Demand For Improved Water Quality: An Analysis of Averting Actions by Cameroonian Households

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Abstract

This study aims to investigate the demand for improved water quality in Cameroon by analysing the determinants of household averting actions to cope with unsafe drinking water. The study is based on primary data collected in 2013 from a sample of 789 households in the cities of Douala and Yaoundé, Cameroon. The econometric approach used in the study is the same as that of McConnell and Rosado (2000). The main findings of the estimated model are: the decision to adjust water quality decreases when income decreases, when there are no children under five in the household, and when the quality of the water consumed is not a concern. Also, the probability of adopting a given avoidance measure decreases with its cost of adoption and increases with its level of efficiency (measured by people's favourable opinion on the quality of water after adjustment). Implications for public policies are discussed in the paper.

Keyword: *Unsafe drinking water, improved water quality, econometric analysis, the IIA assumption, nested logit model*

1. Introduction

Access to safe and reliable water is a daily battle for hundreds of thousands of citizens who mainly live in developing countries (Hinrichsen et al, 2002; Chapitaux et al, 2002; UN-Water/WWAP, 2006). According to the World Health Organization (WHO), more than 1.1 billion people (17% of the world population) do not have access to safe drinking water. Forecasts by the United Nations (UN) and the United Nations Educational, Scientific and Cultural Organization (UNESCO) are alarming: by 2025, the number of people without access to safe water is projected to at least double; one-third of humanity will not have access to safe drinking water.

Various avoidance measures are used by individuals to cope with the poor quality of their water. The most promising and accessible avoidance measures are filtration with ceramic filters, chlorination, and solar disinfection by the combined action of UV rays and heat (WHO, 2012). In general, several avoidance measures are combined. For instance, when the water is not clear or contains dirt, it must first be clarified (through, among other measures, filtration and settling) before being disinfected (chemical disinfection, solar disinfection or boiling) (Cotruvo and Sobsey, 2006).

Many studies have found that the use of avoidance measures has a significant effect on both the water quality and the reduction of the occurrence of diarrhoea. For example, the treatment of water with chlorine may lead to a reduction of 35% to 39% of diarrhoea episodes (WHO, 2005). Two systematic reviews with meta-analyses of the effect of water treatment at home (Arnold and Colford, 2007; Clasen et al, 2007) highlight the efficiency of these interventions in terms of health improvement. Studies also suggest that in-home treatment, as compared to source or storage improvements, provides the most effective method to ensure the consumption of clean drinking water (Brick et al, 2004; Fewtrell et al, 2005).

Despite the effectiveness of in-home treatment, it is worth noting that this practice is not yet widespread in many countries, including Cameroon. The results of the third Multiple Indicator Cluster Survey conducted by the National Institute of Statistics in 2006 show that only 10.2% of the surveyed households treat their drinking water at home. Such results are quite surprising as statistics show that the proportion of the population that has access to safe drinking water is only 43.9% (DSCE, 2009).

Considering the huge investments needed to provide safe drinking water to all, it is clear that a large proportion of the world's population will still have to do without access to improved water supply for a long time, hence the need for averting actions to cope with poor water quality. It is therefore imperative to understand the factors that may explain household averting actions. Thus, the objective of this study is to investigate the demand for improved water quality in Cameroon by analysing the determinants of household averting actions to cope with unsafe drinking water.

The literature on household avoidance behaviour is quite extensive. However, it suffers from many shortcomings. For example, no study to date has tested the influence of responders' bias towards the effectiveness of avoidance measures (in terms of water quality improvement) on such behaviour. Besides, these studies do not take into account the endogeneity of the subjective quality of water in the econometric models as was done by Nauges and Van den Berg (2009). Furthermore, in most existing studies, often only the characteristics of individuals/households are introduced as explanatory variables in the estimated models while the characteristics of the avoidance measures are omitted. The present study seeks to address these shortcomings. It is in line with the studies by McConnell and Rosado (2000) and Yoshida and Kanai (2007). The econometric model used is the nested logit model.

The paper is structured as follows: Section 2 presents the literature review, Section 3 covers methodology, Section 4 presents the results of the empirical analysis discussed in Section 5, and Section 6 concludes.

2. Literature review

The empirical literature on the determinants of the demand for improved water quality in developed countries is quite rich. Among these studies, a number analysing household strategies to cope with unreliable water quality were conducted in the 1980s and 1990s (for example, Smith and Desvousges 1986; Abdalla et al, 1992; Laughland, et al, 1993; Whitehead et al, 1998; Larson and Gnedenko, 1999). In recent years, such studies have prompted increasing interest among economists (among others, Abrahams et al, 2000; Yoshida and Kanai, 2007; Nick and Ysé, 2012).

