

Research Paper

Estimating averting expenditure in domestic water use: evidence from Ghana

Anthony Amoah 

ABSTRACT

Safe water is described as an important resource for the survival of mankind. The outbreak of the Covid-19 pandemic has made safe water 'super' important and critical for the survival of mankind. Most developing countries, especially in Africa, incur additional costs in order to enjoy improved, if not safe domestic water supply. Using the averting expenditure method, this study estimates how much urban households in the Greater Accra Region of Ghana spend to improve the quality of domestic water they use. The study provides evidence that households spend Ghs84.30 (\$14.70) per month, which constitutes 13.25% of their income. These estimates are very informative to the supplier in determining the economic viability of making the required quality of water available to households.

Key words | averting behaviour, Ghana, safe water, SDGs, willingness-to-pay

Anthony Amoah 
Central University,
Post Office Box 2310, Accra,
Ghana
E-mail: anthonyamoahgh@gmail.com

HIGHLIGHTS

- The study presents the first averting behaviour estimate for domestic water use in Ghana.
- The study provides evidence that households spend Ghs84.30 (\$14.70) per month, which constitutes 13.25% of their income.
- The study shows that sachet and bottled water dominate the drinking water choices.
- The study shows that pipe-borne water is mainly used for general household non-drinking purposes.

INTRODUCTION

Access to potable water and residential water supplies in Ghana and other developing countries has been increasing steadily. These success stories follow the concerted global efforts in driving goals such as the Millennium Development Goals (MDGs) and the Sustainable Development Goals (SDGs) in addition to national-level policies. In Ghana, the gains include, but are not limited to, meeting the drinking water target under the MDGs a decade before the

deadline, continuous increase in water coverage, reduction in water-related diseases and its associated impact on infant and child mortality rates (Monney & Antwi-Agyei 2018). Recently, the percentage of people using safely managed drinking water services in Ghana rose from 33.12% in 2015 to 36.41% in 2017 (World Bank 2019).

Despite the gains, several households are still without a connection to the nation's pipe-borne water network. As pointed out by van den Berg & Nauges (2012), generally, households in such situations face hauling costs to access water, they pay relatively higher prices and use relatively lower quality non-piped water sources. A common

This is an Open Access article distributed under the terms of the Creative Commons Attribution Licence (CC BY 4.0), which permits copying, adaptation and redistribution, provided the original work is properly cited (<http://creativecommons.org/licenses/by/4.0/>).

doi: 10.2166/washdev.2020.197

approach by most Ghanaian water users is to adopt averting behaviour as an improvement mechanism to domestic water before use. However, this approach involves time and effort, cost of averting materials or technique, relatively higher water cost, etc. Regardless of the averting behaviour, water quality for domestic use remains questionable. Currently, urban areas in Ghana experience inadequate supply of domestic water because of rising population levels and the high cost incurred by the Ghana Water Company Limited (GWCL) in improving the polluted sources of surface water. This gloomy situation is worse for rural communities where there is a lack of piped-water infrastructure layout. In the few rural communities with piped-water supply, water hardly flows, hence their reliance on boreholes provided mainly by the Community Water and Sanitation Agency (Amoah 2017). The need for stakeholders to act now follows the uncertainty that surrounds the supply of safe domestic water and associated health-related impact on human capital now and in the future. Safe drinking water is water with microbial, chemical and physical characteristics that meet WHO guidelines or national standards on drinking water quality (WHO 2015; www.who.int/water_sanitation_health/mdg1/en).

The primary question this study seeks to answer is, can the averting expenditure be estimated to determine the willingness-to-pay (WTP) for domestic pipe-borne water supply in residences? One of the revealed preferred methods that has proven reliable for the estimation of WTP for water supply is the averting behaviour method (ABM) (see Van Houtven *et al.* 2017). In this study, we define ABM as the actual practice(s) undertaken to prevent the harmful effect of water contamination. The associated cost incurred for engaging in these practices is the averting cost or expenditure. Unfortunately, there is a paucity of studies on this method in developing countries (Pattanayak *et al.* 2010). To the best of our knowledge, no study has provided water-related averting behaviour estimates in Ghana. However, there have been studies on other WTP applications such as contingent valuation method, travel cost method, and hedonic price method in Ghana. Some of these studies include Boadu (1992), Whittington *et al.* (1992), Amoah (2017, 2018) and Amoah & Moffatt (2017). In other jurisdictions, some previous studies have used ABM to provide estimates to inform policy decisions regarding the supply of safe

