational program also significantly increased the proportion of respondents who were able to correctly identify the health implications of arsenic exposure. However, the intervention was not effective in dispelling the misconceptions in the population that arsenicosis is contagious and that illnesses such as cholera, diarrhea, and vomiting could be caused by arsenic. Further research is needed to develop effective communication strategies to dispel these misconceptions. This study demonstrates that a household-level arsenic educational program can be used to significantly increase arsenic awareness in Bangladesh.

Introduction

In Bangladesh, it has been estimated that half of the 10 million tubewells in the country do not meet the World Health Organization (WHO) guideline for arsenic of 10 μg/L because of naturally occurring arsenic in the groundwater of the Bengal Basin (Ahmed, Ahuja et al. 2006). Drinking water containing elevated levels of arsenic has been associated with cancers of the skin, bladder, and lung (Morales, Ryan et al. 2000; Chen and Ahsan 2004; Marshall, Ferreccio et al. 2007), reproductive and developmental effects (Calderon, Navarro et al. 2001; Wasserman, Liu et al. 2011), cardiovascular disease (Chen, Factor-Litvak et al. 2007; Chen, Graziano et al. 2011), skin lesions (Haque, Mazumder et al. 2003; Ahsan, Chen et al. 2006), reduced intellectual function in children (Wasserman, Liu et al. 2004; Wasserman, Liu et al. 2007; Wasserman, Liu et al. 2011)and mortality (Argos, Kalra et al. 2010).

Arsenic mitigation in Bangladesh, though significant, has impacted less than half of the affected population (Ahmed, Ahuja et al. 2006). The most common arsenic mitigation

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option in Bangladesh at 29% is well switching, which involves switching from an arsenic unsafe well to an arsenic safe drinking water source. This is followed by the use of deep tubewells by 12% of the originally exposed population. Studies have shown that deep aquifers are generally lower in arsenic. Arsenic mitigation options such arsenic filters and pond sand filter were utilized by only a very small proportion of the population. The current scientific literature which suggests that the temporal variability of arsenic in tubewell water is low (Steinmaus, Yuan et al. 2005; Z. Cheng 2005; Thundiyil, Yuan et al. 2007; Dhar, Zheng et al. 2008; Fendorf, Michael et al. 2010).

Despite the growing literature on the health implications of arsenic, millions of people in Bangladesh continue to drink well water containing elevated levels of arsenic even though arsenic safe water is often available from other wells located within a short walking distance (100 meters) (Van Geen, Ahsan et al. 2002). The majority of the arsenic communication materials developed in Bangladesh were created in early 2000. Since that time there has been a substantial increase in the scientific knowledge of the health implications associated with chronic arsenic exposure. There is an urgent need to update the health communication materials on arsenic.

Furthermore, there have been no attempts to develop arsenic educational materials based a theoretical framework. Our educational materials were designed based on constructs from the Health Belief Model. This model is used to predict why people will take action to prevent a potential health outcome. This model assumes that if individuals view themselves as susceptible to a health outcome (perceived susceptibility), believe that the consequences of having the health outcome are severe (perceived severity), believe that there is a course of action available to them to reduce susceptibility or severity of the health outcome (self-efficacy), and believe the benefits of this course of action outweigh the barriers, they are likely to take this action to reduce their health risk (Glanz 2008). Our educational materials focused on increasing perceived susceptibility and severity to arsenic related illnesses, and increasing self-efficacy to arsenic related illnesses through arsenic testing and well labeling to identify arsenic safe wells located in a respondent’s village.

In 2010, an arsenic education and water arsenic testing intervention was developed for rural villages in Singair, Bangladesh to increase awareness of the health implications of arsenic and methods to reduce arsenic exposure. A causal pathway was proposed in which the provision of household level arsenic awareness education and water arsenic testing services would increase awareness about arsenic in these communities, and thereby encourage households to utilize arsenic safe drinking water sources, leading to a reduction in urinary As. A decline in arsenic exposure, resulting from our intervention, has been described elsewhere (George et al. 2011). The purpose of this manuscript is to describe the arsenic education intervention itself and evaluate the effectiveness of the intervention in improving arsenic awareness as assessed through a pre- and post-intervention knowledge of arsenic quiz.

