

Domestic water improvement behaviour: the probability determinants and policy implications

Anthony Amoah^{a,b,*}, Rexford Kweku Asiamah^{c,d}, Kofi Korle^c and Edmund Kwablah^c

^aSchool of Sustainable Development, University of Environment and Sustainable Development, Somanya, Ghana

^bAfrica Centre for Applied Economics and Policy Research (ACAEP), Accra, Ghana

^cDepartment of Economics, Central University, Accra, Ghana

^dDST/NRF SARCHI Industrial Development, University of Johannesburg, Auckland Park, South Africa

*Corresponding author. E-mail: aamoah@uesd.edu.gh

Authors are listed in alphabetical order.

 AA, 0000-0002-3564-6464

ABSTRACT

Although water is important for human livelihoods, access and use of improved domestic water for households in most developing countries is still a major problem. Households adopt several domestic water improvement mechanisms to improve the quality of their water before consumption. However, the drivers of the probability to engage in this behaviour have not been adequately explored in developing countries. Therefore, this study investigates the factors that determine the probability of choosing to improve domestic water quality before consumption, with data from a household survey implemented in Ghana. Using the Logit econometric model with its associated margins, this study shows evidence that environmental knowledge, age, gender and wealth are key drivers of the probability of engaging in a water improvement behaviour. Based on the identified drivers, practical lessons are discussed to inform policy decisions on the quality of water supply.

Key words: Averting behaviour, Ghana, Household, Improved water, Logit, Marginal effects

HIGHLIGHTS

- This developing country study investigates the drivers of the probability to improve domestic water before consumption.
- The study applies econometric techniques to determine the drivers.
- The study finds a significant difference between those who choose to avert and otherwise.
- A significant proportion of the respondents engage in averting behaviour.
- The study shows that even with packaged water sources, households still avert.

1. INTRODUCTION

Water is a crucial resource for sustaining life. Its importance to development is confirmed, as global development organisations are working towards achieving Sustainable Development Goal (6), which relates to ensuring access to clean water and sanitation. Despite the progress made in improving access to water, there are still developing countries that have difficulties accessing potable water (World Bank, 2019). Globally, one in three people is unable to access safe drinking water, suggesting that there are people predominantly in the developing world who are at risk of water insecurity (United Nations, 2020).

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For those who have access to water, concerns about the quality of water they consume have arisen. According to the [World Bank \(2019\)](#), close to 40% of residents globally had access to safely managed drinking water in 2017, leaving a wider gap to be filled concerning the quality of water that the broader population use. The common practice, among many users, therefore, is to adopt averting behaviour. In this study, we define averting behaviour as mechanism users employ to improve the quality of domestic water before utilisation. Such behaviours include the use of packaged water (sachet or bottled), applying chemicals such as alum or antiseptic (e.g. Dettol), boiling, allowing water to settle, sieve water with a cloth or net before use. This behaviour is intuitive because high-quality water consumption is correlated with better health outcomes, and therefore, one would expect a rational consumer to choose quality water sources over poor-quality sources. In the event that quality sources are scarce, rational consumers adopt mechanisms to improve water quality ([Abrahams *et al.*, 2000](#); [Renzetti *et al.*, 2015](#)). The insecurity from water consumption, therefore, is the main issue in this paper. Hence, we seek to investigate the factors that will drive households to engage in an averting behaviour or otherwise.

In urban areas, population growth has contributed to an increased demand for public services. Similarly, for water supply, the state provider must incur higher costs to filter primary water sources and pump to outlets, in order to ensure that residents have clean water. Unfortunately, the free-rider problem is prevalent with such public goods and in no time, burst pipes and poor maintenance cause the state supplier to struggle with purifying the water that is supplied. Added to this problem is the pollution of water bodies like rivers, streams and others in rural areas by activities of mining firms, who end up leaving large amounts of chemicals in the water bodies and threatening human and aquatic life ([Attua *et al.*, 2014](#)). Water is price and income inelastic, and the probability to engage in an averting behaviour is a more practical mechanism used to avoid environmental risk. Residents usually dedicate certain fractions of their incomes to ensuring that they have quality water to support their upkeep ([Stoler *et al.*, 2020](#)).

Consequently, the Ghana Water Company Limited (GWCL) has plenty of surface water supplies to satisfy existing and potential urban market demand ([Yirenkyi-Fianko, 2019](#)). Unfortunately, the quality of groundwater and surface water supplies is starting to deteriorate at an alarming pace. This is primarily due to rapid population growth without corresponding infrastructure replacement and extension, pollution from mining fields, unsuitable waste disposal, agricultural and fishery chemicals, etc. (see [Yeleliere *et al.*, 2018](#)). Therefore, the declining quality of surface and groundwater supplies in recent times has rendered averting actions, which is a standard activity with urban households. Ghana Statistical Service data ([GSS, 2014](#)) indicates that although piped water is for general use, most households usually rely on sachet water as their main source of drinking water.

This paper addresses the following research question: What are the determinants of averting behaviour for water consumption of residents in the Greater Accra Region (GAR), Ghana? Admittedly, some literature focus on analysis of developing countries, this paper argues that the country perspective is important because certain country-specific characteristics could influence residents' averting behaviour for the water they consume. Earlier studies acknowledge the problem of extra burden of averting behaviour ([Dupont *et al.*, 2014](#); [Renzetti *et al.*, 2015](#); [Abrahams *et al.*, 2000](#); [Amoah, 2020](#); [Stoler *et al.*, 2020](#)). Generally, these studies acknowledge that averting behaviour drives cash water expenditures of households in developing countries. However, none of these studies focus on the problem by looking at the extent of averting behaviour for both aggregated sources and disaggregated sources of water for residents in Ghana. The paper empirically models household averting behaviour in water use and its associated drivers in an attempt to answer the research question.

