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Determinants of household avoidance behavior to cope with unsafe drinking water: Case study of Cameroon

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Abstract: This study analyses the determinants of household avoidance behavior to cope with unsafe drinking water in Cameroon. The study is based on primary data collected in 2013 from a sample of 789 households in the cities of Douala and Yaoundé. The econometric approach used in the study is the same as McConnell and Rosado (2000). The main findings of the estimated model are the following: the decision to adjust water quality decreases when income decreases, when there is no child 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 efficiency (measured by people's favourable opinion on the quality of water after adjustment). Implications for public policies are discussed in the paper.

Keywords: determinants, household avoidance behavior, drinking water, nested logit model

1. Introduction

Access to safe and reliable water is nowadays a daily battle for hundreds of thousands of citizens who live mainly 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 of 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 should at least double; one third of humanity will not have access to safe drinking water.

A palliative to enable individuals to cope with the poor quality of their water is the use of various avoidance measures. 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 (OMS, 2012). In general, several avoidance measures may be combined. For instance, when the water is not clear or contains dirt, it must first be clarified (filtration, settling, etc.) before being disinfected (chemical disinfection, solar disinfection, 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 diarrhea. For example, the treatment of water with chlorine may lead to a reduction of 35 to 39% of diarrhea episodes (OMS, 2005). Two systematic reviews with meta-analyzes on 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 since statistics show that the proportion of the population that has access to safe drinking water is only 43.9% (DSCE, 2009).

Looking at 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 go for a long time with no access to improved water supply, hence the need of averting actions to cope with poor water quality. It is therefore imperative to understand the factors that may explain household avoidance behavior. Thus, the objective of this study is to analyze the determinants of household avoidance behavior to cope with unsafe drinking water in Cameroon.

The literature on household avoidance behavior is quite extensive. However, it suffers from many shortcomings. For instance, no study to date has tested the influence of people's opinion about the effectiveness of avoidance measures (in terms of water quality improvement) on averting behavior. Besides, these studies do not take into account the endogeneity of the subjective quality of water in the econometric models as done by Van Den Berg and Nauges (2009). Furthermore, in most existing studies, only the characteristics of individuals/households are often 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 the same vein as line with the studies of McConnell and Rosado (2000), Kentaro Yoshida and Sohey 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.

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 analyzing household strategies to cope with unreliable water quality were conducted in the 1980s and 1990s (Smith and Desvousges 1986; Abdalla et al, 1992; Laughland, et al, 1993; Whitehead et al, 1998 ; Larson et al., 1999; etc.). In recent years, such studies have prompted increasing interest among economists

(Abrahams et al, 2000; Kentaro Yoshida and Sohey Kanai, 2007; Johnstone and Serret, 2012; etc.).

The literature on the determinants of household avoidance behavior in developing countries is more recent 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 Somathan 2008 ; Jalan et al, 2009; Nauges and Van Den Berg, 2009; Kraemer and Mosler, 2010). Few studies like those of McConnell and Rosado (2000) have been conducted in South America. Likewise, few studies such as 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 behavior on one hand, and the assessment of the avoidance expenditures followed by the identification of the determinants of these avoidance expenditures on the other hand.

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 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 pay for better drinking water quality. 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, it is worth nothing that the main measure used in existing studies to proxy welfare is either income (Whitehead et al., 1998; Haq et al., 2007; Bukenya, 2006; Johnstone and Serret, 2012) or wealth index constructed on the basis of household 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; Johnstone and Serret, 2012). The study of 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 (Johnstone and Serret, 2012), occupational status (Jalan et al., 2009; Nauges et Van Den Berg, 2009), gender (Ahmed et 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 surveyed households in Uganda. Its 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 water filter. It also suggests that income, educational level, location and the presence of children and 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

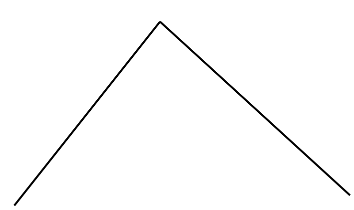
the likelihood of adjusting it (Nauges and Van Den Berg, 2009; Johnstone and Serret, 2012; etc.), omitting to test the impact of perceived final water quality on the choice of avoidance measures. Yet, it is logical to think that the adoption of a given avoidance measure over the other may be due to the 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 behavior 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 behavior. McConnell and Rosado (2000) as well as Kentaro Yoshida and Sohey Kanai (2007) are the only few authors to have investigated the effect of such cost in their analysis. Two types of costs are considered in the literature: variable costs equal to the purchase price of inputs used to improve water quality (cotton, fuel for boiling, etc.) and opportunity costs of improvement equal to the value of time spent adjusting the quality of water.
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. The study however failed to test the impact of avoidance measures characteristics on household behaviors due to the lack of relevant data. This study uses a more relevant dataset that allow the implementation of such test. Furthermore, the study of Totouom et al. (2012) 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

3.1 The econometric model

In this study, household avoidance behavior modelling follows the method used by McConnell and Rosado (2000), relying on the nested logit model in their econometric analysis. To date, these authors are probably the only ones to have used the nested logit 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: 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.
The figure below gives a simplified structure of household decisions:

