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RESEARCH ARTICLE

Determinants of the avoidance behaviour of households to cope with unsafe drinking water: case study of Douala and Yaoundé in Cameroon

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Abstract Despite the effectiveness of home water treatment methods, this practice is not yet widespread in many countries, including Cameroon. This study analyses the determinants of the avoidance behaviour of households to cope with unsafe drinking water in the cities of Douala and Yaoundé in Cameroon. The study is based on primary data collected in 2013 from a sample of 789 households in the two cities. The nested logit model is used for empirical analysis. The main findings of the estimated models are as follows: the decision to improve water quality decreases when the head of the household is a man and when there is no child in the household. Furthermore, it decreases when wealth and the level of education are low. In addition, the probability of using a given avoidance method decreases with its cost of adoption and increases with its perceived efficiency (that is, the favourable opinion on the quality of water after treatment). The implications for public policies are discussed in this paper.

Keywords Household avoidance behaviour · Drinking water · Nested logit model · Cameroon

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Introduction

Access to safe and reliable water remains a daily battle for hundreds of millions of people in the world. According to the World Health Organization and the United Nations Children's Fund (2017), 844 million people still lack a basic drinking water service, including 159 million people who rely on surface water to meet their daily drinking-water needs. A way to enable individuals to cope with the poor water quality is the use of various avoidance methods. The most promising and accessible avoidance methods are filtration with ceramic filters, chlorination and solar disinfection by the combined action of UV rays and heat (World Health Organization 2012). Generally, several avoidance methods may be combined; for instance, when water is turbid (not clear or contains visible particles), it must first be clarified before being disinfected (chemical disinfection, solar disinfection, boiling) (Cotruvo and Sobsey 2006).

Many studies have found that point-of-use water treatment (that is, water purification at the point of consumption) has a significant effect on both water quality and the reduction in the occurrence of waterborne diseases. The systematic reviews of Speich et al. (2016) and Wolf et al. (2014) support these results. Zin et al. (2013) concluded in their review that promoting household water treatment is most essential in preventing diarrhoea and in reducing the number of deaths caused by it among patients. Moreover, studies suggest that home treatment as compared to source or storage improvements provides the most effective method of ensuring the consumption of clean drinking water (Brick et al. 2004; Fewtrell et al. 2005).

Despite the effectiveness of home water treatment methods, this practice is not yet widespread in Cameroon. According to the National Institute of Statistics (NIS) and ICF International (2012), about 87% of the population do not have the habit of treating water at home. This rate is 76% in Douala and Yaoundé, the two biggest cities of the country that face serious problems of water quality and supply. The consequence of this low water treatment is that, although 71% of households in Cameroon (91% of urban households and 98.6% of households in Douala and Yaoundé) consume water from an improved source (NIS and ICF International 2012), the country regularly faces outbreaks of waterborne diseases, such as the cholera outbreak of 2004 which started from an unprotected well at the Bépanda neighbourhood in Douala and affected more than 7000 individuals causing 130 deaths (Assako Assako et al. 2005). Also, there was another cholera outbreak in May 2010 which affected all the regions of the country and caused several hundreds of deaths. These cholera outbreaks reflect the poor quality of water that people drink. For instance, a research conducted in the neighbourhood of Mvog Betsi in Yaoundé by Nnanga et al. (2014) shows that most of the inhabitants drink water from wells, boreholes or springs and almost all these sources are polluted with *Escherichia coli*. Another study by Djuikom et al. (2009) conducted in Douala on a water sample from wells shows that the water contains numerous pathogenic bacteria, faecal coliforms and faecal streptococci.

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 for averting actions to cope with poor water quality. It is therefore imperative to understand the factors that may explain household averting behaviours. The objective of this study is to analyse the determinants of households' avoidance behaviour to cope with unsafe drinking water in the cities of Douala and Yaoundé in Cameroon.

The literature on the determinants of households' avoidance behaviour is quite extensive. However, no research has addressed the influence of households' opinion on the effectiveness of avoidance methods in terms of water quality improvement. Indeed, in most existing studies, only the characteristics of individuals/households are often handled, while the characteristics of the avoidance methods are omitted. The main contribution of this study is to test the effects of perceived efficiency of avoidance methods on water averting behaviours. Our findings suggest that the probability of adopting a given avoidance method significantly increases with its efficiency and decreases with its cost of adoption. The findings also suggest the significant effects of wealth, education, gender and the presence of children on avoidance behaviours.