domestic water. For example, in Korea, Um *et al.* (2002) estimated WTP for improved water quality using the conventional ABM. They found that for 10 mg/L of suspended solid concentration in tap water from 335 to 325 mg/L, households' WTP ranged from \$0.70 to \$1.70/month. However, for their perception ABM, WTP was observed to be higher and ranged from \$4.2 to \$6.1. Similarly, in June 1987, the water supplied in College Township, a community in central Pennsylvania with approximately 5,000 people, was contaminated with perchloroethylene. The Department of Environmental Resources was concerned about potential health risks of the chemical to the population and provided avoidance steps to households. The water users were left to their fate to decide on the usage of the water. Using household-level data, Abdalla (1990) estimated the economic losses from the groundwater contamination using ABM. The households were surveyed using the mail method, and 1,045 completed questionnaires were received. The WTP for households engaging in an averting behaviour was estimated at \$21/month/household.

Relatively, most developing countries use low-quality domestic water, however, only a handful of studies have focused on averting behaviour. For example, Vásquez *et al.* (2009) used a variety of averting measures to investigate private investment choices that improve water quality for households in Parral, Mexico. The study found that apart from bottled-water cost, several other home-based methods are used for tap water treatment. The estimated cost of this method was found to constitute 7.5% of household income. In a more recent study, Tarfasa & Brouwer (2013) used one of the stated preference methods, the choice experiment (CE), to investigate public benefits of urban water supply improvements in Ethiopia. They revealed that the estimated average monthly averting cost was 32.1 Ethiopian birr (approximately \$1) per household. The authors concluded that averting behaviour is essential to water use in Hawassa, Ethiopia.

We infer that because the degree of water contamination or water quality is not the same across countries and communities (be it developed or developing), averting behaviour and associated cost estimates can also not be the same. The pieces of evidence from the previous studies reviewed, and the findings of the current study are externally

validated by [Amoah & Moffatt \(2017\)](#), who have shown with empirical literature that households generally are willing to spend an average of 2%–18% of their income to improve the quality of their domestic water.

The main contribution of the study is using ABM and a survey approach to determine how much it costs urban households in the Greater Accra Region (GAR) to improve the quality of water before use. In addition, it provides a demand-side estimate to inform private sector decisions for water sector investment. Also, this study contributes to the empirical literature on averting behaviour and domestic water use in response to the paucity of literature on the application of ABM in developing countries, as acknowledged by [Pattanayak et al. \(2010\)](#).

Urban water situation in Ghana

Ghana is a fairly water-endowed country. The Ghana Water Company Limited (GWCL) is a state-owned company responsible for urban water supply which is almost entirely from surface water resources. The GWCL, therefore, has abundant surface water resources to meet the current and future urban consumptive demand ([Yirenkyi-Fianko 2019](#)). Unfortunately, the quality of surface water and groundwater sources keep deteriorating at an alarming rate. This is mainly attributed to rapid population growth without a corresponding replacement and expansion in infrastructure, pollution from mining areas, improper waste disposal, chemicals from agriculture and fishing, etc. (see [Yeleeiere et al. 2018](#)). In recent times, the deteriorating nature of surface and groundwater sources have made averting behaviour a common practice with urban households. Available data from the Ghana Statistical Service ([GSS 2014](#)) shows that sachet water is the main source of household drinking water while the pipe-borne water is for general use (washing, bathing, cleaning, etc.).

METHODS

Data collection process

This study focuses on the ten districts in the GAR as defined by the 2010 Housing and Population Census by the [GSS](#)

(2012). The Region has a total population and number of households of 4,010,054 and 1,036,426, respectively. Out of the latter, the urban and rural household population constitutes 766,955 and 269,471, respectively. Given that the rural case is dire and piped infrastructure is lacking, we focused on the urban area, hence our reference sampling frame is 733,955 households. In anticipation of a representative sample, the [Yamane \(1967\)](#) sample size formula was used to compute the sample size which yielded approximately 400 households. The study over-sampled to as high as 1,650 households.

The instrument used for the data collection was a structured questionnaire. The first section of the questionnaire had the demographic or socio-economic data of the respondent (personal data), the other sections had water, sanitation and other environmentally related questions. This included improved water valuation questions such as averting behaviour and expenditure.

The questionnaire was administered by 20 trained field-workers who were supervised by four coordinators. The principal investigator was responsible for the overarching supervision and ethical adherence by the entire team. Before the commencement of the main survey, the team undertook a pre-pilot survey before the actual pilot survey. This was done to avoid possible trial and error before the main survey. All responses in both pilot surveys were analysed to inform possible amendments of some of the questions before the survey. It is important to point out that the pilot datasets were not included in the final dataset.