The literature on the determinants of household avoidance behaviour in developing countries is more current than in developed countries. Most of the studies carried out in developing countries have been in Asia (Um et al, 2002; Pattanayak et al, 2005; Roy et al, 2004; Haq et al, 2007; Jalan and Somanathan, 2008; Jalan et al, 2009; Nauges and Van den Berg, 2009; Kraemer and Mosler, 2010). A few studies, like that by McConnell and Rosado (2000), have been conducted in South America. Likewise, only a few studies, such as those by Dubois et al (2010) and Anderson et al (2010), have so far been conducted in Africa.

Two main methods are often adopted in existing studies: the identification of the determinants of household avoidance behaviour on the one hand, and the assessment of the avoidance expenditures followed by the identification of the determinants of these avoidance expenditures on the other hand. The two approaches are jointly used by Abdalla et al (1992) in their study. The first approach was used by the authors in discussing the reasons behind the choice of households to undertake averting actions to reduce exposure to water contaminated with trichloroethylene. The authors conducted a study on a sample of households in the municipality of Perkasie, Pennsylvania (USA), following the discovery of trichloroethylene in groundwater. The study shows that among the respondents, only 43.2% were aware of the presence of trichloroethylene in their water. Of these, 133 (43.75%) said they had undertaken specific actions to avoid exposure after learning of the presence of trichloroethylene in their water.

Abdalla et al (1992) adopted the second approach when analysing the intensity of the measures taken to deal with water contaminated with trichloroethylene. The dependent variable of the estimated OLS model is the estimated household averting expenditure as a direct function of trichloroethylene contamination over the period of water contamination. The cost of these measures during the 88 weeks of water contamination by trichloroethylene varied between US$ 61,313.29 and US$ 131,334.06 when extrapolated to the entire population of Perkasie. The results of the econometric estimates highlight the significance and positive impact of the presence of at least one child under three years old in the household on these costs.

There is extensive economic literature that attempts to understand factors behind household choices to purify drinking water. Education is an important determinant, highlighted by studies such as those by McConnell and Rosado (2000), Dasgupta (2004) and Roy et al (2004). Jalan et al (2009) estimate the effects of schooling, exposure to mass media, and occupational variables as measures of awareness on home water purification in urban India. They find that these awareness indicators have statistically significant effects on home purification and, therefore, on willingness to payfor better quality drinking water. The role of several other socioeconomic factors such as welfare level and presence of children in the household is further highlighted in existing studies. Concerning welfare level, it is worth nothing that the main measure used in existing studies on proxy welfare is either income (Whitehead et al, 1998; Haq et al, 2007; Bukenya, 2006; Nick and Ysé, 2012) or a wealth index constructed on the basis ofhousehold ownership of various consumer durables (Jalan et al, 2009; Ahmed and Sattar, 2007; Ahmad et al, 2010). The existence of strong relationships between the presence of children in the household and the use of avoidance measures is suggested by several studies (McConnell and Rosado, 2000; Bukenya, 2006; Nauges and Van den Berg, 2009; Nick and Ysé, 2012). The studyby Abdalla et al (1992) suggests that the decision to undertake averting actions is positively related to the presence of children aged between 3 and 17 in the household. The effect of factors such as zone of residence (Haq et al, 2007), household size (Nick and Ysé, 2012), occupational status (Jalan et al, 2009; Nauges and Van den Berg, 2009), gender (Ahmed and Sattar, 2007), concern about water quality (Whitehead et al, 1998; Abrahams et al, 2000) is also explored in the literature.

Bukenya (2006) used data from a sample of 487 households surveyed in Uganda. It shows that the boiling of water reduces the probability of using bottled water, while the demand for bottled water does not affect the probability of using a water filter. It also suggests that income, educational level, location, the presence of childrenand opinion of the quality of drinking water are strong determinants of the use of avoidance measures. Regarding quality of water, existing studies only focus on the impact of perceived initial water quality on the likelihood of adjusting it (among others, Nauges and Van den Berg, 2009; Nick and Ysé, 2012), omitting to test the impact of perceived final water quality on the choice of avoidance measures. Yet, it is logical to think that the adoption of a given avoidance measure rather than another may be due to the fact that the preferred method provides better water quality. This study addresses this issue and considers the perceived final water quality as a proxy of the efficiency of avoidance measures.This perceived efficiency is likely to be an endogenous explanatory variable in the averting behaviour models, while the risk of endogeneity will be addressed. The study also attempts to assess the impact of the cost of avoidance measures on household behaviour. McConnell and Rosado (2000) as well as Yoshida and Kanai (2007) are the only authors to have investigated the effect of such cost in their analyses. Two types of costs are considered in the literature: variable costs equal to the purchase price of inputs used to improve water quality (such as cotton and fuel for boiling) and the opportunity costs of improvement.