This study contributes to the academic literature by generating new evidence that informs domestic water quality decisions in Ghana. Again, findings of this study contribute towards the revision of Ghana's national water

policy that seeks to guarantee sound water quality with recourse to relevant drivers that focus on household welfare.

The rest of the paper is structured as follows: Section 2 reviews theoretical and empirical literature regarding averting behaviour for water consumption, while section 3 presents the empirical strategy used in this paper. Section 4 discusses the results obtained from the analysis of data and section 5 presents concluding remarks and suggestions for policymakers.

2. LITERATURE REVIEW

The household production approach in consumer theory explains averting behaviour and the assessment of the link between averting expenditures and the economic cost of contamination. This theory is based on the opinion that satisfaction of households is not directly derived from all goods bought, but rather households use some of the goods and time as factors to produce services valued by the household. Thus, household production function, preferences and prices explain observed behaviour (Abdalla, 1990; Abdalla *et al.*, 1992).

In the case of averting behaviour models, households employ a number of sources to produce consumption goods. Some of these sources are contaminated. Thus, households respond to increased contamination of these sources in various ways known as averting behaviour. For instance, if the water source used by households for food preparation and cleaning is compromised, it reduces its aptness for such activities. Consequently, households may switch to bottled water consumption, hauling from other sources, boiling or installation of water purification systems (Abdalla *et al.*, 1992; Johnstone & Serret, 2012) to avoid exposure to health risk.

On the empirical front, averting behaviour is usually found to vary across households, depending on their socio-economic characteristics such as age, income, education, size and composition of household (Abrahams *et al.*, 2000; Johnstone & Serret, 2012; Tarfasa & Brouwer, 2013); perception of risk (Um *et al.*, 2002; Jakus *et al.*, 2009; Johnstone & Serret, 2012) and knowledge of contamination (Abdalla *et al.*, 1992; Boadu, 1992). These studies can be grouped into developed (Abdalla, 1990; Um *et al.*, 2002; Jakus *et al.*, 2009; Johnstone & Serret, 2012) and developing country studies (Vásquez *et al.*, 2009; Tarfasa & Brouwer, 2013; Amoah, 2017).

In a developed country analysis, Abdalla (1990) estimated economic losses from ground water pollution in Central Pennsylvania with about 5,000 people. The household survey was carried out via mail and 1,045 questionnaires were received. Employing an averting behaviour method, the authors found that the estimated household willingness to pay (WTP) for improved water was \$21/month/household. In a parallel study, Abdalla *et al.* (1992) estimated economic costs of groundwater contamination using a variety of averting behaviour decisions: installation of home water purification systems; the consumption of bottled water; hauling water from alternate sources and boiling water in Southeastern Pennsylvania. The authors revealed that the presence of children, knowledge of contamination and perception of risk are the drivers of averting actions. In both studies, household's engagement in averting behaviour is a reaction to groundwater contamination which has significant economic implications. However, the severity of contamination may differ across space which may affect willingness to pay. Thus, this needs to consider economic cost in policy formulation and implementation regarding safe drinking water.

Abrahams *et al.* (2000) also investigated the preference for bottled, filtered tap and unfiltered tap water for residents in Georgia. By applying the multinomial model, the authors found that the main drivers of bottled water consumption are age, race, perceived risk from tap water and concerns about water quality (appearance of tap water, odour and taste). The factors that influenced the choice of filtered water are income, perceived risk from tap water and information about prevailing or past challenges with tap water. Similarly, Um *et al.* (2002) estimated the WTP for improved water due to water contamination in Korea using an averting behaviour

method with perception measure. The authors found that subjective perception is the main determinant of averting behaviour and not actual water quality.

Jakus *et al.* (2009) also examined whether the perceived risk of arsenic contamination in tap water informed the choice of bottled water consumption. Using a sample with the evidence of arsenic contamination from four regions in the United States, the authors applied a survey method and revealed that the increase in perceived risk of tap water increases the expenditure on bottled water. They suggested the need for policymakers to determine whether perceived risk of consumers is appropriate from a public assessment, or the public provides adequate information on the risks of tap water consumption and the alternatives existing for households. Their findings are consistent with the previous studies by Abdalla *et al.* (1992) and Abrahams *et al.* (2000). Whereas Abdalla *et al.* (1992) and Abrahams *et al.* (2000) incorporated socio-economic factors, risk perception and information in their analysis, Jakus *et al.* (2009) focused only on perception. These studies demonstrate that both socio-economic factors and perception affect averting behaviour and should be considered in policy formulation and implementation.

In a panel analysis of 10,000 households in 10 OECD countries, Johnstone & Serret (2012) examined the factors that affect bottled water and purified water consumption. The authors used the probit model to examine the determinants of bottled water consumption and the multinomial logit model to analyse private water provision strategies. The study revealed that negative perception of tap water (health and odour) informed the choice of both bottled water and purified water consumption, but the effect on bottled water is much greater. Household size, income, length of residence and presence of children were found to be the significant drivers of water purification. Car ownership was found to have a positive and significant effect on bottled water consumption, while solid waste had a negative effect. These findings are consistent with the earlier country-specific studies by Abrahams *et al.* (2000) in Georgia and Abdalla *et al.* (1992) in Southeastern Pennsylvania.