Given the unplanned nature of settlements in most urban areas in Africa, of which the GAR is no exception, we applied a multistage probability sampling technique. This was achieved by first defining the various districts as unique clusters, followed by listing the communities in each cluster as prescribed by the Town and Country Planning Department. Households within each community were also listed and randomly selected until our expected quota was reached. In all, based on a multistage probability sampling technique, this study relies on 1,648 observations after two observations were excluded due to missing data points. This gives a very high response rate of about 99% which is very common in most surveys in the GAR (e.g., [Amoah et al. 2019](#)).

Econometric modelling

The principal aim of modelling the averting expenditure is to calculate the conditional averting average cost (conditional mean) instead of just the mean of averting cost (unconditional). Second, this study seeks to determine the drivers of averting behaviour and provide evidence that supports the internal and external validity of the study. The data show that approximately 10% of the sample do not incur any averting cost as they enjoy regular flow of safe piped water that does not require an averting behaviour. In the regression and the averting cost estimates, the study excluded the 10% to only focus on households that engage in averting behaviour and have incurred an expenditure in that respect. Thus, the discrete dependent variable, total averting expenditure or cost per household (C_i), depends on socio-economic, demographic, context relevant variables and district dummies. Following Amoah *et al.* (2019), the econometric model is specified as:

$$C_i = \alpha + X_i\beta + u_i$$

where C_i is as already defined, X_i is a vector of independent variables used for the estimation, α and β are the unknown parameters to be estimated. The stochastic term, u_i , follows a standard normal distribution. In order to interpret the results as elasticities, we transformed the model into a natural logarithm form. The raw data and their descriptive statistics are presented in Table 1 before transformations. From Table 1, the averting cost per day reported ranges from a minimum of Ghs0.06 (6 pesewas or 1 cent) and a

maximum of Ghs36.48 (\$6.29). The unconditional mean averting expenditure or cost is Ghs4.36 (\$0.75) per day. The average household income per month is Ghs636.37 (\$109.72) which is quite close to the national estimate of Ghs544 (\$93.79) (GSS 2008). The average age of respondents is 39 years with 89% of household heads being males. The majority (59%) of the respondents are married. Sixty-eight per cent claim they have reliable or regular supply, yet they still engage in averting behaviour. This shows that the quality of water is not always as perfect or safe as one would expect. The household life cycle variable shows the various stages of households with the average representation being families with or without children.

RESULTS AND DISCUSSION

In Table 2, we show the various sources of water being used by urban households in the GAR. The main sources are categorized into water for drinking and water for general use. For the drinking water sources, it is observed that approximately 82% of the respondents use sachet or bottled (packaged) water. This is due to unreliability and poor quality from the pipe-borne system. Hence, most households depend on the commercial (public or private) standpipe water sources which are relatively reliable because of available storage facilities. Consistent with our evidence, the Ghana Statistical Service (GSS 2014) reports that in the urban areas of Ghana, sachet water constitutes the main source of household drinking water and where households use pipe-borne water, they mostly rely on either private or public standpipes.

Table 1 | Descriptive statistics

Stats	Averting	HH-income	Male	MS	Age	Age ²	Reliability	Life cycle	Access
Mean	4.36	636.37	0.89	0.59	39.30	1,685.04	0.68	3.28	1.27
Median	3.19	380.00	1.00	1.00	37.00	1,369.00	1.00	3.00	1.00
SD	3.97	581.35	0.31	0.49	11.86	986.86	0.47	1.36	0.44
Skewness	2.25	2.08	-2.49	-0.37	0.31	0.79	-0.76	-0.10	1.06
Kurtosis	12.65	8.17	7.18	1.14	2.17	3.00	1.58	2.78	2.13
Minimum	0.06	160.00	0.00	0.00	18.00	324.00	0.00	1.00	1.00
Maximum	36.48	4,400.00	1.00	1.00	72.00	5,184.00	1.00	7.00	2.00
N	1,490.00	1,604.00	1,648.00	1,648.00	1,648.00	1,648.00	1,489.00	1,645.00	1,619.00

Table 2 | Sources of water for drinking and general use in urban Greater Accra Region