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

Literature review

The empirical literature on the demand for improved water quality in developed countries is quite rich. Among these studies, a number of them analysing 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; Larson and Gnedenko 1999). The literature on household avoidance behaviours in developing countries is more recent. Most of the studies carried out in these countries have been in Asia. Few studies like those of McConnell and Rosado (2000) have been conducted in South America. Likewise, few studies such as Dubois et al. (2010), Anderson et al. (2010), Totouom et al. (2012) and Miner et al. (2015) have so far been conducted in Africa.

Two main approaches are often used in the literature to understand factors behind household averting behaviours in response to poor water quality: the analysis of the determinants of households' choice in adopting avoidance methods on the one hand, and the assessment of the avoidance expenditures followed by the identification of their determinants on the other hand. The econometric models that are selected depend on the question that is addressed: Determinants of avoidance expenditure are commonly estimated using ordinary least squares models, while adoption studies rely either on binary probit/logit models or multinomial logit models. Binary probit/logit models have been used to study household decisions to purify water (Nauges and Van Den Berg 2009; Anderson et al. 2010; Katuwal et al. 2015) or household decisions to adopt a given treatment method (Larson and Gnedenko 1999; Anderson et al. 2010; Katuwal et al. 2015). The multinomial logit model has been used when the entire avoidance strategies available are considered (Haq et al. 2007; Jalan et al. 2009; Katuwal et al. 2015). However, the multinomial logit model is restrictive since it is based on the key assumption of the Independence of Irrelevant Alternatives (IIA), which is hardly conclusive. It is structured in a way that individuals choose between two avoidance options, 'a' and 'b' independently of the other choices available.[1] Despite the fact that more flexible alternative models have been developed to overcome the questionable IIA assumption, such alternative models are not very much used in the literature.[2]

Most existing studies only considered socioeconomic characteristics as conditioning factors. Results suggest that avoidance behaviour may be affected by a number of these characteristics. The positive effect of education is highlighted by McConnell and Rosado (2000), Dasgupta (2004), Roy et al. (2004) and Katuwal et al. (2015). The underlying assumption is that education increases awareness about waterborne diseases and knowledge about their prevention. Jalan et al. (2009) in a study carried out in urban India estimated the effects of schooling, exposure to mass media and occupational variables on home water purification. They found that these awareness indicators had statistically significant effects on home water purification and therefore, on the willingness to pay for better drinking water quality.

The positive effect of the presence of children on household averting decisions is also highlighted in existing studies (McConnell and Rosado 2000; Nauges and Van Den Berg 2009; Johnstone and Serret 2012). The idea is that having more children leads to greater awareness of health effects of consuming water of poor quality. Concerning wealth, it is suggested that poor households are less likely to adjust the quality of their water due to related costs. The two most common proxies for wealth are income (Haq et al. 2007; Johnstone and Serret 2012; Katuwal et al. 2015) and wealth indexes constructed on the basis of household ownership of various durables (Jalan et al. 2009). Many studies also point out the positive effect of some socioeconomic characteristics on adoption of averting behaviour such as better occupational status (Jalan et al. 2009; Nauges and Van Den Berg 2009) which may be considered as an indicator of wealth, age (Bontemps and Nauges 2016; Lanz and Provins 2017) due to the greater experience of the aged about the detrimental effects of poor water quality (Lanz and Provins, op. cit.) and being a woman (Abdalla et al. 1992; McConnell and Rosado 2000).

The impact of concern about water quality is also explored in the literature (Abrahams et al. 2000; Jakus et al. 2009; Jain et al. 2014; Beaumais and Veyronnet 2017; Lanz and Provins 2017). Regarding the current water quality level itself, existing studies suggest the positive and significant impact of perceived water quality before treatment on the adoption of water averting behaviour (Nauges and Van Den Berg 2009; Johnstone and Serret 2012; Vásquez et al. 2015). The explanation is that the more people are concerned about the quality of the water they consume or have the perception that it presents a real health risk for them, the more they will purify their water to reduce the risks involved. However, existing studies did not test the

[1] A particularly disturbing manifestation of this assumption is the fact that the introduction of a new element in the set choice does not reassess the weight that individuals in their decision-making process accord to a and b. More flexible alternative models have been developed to overcome the questionable IIA assumption.

[2] The multinomial logit has been extended in two directions to overcome the questionable IIA assumption: the GEV models (Generalised Extreme-Value Logit Models) whose nested logit model is a special case and the mixed multinomial logit developed in the 1990s.

impact of perceived water quality after treatment on the choice of avoidance methods. It is however logical to think that the adoption of a given avoidance method over the other may be due to the fact that the preferred method provides better water quality.