Methods

Setting

This study was conducted in a rural setting in Singair Upazila, located in the Manikganj district of Bangladesh. This site was chosen because of the wide range of water arsenic concentrations present.

Study Design

This study was an evaluation of an arsenic educational program disseminated to 1000 randomly selected households located in 20 villages in Singair, Bangladesh. Fifty eligible

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households, with one respondent each, were randomly selected from each village to participate in this study.

Eligibility Criteria

A household drinking water survey was administered to 6746 households in 26 villages as a screening tool for both village and household selection. The household drinking water survey obtained the following information about each household's primary drinking water source: Arsenic status (safe, unsafe, untested), well depth, and well installation date.

To be eligible villages had to have at least 40% of wells exceeding the Bangladesh arsenic standard, and at least 50 individuals who met the participant eligibility criteria. For individuals to be eligible for enrollment in the study they had to: 1) be the person in the household responsible for primary drinking water collection; 2) be using an untested well; and 3) be 18 years of age or older. Individuals were excluded if: 1) they had an arsenic filter; 2) obtained water from an arsenic treatment plant; and 3) did not have a primary well from which they collected most of their household's drinking water.

Intervention

This arsenic educational program provided household-level arsenic education to study households based on the current scientific literature concerning the health implications of As, previous studies assessing arsenic awareness in the population (Paul 2004; Aziz, Boyle et al. 2006; Caldwell, Smith et al. 2006; Parvez, Chen et al. 2006), and the results of our own three month arsenic educational pilot study.

Twenty village workers, selected by CCDB based on the recommendation of local village leaders, participated in this study. The arsenic testers resided in the upazlia where they worked and their demographics were similar to the villages they worked in (Table 1). These "As testers" were required to be at least 18 years of age and literate, assessed by a reading and writing test. Arsenic testers received a five day intensive training on how to effectively disseminate arsenic education and measure the arsenic content of wells using a field testing kit.

The arsenic testers went to each study household at least once to conduct a structured 40 minute arsenic educational session, measure the arsenic concentration of the household's primary well, and assist participants with unsafe wells to locate a nearby As-safe drinking water source. The arsenic testers conducted these tasks in each study village for three months.

The arsenic educational awareness session focused on disseminating 10 key arsenic educational messages on the health implications of arsenic and recommendations to reduce arsenic exposure. These key messages are presented in the supplementary materials. Anyone present in the community at the time the educational session was conducted was invited to attend. Participants were asked questions about the messages discussed, and were also encouraged to ask questions. At the end of each session, the audience was asked to pledge their commitment to drink arsenic safe water and share arsenic safe wells with others.

Evaluation of the intervention

The arsenic educational program was evaluated using a 20 item pre- and post-intervention quiz to assess the respondents' knowledge of arsenic. Each study respondent was interviewed at baseline and at follow-up, 4–6 months after receiving the intervention. In the baseline and follow-up questionnaires, information was obtained on sources of knowledge about arsenic and socio-demographic characteristics.

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In the quiz, respondents were asked questions on the following health implications of arsenic and arsenic mitigation options. This quiz can be found in the supplementary materials. One point was given for a correct item, and zero points for an incorrect item. Possible quiz scores ranged between zero and 20.

Statistical Methods

The primary hypothesis was that the provision of arsenic education and water arsenic testing would significantly increase knowledge of arsenic in the study population at follow-up in comparison to baseline. The outcome variable was change in knowledge of arsenic quiz score between baseline and follow-up. McNemar tests were used to compare differences between the baseline and follow-up knowledge of arsenic quiz scores. The determinants of baseline and follow-up knowledge of arsenic were evaluated.