Main source of water for drinking			Main source for general use		
Sources	Frequency	Per cent	Sources	Frequency	Per cent
Indoor plumbing	14	0.85	Indoor plumbing	406	24.76
Private inside standpipe	43	2.61	Private inside standpipe	345	21.04
Water truck/Tanker service	8	0.49	Water truck/Tanker service	456	27.8
Water vendor(gallons)	4	0.24	Water vendor(gallons)	56	3.41
Pipe in neighbouring household	24	1.46	Pipe in neighbouring household	88	5.37
Private outside standpipe	22	1.34	Private outside standpipe	145	8.84
Public standpipe	95	5.77	Public standpipe	81	4.94
Borehole	64	3.89	Borehole	36	2.2
Protected well	21	1.28	Protected well	26	1.59
River/Stream/Lake/Dam	5	0.3	Unprotected well	1	0.06
Sachet/Bottled (packaged) water	1,346	81.77	Sachet/Bottled (packaged) water	0	0
Total	1,646	100	Total	1,640	100

In the case of water for general use (washing, bathing, cleaning, etc.), most households mainly depend on pipe-borne related sources. Given that pipe-borne sources do not flow reliably, most households use water-saving containers to reserve water during piped-water opening or flowing days. Such sources are susceptible to contamination, hence the need for averting practices. Evidently, the *GSS (2014)* reports that households in urban areas mainly use piped-system and/or tanker services (pipe-borne or borehole or wells).

Overall, our results suggest that most households in the urban areas rely mainly on packaged water for drinking while pipe-borne sources are used for other general household purposes. This evidence may be driven by pipe-borne water quality concerns in the GAR.

Next, we show how most households improve their quality of water before use. *Table 3* shows that 36.47% of households buy disinfectant chemicals (e.g., Dettol, alum, camphor, etc.) to treat their water before use, while only 9.88% buy filters. The low patronage for filters is because most households use either bottled or sachet water for drinking and prefer to use other quality improvement methods for bathing, cleaning, washing, and laundry, among others.

Averting expenditure/cost analysis

From *Table 4*, we report and discuss the conditional mean as it represents the predicted average based on the drivers of

Table 3 | Averting behaviour in urban Greater Accra Region

Averting behaviour practised	Method of computation	Frequency	Per cent (%)
Applying disinfectant chemicals	Cost of chemical used	550	36.47
Allowing water to settle	Opportunity cost of waiting time using the current minimum wage	352	23.34
Boiling	Estimated cost of fire used	457	30.31
Filtering	Cost of filter	149	9.88
Total		1,508	100

Note: Bottled water and sachet water are used by almost all households.

household averting expenditure. The results show that households spend as high as Ghs84.30 (\$14.70) per month to improve the quality of their domestic water. This constitutes 13.25% of the household's take-home income. The unconditional mean is not used because it is prone to either overestimation or underestimation. In the case of this study, it overestimates the averting cost by 7.30 percentage points.

In urban GAR of Ghana, the estimated total averting cost for improved water supply is deemed very informative to policy-makers as well as the supplier (GWCL). The total averting cost provides an estimate of the additional

Table 4 | Averting expenditure for urban Greater Accra Region

Measures	Expenditure/HH/Day in Ghs	Expenditure/HH/Month in Ghs	Share of income	Calculated expenditure/Month for urban Greater Accra Region in Ghs
Mean averting expenditure	4.36 (\$0.76) [4.16–4.56]	130.80 (\$22.80) [124.80–136.8]	20.55%	96,001,314.00 (\$16,734,174.00) [91,597,584.00–100,405,044.00]
Conditional mean averting expenditure	2.81 (\$0.49) [2.75–2.87]	84.30 (\$14.70) [82.50–86.10]	13.25%	61,872,406.5 (\$10,789,138.50) [60,551,287.50–63,193,525.50]

Note: Ghs 1 = (US\$0.17) [*] implies 95% confidence interval.

amount households would be willing to pay for improvement in their domestic water supply to avoid averting behaviour. Next, we investigate the drivers of averting cost.

Regression analysis of drivers of averting cost

To commence our discussion, we perform some diagnostic tests to ensure the validity of our results. In cross-sectional data analysis, multicollinearity and heteroskedasticity tests are a pre-requisite. To ensure that no exact linear relationship exists among the independent variables, we used the pairwise correlation matrix to compute their respective degree of correlation. From the test results (Table A1 in the Appendix), the highest degree of correlation is found between age and marital status with a correlation coefficient of approximately 0.29. It suggests that there is no concern for multicollinearity among the variables in the data. The other problem is heteroscedasticity, which arises when there is unequal variance in the error term. To control for this in our study, the coefficients are estimated with White's heteroskedasticity-consistent robust standard errors. In addition, we do not assume homogeneity among the districts, so we introduced district fixed effects to account for possible bias that may arise as a result of differences in the districts. We report an R-squared (coefficient of variation) of 15% which fits the minimum value for reliable valuation studies as proposed by Mitchel & Carson (1989). The F-statistics of 8.73 and a *p*-value of 0.00 provide evidence that the overall model is fit for prediction. Following the evidence from the diagnostic tests, we confidently argue that the estimated results are not severely biased and can be trusted in making policy decisions. The interpretation and discussion of our results assume that all other factors are held constant (*ceteris paribus*).