So far, the research by Totouom et al (2012) remains the only study conducted in Cameroon. The estimated bivariate probit model used in their study highlights the positive and significant impact of educational level, wealth quintile and number of children in households. This study, however, failed to test the impact of avoidance measure characteristics on household behaviours due to the lack of relevant data. Furthermore, the study only focuses on the decision to treat water, but does not investigate the choice of the treatment method. This study attempts to remedy these shortcomings.

3. Methodology

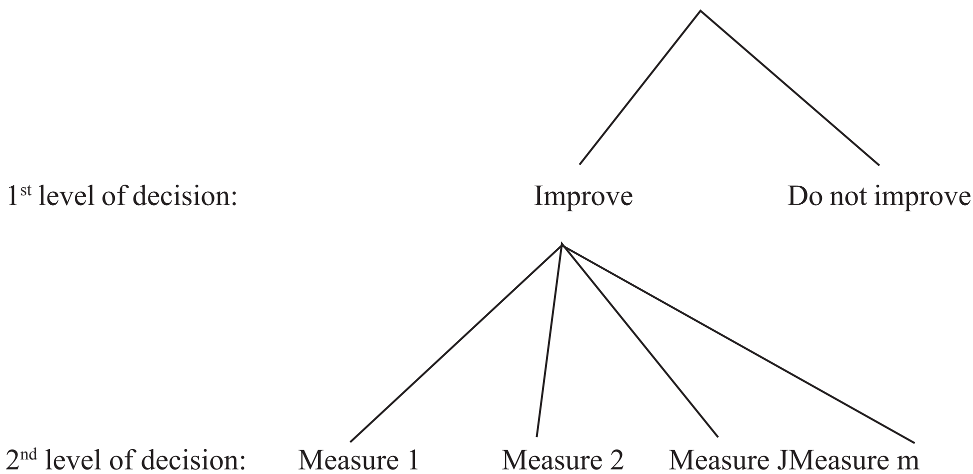
The econometric model

In this study, household avoidance behaviour modelling follows the method used by McConnell and Rosado (2000), who rely on the nested logit model in their econometric analysis. To date, these authors are probably the only ones to have used the nested logit model to examine household determinants of adjusting water quality. McFadden (1978) demonstrated that, under certain conditions, the IIA assumption of the multinomial logit model could be relaxed in order to take into account correlations between choices available in a particular subset or nest and maintaining the restriction of IIA between nests.

The nested logit model was first proposed by Ben-Akiva (1973). Its use in this study implies that the choice to adopt a particular coping strategy is dependent on the decision to improve water quality: a household first decides whether or not to improve its water quality and later chooses its improvement measure j (j = 1, 2, ..., m) from a set of available avoidance measures.

Figure 3.1 gives a simplified structure of household decisions

Figure 3.1: Structure of the decision model



The coping strategies considered in this study based on the survey are: boiling, filtering with cotton, filtering with a ceramic filter, the use of chemicals (bleach or chlorine), and consumption of bottled water.

The indirect utility of a household can be expressed as follows:

$$u_{ij} = v_{ij} + \varepsilon_{ij} = Z_{ij}\alpha + X_i\beta + \varepsilon_{ij} \tag{1}$$

Where i is the household index and j the avoidance measures index.

$v_{ij} = Z_{ij}\alpha + X_i\beta$ is the deterministic component of utility and ε_{ij} is the error term known by the household but not observed by the researcher. This is a random utility model developed by McFadden (1974). The error term is assumed to be a random variable independently distributed according to an extreme-value law. X_i is the vector of household characteristics. These variables vary between households, but remain constant between alternatives. Z_{ij} is the vector of the attributes related to the treatment options. These attributes vary from one alternative to another, and from one household to another.

McFadden (1978) shows that conditional and marginal choice probabilities are given by the multinomial logit formulas $P_{j/i}$ and P_i.