In the most developing countries, the quality of drinking water is low. However, few studies have focused on household's averting behaviour. For instance, Vásquez *et al.* (2009) used a number of averting procedures to examine private investment alternatives to enhance the quality of drinking water for households in Parral, Mexico. They used a random sample of approximately 400 geographically stratified households. The authors found that consumers are sensitive to demand for water with respect to price. The coefficient of age was found to be negative, and age-squared positive, indicating that middle-aged respondent records lower willingness to pay. Education and income both had a positive and significant effect, but home ownership exerts no effect. Van Den Berg & Nauges (2012) also investigated the willingness to pay for piped water for 1,813 households in three districts in Southwest Sri Lanka. Employing hedonic house price analysis, the authors found that the WTP for piped water as a share of total income declines as income rises. They argued that the connection to the piped water network should be weighed against access and reliability of alternative water sources.

Regarding recent evidence from Ghana, Amoah (2020) estimated how much people in Ghana spend on averting behaviour as a mechanism to improve their domestic water quality. The study found that households spend Ghs84.30 (\$14.70) per month which constitutes 13.25% of their take-home income. Similarly, several other studies have demonstrated people's commitment to averting behaviour through their unflinching willingness to pay for an improved domestic water source. For example, using the choice experiment method, Tarfasa & Brouwer (2013) estimated the public benefit of urban water supply improvements in Ethiopia. The authors revealed that regardless of income constraints, households are willing to pay for improved water supply. Women and poor households were found to value improvement in the water quality most. Similarly, Boadu (1992) examined the effect of socio-economic factors on household's WTP for water in selected rural communities in Ghana. Using survey data, the author revealed that household income and history of water-related

illness had a positive and significant effect on WTP. It is likely that household's WTP for improved water is to avoid the high medical bills associated with ill health.

Likewise, Amoah (2017) developed an innovative borehole system with an averting technology and estimated household's WTP for water from the system. Regarding data collection, a multistage quota sampling technique was used to select 610 respondents from seven rural districts in the Greater Accra Region of Ghana. The study applied two unique valuation techniques and found that households are willing to spend between 3 and 6% of their household monthly income to access water from the innovative averting mechanism. Furthermore, the author found that income, gender and reliability of improved water supply were positive and significant determinants of WTP for improved water. However, age was found to be negative and significant contrary to the *a priori* expectations, indicating that older folks are less likely to pay for improved water. This phenomenon could be attributed to the differences in taste and preferences for different age groups and also to the fact that the youth are early adopters of innovation. The author proposed the use of cost-effective averting technology to reduce household water cost.

Regarding domestic water consumption, scores of studies have estimated averting expenditures using different methods. These include an averting behaviour method, travel cost, hedonic pricing, contingent valuation, choice experiments, etc. (see Abdalla *et al.*, 1992; Johnstone & Serret, 2012; Tarfasa & Brouwer, 2013; Amoah, 2017, 2018, 2020). However, there is paucity of literature on the factors that can influence household's decision to engage in averting behaviour in developing countries. This study seeks to fill the gap by investigating the determinants of averting behaviour in domestic water use in Ghana.

3. CONCEPTUAL FRAMEWORK

The theory of consumer behaviour suggests that the choice of a rational consumer maximises his utility. Thus, the utility, which is obtained by a consumer from consuming water from an improved source as a result of engaging in an averting behaviour, is expected to be higher relative to the utility from an unimproved source. This behaviour is explained by the Additive Random-Utility theory or method (ARUM) (McFadden, 1978). Similar to Mensah & Adu (2015), the ARUM is used to model household's choice of averting behaviour in domestic water consumption. We consider the case of a household faced with two options, that is, either the household engages in domestic water averting behaviour or not. If we assume the household engages in averting behaviour, then the satisfaction the household would derive depends on a number of observable factors (household characteristics, e.g. age, income and education), non-household-specific factors (e.g. location of residents) and unobservable components (e.g. inherent household preferences or some random factors). Thus, the utility derived from averting behaviour can be written as:

$$U_i = \partial_i + \varepsilon_i \quad (1)$$

where U_i is the utility derived by household i for engaging in averting behaviour; ∂_i is a vector of observed or deterministic component and ε_i is an unobserved component. Likewise, ∂_i is specified to depend on a vector of observable household characteristics (\mathbf{X}_i), thus $\partial_i = \beta_i \mathbf{X}_i$, where β_i is an unknown parameter to estimate. We re-write Equation (1) as Equation (2)

$$U_i = \beta_i \mathbf{X}_i + \varepsilon_i \quad (2)$$

For the simplicity of exposition, we assume that Y is the monthly income and R is the income loss or cost due to ill health for consuming poor (or unimproved) water quality. Thus, household's utility in a month where the

household engages in an averting behaviour and does not contract any water-related disease is $U(Y)$, and $U(Y - R)$ is the utility in the event that says a member of the household contracts a disease in the month for not engaging in an averting behaviour. Therefore, $U(Y) - U(Y - R)$ measures the difference between household utilities in a month for engaging in an averting behaviour. Thus, the probability that measures the difference in the utilities is:

$$\text{Prob}(U) = \text{Prob}[U(Y) - U(Y - R)] \quad (3)$$

where

$$\text{Prob}[U(Y)] > \text{Prob}[U(Y - R)]$$

The probability of the utility as a result of choosing to avert can also be written as:

$$\text{Prob}(U) = \text{Prob}[U(Y - R)] \quad (4)$$

Indeed, the reverse is true (i.e., no averting cost means $R = 0$). So, Equation (4) can be simplified as