In line with the theoretical construct which satisfies an internal validity test, we argue that a consumer's demand is expected to vary with his/her income. If the good is a normal good, we expect that an increase in income will increase consumption of the good in question. In Table 5, we found that there is a positive and statistically significant relationship between income and averting expenditure. That is, if a household's income increases by 1%, the average averting expenditure will increase by 0.0880%. This suggests that water is not just a normal good but a necessity, and households with higher incomes are willing to spend more to improve the quality of water they use. This is consistent with theoretical expectations and justifies the internal validity of the model estimated.

Also, we introduced gender into the model because gender disparity matters in household choices. We found a positive relationship between gender and averting expenditure, albeit insignificant. That is, regarding averting behaviour, gender is statistically immaterial.

Again, we argue that the behaviour of a single financial and health decision-maker and that of a joint financial and health decision-maker cannot assume homogeneity. The decisions regarding household choices in a marital home are generally assumed to be jointly taken while singles take individual decisions without consultation. In this study, we found that there is a positive and statistically significant relationship between those who are married and averting expenditure. That is, if the respondent is married, on average, his/her averting behaviour will increase by 0.1238% relative to the unmarried. This is intuitively not far-fetched. Relatively, the married are likely to use more litres of water, care more about each other's health and support each other financially. Thus, they can afford to spend more to improve the quality of their domestic water as

Table 5 | Ordinary least squares regression results

Variables	Log-log model	Robust standard errors	[95% Conf. interval]
Socio-economic characteristics			
HH-income(Log)	0.0880**	(0.039)	[0.01089 0.16509]
Gender = 1, male	0.0192	(0.098)	[-0.17339 0.21177]
Marital status (MS) = 1	0.1238**	(0.060)	[0.00550 0.24207]
Age of respondent in years (age)	-0.0476**	(0.019)	[-0.08463 -0.01063]
Age of respondent in years squared (age ²)	0.0005**	(0.000)	[0.00007 0.00095]
Family life cycle characteristics			
Life cycle = 2, new couple (<= 1 yr)	0.6530***	(0.192)	[0.275441 1.03054]
Life cycle = 3, family with children (<teenage)	0.8127***	(0.107)	[0.60335 1.02202]
Life cycle = 4, family with teenagers (<'launching' children)	0.9923***	(0.111)	[0.77415 1.21036]
Life cycle = 5, family with 'launching' children	1.0924***	(0.112)	[0.87319 1.31165]
Life cycle = 6, several adults living together	1.0506***	(0.192)	[0.67453 1.42662]
Residential characteristics			
Reliability of water supply = 1	-0.2786***	(0.067)	[-0.40918 -0.14804]
Access to toilet in residence = 1	-0.1259*	(0.066)	[-0.25633 0.00453]
Districts (fixed effects)			
<i>Abokobi</i>	-0.1116	(0.102)	[-0.31188 0.08865]
<i>Accra</i>	0.3219*	(0.169)	[-0.00871 0.65256]
<i>Ada-Foah</i>	-0.1098	(0.145)	[-0.39459 0.17504]
<i>Adenta</i>	0.2939**	(0.146)	[0.00845 0.57944]
<i>Amasaman</i>	0.0964	(0.147)	[-0.19253 0.38528]
<i>Ashiama</i>	0.2325	(0.168)	[-0.09625 0.56132]
<i>Dodowa</i>	0.5655***	(0.178)	[0.21649 0.91443]
<i>Tema</i>	0.1668	(0.130)	[-0.0873 0.42089]
<i>Teshie-Nungua</i>	0.0955	(0.139)	[-0.17724 0.36824]
<i>Weija (reference category)</i>	XXXX	(XXXX)	[XXXX XXXX]
Constant	0.8272*	(0.436)	
Turning point for age and age ² (nlcom)	46.6212***		
Observations	1,282		
F (21, 1,260)	8.73***		
R-squared	0.15		

Dep variable: averting expenditure or household's amount spent on water treatment per day (log).

Robust standard errors in parentheses: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. (Note: coefficients approximate to 4 decimal places.).

compared to a single resident who uses less water, cares for himself and solely absorbs all household financial burden.