Arsenics quiz scores were treated as a continuous variable. Linear regression was used to compare differences in quiz scores between groups of different attributes. Generalized estimating equations (GEE) were used to account for within village differences (Pan 2001). All analyses were performed using SAS, version 9.2 (SAS Institute Inc., Cary, NC, USA).

Ethics Section

The study protocol was approved by the Columbia University Medical Center Institutional Review Board and the Bangladesh Medical Research Council. Informed consent was obtained from all study respondents.

Results

Overall, 1000 participants received the arsenic educational intervention. The final response rate at follow-up was 97%. A total of 30 respondents had either permanently moved (29) or died (1). The demographic characteristics of the study population are summarized in Table 2. The mean age of the study respondents was 37 years (Range 18–102), and 99.9% were female. The majority of the study population could not read or write (60%). The average village size was 244 households; the population of each village ranged from 104 to 751 households. The baseline primary drinking water source of 46% of respondents was found to be unsafe relative to As. Household arsenic education sessions had between 2 – 31 participants (mean=8). On average, sessions were composed of 5 women, 2 men, and 3 children.

Baseline Sources of Arsenic Information

Participants were asked at baseline to report the media sources from which they obtained the most information about As. Five hundred eighty five participants (60%) reported obtaining the most information from television. The second most common source reported was radio. Twenty nine % reported receiving no information from media sources, and 4% reported receiving information from leaflets, posters, and books.

Pre- and post-intervention arsenic quiz score comparison

The knowledge of arsenic quiz scores for study participants were significantly higher at follow-up compared to baseline. The average quiz scores at baseline and follow-up were 8.5 and 14.1 (out of 20), respectively. The determinants of baseline and follow-up knowledge of arsenic were examined using GEE models (Table 3). Both at baseline and at follow up, the ability to read and write ($p < .0001$) and the level of education of the head of household ($p < .01$) were positively associated with quiz scores, while age was negatively associated with scores ($p < .02$).

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Respondents who received arsenic information from television and/or radio prior to the baseline survey were found to have a significantly higher scores at baseline when compared to those who received no information from media sources (p for ANOVA <0.05). Finally, those who received information from television and radio scored significantly higher than those who received only information from the radio or television alone (p for ANOVA <0.05). Follow-up knowledge of arsenic quiz score was significantly greater in those with unsafe wells who had more wells tested to locate an arsenic safe drinking water source (p = 0.0002).

Pre and post intervention quiz item comparison

All the responses to quiz items significantly improved at follow-up compared to baseline. Table 3 summarizes the changes in specific quiz items between baseline and follow-up. The quiz items were divided into the following four sections: Arsenic Standard and Identification of Sources; Health Implications of Arsenic Exposure; Disease Transmission and Removal of Arsenic; and Use of Arsenic Contaminated Water. Regarding the arsenic standard and identification of sources, at follow-up of those who answered incorrectly at baseline 98% and 99% respectively could correctly identify the meaning of a red and green marked tubewell. At follow-up, 61% of those who answered incorrectly at baseline could correctly define the Bangladesh arsenic standard. Of the 20% of respondents who at baseline incorrectly stated the source of arsenic contaminated water, 87% correctly answered this item at follow-up.

Regarding disease transmission and removal of arsenic, 67% of respondents who at baseline incorrectly stated that boiling water could remove arsenic answered correctly at follow-up. However, only 48% of respondents who at baseline incorrectly stated that eating or sleeping with an arsenicosis patient could cause the transmission of the disease answered correctly at follow-up.

Regarding the use of arsenic contaminated water, of the respondents who answered incorrectly at baseline, 100% and 96% respectively correctly stated at follow-up it was *not* okay to use arsenic contaminated water for drinking and cooking. At baseline over 80% of the study population stated incorrectly that it was *not* okay to use arsenic contaminated water for bathing, washing clothes, and washing animals. The majority of these respondents were able to answer correctly at follow-up. Furthermore, at follow-up it was found that the majority of households using unsafe wells at baseline who switched to alternative drinking water sources continued to use their previous tubewells for washing hands (95%), bathing (59%), and clothes washing (63%).