$$\text{Prob}(U) = \text{Prob}[U(Y)] \quad (5)$$

From Equations (2) and (5), we specify the empirical model as

$$\text{Prob}(U) = \beta_1 + \beta_2 X_i + \varepsilon_i \quad (6)$$

4. METHODOLOGY

In the last Census for Ghana (i.e., 2010 Population and Housing Census, Final Report), the Ghana Statistical Service (GSS, 2012) identified 10 Districts and Municipal Assemblies in the Greater Accra Region (GAR). This present study is based on all the Districts and Municipal Assemblies in the GAR. In this region, while the total population is 4,010,054; the urban number of households is 733,955. Based on this, we used a representative sample of 1,650 household-heads to represent the households. The head presents a better representation of the household as by definition the head is generally responsible for the economic and social wellbeing of his/her household. In the absence of the household-head at the time of the enumeration, the next person in authority was interviewed on behalf of the household. Such persons were supposed to demonstrate knowledge about their domestic water use and averting behaviour of the household.

The data collection took place between April and May 2014. The sampling technique used in this survey is a multistage probability sampling technique. This sampling method is considered because of the haphazard settlement of most communities within the districts of GAR. To apply this method, first, the districts were defined as clusters yielding 10 unique clusters. Second, the communities within the clusters were listed in line with the Town and Country Planning Department's list of communities. Thirdly, using the simple random approach, the listed communities and households were randomly selected until the target quota for each community was reached. After the data were collated and cleaned, two observations were completely dropped from the dataset owing to missing responses. Thus, the sample size used for the study is 1,648. Furthermore, during the estimation, due to non-responses to some questions and further transformation of variables, the observations for our logit

model estimation dropped to 1,055. This is still considered as very high and representative for the purposes of this study.

One of the highly recommended instruments in a household survey administration is a structured questionnaire. This instrument was designed following two main standard national survey instruments. The questionnaire had a section on respondent's demographics, followed by a section on water, valuation and averting behaviour as well as sanitation and general environmental questions. After the first draft of the questionnaire, the questionnaire was given to experts in the field for their inputs and comments, after which a presentation of the study together with the questionnaire was made during an internal seminar for general faculty feedback. This study sought the needed ethical approval before commencing two pilot-surveys. Both pilot-surveys were analysed to provide useful feedback before the survey started.

The principal investigator employed four supervisors who are already experienced in surveys. Nonetheless, they were trained for this particular purpose. Together with the supervisors, 20 additional fieldworkers were employed and trained. The fieldworks were then placed into groups of five, with each group having one person acting as a lead supervisor. The core responsibility of the supervisor was to monitor the fieldworkers, randomly selecting and vetting the completed questionnaires and approving before the final submission. Despite the role of the supervisors, the principal investigator remained finally responsible for the supervision and upholding of ethical standards during the fieldwork. Another team was put together for the data entry, while the data cleaning was done by the principal investigator.

4.1. Empirical strategy

In this study, the outcome variable is of a binary nature; hence, one of the ideal econometric techniques for such estimations is the logit model. In line with the theoretical model in Equation (5), and empirical studies like Gujarati (1995), Amoah *et al.* (2020), Amoah & Addoah (2021), we specify a linear probability model of the form:

$$P_i = E(Y = 1 | \mathbf{X}_i) = \beta_1 + \beta_2 \mathbf{X}_i \quad (7)$$

where P_i is the expected probability that a household (i), which will engage in averting behaviour (yes = 1, otherwise = 0) to improve domestic water quality. This is contingent on a vector of household and their water-related characteristics (\mathbf{X}_i). We re-write Equation (7) in line with a logistic probability function and present it as Equation (8):

$$P_i = \frac{1}{1 + e^{-Y_i}} = \frac{1}{1 + e^{-(X_i'\beta)}}, \quad i = 1, 2, 3, \dots, n \quad (8)$$

In the event that the household does not engage in any averting behaviour, we treated that as otherwise and specified the equation as:

$$1 - P_i = \frac{1}{1 + e^{Y_i}} \quad (9)$$

The associated marginal effects of both probabilities are expressed as the ratio of Equation (8) over Equation (9):

$$\frac{P_i}{1 - P_i} = \frac{1 + e^{(X_i'\beta)}}{1 + e^{-(X_i'\beta)}} = e^{(X_i'\beta)} \quad (10)$$

Next, we log both sides of Equation (10) and present it as

$$\log \left[\frac{P_i}{1 - P_i} \right] = \log \left[\frac{1 + e^{(\mathbf{X}'_i \beta)}}{1 + e^{-(\mathbf{X}'_i \beta)}} \right] = Y_i = \log[e^{(\mathbf{X}'_i \beta)}] \quad (11)$$

Equation (11) is simplified to yield:

$$Y_i = f(\mathbf{X}'_i \beta) \quad (12)$$

Given that the dependent variable, Y_i , and the independent variables represented by vector, \mathbf{X}_i , we explicitly re-specify Equation (12) as an econometric model for estimation. This is presented as Equation (13):

$$P_r(\text{Avert}[Y]1|\mathbf{X}) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + u \quad (13)$$

where $P_r(\text{Avert}[Y]1|\mathbf{X})$ is the probability that a household engages in an averting behaviour or otherwise is conditioned on a vector \mathbf{X} , X_1 is a dummy variable for local or international environmental knowledge (*knowledge*), X_2 is the age of the respondent in years (*age*), X_3 is the age-squared (*age*²), X_4 is the gender (*male*), X_5 is the household size (*HH*), X_6 is a dummy variable for access to the water system in residence (*access*), X_7 is log of savings (*wealth*), and u is the normal error term.