Age of the respondent has been used in the literature as a proxy for experience. According to [Cameron & Englin \(1997\)](#), age is crucial in valuation studies. It further provides an upper bound estimate on the respondent's experience. In this study, we found that as people age, they tend to focus on

things other than spending to improve the quality of their water. That is, if age should increase by one year, the average averting expenditure will decrease by 0.0476%. However, if age should double, based on the respondent's experience, the average amount spent on averting expenditure will increase by 0.0005%. Age and age-squared together depict a U-shaped relationship with averting expenditure. This

provides a minimum turning point of approximately 47 years with a 95% confidence interval ranging from a minimum threshold of 40 years to a maximum threshold of 53 years. This reflects the changing preferences of the respondent as the years go by.

In addition, we represented the household size with household life cycle to better represent the different phases of the household and their expected sizes. This seeks to help in understanding the level of the life cycle at which more is spent on averting behaviour. The intuition is that as the household advances in the life cycle, its water demand (use or consumption) increases. Indeed, such households would be expected to spend more on averting expenditure. To start with, we considered the case where there are only two people living together as a couple. (Here, we considered only respondents without children.) Next in the household life cycle is the family with children (below teenage age only), followed by the family with teenagers (excluding 'launching' children, i.e., those who are ready for marriage and may leave the house anytime soon), then the family with 'launching' children, and finally families with several adults living together. On average, we observed an increasing ordered effect on the trend of the household life cycle. Thus, there is a positive and statistically significant relationship between households in their advanced stage of the life cycle and averting expenditures. If a household advances by one unit in the life cycle, the average averting expenditure increases from 0.65% to 1.1% approximately. This evidence is consistent with the a priori expectation.

Again, we introduced a control variable for households with a regular pipe-borne water supply and compared them with households without access to regular pipe-borne water supply, where the latter is used as the reference category. We found a negative and highly statistically significant relationship between regular pipe-borne water supply and averting expenditure. That is, if a household has access to a regular supply of water through the piped system, the average amount they spend on averting decreases by 0.2786%. This implies that households with access to pipe-borne water on average spend less to improve domestic water before use. This may include the purchase of bottled water and sachet water for drinking, while the pipe-borne water is used for all other purposes without having to subject it to further water treatment. This suggests that some consumers

do not trust the quality of the piped water for drinking, hence they resort to alternatives. The GWCL should find a way of winning back the trust of consumers regarding the quality of piped water to save consumers from expensive alternative sources.

Also, one reason why people treat their water before use is when they suspect that indiscriminate disposal of human or animal faecal matter has made its way into the type of water they use. It is expected that households without toilet facilities and piped water in residences are more likely to dispose of their faeces indiscriminately, which may end up in the non-piped domestic water for household use. We have evidence of a negative and statistically significant relationship between households with access to toilet facilities in their residence and averting expenditure. That is, if a household has access to a toilet facility in their residence, the average averting expenditure will decrease by 0.1259%.

District level analysis

After including the district dummies in the model, we observed differences in the results vis-à-vis signs and significance. This suggests that the case of engaging in averting behaviour and incurring an additional cost in order to improve domestic water supply is not homogeneous across the districts. From [Table 2](#), we deduce from our data and results that Accra, Adenta and Dodowa exhibit positive and statistically significant relationships with averting behaviour. This suggests that, with Weija as the reference district, households in these districts are prone to engaging in averting behaviour because of water supply challenges, hence incurring averting expenditure. [Grönwall & Oduro-Kwarteng \(2018\)](#) reiterated an alternative approach to surviving the water challenges in these districts. They indicated that the GWCL has been supplying households in Dodowa and Adenta with groundwater once a week as a way of improving resilience to water shortages. Similarly, [Vinorkor & Afari-Mintah \(2008\)](#) have re-echoed the Ministry of Water Resources, Works and Housing's intentions to address the water supply challenges in Accra. However, statistical significance evidence was not found with those in Abokobi, Ada-Foah, Amasaman, Tema and Teshie. This is

because the severity of the evidence in the aforementioned districts may not be the same across districts.

Heterogenous effect of averting expenditure cost

In most developing countries, gender inequality is found in every space where gender matters. Several studies have shown that women bear the water supply burden in most households. Further, this study finds it interesting to investigate which gender is most sensitive to water quality improvement, engages more in averting behaviour and bears most of the averting burden? The study used both parametric and non-parametric statistical tests to investigate whether the averting burden falls more on women than men or the reverse is true.

From Table 6, we have evidence that there is no statistically significant difference between the males and the females in bearing averting cost. The evidence from the parametric and non-parametric tests provides robust results. By implication, we argue that there is no gender disparity gap when it has to do with improving water quality as human beings are naturally inclined to practices that may improve their health and well-being.