Regarding the health implications of arsenic exposure, although there was a significant increase at follow-up in the proportion of study respondents that could correctly identify the health implications of arsenic exposure, the majority were still unable to do so. Less than one third of those who answered incorrectly at baseline could correctly state at follow-up that cholera, diarrhea, and vomiting could not be caused by arsenic.

Conclusion

This study represents one of only a handful of studies in Bangladesh that provide scientifically rigorous methodology to evaluate the impact an arsenic awareness educational program implemented. This study provided an opportunity to assess the study population's current awareness of the arsenic problem. The study hypothesis was that the provision of arsenic education and water arsenic testing would significantly increase knowledge of arsenic at follow-up in comparison to baseline.

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Arsenic Awareness in the Population

At baseline, nearly 20% of the study population was unaware of the meaning of a red and green tubewell. This was surprising given that this area had received well water arsenic testing of all drinking water sources by the BAMWSP program in 2004. The results of the baseline survey also indicated confusion in the population regarding the health implications of chronic arsenic exposure. The majority incorrectly stated that cholera, diarrhea, and vomiting could be caused by As. This is consistent with previous studies that suggest a lack of understanding of the health implications of arsenic exposure beyond skin lesions (Hanchett, Nahar et al. 2002; Caldwell 2003; Paul 2004; Aziz, Boyle et al. 2006). At baseline, nearly 70% of participants incorrectly stated boiling could remove arsenic from drinking water, and that eating or sleeping with an arsenicosis patient could cause the transmission of the disease. Similarly, more than a decade ago, Hanchett et al reported that 41% of women surveyed (n=251) thought that arsenicosis was a contagious disease (Hanchett, Nahar et al. 2002). At baseline, the majority of participants were aware that one should not cook or drink with arsenic contaminated water. However, more than 80% of respondents incorrectly stated that water from an arsenic contaminated well should not be used for any purpose. These findings suggest that the current awareness in the population on the health implications of arsenic is low. Furthermore, many households are unaware of the safe uses of arsenic contaminated water, and how to effectively remove arsenic from water.

At baseline, the majority of study households had obtained their knowledge about arsenic from radio, television, family members, and neighbors. This result is consistent with a nationally representative survey conducted by Caldwell in 2000 (Caldwell, Smith et al. 2006). Arsenic information provided through television and radio was significantly associated with increased arsenic awareness in the study population at baseline. However, the majority of respondents still had an incomplete understanding of the health implications of arsenic and mitigation strategies. These findings suggest that more effective communication strategies are necessary to effectively disseminate these messages.

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Evaluation of the Arsenic Education Program

Overall, the arsenic education program was successful in increasing arsenic awareness. We observed a significant increase in follow-up knowledge of arsenic quiz scores compared to baseline quiz scores demonstrating support for our primary study hypothesis. The most important messages for reducing one’s as exposure were understood by almost the entire study population, i.e. the meaning of a red and green marked tubewell relative to arsenic (99%), and not to drink or cook with arsenic contaminated water (100% and 96% respectively). The majority of respondents correctly defined the arsenic standard in Bangladesh. The education program was also effective in increasing awareness on most of the safe uses of arsenic contaminated water. Furthermore the majority of households with unsafe wells at baseline who switched to alternative wells continued to use their previous wells for hand washing, bathing, and clothes washing. This is important because using a previously existing, albeit contaminated tubewell for *these* tasks often lessens the time required to collect water, and reduces the burden of sharing a well with another household.

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The educational intervention significantly increased the proportion of respondents who were able to correctly identify the health implications of arsenic exposure at follow-up. The majority of respondents who answered incorrectly at baseline correctly stated at follow-up that skin lesions and cancer could occur from arsenic. However, many of the study respondents still incorrectly reported that illnesses such as cholera, diarrhea, and vomiting could be caused by As. Furthermore, the majority of respondents also incorrectly stated at follow-up that eating or sleeping with an arsenicosis patient could cause the transmission of the disease.