According to Amoah & Addoah (2021), knowledge influences good behavioural practices. Similarly, knowledge of contamination influences one's decision to engage in averting behaviour or otherwise (see Abdalla *et al.*, 1992; Boadu, 1992). Thus, we expect that knowledge about good or bad environment will influence averting behaviour. Therefore, we expect a positive relationship between environmental knowledge and averting behaviour. Also, age is used in this study as a measure of experience. The more experienced a person is, the more cautious they are in their behavioural practices. Thus, we expect older respondents to practise averting behaviour when compared with younger respondents. Therefore, a positive relationship is expected between age and averting behaviour. However, we expect a turning point at a certain age. In theory, females are generally more risk-averse than males; hence, we expect a positive relationship between females and averting behaviour. Likewise, relatively larger household sizes provide the opportunity to share in averting responsibilities; hence, we expect a positive relationship between household size and averting behaviour. Access to pipe-borne water in the study area suggests the availability of improved drinking water sources; hence, averting behaviour is not expected in such instances. That is, we expect a negative relationship between residences with pipe water and averting behaviour. Lastly, in demand theory, wealth here suggests ability to pay to engage in better averting practices. So, in the absence of reliable supply of pipe-borne water, we expect respondents to spend more on averting behaviour. That is, a positive relationship is expected between wealth and averting behaviour.

5. RESULTS AND DISCUSSION

The descriptive statistics of the variables used for the estimation are presented in Table 1. The dependent variable (*avert*) shows whether the respondent engages in any form of averting behaviour towards improving the quality of domestic water use (1) or otherwise (0). On average, 90% of the respondents engage in a type of averting behaviour, while only 10% indicated that they do not engage in any form of averting behaviour. The distribution implies that an overwhelming majority of people in the GAR engage in some sort of averting behaviour to improve the quality of water before consumption. A detailed description of variables is presented in Supplementary Material, Table A1 (Appendix) with its descriptive statistics as presented in Table 1.

Table 1. | Descriptive statistics.

	Avert	Knowledge	Age	Age-squared	Male	HH	Access	Wealth
Mean	0.90	0.39	39.00	1685.04	0.89	4.01	0.84	3.91
Median	1.00	0.00	37.00	1369.00	1.00	4.00	1.00	3.91
SD	0.29	0.49	11.86	986.86	0.31	1.98	0.37	1.03
Skewness	- 2.75	0.45	0.31	0.79	- 2.49	0.84	- 1.82	- 0.35
Kurtosis	8.54	1.20	2.17	3.00	7.18	5.69	4.33	2.89
Minimum	0.00	0.00	18.00	324.00	0.00	1.00	0.00	0.00
Maximum	1.00	1.00	72.00	5184.00	1.00	17.00	1.00	6.91
N	1,648	1,648	1,648	1,648	1,648	1,648	1,644	1,098

For the independent variables, an average of 39% indicated that they have *environmental knowledge*, while 61% do not have *environmental knowledge*. This implies that majority of the respondents do not have adequate knowledge about the environment. The age of the respondent is a discrete variable that ranges from 18 to 72 years. The mean age of the respondents is 39 years. This suggests that on the average, the respondents are youthful, yet the distribution shows a good spread of the different age groups. Given that most household-heads in Ghana are male-dominated, we found that 89% of the respondents are males, while only 11% are females. Also, our results showed different household sizes, ranging from one-man households to 17-person households. Nevertheless, the average household size of four is reflective of the national estimate of 4.4 reported in the 2010 Population and Housing Census (GSS, 2012). Although most houses have pipe infrastructure layouts in the GAR of Ghana, water does not flow through these systems. Thus, 84% have access to a type of water system in their residence, yet one cannot argue that the availability of the system implies the flow of improved water supply. In addition, having some savings which is mainly borne out of excess income over expenditure is treated as a measure of *wealth*, given that the saving rate is very low in most developing countries especially Ghana. The minimum amount of *wealth* is 0, while the maximum is GH¢1,002.25 (\$173.85) per month, with an average *wealth* (or *savings*) of approximately GH¢50 (\$9)/month. These values are transformed into natural logs to help in interpreting our *wealth* variable in percentages. The reason underlying the poor-saving behaviour is mainly attributed to low incomes, larger household sizes with its associated large expenditures leaving the majority in lower- or middle-income brackets.

Next, we further interrogate the main sources of water for drinking and averting behaviour. We group them into the piped system and other systems. For respondents who use indoor plumbing as their main source of drinking water, one would expect that such sources do not need further quality improvement. However, 79% indicated that they engage in averting behaviour before consumption, while 21% do not use any averting mechanism. Similarly, 95% of those who use private inside standpipes engage in averting behaviour, while only 5% do not use any averting mechanism. Also, 58% of those who use the piped system from a neighbour's house and mostly share cost indicated that they engage in averting behaviour. However, 42% did not use any averting mechanism after fetching from neighbour's house. For private outside standpipes, all respondents indicated that they engage in averting behaviour after fetching. Again, 97% of those who use public standpipes showed that they engage in averting behaviour, while only 3% do not. These findings affirm the evidence by the Ghana Statistical Service (2014) and more recently by Amoah (2020) that the majority of urban households in Ghana depends on sachet or bottled (packaged) water as their main source of drinking water.