Again, to inform policy in subsidy allocation to different income groups, the study employs the poverty headcount index by the World Bank for lower middle-income countries and categorizes the respondents into low-income (poor) and high-income (non-poor) groups. Subsequently, we use both parametric and non-parametric tests to investigate whether there is a statistically significant difference between the poor and non-poor averting expenditures.

In Table 7, we find evidence to reject the null hypothesis that there is no statistically significant relationship between low- and high-income groups in their averting

Table 7 | Household income differences and averting expenditure/cost burden

Parametric test	Non-parametric test
Hypothesis (H1): Averting cost (high income) \neq Averting Cost (low income)	
Two-sample t test with equal variances	Two-sample Wilcoxon rank-sum (Mann-Whitney) test
-3.0298 Pr(T > t) = 0.0025***	-2.261 Prob > z = 0.0238**
Statistically significant	Statistically significant

*** $p < 0.01$, ** $p < 0.05$.

expenditures. That is, the high-income group is observed to spend more on averting expenditures than the low-income group. This study argues that for policy purposes, two scenarios are possible. First, in the case where the poor and the non-poor are exposed to the same sources (e.g., residential pipe-borne system), we expect the poor to consume less relative to the non-poor, hence the government can subsidize the consumption of the poor based on volume used. Second, in the case where both income groups are exposed to different water sources because of the ability to afford (e.g., the high-income group can afford bottled water), the government can subsidize the sources being patronized by the poor.

CONCLUSION

Despite considerable achievement in access to improved water over the years, substantial inequality in the supply of improved water by the GWCL still exists. Using household-level primary data of 1,648 observations, we have identified households' averting behaviours together with associated cost and drivers. This study has shown that, on average, a household is willing to pay Ghs84.30 (\$14.70) per month to improve the quality of their domestic water. Our current estimate constitutes 13.25% of household take-home income.

For policy purposes, this study has provided a demand-side estimate necessary for determining the economic viability of connecting households in urban GAR to the regular piped supply network and ensure that improved quality water is served to households. Thus, to permanently end domestic water-borne diseases and provide safe pipe-borne

Table 6 | Gender differences and averting expenditure cost burden

Parametric test	Non-parametric test
Hypothesis (H1): Averting cost (male) \neq Averting cost (female)	
Two-sample t test with equal variances	Two-sample Wilcoxon rank-sum (Mann-Whitney) test
-0.3703 Pr(T > t) = 0.7112	-1.212 Prob > z = 0.2255
Statistically insignificant	Statistically insignificant

water at a relatively cheaper price, this study is arguing that households are currently spending an average of 13.25% of their take-home income to enjoy improved water. This estimate depicts households' average WTP for safe pipe-borne water in urban GAR. For the supply of reliable safe pipe-borne water, this estimate is very informative for the GWCL and government in determining pricing and subsidy strategies for households, especially the poor and non-poor. Lastly, the evidence of households' WTP supports the call for the provision of residential reliable safe pipe-borne water for households in urban GAR and by extension, the entire country.

ETHICAL DECLARATION

The data collection process which is part of my PhD research was approved by the Ethics Committee, Faculty of Social Sciences, University of East Anglia, UK. The data were presented at a seminar as well as shared with key supervisors.