Till date, the research of Totouom et al. (2012) remains the only one conducted in Cameroon. The estimated bivariate probit model used in their study highlights the positive and significant impact of education, wealth and the number of children on household avoidance behaviour to cope with unsafe drinking water. However, the study fails to test the impact of avoidance methods' characteristics on household behaviour due to the lack of relevant data. It only focuses on the decision to treat water and does not investigate the choice of the treatment method.

This study uses a more relevant dataset that allows for the remedying of these shortcomings. Using a nested logit model, this study considers the perceived water quality after treatment as a proxy of the efficiency of avoidance methods in the analysis. It takes into account the potential endogeneity of the subjective quality of water as pointed out by Whitehead (2006). We also assess the impact of the cost of avoidance methods on household behaviour. McConnell and Rosado (2000) are the only few authors to have investigated the effect of such cost in their analysis. Two types of costs are considered in this study: 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 improving the quality of water. Appendix 1 provides a table summarising the main characteristics of selected papers from the literature.

Methodology

The econometric model

Following McConnell and Rosado (2000), this study uses the nested logit model to analyse households' avoidance behaviour to cope with unsafe drinking water in the cities of Douala and Yaoundé in Cameroon. The use of a nested logit (instead of the multinomial logit model largely used in the literature) allows to take correlations between choices available in a particular subset or nest into account (while it maintains the restriction of the IIA between the nests); see McFadden (1978). The use of a nested logit model implies that the choice to adopt a particular coping strategy is dependent on the decision to improve water quality: households first decide whether or not to improve their water quality and later choose their improvement method j ($j = 1, 2, ..., m$) from a set of available avoidance methods.

Based on the survey carried out, the coping strategies considered in this study are boiling, filtering with cotton, filtering with ceramic filter, 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's index and j represents the avoidance method.

$$v_{ij} = z_{ij}\alpha + X_i\beta$$

is the deterministic component of utility and ε_{ij} is the random component 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 socioeconomic 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) showed 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 method j given that it has chosen to improve the quality of its water is

$$P_{j/i} = \frac{e^{\left(z_{ij}\alpha\right)}}{\sum_{j=1}^{m} e^{\left(z_{ij}\alpha\right)}} \tag{2}$$

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

$$P_i = \frac{e^{(X_i\beta)+\sigma\, \mathrm{I}_i}}{\sum_{i=1}^{n} e^{(X_i\beta)+\sigma\, \mathrm{I}_i}} \tag{3}$$

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

$$I_i = ln\left(\sum_{j=1}^{m} e^{\left(z_{ij}\alpha\right)}\right) \tag{4}$$

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

$$P_{ij} = P_{j/i}P_i \tag{5}$$

The nested logit model is consistent with utility maximisation 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 or by the maximum likelihood techniques. The maximum likelihood technique is used in this study because it yields more efficient estimates.[3] To test the IIA assumption, i.e. the importance of using a nested logit model instead of the multinomial logit, the parameters of the inclusive value will be used. In addition, the likelihood ratio test will also be useful to test the null hypothesis of the dissimilarity parameters being equal to 1.

Data

Data used in the study come from a field survey conducted in 2013 among a sample of urban households of Douala and Yaoundé. These cities face serious problems of water supply. The objective of the survey was to provide an overview of the water situation in Cameroon's households living in urban areas. Information related to all available water sources, collection of water strategies, consumption quantities and avoidance methods to cope with unreliable water quality were collected. Details on socioeconomic and demographic characteristics of the surveyed households were also gathered. Data were collected through personal interviews. The questionnaire was first pre-tested to assess the content of survey tools. Feedback from the pre-test was used to revise the final questionnaire. The estimation of the theoretical sample size of 845 households (522 in Douala and 323 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 95% confidence interval, p represents the proportion of the population showing interest and λ is the tolerable error, that is the margin of error for the survey. The proportion of the population that purify water in the cities of Douala and Yaoundé is 32 and 16%, respectively, in the Third Multiple Indicators Cluster Survey (MICS3) conducted in 2006 by the National Institute of Statistics. Therefore, $p = 0.32$ for Douala and $p = 0.16$ for Yaoundé. If the tolerable margin of the error value of 4% is taken, then the above formula will yield the sample size for the cities of Douala and Yaoundé of $n_1 = 522$ and $n_2 = 323$, respectively. At the end of the survey, only 789 questionnaires were correctly filled and exploited (491 in Douala and 298 in Yaoundé), corresponding to a response rate of 93% (94% in Douala and 92% in Yaoundé) compared to the set target of 845.