As sachet/bottled/package is considered a high-quality source of water, majority of urban dwellers depends on it for drinking purposes. Interestingly, 10% of users of sachet/bottled/package water sources indicated that they still engage in averting behaviour. We observed that Aqua Salveo¹ is the most common chemical treatment used by these groups of consumers. This evidence is not strange because a study by *Stoler et al. (2012)* has shown that most sachet water produced have pathogens or contaminants because of their sources (pipe, tanker services, borehole etc.) and poor sector regulation. Furthermore, the GWCL's inability to provide quality water to the region is due to production and distribution limits, continued population growth without urban planning, non-revenue water losses (see *Van Rooijen et al., 2008*) and polluted water bodies with the higher cost of water treatment. These challenges keep weakening the utility company from supplying quality domestic water to the region.

Indeed, with the other non-piped sources of water, except for borehole which 88% of users reported to have engaged in averting behaviour, all the other sources such as water truck/tanker services, water vendor (gallons), protected well and river/stream/lake/dam show that all users engaged in averting behaviour.

With the aid of the Pearson X^2 square test (see *Table 2*), we further examined whether given the various drinking water sources, there is a statistically significant difference between those who engage in averting behaviour and those who do not. The results reject the null hypothesis and suggest that, given the various drinking water sources, there is a statistically significant difference between those who engage in averting behaviour and those who do not. Likewise, we investigated whether there is a statistically significant difference between those who engage in averting behaviour and those who do not, given the differences in income. To achieve this, we first used the World Bank's International Poverty Line index of US\$1.90 (2011 PPP) at the current exchange rate of GH¢5.77 as the benchmark to categorise income groups into two, namely, higher income and lower income. The former is defined as those whose monthly income is above the threshold, while the latter is defined as those whose monthly income is equal to or below the threshold. In *Table 3*, we present the results which show that there is no statistically significant difference between higher income and lower income in engaging averting behaviour. This implies that both higher- and lower-income groups engage in averting behaviour.

5.1. Diagnostic tests

To commence with our estimation, we find it expedient to undertake some diagnostic tests on our model as a way of validating our estimates. Three common identification issues that are relevant to cross-sectional studies include multicollinearity, endogeneity and heteroskedasticity econometric problems (see *Greene, 2002; Wooldridge, 2010; Amoah et al. 2017*). We first use the pairwise correlation test to investigate whether the covariates are highly linearly related. The test results are shown in *Table 4*. The results show that the highest correlation coefficient of $|0.1798|$ exists between knowledge and gender (male). Similarly, the lowest correlation coefficient of $|0.0025|$ exists between household size (HH) and access to the water system in residence (access). Our correlation coefficients suggest that our model does not suffer from severe multicollinearity concerns.

In theory, we expect environmental knowledge and wealth to be endogenous. Thus, our model is prone to endogeneity concerns. Unfortunately, data constraints regarding the right instrument pose an empirical challenge. Similar to earlier studies (e.g., *Amoah et al. 2017*), we posit that our estimates should be treated as association instead of causal effect.

In order to avoid heteroskedasticity problems, all models are estimated with robust standard errors. In addition, we included community fixed effects to account for unobserved heterogeneity within the communities. Thus, this accounts for the possible unique differences that exist among the communities.

¹ Aqua Salveo is a pathogenic bacteria-free water disinfectant, which is effective in destroying bacteria found in (drinking) water.

Table 2. | Averting behaviour and drinking water analysis.

Main source for drinking	Frequency	Percent	Averting behaviour		Total (%)
			No (%)	Yes (%)	
Indoor plumbing	14	0.85	21	79	100
Private inside standpipe	43	2.61	5	95	100
Water truck/tanker services	8	0.49	0	100	100
Water vendor (gallons)	4	0.24	0	100	100
Pipe in neighbouring household	24	1.46	42	58	100
Private outside standpipe	22	1.34	0	100	100
Public standpipe	95	5.77	3	97	100
Sachet/bottled/packageged	1,346	81.77	90	10	100
Borehole	64	3.89	12	88	100
Protected well	21	1.28	0	100	100
River/stream/lake/dam	5	0.3	0	100	100
Total	1,646	100%			

*** $p < 0.01$.**Table 3.** | Parametric and non-parametric test of averting behaviour and income.

Parametric test	Non-parametric test
Hypothesis (H0): averting behaviour (low income) = averting behaviour (high income)	
Two-sample <i>t</i> -test with equal variances	Two-sample Wilcoxon rank-sum (Mann–Whitney) test
–0.3465	–0.420
Pr(<i>T</i> > <i>t</i>) = 0.7290	Prob > <i>z</i> = 0.6747
Statistically insignificant	Statistically insignificant

Table 4. | Correlation of covariates test results.

	Knowledge	Age	Male	HH	Access	Wealth
Knowledge	1					
Age	– 0.1003	1				
Male	– 0.1798	– 0.0259	1			
HH	– 0.0368	0.0072	– 0.009	1		
Access	0.0065	0.0457	0.0034	– 0.0025	1	
Wealth	0.0976	0.0134	– 0.0678	0.1054	– 0.0552	1

Also, we tested whether the explanatory variables are simultaneously equal to zero using the Wald test. To do this, we first specify our null hypothesis that all the explanatory variables are equal to zero. The test results as shown by the Wald Chi-square in Table 5 indicate a highly statistically significant Wald Chi-square value;

Table 5. | Logit regression model.