DATA AVAILABILITY STATEMENT

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

REFERENCES

- Abdalla, C. W. 1990 Measuring economic losses from ground water contamination: an investigation of household avoidance costs. *Journal of the American Water Resources Association* **26** (3), 451–463.
- Amoah, A. 2017 Demand for domestic water from an innovative borehole system in rural Ghana: stated and revealed preference approaches. *Water Policy* **19** (1), 46–68.
- Amoah, A. 2018 Is access to reliable improved water a determinant of urban rental values? *Interdisciplinary Environmental Review* **19** (3–4), 306–322.
- Amoah, A. & Moffatt, G. P. 2017 *Estimating Demand for Reliable Piped-Water Services in Urban Ghana: An Application of Competing Valuation Approaches*. Working Paper: No. 2017-01. School of Economics, University of East Anglia, Norwich, UK.
- Amoah, A., Ferrini, S. & Schaafsma, M. 2019 Electricity outages in Ghana: are contingent valuation estimates valid? *Energy Policy* **135**, 110996.
- Boadu, F. O. 1992 Contingent valuation for household water in rural Ghana. *Journal of Agricultural Economics* **43**, 458–465.
- Cameron, T. A. & Englin, J. 1997 Respondent experience and contingent valuation of environmental goods. *Journal of Environmental Economics and Management* **33** (3), 296–313.
- Ghana Statistical Service 2008 *Ghana Living Standards Survey Report of the 5th Round (GLSS 5)*. Available from: https://www2.statsghana.gov.gh/docfiles/glss5_report.pdf (accessed 21 April 2020).
- Ghana Statistical Service 2012 *The 2010 Population and Housing Census, Summary Report of Final Results*. Sakoa Press Limited, Ghana.
- Ghana Statistical Service 2014 *Ghana Living Standards Survey Round 6 (GLSS 6), Main Report*. Available from: https://statsghana.gov.gh/gssmain/fileUpload/Living%20conditions/GLSS6_Main%20Report.pdf (accessed 22 June 2020).
- Grönwall, J. & Oduro-Kwarteng, S. 2018 Groundwater as a strategic resource for improved resilience: a case study from peri-urban Accra. *Environmental Earth Sciences* **77** (1), 6.
- Mitchel, R. C. & Carson, R. T. 1989 *Using Surveys to Value Public Goods: The Contingent Valuation Method*. Resources for the Future, Washington, D.C., USA.
- Monney, I. & Antwi-Agyei, P. 2018 Beyond the MDG water target to universal water coverage in Ghana: the key transformative shifts required. *Journal of Water, Sanitation and Hygiene for Development* **8** (2), 127–141.
- Pattanayak, S. K., Poulos, C., Yang, J. C. & Patil, S. 2010 How valuable are environmental health interventions? evaluation of water and sanitation programmes in India. *Bulletin of the World Health Organization* **88**, 535–542.
- Tarfasa, S. & Brouwer, R. 2013 Estimation of the public benefits of urban water supply improvements in Ethiopia: a choice experiment. *Applied Economics* **45** (9), 1099–1108.
- Um, M. J., Kwak, S. J. & Kim, T. Y. 2002 Estimating willingness to pay for improved drinking water quality using averting behavior method with perception measure. *Environmental and Resource Economics* **21** (3), 285–300.
- Van Den Berg, C. & Nauges, C. 2012 The willingness to pay for access to piped water: a hedonic analysis of house prices in Southwest Sri Lanka. *Letters in Spatial and Resource Sciences* **5** (3), 151–166.
- Van Houtven, G. L., Pattanayak, S. K., Usmani, F. & Yang, J. C. 2017 What are households willing to pay for improved water access? results from a meta-analysis. *Ecological Economics* **136**, 126–135.
- Vásquez, W. F., Mozumder, P., Hernandez-Arce, J. & Berrens, R. P. 2009 Willingness to pay for safe drinking water: evidence from Parral, Mexico. *Journal of Environmental Management* **90** (11), 3391–3400.

- Vinorkor, M.-A. & Afari-Mintah, J. 2008 *Water: Accra to Benefit From 13 Boreholes*. Modern Ghana Accra, Ghana. Available from: <https://www.modernghana.com/news/160003/water-accra-to-benefit-from-13-boreholes.html>.
- Whittington, D., Lauria, D. T., Wright, A. M., Choe, K., Hughes, J. & Swarna, V. 1992 *Household Demand for Improved Sanitation Services; A Case Study of Kumasi, Ghana*. prepared for the UNDP-World Bank Water and Sanitation Program, Water and Sanitation Division, Infrastructure and Urban Development Department. Technical Report, World Bank, Washington, DC, USA.
- World Bank 2019 *People Using Safely Managed Drinking Water Services (% of Population)-Ghana*. Available from: <https://data.worldbank.org/indicator/SH.H2O.SMDW.ZS?locations=GH> (accessed 21 April 2020).
- WHO 2015 *Guidelines for Drinking-water Quality First addendum to third edition*, Vol. 1 Recommendations. World Health Organization, Geneva, Switzerland. Available from: https://www.who.int/water_sanitation_health/dwq/gdwq_0506.pdf (accessed 21 April 2020).
- Yamane, T. 1967 *Elementary Sampling Theory*. Prentice Hall, Upper Saddle River, NJ, USA.
- Yeleliere, E., Cobbina, S. J. & Duwiejuah, A. B. 2018 *Review of Ghana's water resources: the quality and management with particular focus on freshwater resources*. *Applied Water Science* 8 (3), 93.
- Yirenkyi-Fianko, A. B. 2019 Impact of artisanal and small-scale mining on the environment in Ghana. In: *Essays on the Land, Ecotheology, and Traditions in Africa* (B. A. Ntneh, M. S. Aidoo & D. N. A. Aryeh, eds). Wipf and Stock, Eugene, OR, USA.

First received 7 May 2020; accepted in revised form 21 July 2020. Available online 1 September 2020