The probability that a household would choose avoidance measure j given that it has chosen to improve the quality of its water is:

$$P_{j/i} = \frac{e^{(Z_{ij}\alpha)}}{\sum_{l=1}^{m} e^{(Z_{il}\alpha)}} \tag{2}$$

In this probability, the variables that vary between households but remain constant between alternatives are excluded. The marginal probability that a given household chooses to improve the quality of its drinking water is given by:

$$P_i = \frac{e^{(X_i\beta)+\mu_i I_i}}{\sum_{k=1}^{n} e^{(X_k\beta)+\mu_k I_k}} \tag{3}$$

In this formula, I_i is called the inclusive value and is given by:

$$I_i = \ln\left(\sum_{l=1}^{m} e^{(Z_{il}\alpha)}\right) \tag{4}$$

To jointly estimate models related to the decision to improve water quality and the choice of the avoidance measure, the nested logit combines the probabilities in

Equations 2 and 3. The probability of a household's decision to use avoidance measure j to improve the quality of drinking water is:

$$P_{ij} = \mathrm{P}_{j/i}\,\mathrm{P}_i \qquad (5)$$

The nested logit model is consistent with utility maximization if and only if the coefficients of the inclusive values parameters are in the unit interval. When they are equal to one, the probabilities of choices are given by the standard multinomial logit. When they are equal to zero, the error terms become perfectly correlated and households choose the alternative with the highest utility.

The parameters of the nested logit model may be estimated by the sequential method. It may also be estimated by the maximum likelihood technique. The maximum likelihood technique is used in this study becauseit yields more efficient estimates.[1]

Data

Data used in the study come from a field survey conducted among a sample of households in Douala and Yaoundé in 2013 with the support of the Centre of Studies and Research in Economics and Management of the University of Yaoundé II. The objective of the survey was to provide an overview of the water situation in Cameroonian households. Information related to all available water sources, collection of water, consumption quantities, and avoidance measures to cope with unreliable water quality was collected. Details on socioeconomic and demographic characteristics of the surveyed households were also gathered. Data were gathered through personal interviews. The questionnaire was pre-tested to evaluate its effectiveness and feedback from the pre-test was used to revise the final questionnaire used during the survey. The estimation of the theoretical sample of 982 households (669 in Douala and 313 in Yaoundé) to use for the survey was based on the following formula developed by Sudman and Bradburn (1982):

$$n = \frac{(1.96)^2\, p(1-p)}{\lambda^2}$$

This model is recommended for a large population (over 100 000 individuals). n is the sample size to calculate; 1.96 corresponds to the choice of a confidence interval of 95%; p represents the proportion of the population showing interest and λ is the tolerable error, that is the margin of error for the survey. As the proportion of the population that purifies water in the cities of Douala and Yaoundé is 30.87% and 11.27%, respectively, in the MICS dataset, $p_1 = 0,3087$ and $p_2 = 0,1127$ are considered for Douala and Yaoundé, respectively. If the tolerable margin of error value of 3.5% is taken, then the above formula will yield the sample size for the cities of Douala and Yaoundé as $n_1 = 669$ and $n_2 = 313$, respectively.

After cleaning and tallying the data from the questionnaires, only 789 (491 in Douala and 298 in Yaoundé) were relevant, corresponding to a response rate of 80.35%

(73.39% in Douala and 95.21% in Yaoundé) compared to the set target of 982.

The cartographic data from the Bureau of Census and Population Studies (BUCREP), developed in 2003 under the 3rd General Census of Population and Housing (RGPH), were used as the sampling frame for the survey. For sample collection, a two-stage random sampling method was adopted: a random selection of a number of enumeration areas within each sub-division of Douala and Yaoundé, followed by a random selection of a number of households to be interviewed in each enumeration area sampled. A total of 26 enumeration areas involving 26 neighbourhoods were taken (11 in Yaoundé and 15 Douala). As indicated previously, all the sub-divisions of Douala and Yaoundé were involved in the survey to ensure sufficient geographical coverage and spatial representation of the population. There was an attempt to achieve equitable distribution of the number of surveyed households among sub-divisions in each city (approximately 133 households/sub-divisions in Yaoundé and 52 households/sub-divisions in Douala).

The surveyed households were withdrawn in order to extrapolate the survey findings to the whole population. The random selection of the surveyed households ensured that the sample is representative and provided a basis to generalize the findings.

Data show that a piped network is the main source of water in the study area. Of the 789 households surveyed in the study, 558 (70.72%) collect water from the piped network. However, among these households, only 360 (45.63%) are connected to a piped network at home. The other 198 households are supplied by public taps. In general, people have a good opinion of the quality of the water supplied (about 85% of the whole sample). This favourable opinion is more significant in the sub-group of households undertaking averting actions (85.3%) than in the sub-group of households not undertaking any averting action (81.5%). Regarding avoidance measures undertaken to get better water quality, survey data show that of the 789 surveyed households, 402 (about 51% of the whole sample) usually do something to get better quality of water.A description of the avoidance measures used, as well as the household socioeconomic and demographic profiles, are reported in Section 4 of this paper.

Explanatory variables

The explanatory variables used in this study can be classified into two main categories: Characteristics of the households and characteristics of the avoidance measures.

Characteristics of the households

Income: As noted in the study of McConnell and Rosado (2000), income is a binary variable which represents the income of the household head. It takes a value of 1 if the income of the household head is strictly lower than the average income of the sample and 0 otherwise.