Variables	(1) Logit model	(2) Margins (dy/dx)
Environmental knowledge	1.1443*** (0.262)	0.0956*** (0.022)
Age of the respondent	0.1272** (0.056)	0.0106** (0.005)
Age-squared (Age ²) of the respondent	-0.0016** (0.001)	-0.0001** (0.000)
Male = 1, gender	1.5334*** (0.275)	0.1824*** (0.041)
Household size	-0.0276 (0.052)	-0.0023 (0.004)
Water system in residence = 1, piped water	-0.3696 (0.327)	-0.0284 (0.023)
Wealth (log)	0.2015** (0.103)	0.0168** (0.009)
Constant	-1.8754 (1.244)	
<i>Community fixed effect</i>	<i>Yes</i>	
<i>AIC (df = 16)</i>	<i>648.1439</i>	
<i>BIC (df = 16)</i>	<i>727.5247</i>	
<i>Wald Chi² (16)</i>	<i>72.24***</i>	
<i>Turning point (nlcom in STATA)</i> <i>[Confidence interval]</i>	<i>40*** [34.00 – 46.00]</i>	
<i>Pseudo R²</i>	<i>0.1167</i>	
Observations	1,055	

Dependent variable: household water treatment behaviour (dummy).

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

hence, we reject the null hypothesis and accept the alternative that the explanatory variables together are not different from zero. Thus, the covariates are relevant predictors of variations in the outcome variable.

The results of the study are displayed in Table 5; model 1 shows the apparent relationship between *household water treatment behaviour* (averting behaviour) and the covariates. Generally, the results show that environmental knowledge, experience, gender and wealth are positively related to averting behaviour. Model 2 reports the corresponding margins which measure the change in the probability of the dependent variable as a result of a unit change in each independent variable. That is, the marginal effects measure the probable association with averting behaviour, given a unit change in an explanatory variable. In order to account for potential unobserved community characteristics that could bias the estimates, we include community fixed effects as a control variable.

Environmental knowledge improves the associated chance of averting behaviour by about 9.6%, given a unit increase in targeted education on the environment. The positive relationship between environmental knowledge and behavioural intentions found in this study corroborates findings of Amoah & Moffatt (2021). This finding follows

an established principle that pro-environmental actions are influenced by behavioural actions through appropriate education (Blankenberg & Alhusen, 2018). So, we posit that environmental knowledge and/or education correlates with behavioural attitude. In a broader perspective, knowledge about the safety of household water supply would influence averting behaviour. Water supply from various sources in Ghana does not come with the highest of safety and purity standards for domestic use. In line with Vicente-Molina *et al.* (2013), we argue that knowledge of safety and treatment choices of water would influence households who are concerned about hygiene to engage in averting behaviour for a healthy life. There is obviously a cost to having environmental knowledge seen in engaging in extra expenditure. It is an undoubted fact that the benefits associated with engaging in averting behaviour (example shirking off possible sicknesses with its associated repercussions) far exceed the daily pecuniary cost burden. This trade-off, which is motivated by knowledge, is considered essential in promoting household welfare.

The associated probability that an individual will participate in averting behaviour increases by approximately 11% with an increase in age by a year. This is plausible because age, used as a proxy for experience, could indicate how one can attest to the safety of water supplied over the years. This positive result is consistent with the age and pro-environmental behaviour findings of Amoah & Korle (2020) as well as Amoah & Addoah (2021). In Ghana, household water supply from traditional sources (borehole, streams and rivers) is not safe for drinking purposes. The GWCL, a state monopoly supplier of piped-borne water, mainly applies chlorine treatment to source water bodies before delivering to households. However, the final product received may not be wholly safe for drinking and other direct purposes. This is because the level of safety is further compromised through growing illegal small-scale mining activities, irregular flow of piped water which corrodes the pipes, and poor sanitation consciousness. Indeed, the poor environmental practices worsen the state of water bodies that the GWCL relies on as its raw material for onward processing and treatment. The non-linear effect of age (age^2), however, decreases the possibility of averting behaviour which suggests a turning point effect with an increase in age. It means that there is a maximum age (40 years) beyond which an individual will reduce or spend less on treating household water supply before direct usage. This is plausible if households relax their averting mechanisms due to adaptation to the sources and changing essential priorities in their lifetime.

Besides, our results indicate that being male as a gender attribute enhances the associated chance of averting behaviour compared with the female. This positive evidence is consistent with Amoah (2017) and Amoah & Addoah (2021). It is conceivable in the case of Ghana, as most household-heads are males. The responsibility to take care of household utility expenditure is traditionally assigned to the male gender, unless re-assigned by other mutual agreement. This explains why a change in gender role increases the probability of averting behaviour.

The wealth of households, as expected, is positively associated with the decision to apply water treatment for several sources of water supply. In effect, the associated chance that households would engage in averting behaviour improves by about 17% with a unit increase in wealth. It presupposes that as income and other claims to assets increase, households tend to spend more on further treatment options available to keep domestic water supply safe for consumption. In line with consumer demand theory, we unearth evidence to demonstrate that wealth is an important determinant of household averting behaviour. The ability to pay evidence is consistent with the findings of Boadu (1992), Amoah (2017) and Amoah & Addoah (2021).

5.2. Robustness check

Given that sachet water is the main drinking water source in urban areas of Ghana, we modelled averting behaviour for only sachet/bottled/package water as a function of the independent variables. This means that we model for main drinking water excluding main water for general use.

Table 6 reports the relationship and chance of engaging in averting behaviour using only sachet/bottled/package water. Similar results are found as in the case for all sources of water. Notably, the availability of a piped

water system in households appears to be statistically significant. That is, change in the source of water supply to piped water reduces associated averting behaviour in using sachet/bottled/package water slightly by about 7.3%. These findings provide further robustness evidence to our estimated results. In addition, the turning point estimate is still consistent with the results from Table 5.