Figure 4.1: Structure of the decision model



1st level of decision: Improve Do not improve

2nd level of decision: Measure 1 Measure 2 ………….. Measure J……….. Measure m

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

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

$$u_{ij} = \nu_{ij} + \varepsilon_{ij} = Z_{ij}\alpha + X_i\beta + \varepsilon_{ij} \quad (1)$$

Where i is households index and j avoidance measures index

$\nu_{ij} = Z_{ij}\alpha + X_i\beta$ 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 chooses avoidance measure j given that it has chosen to improve the quality of its water is:

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

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;

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

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

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

To jointly estimate models related to the decision to improve water quality and the choice of the avoidance measure, the nested logit combines probabilities (2) and (3). The probability of a household's decision to use avoidance measure j to improve the quality of drinking water is:

$$P_{ij} = \mathrm{P}_{j/i}\,\mathrm{P}_i$$

(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 techniques. The maximum likelihood technique is used in this study because they yield more efficient estimates.

3.2 Data

Data used in the study come from a field survey conducted in 2013 among a sample of households in Douala and Yaoundé. The objective of the survey was to provide an overview of the water situation in Cameroon households. Information related to all available water sources, collection of water, consumption quantities, and avoidance measures to cope with unreliable water quality were collected. Details on socioeconomic and demographic characteristics of the surveyed households were also gathered. Data were gathered through personal interviews. The estimation of the theoretical sample of 982 households (669 in Douala and 313 in Yaoundé) to 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 confident 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 $n_2 = 313$.

At the end of the survey, only 789 questionnaires (491 in Douala and 298 in Yaoundé) were correctly filled and exploitable, corresponding to a response rate of 80.35% (73.39% at Douala and 95.21% at Yaoundé) compared to the set target of 982.

For sample collection, a two-stage random sampling method was adopted: a random selection of a number of enumeration areas[1] 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 neighborhoods were taken (11 in Yaoundé and 15 Douala). As said above, all the sub-divisions of Douala and Yaoundé were involved in the survey to ensure sufficient geographical coverage and spatial representation of the population.

3.3 The explanatory variables

The explanatory variables used in this study can be classified into two main categories:

Characteristics of the households

low_income: As in the study of McConnell and Rosado (2000), low_income variable is a binary variable which represents the income of the household head. In this study, low_income takes the 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 the 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.

No_child: This variable indicates whether there is at least a child under 5 in the household or not. It is also a binary variable consistent with McConnell and Rosado (2000) and takes the value of 1 for households not having at least a child at home and 0 otherwise.

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

no_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?*" To this question, the interviewees were asked to answer yes or no.

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

Characteristics of the avoidance measures

[1] Enumeration areas are the cutouts of cities in clusters of relatively equal size, carried by the part the BUCREP during the RGPH.

Quality: It is household opinion on the quality of water after adjustment of its quality with each one of 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 et al., 2006). However, there is still a gap in literature for appropriate and valid instruments to measure the perception of water quality, whereas those used by Whitehead et al. (2006) and Danielson et al. (1995) are questionable. To avoid the problem of endogeneity bias arising from the introduction of subjective quality of water in averting behavior models, the opinion of each household is replaced by the average opinion of the households of its neighborhood (Briand et al., 2009; Nauges and Van Den Berg, 2009; Briand et al, 2010; Briand and Lare, 2010). This average opinion is equal to the share of households of the district that have a favourable opinion of the quality of water after adjustment with 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 is financial cost associated with 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 survey. In order to get a monthly value, this ratio is then divided by 12. For households using the consumption of bottled water as coping strategies, 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 the 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 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, 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.

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

The opportunity cost of time associated with a coping strategy is defined only for households that use it. For the other households that improve drinking water quality, it is associated in this study the average opportunity cost of the sub-group of using this strategy.
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 month, the hourly time of work is equal to 35 * 4 = 140 hours.

4. Results

4.1 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 measures

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 ceramic filter remains the main avoidance measure used by the surveyed households (about 36%). The use of ceramic filter is also widespread in the cities of Douala and Yaoundé with a proportion of 33% and 41% respectively. Filtering of water with cotton is also widely practiced. The proportion of surveyed households filtering their water with cotton is 34%; 23% and 30% 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**
Low_income	0.557	0.497	0.557	0.497	0.557	0.497
Douala	0.623	0.485	0.623	0.485	0.623	0.485
Primary_education	0.104	0.305	0.104	0.305	0.104	0.305
No_child	0.597	0.490	0.597	0.490	0.597	0.490
No_concern	0.117	0.322	0.117	0.322	0.117	0.322
Genquality	0.853	0.160	0.815	0.156	0.847	0.160
Safquality	0.867	0.157	0.831	0.126	0.861	0.153
Varcost	4387.52	6191.38	0	0	3656.26	5883.63
Totalcost	5580.90	6710.74	0	0	4650.75	6469.43

Table 2 shows that about 62% of the surveyed households were interviewed in the city of Douala. The data further revealed that 10.4% of household heads have attained not more than primary education. As to the presence of young children in the household, it emerges that about 60% of households do not have children. Table 2 also shows that about 56% of household heads have a monthly income that is strictly below the average sample mean.