Douala: This is the hometown of the household. It is a dummy variable that takes a value of 1 if the household lives in the city of Douala and 0 if it lives in Yaoundé. Larson and Gnedenko (1999) show that, in some cases, the place of residence can significantly affect household choices.

Child: This variable indicates whether there is at least one child under 5 in the household or not. It is also a binary variable consistent with McConnell and Rosado

(2000) and takes a value of 1 for households that have at least one child under 5 at home and 0 otherwise.

Education: This variable measures household educational level. As used by McConnell and Rosado (2000), it is a dummy variable. It takes a value of 1 if the highest level of education attained by household head is primary and 0 otherwise.

Concern: This variable measures household concern about the quality of its drinking water. During the investigation, the following question was asked: "*Is the quality of your drinking water a major concern to you?*" The interviewees were asked to answer yes or no.

In this study, the variable takes a value of 1 for households that answered no to the question and 0 otherwise.

Characteristics of the avoidance measures

Quality: This is household opinion on the quality of water after adjustment of its quality with eachof the avoidance measures available. It is used as a proxy variable to measure the effectiveness of these avoidance measures. The introduction of perceived water quality in models can potentially cause endogeneity bias (Whitehead, 2006). However, there is still a gap in the literature for appropriate and valid instruments to measure the perception of water quality, as those used by Whitehead (2006) and Danielson et al (1995) are questionable. To avoid the problem of endogeneity bias arising from the introduction of quality of water in averting behaviour models, the opinion of each household is replaced by the average opinion of the households in its neighbourhood (Briand et al, 2009; Nauges and Van den Berg, 2009; Briand et al, 2010; Briand and Laré, 2010). This average opinion is equal to the share of households in the district that have a favourable opinion of the quality of water after adjustment by the different avoidance measures available. Two types of opinion are considered in this study: opinion on water safety *Safquality*, and opinion on overall water quality *Genquality*.[2]

Cost: This variable represents the financial cost associated with the acquisition and use of each avoidance measure. Two types of cost are considered in the present study: variable cost and total cost. For households boiling their drinking water, variable cost (*Varcost)* is given by the average purchase cost of fuel used each month. For households that purify their water with bleach, chlorine or cotton, *Varcost* is determined by the average purchase cost of these inputs per month. For households using a ceramic filter, *Varcost*is determined by the ratio between the purchase cost of the filter and the number of years from the purchasing date of the filter to the date of the survey. In order to get a monthly value, this ratio is divided by 12. For households using the consumption of bottled water as a coping strategy, variable cost is given by the average cost of purchased water each month. *Varcost* is associated with an avoidance measure and is given only for households that use it. For other households that improve drinking water quality, it is associated in this study by the average variable cost of the sub-group of households using this method.

Totalcost is associated with coping strategies. It is equal to variable cost plus the opportunity cost of time spent treating water. This opportunity cost is given by the average time (in hours) spent every month to adjust water quality multiplied by the household's hourly income.

For households boiling water, the average time spent treating water is calculated by average time spent boiling water each time multiplied by the number of times the water is boiled in a month. For households that use bleach, chlorine or cotton to treat their water, time spent treating water is calculated by the average time spent going to and from the usual point of purchase multiplied by the average number of trips made per month. For households consuming mineral water, this time is determined by average time spent going to and from the usual point of purchase multiplied by the average number of trips made per month. For households using an ordinary filter, the opportunity cost is zero.

The opportunity cost of time associated with a coping strategy is defined only for households that use it. For other households that improve drinking water quality, calculated over the entire sub-sample of households which adopted that particular measure.

Household hourly income is obtained by dividing the income of the household head by his/her monthly time of work (in hours). By assuming that people work 35 hours a week, the monthly time of work is equal to 35 * 4 = 140 hours.

4. Results

Statistical analysis of the variables

Survey data show that different avoidance measures are used by surveyed households. Table 1 below provides a distribution of surveyed households by avoidance measures.

Table 1: Distribution of households by avoidance measure

Avoidance measures	Douala		Yaoundé		Total	
	Number	**Frequency (%)**	**Number**	**Frequency (%)**	**Number**	**Frequency (%)**
Boiling	25	9.84	12	8.11	37	9.20
Use of chemicals	37	14.57	27	18.24	64	15.92
Filtering with cotton	87	34.25	34	22.97	121	30.10
Filtering with ceramic filter	84	33.07	60	40,54	144	35.82
Bottled water	19	7.48	12	8.11	31	7.71
Solar disinfection	0	0	3	2.27	3	0.75
Others	2	0.79	0	0	2	0.50
Total	254	100	148	100	402	100

It is observed from Table 1 that the use of a ceramic filter remains the main avoidance measure used by the surveyed households (35.82%). The use of a ceramic filter is also widespread in the cities of Douala and Yaoundé with a proportion of 33.07% and 40.54%, respectively. Filtering water with cotton is also widely practised. The proportion of surveyed households filtering their water with cotton is 34.25%, 22.97% and 30.10%, respectively in Douala, Yaoundé, and the total sample.