5.3. Implications for water policy

Towards achieving the overarching Sustainable Development Goal (Goal 6, SDG 6) which seeks to ensure the availability and sustainable management of water and sanitation for all, it is alarming that the majority of respondents in this study engage in an averting behaviour of a sort. All else held constant, with both direct and indirect cost implications, estimating these costs to inform a possible price adjustment for reliable piped water supply is ideal. The benefit of accessing piped water is enormous and cannot be traded for an unimproved source which is relatively expensive, ultimately. Thus, if possible, ways of charging realistic prices and making the services

Table 6. | Logit regression model for sachet/bottled/package water.

Variables	(1) Logit model	(2) Marginal effect
Environmental knowledge	1.1201*** (0.274)	0.0962*** (0.023)
Age of the respondent	0.1348** (0.059)	0.0116** (0.005)
Age-squared (Age ²)	-0.0017** (0.001)	-0.0002** (0.000)
Male = 1, gender	1.5365*** (0.297)	0.1320*** (0.0252)
Household size	-0.0300 (0.055)	-0.0026 (0.005)
Water system in residence = 1, piped water	-0.8530** (0.392)	-0.0733** (0.034)
Wealth (log)	0.2369* (0.121)	0.0204* (0.010)
Constant	-1.5373 (1.359)	
<i>Community fixed effect</i>	<i>Yes</i>	
<i>AIC (df = 15)</i>	<i>537.1461</i>	
<i>BIC (df = 15)</i>	<i>608.3775</i>	
<i>Wald Chi² (14)</i>	<i>61.61***</i>	
<i>Pseudo R²</i>	<i>0.1244</i>	
<i>Turning point (nlcom in STATA)</i> <i>[Confidence interval]</i>	<i>40*** [34.00–46.00]</i>	
Observations	853	

Dependent variable: household water treatment behaviour (dummy).

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

available are not adhered to by regulatory bodies, then the efforts towards achieving SDG 6 will remain an illusion if not a big joke! Subsequently, given that individuals are willing to pay an extra amount in improving water safety, there is empirical evidence attesting to the economic viability of both private and public suppliers in the provision of quality water (see Whittington *et al.*, 2002; De Oca *et al.*, 2003; United Nations, 2004; Amoah, 2020; Amoah & Moffatt, 2021). In addition, specific public incentives such as subsidies targeting the poor and reducing costs of providing quality water are important. Such policies will significantly contribute towards achieving universal access to water without jeopardising affordability to low-income households.

Additionally, for policy purposes, we acknowledge the relevance in placing a premium on the determinants of the probability that a household will engage in some sort of averting behaviour. Generally, one cannot lose sight of the fact that poor management of the environment contaminates water supply. This calls for attitudinal changes that seek to promote the environment. Our present study finds that environmental knowledge influences the probability that a household will engage in averting behaviour towards domestic water consumption. It is widely known in the environmental literature that environmental knowledge is a strong prerequisite for a person's behaviour. Henceforth, requisite information and sensitisation on how poor management of the environment (e.g., open defecation, poor refuse dumping practices, etc.) affects quality water supply are critical. This can be achieved through targeted sanitation and environment educational campaigns in schools, communities, churches, among others.

In developing countries, water-borne diseases caused by poor sanitation are prevalent with inadequate large-scale water treatment mechanisms for domestic water supply. District or community water quality analysis should be regular, and findings shared with households to inform them on how poor management of the environment contaminates water supply. Also, given that an averting behaviour translates into additional water burden or cost, behavioural practices that pollute the water bodies should be checked by the law enforcement agencies. Similarly, district- or community-level water quality analysis should be undertaken, and findings shared with households to inform households on how poor management of the environment contaminates water supply. Lastly, we recommend that the Public Utilities Regulatory Commission should ensure that GWCL expands their infrastructure throughout the country and complies with international quality standards, while consumers are also sensitised to restore their confidence as in the pipe water.

6. CONCLUSION

Despite the rising statistics on access to water in Ghana, water quality concerns have not been fully addressed. Households have therefore adopted several household-level mechanisms aimed at improving the quality of water before consumption. Averting behaviour in a developing country with high levels of poverty and inequality implies that the predicament of the poor will be worsened by the additional water cost. Thus, those who can afford may engage in an averting behaviour; however, those who cannot afford may be forced to use contaminated or polluted water at the expense of their health.

Using household data from Ghana and an econometric approach, we show that the majority of households engage in an averting behaviour. Generally, sachet/bottled/package water sources are expected to be of high quality and that an averting behaviour may not be needed. Surprisingly, we show evidence that 10% of the respondents who use sachet/bottled/package still engages in averting behaviour. Implying that some of the sachet/bottled/package sources of water are not of high quality as one may expect, and that enforcement of quality standards is of prime importance going forward. Again, we did not find any evidence of a statistically significant difference between the rich/wealthy (high income) and poor (low income) in their averting behaviour, suggesting that both rich and poor engage in averting behaviour. However, wealthy households are more likely to engage in an averting behaviour when compared with the poor. In summary, we show evidence that households with

environmental knowledge, experience (age), gender (male) and wealth (savings) are more inclined to engage in averting behaviour.

For policy purposes, in the short run, while policymakers are still grappling with the huge cost of making quality pipe-borne water accessible to all, we recommend that averting behaviour must be considered in the context of its determinants when policy options are being examined. Furthermore, our estimate is informative as it provides a lower-bound estimate for water contamination cost in Ghana. Thus, going forward, this study recommends the estimation of other costs, for example, cost of illness borne as a result of using contaminated water to present a better understanding of the cost of using contaminated water.

DATA AVAILABILITY STATEMENT

Data cannot be made publicly available; readers should contact the corresponding author for details.

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First received 21 March 2021; accepted in revised form 11 June 2021. Available online 5 July 2021