This average sample mean is about 158 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 about 85% of households are satisfied with the general quality of their water. This percentage is 86% 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 measures to 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 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 FCFA per month. This total cost represents about 3% of the average monthly income of the households which is 158 FCFA.

4.2 Results of the econometric model

After treatment of the sample by removing households with missing data, a total of 769 households where finally considered. Given the nature of the nested logit model used, the number of observations on each variable is 6 per household[5]. Estimates therefore involved 769 * 6 = 4614 observations. Results of the estimation of the determinants of household choices to improve drinking water quality in Cameroon are reported in Table 3. Estimates were performed using STATA 12 software.

<u>Table 3</u> : Results of the nested logit model

Variables	Coefficients
Second level of decision : boiling, using chemicals, filtering with cotton, filtering with a ceramic filter, bottled water	
Totalcost/1000*	-0.0756***
	(0.0140)
Genquality	2.742***
	(0.425)
First level of decision: improve/not improve	

[3] This average monthly income was also affected the 42 households in the sample for which data were missing.
[4] For households not involve in averting actions.
[5] Due to the existence of 6 possible choices: Choice of one of the five avoidance measure or the option “do not improve water quality".

Low_income	-0.522***
	(0.155)
No_child	-0.507***
	(0.148)
Primary_education	-0.116
	(0.260)
No_concern	-1.294***
	(0.257)
Inclusive value	
Treat:	0.687***
	(0.0921)
Do not treat:	1
	(58248)
Likelihood ratio test for IIA $\left(\chi^2(2)\right)$	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 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), variable indicating the city of residence of the households is introduced into the model. Indeed, a household may purify its drinking water because its neighborhood 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 the robustness checks

Variables	Model 1	Model 2	Model 3	Model 4
Second level of decision making : boiling, using chemicals, filtering with cotton, filtering with ceramic a filter, bottled water				
cost/1000*	-0.0776***		-0.0778***	
	(0.0144)		(0.0149)	

[6] This technique is preferred here to the logarithmic transformation.

Varcost/1000*		-0.0735***		-0.0731***
		(0.0135)		(0.0143)
Genquality	2.811***	2.715***		
	(0.434)	(0.419)		
Safquality			2.736***	2.636***
			(0.459)	(0.452)
First level of decision making: improve/not improve				
Low_ncome	-0.503***	-0.470***	-0.501***	-0.434***
	(0.157)	(0.152)	(0.156)	(0.155)
No_hild	-0.458***	-0.504***	-0.493***	-0.470***
	(0.160)	(0.148)	(0.150)	(0.163)
Primary_education	-0.0947	-0.107	-0.112	-0.0980
	(0.262)	(0.260)	(0.259)	(0.260)
No_concern	-1.268***	-1.296***	-1.311***	-1.310***
	(0.260)	(0.257)	(0.257)	(0.259)
Douala	-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 $\left(\chi^2(2)\right)$	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 variable have been divided by 1000 in order to reduce 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

[7] This technique is preferred here to the logarithmic transformation.

in Table 3. The coefficient of the different variables keeps the same sign and the same significance.

The results of the estimation of the Model 3 are reported in column 4. This model is closed to the one reported in Table 3. The difference here is that, a specific aspect of quality water, 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 the 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 them 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 low_income variable is statistically significant and negative. This result suggests that the more a household is poor, the less likely it will 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 household 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 (McConnell and Rosado, 2000; Bukenya, 2006, Nauges and Van Den Berg, 2009; Johnstone and Serret, 2012; etc.). The estimation findings are consistent with those of the literature to the extent that the estimated coefficient of the variable no_child is negative and statistically significant at 1%.

As expected, the variable education that measures awareness about health effects of consuming contaminated water has a negative sign. However, the coefficient of the variable primary_education 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 by 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 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 which do not use avoidance measures is relatively higher among households which are not concerned by the quality of their drinking water (75%) than among the households concerned by the quality of their water (45.95%). Based on such observations, it is safe to say that the adoption of avoidance measures and variable no_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 of using such avoidance measures is precisely to obtain better water quality. Actions of education and sensitization of the population on health hazards of waterborne diseases should thus be undertaken consistently by health authorities in order to prompt the population to pay special attention to the quality of water they drink. Such actions which may be conducted through media are likely to produce positive effects on the population in support of the Health Belief Model which suggests that alerts or sensitization messages of the population about health issues serve as a signal that triggers the perceived threat and the likelihood of the action.

Result show that the estimated cost of water quality improvement has a negative and statistically significant coefficient, indicating that the more an avoidance measure is expensive, the less likely it will be chosen. This result is consistent with the demand theory according to which as the price of 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 of the population to avoidance technologies, authorities should put in place appropriate measures to reduce their cost. Such measures could take the form of tax exoneration on the production/importation and/or sale.

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 (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 water quality. This is a new finding in the literature. In order to popularize the adoption of avoidance measures in Cameroon, emphasis should be laid 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 diarrheal cases (OMS, 2005). Priority should be given to the promotion of the most efficient avoidance methods.

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