"Solar disinfection" and "Others" are the least used methods with a percentage of 0.75% and 0.50%, respectively. These two methods will be excluded from the next econometric analysis. The consumption of bottled water is marginal among the surveyed households (7.71%). In developing countries in particular, bottled water is reserved for the fortunate few.

Table 2 provides a descriptive statistic of the different explanatory variables used in the econometric analysis.

Table 2: Descriptive statistics of explanatory variables

Variables	Households that undertake avoidance measures		Households that do not undertake avoidance measures		Total sample	
	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation
Income (continuous, in FCFA)	0.557	0.497	0.557	0.497	0.557	0.497
Douala (=1, 0 otherwise)	0.623	0.485	0.623	0.485	0.623	0.485
Education (primary=1, 0 otherwise)	0.104	0.305	0.104	0.305	0.104	0.305
Child (no child=1, 0 otherwise)	0.597	0.490	0.597	0.490	0.597	0.490
Concern (no concern=1, 0 otherwise)	0.117	0.322	0.117	0.322	0.117	0.322
Genquality (continuous)	0.853	0.160	0.815	0.156	0.847	0.160
Safquality (continuous)	0.867	0.157	0.831	0.126	0.861	0.153
Varcost (continuous, in FCFA)	4387.52	6191.38	0	0	3656.26	5883.63
Totalcost (continuous, in FCFA)	5580.90	6710.74	0	0	4650.75	6469.43

Table 2 shows that about 62.3% of surveyed households were interviewed in the city of Douala. The data further reveal that 10.4% of household heads had not attained a level of education beyond primary level, implying that 89.6% attained at least primary level education. As to the presence of young children in the household, it emerges that 59.7% of households do not have children. Table 2 also shows that 55.74% of household heads have a monthly income that is strictly below the average sample mean. This average sample mean is 157,535 FCFA.[3] The table also shows that quality of water consumed is not a concern for 11.7% of the surveyed households.

Concerning household perception of the quality of water after adjustment, Table 2 shows that 84.7% of households are satisfied with the general quality of their water. This percentage is 86.1% when quality of water in terms of health safety is considered. It is worth noting that values taken by the two variables are higher among households that actually undertake avoidance measuresto adjust their water quality.

Regarding avoidance expenditures, statistics reveals that the average variable cost of adjustment with the avoidance measures used by surveyed households is 3656.26 FCFA per month. These costs vary from a minimum value of 0[4] to a maximum value of 56.000 FCFA. By integrating the opportunity cost of time spent improving water quality, the average total cost is 4650.75 FCFA per month. This total cost represents about 3% of the average monthly income of the households, which is 157.535 FCFA.

Results of the econometric model

After removing households with missing data from the sample, a total of 769 households were finally considered. Given the nature of the nested logit model used, the number of observations for each variable is 6[5] per household. Estimates therefore involved 769 * 6 = 4,614 observations. Results of the estimation of the determinants of household choices to improve drinking waterquality in Cameroon are reported in Table 3. Estimates were performed using STATA 12 software.

Table 3: Results of the nested logit model Variables

	Coefficients
Second level of decision: Boiling, using chemicals, filtering with cotton, filtering with aceramic filter, bottled water	
Totalcost/1000*(continuous, in FCFA)	-0.0756***
	(0.0140)
Genquality (continuous)	2.742***
	(0.425)
First level of decision: Improve/not improve	
Income (lower than the sample average=1, 0 otherwise)	-0.522***
	(0.155)
Child (no child=1, 0 otherwise)	-0.507***
	(0.148)
Education (primary=1, 0 otherwise)	-0.116
	(0.260)
Concern (no concern=1, 0 otherwise)	-1.294***
	(0.257)
Inclusive value	
Treat:	0.687***
	(0.0921)
Do not treat:	1
	(58248)
Likelihood ratio test for IIA $(\chi^2(2))$	10.07 ***
Number of observations	4614
Log likelihood	-1059
Significance of the model (Wald $\chi^2(6)$)	66.58***

*Variable Totalcost has been divided by 1000 in order to reduce the scale effect.[6]

Several tests were later conducted in order to assess the robustness of the results. To that end, various alternative specifications of the estimated econometric model were performed. In the first alternative specification (Model 1), the variable indicating the city of residence of the households is introduced into the model. Indeed, a household may purify its drinking water because its neighbourhood does so (Jalan et al, 2009). Estimation results are reported in the second column of Table 4. The results are a little different from those previously obtained. The sign and significance of all the variables remain the same. The variable indicating the place of residence has a coefficient that is not statistically significant, indicating that household choices are not significantly influenced by specific territorial factors.