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Our findings are consistent with two other educational intervention studies in Bangladesh. A study by BRAC, the largest non-governmental organization in Bangladesh, involved training community members to test tubewells for arsenic and provide arsenic awareness information. One year later the majority of respondents (55%) could not correctly identify the transmission of arsenicosis. Furthermore only 44%, of respondents were able to correctly identify two or more diseases associated with arsenic exposure (Hadi 2003). A second study of the 18 District Towns Project, an arsenic education and water arsenic testing program, found that many people were unaware of the less visible symptoms of arsenic exposure such as cancers and effects on child and maternal health (Hanchett, Nahar et al. 2002). These results indicate that future research is needed to develop effective media communication strategies to dispel these misconceptions.

A reduction in arsenic exposure associated with our intervention has been previously reported (Unpublished). The two main outcome variables used to assess arsenic exposure were self reported well-switching and change in urinary arsenic concentration from baseline to follow-up. Overall, 53% of respondents with unsafe wells at baseline reported switching to alternative wells at follow-up. The most common reported reasons for not switching wells among unsafe well owners were: 1) long distance to a safe well (57%); 2) family ownership of well (20%); and 3) owner(s) of safe wells near the respondent's home do not want to share (11%). Follow-up knowledge of arsenic quiz scores were positively related to well switching, although not significantly so. The average urinary arsenic concentrations for those with unsafe well at baseline who switched to safe wells at follow-up decreased significantly (Unpublished). These results demonstrate that this intervention was effective in encouraging the majority of households with unsafe wells to switch to alternative drinking water sources.

The unavailability of As-safe drinking water sources in a village was the greatest barrier to well switching. In villages with $< 60\%$ unsafe wells, 72% of respondents with unsafe wells switched, compared to 35% well switching in villages with $\geq 60\%$ unsafe wells. Walking time to a safe water source was also a significant barrier to well switching. Previous studies have indicated that well switching significantly declines if the nearest safe well is located > 100 meters away (Schoenfeld 2005; Chen, van Geen et al. 2007; Opar, Pfaff et al. 2007). A recent report of a nationwide survey in Bangladesh indicated that 77% of the population lives in areas with between 0–60% arsenic contamination (DPHE June 2010). Therefore, our intervention is a viable option for the majority of the population residing in arsenic affected areas of Bangladesh.

A limitation of this study was that there was not a control group. Therefore we are unable to distinguish the impact of the arsenic testing itself and the arsenic education that we provided on the knowledge of As. A second limitation was the relatively short three month duration of our program. We suspect that the impact of the intervention would be greater if provided over a longer duration.

In conclusion, these results suggest that arsenic education coupled with water arsenic testing programs can be used effectively to increase arsenic knowledge in the population. However, future research is urgently needed to identify why health messages on arsenic beyond skin lesions are being poorly understood, and to determine the factors that influence the misconception concerning the disease transmission of arsenicosis.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1

Characteristics of Study Population

Characteristics	Frequency	%
Gender (%)		
Female	999	99.9
Male	1	0.1
Religion (%)		
Muslim	913	94
Hindu	57	6
Respondent can Read and Write (%)		
No	584	60
Yes	386	40
Head of Household Education (%)		
No Education	510	54
Elementary or Higher	443	46
Radio Ownership (%)		
No	713	74
Yes	257	26
Land Ownership (%)		
No Land Ownership	122	15
Less than 1 Acre	475	59
1 to 2 Acres	206	26
Well Ownership (%)		
No	210	22
Yes	760	78
Proportion of Unsafe Wells in Respondent's Village (%)		
0–60%	632	65
Greater than 60%	338	35
Minutes to an Arsenic Safe Drinking Water Source for Unsafe well owners (%) (N=587)		
Less than or equal to 5 minutes	282	55
Greater than 5 minutes	227	45
Arsenic Status of Baseline Tubewell		
Safe	543	56
Unsafe	427	44