Table 4: Results of robustness checks

Variables	Model 1	Model 2	Model 3	Model 4
Second level of decision making: Boiling, using chemicals, filtering with cotton, filtering with a ceramic filter, bottled water				
Cost/1000*(continuous, in FCFA)	-0.0776***		-0.0778***	
	(0.0144)		(0.0149)	
Varcost/1000*(continuous, in FCFA)		-0.0735***		-0.0731***
		(0.0135)		(0.0143)
Genquality (continuous)	2.811***	2.715***		
	(0.434)	(0.419)		
Safquality (continuous)			2.736***	2.636***
			(0.459)	(0.452)
First level of decision making: Improve/not improve				
Income (lower than the sample average=1, 0 otherwise)	-0.503***	-0.470***	-0.501***	-0.434***
	(0.157)	(0.152)	(0.156)	(0.155)
Child (no child=1, 0 otherwise)	-0.458***	-0.504***	-0.493***	-0.470***
	(0.160)	(0.148)	(0.150)	(0.163)
Education (primary=1, 0 otherwise)	-0.0947	-0.107	-0.112	-0.0980
	(0.262)	(0.260)	(0.259)	(0.260)
Concern (no concern=1, 0 otherwise)	-1.268***	-1.296***	-1.311***	-1.310***
	(0.260)	(0.257)	(0.257)	(0.259)
Douala (=1, 0 otherwise)	-0.123			-0.0362
	(0.156)			(0.154)
Inclusive value				
Treat:	0.705***	0.624***	0.687***	0.619***
	(0.0953)	(0.0830)	(0.0959)	(0.0881)
Do not treat:	1	1	1	1
	(124609)	(106446)	(91300)	(93661)

Likelihood ratio test for $(\chi^2(2))$	8.43 **	17.51* **	9.48* **	16.46***
Number of observations	4614	4614	4614	4614
Log likelihood	-1058	-1064	-1065	-1073
Significance of the model (Wald $\chi^2(7)$)	67.08***	66.18***	61.11***	59.60***

* These variables have been divided by 1,000 in order to reduce the scale effect.[7]

Column 3 presents the results of the estimation of the second alternative specification. In Model 2, the variable cost is used instead of the total cost. This specification is used to test the robustness of the negative and significant impact of the cost of an avoidance measure on its probability of adoption. Once again, results are not different from those of the model presented in Table 3. The coefficient of the different variables keeps the same sign and the same significance.

The results of the estimation of Model 3 are reported in column 4. This model is close to the one reported in Table 3. The difference here is that a specific aspect of water quality, namely the degree of safety (or conversely, the low level of health risk) is incorporated into the model as an explanatory variable instead of the variable's general quality. The results are interesting in the sense that they do not significantly differ from the others. They suggest that a favourable opinion about the effectiveness of an avoidance measure increases its probability of adoption.

A final alternative specification of the nested logit model is made (Model 4). This specification incorporated the variable *Douala*, the variable cost and the degree of safety. The estimation results are contained in column 5.

The observation of the results of the different alternative estimations show that they are very similar and close to those presented in Table 3. Results show that the sign and the significance of all the variables remain the same, indicating a certain robustness of the findings.

5. Discussion

The parameters of the inclusive value are useful to test the IIA assumption; indeed, a test of the hypothesis that all dissimilarity parameters are equal to 1 can be an effective test of the IIA assumption, i.e. the importance of using a nested logit model. The estimated parameter of the inclusive value in the branch “improve” is equal to 0.687. This means that the five avoidance measures are more substitutable among themselves than with the alternative “do not improve”. The parameter of the inclusive value for the branch “do not improve” option is set to 1 because it is a degenerate branch (or single option).

In addition, the likelihood ratio test indicates that the null hypothesis is rejected at 1% in the estimated model, which justifies the appropriateness of using a nested logit model.

The study explores the effect of household income on its decision to improve drinking water quality. The coefficient of the income variable is statistically significant and negative. This result suggests that the poorer a household is, the less likely it will be to improve its drinking water quality. The interpretation seems to be that avoidance measures for some households may involve significant costs so that income constraint becomes a factor that limits their choices. Such a result is not new in the literature. Previous studies such as those of McConnell and Rosado (2000) and Abrahams et al (2000) already discussed the influence of income on the likelihood of treating water.

According to existing studies, an important variable determining a household’s decision to use avoidance measures is the presence of children in the household, since they are more vulnerable to health risks from unreliable water than adults. Thus, households are generally less sensitive to water quality issues when they do not have children. The impact of the presence/absence of children on the choice to purify water or to consume bottled water is demonstrated by many authors (among others, McConnell and Rosado, 2000; Bukenya, 2006; Nauges and Van den Berg, 2009; Nick and Ysé, 2012). The estimation findings are consistent with those of the literature to the extent that the estimated coefficient of the child variable is negative and statistically significant at 1%.

As expected, the education variable that measures awareness of health effects of consuming contaminated water has a negative sign. However, the coefficient of the variable is not statistically significant.

This study also tested the effect of concern about the quality of the drinking water on household choices. The results suggest that this concern is a key determinant of household choices. The fact that a household is not concerned about the quality of its water significantly reduces the probability to undertake avoidance measures to improve it. This result is reflected in the sample as the proportion of households using avoidance measures is relatively low among households that indicated during the survey that the quality of their drinking water is not a matter of concern. This proportion increases from 25% among these households to 54.05% among those who expressed concern about the quality of their drinking water. Conversely, the proportion of households that does not use avoidance measures is relatively higher among households that are not concerned by the quality of their drinking water (75%) than among the households concerned about the quality of their water (45.95%). Based on such observations, it is safe to say that the adoption of avoidance measures and the variable *concern* would be negatively and significantly correlated. The estimation results of the econometric model confirm this hypothesis. The finding that the likelihood of using avoidance measures decreases when the household does not pay attention to the quality of water is logical since the interest in using such avoidance measures is precisely to obtain better water quality. Health authorities should therefore undertake consistent education measures and sensitize the population about the health hazards of waterborne diseases in order to prompt the population to pay special attention to the quality of water they drink. Such actions, which may be conducted in the media,are likely to produce positive effects in support of the Health Belief Model,which suggests that alerts or sensitization messages conveyed to the population about health issues serve as a signal that triggers the perceived threat and the likelihood of the action.

Results show that the estimated cost of water quality improvement has a negative and statistically significant coefficient, indicating that the more expensive an avoidance measure is, the less likely it will be chosen. This result is consistent with the demand theory,according to which,as the price of a good increases, the demand for that good will, ceteris paribus, decrease. The negative impact of the cost of water treatment on household choice is also highlighted in the study by McConnell and Rosado (2000). For better access to avoidance technologies by the population, authorities should put in place appropriate measures to reduce their cost. Such measures could take the form of tax exoneration on production/importation and/or sale of these technologies.

As to the impact of household opinion on the quality of drinking water, findings show that the coefficient of the variable *quality* is positive and statistically significant at 1%. This result suggests that the more households consider an avoidance method as efficient (i.e. it produces better water quality), the more likely they will adopt it. This result is consistent with expectations and may be justified by the fact that the ultimate objective of adopting avoidance measures is to obtain better quality water. This is a new finding in the literature. In order to popularize the adoption of avoidance measures in Cameroon, emphasis should be placed on community sensitization and education actions highlighting its efficiency as means to improve the quality of water and to reduce waterborne diseases. The treatment of water at home using chlorine, for instance, may lead to a reduction of 35%–39% of diarrhoeal cases (WHO, 2005). Priority should be given to the promotion of the most efficient avoidance methods.

6. Conclusion

Based on the survey data collected from a sample of 789 households in Douala and Yaoundé, this study uses a nested logit model to identify factors that influence household averting actions to cope with unsafe drinking water in Cameroon. The study contributes to the existing literature by addressing a number of shortcomings observed in previous studies. The robustness checks carried out suggest a certain robustness of the findings. In particular, results show that the probability of adopting avoidance measures decreases with their cost and increases with their subjective efficiency (people's favourable opinion of the water quality after adjustment).

Notes

1 The sequential estimation creates two difficulties. First, the standard errors of the upper-model (improved water quality or not) are biased downward as Amemiya (1978) first pointed out. Second, it is usually the case that some parameters appear in several sub-models. Estimating the various upper and lower (choice of avoidance measure) models separately provides separate estimates of whatever common parameters appear in the model. Therefore, while consistent, parameters of the sequential method are not as efficient as simultaneous estimation by maximum likelihood.

2 General quality of water is a wider concept involving colour, odour, taste, and safety.

3 This average monthly income also affected the 42 households in the sample for which data were missing.

4 For households not involved in averting actions.

5 Due to the existence of 6 possible choices: Choice of one of the five avoidance measures, or the option “do not improve water quality”.

6 This technique is preferred to the logarithmic transformation.

7 This technique is preferred to the logarithmic transformation.

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