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Table 2

Determinants of Knowledge of Arsenic Quiz Scores at Baseline and Follow-up

Characteristics	Knowledge of Arsenic Quiz Scores N	Mean	SD	P-values[1]
Baseline Knowledge of Arsenic				
Respondent Read and Write				
No	595	7.7	2.7	<.0001
Yes	406	9.7	2.8	
Head of Household Education				
No Formal Education	526	7.8	2.9	
Level 1–5	233	8.8	2.6	0.0017
Greater than Level 5	224	9.8	2.9	
Age (Years)				
18–27	242	9.5	3.0	
27–36	269	8.7	2.8	<0.0001
36–43	252	8.2	2.7	
44–102	238	7.5	2.9	
Sources of Arsenic Knowledge				
No Radio or Television	312	6.8	2.8	
Radio	42	8.3	2.3	<.0001
Television	277	8.9	2.7	
Radio and Television	370	9.6	2.6	
Follow-up Knowledge of Arsenic[2]				
Age (Years)				
18–27	223	15.0	3.1	
27–36	263	14.8	3.3	0.0191
36–43	248	14.0	3.2	
44–102	236	12.8	3.5	
Head of Household Educational Level				
No Formal Education	510	13.4	3.4	
Level 1–5	226	14.9	3.3	0.0113
Greater than 5	217	15.1	3.1	
Respondent Reads and Writes				
Yes	584	13.3	3.4	<.0001
No	386	15.5	3.0	
Wells Tested to Locate an Nearby Arsenic Safe Well (Baseline Unsafe Well Users)				
1 Well Tested	176	14.2	3.4	
2 Wells Tested	129	14.3	3.5	0.0002
3 or More Wells Tested	192	15.1	2.9	

[1] p-values are from GEE models which were adjusted for all variables in each section of the table

[2] GEE model was adjusted for baseline knowledge of arsenic quiz score

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Table 3

Changes in specific quiz items between baseline and follow-up

Arsenic Educational Messages	% Incorrect at Baseline		% Correct at Baseline	
	N (%)	Follow-up % Correct	N (%)	Follow-up % Correct
Arsenic Standard and Identification of Sources				
Arsenic contamination is mainly found in tubewell water *	198 (20%)	87	772 (80%)	94
Bangladesh arsenic standard is 50 ppb *	950 (98%)	61	20 (2%)	50
Green marked tubewell is safe for arsenic *	193 (20%)	99	777 (80%)	99
Red marked tubewell is unsafe for arsenic *	162 (17%)	98	808 (83%)	99
Health Implications of Arsenic Exposure				
Cholera does *not* occur from arsenic exposure *	815 (84%)	22	155 (16%)	43
Diarrhea does *not* occur from arsenic exposure *	840 (87%)	25	130 (13%)	44
Vomiting does *not* occur from arsenic exposure *	838 (86%)	23	132 (14%)	39
Cancer can occur from arsenic exposure *	348 (36%)	61	622 (64%)	75
Skin Lesion can occur from arsenic exposure *	137 (14%)	91	833 (86%)	96
Disease Transmission and Removal of Arsenic				
Eating or sleeping with an arsenicosis patient does not cause the transmission of disease *	666 (69%)	48	304 (31%)	72
Arsenic cannot be removed by boiling water *	685 (71%)	67	285 (29%)	85
Use of Arsenic Contaminated Water				
It is *not* okay to drink arsenic contaminated water *	45 (5%)	100	925 (95%)	100
It is *not* okay to cook with arsenic contaminated water *	97 (10%)	96	873 (90%)	96
It is okay to wash hands with arsenic contaminated water *	798 (82%)	49	172 (18%)	71
It is okay to bathe with arsenic contaminated water *	835 (86%)	51	135 (14%)	75
It is okay to wash clothes with arsenic contaminated water *	790 (81%)	56	180 (19%)	77
It is okay to wash animals with arsenic contaminated water *	821 (85%)	54	149 (15%)	73

(1) There were a total of 970 respondents included in this table (2) p-values were calculated using a McNemar test for categorical variables and a paired t-test for continuous variables

* Indicates significantly difference from baseline at .01 or lower