The cartographic data from the Bureau of Census and Population Studies (BUCREP) developed in 2003 under the Third 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

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

number of enumeration areas within each sub-division of Douala and Yaoundé followed by a random walk 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 in Douala). As mentioned above, all the sub-divisions in Douala and Yaoundé were involved in the survey to ensure a sufficient geographical coverage and a spatial representation of the population. There were attempts to achieve an equitable distribution of the number of surveyed households among the sub-divisions in each city (approximately 133 households per sub-division in Yaoundé and 52 households per sub-division in Douala). The random selection of the surveyed households ensured that the sample was representative. The observation units during the survey were households. Information was gathered through face-to-face interviews with the heads of households. If the heads of the households were absent, we spoke to their close relatives, who gave us information about them like their age, marital status and educational levels.[4]

Data collected showed that piped network was the main source of water in the study area. Of the 789 households surveyed in the study, 558 (70.7%) collected water from the piped network. However, among these households, only 360 (45.6%) had pipe borne water at home. The 198 other households were supplied by public taps. In general, respondents had a positive opinion on the quality of the water supplied (about 85% of the whole sample). Regarding avoidance methods used to get better water quality, survey data showed that out of the 789 surveyed households, 402 (about 51% of the whole sample) usually did something to get better water quality. Households were asked to only report the main averting action usually undertaken. Description of the avoidance methods used, and the households' socioeconomics and demographics characteristics are reported in Sect. 4 of the paper.

The explanatory variables

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

Socioeconomic characteristics

Wealth Multiple component analysis has been used to build the households' wealth index based on several variables such as housing characteristics (access to electricity, access to piped water, presence of modern toilets, quality of the building materials, etc.) and ownership of some durable items (cars, mobile phones, etc.). This wealth index is further normalised in order to obtain values that vary between 0 and 1. This normalisation is based on the following formula:

$$\mathrm{wealth}_N = \frac{wealth_G - \min(wealth_G)}{\max(wealth_G) - \min(wealth_G)}$$

where $wealth_G$ is the gross indicator and wealth_N is the normalised indicator. Values of the normalised wealth index are grouped to obtain four ordered classes represented by

[4] About 31% of the respondents were not the heads of households. This includes the spouse of the household head (15%) and his eldest child (13%).

four dummies. It is expected that worse-off households are less likely to improve their water quality because of the costs involved.

Education This variable measures the level of education of the heads of households. It is a categorical variable which has been classified into three dummies: *Primary education* (1 if the head of the household has gone at most through primary education, 0 otherwise), *Secondary education* (1 if the head of the household has gone at most through secondary education, 0 otherwise), and *Higher education* (1 if the head of the household has gone through higher education, 0 otherwise).

Male This variable captures the gender of the head of the household. It is equal to 1 for male-headed households and 0 for female-headed households.

No child This variable is equal to 1 for households that do not have at least one child under five and 0 otherwise.

Characteristics of the avoidance methods

Quality It is the respondent's opinion on the quality of water after treatment with each of the avoidance methods available. For each of the avoidance methods, respondents were asked to give their opinion on the quality of water after treatment. Of the four answers proposed in the questionnaire, the answers 'bad' and 'too bad' (or 'very high risk' or 'high risk') were coded 0, while answers 'good' and 'excellent' (or 'moderate risk' and 'no risk') were coded 1. The variable *Quality* is used as a proxy variable to measure the effectiveness of the avoidance methods.

The introduction of perceived water quality in averting-decision models can potentially cause endogeneity bias (Whitehead 2006; Bontemps and Nauges 2016; Lanz and Provins 2017). However, it is not obvious to have appropriate and valid instruments and those chosen by Vásquez et al. (2015), Whitehead (2006) and Danielson et al. (1995) are questionable. Bontemps and Nauges (2016) used regional variables as instruments for the household's perceived health impacts of tap water in 2011. Beaumais and Veyronnet (2017) and Lanz and Provins (2017) modelled perceived water quality as a function of objective water quality. However, such objective measure of water quality is not available in our dataset. To avoid the problem of endogeneity bias arising from the introduction of subjective quality of water in averting behaviour models, the opinion of each respondent is replaced in the study by the average opinion of the respondents of the municipality having the same avoidance behaviour (no treatment of water, boiling, filtering with cotton, filtering with ceramic filter, use of chemicals or consumption of bottled water). This average opinion is equal to the share of households of the municipality that have a favourable opinion on the quality of water after treatment with each of the above strategies. Two types of opinion are considered in this study: opinion on *water safety* and opinion on *overall water quality*.[5]

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

Cost This variable is the financial cost associated with the acquisition and the use of each avoidance method. Two types of costs are considered in the present study: *variable cost* and *total cost*. For households who boil their drinking water, variable cost is given by the average purchase cost of fuel used each month. For households who purify their water with bleach, chlorine or cotton, variable cost is determined by the average purchase cost of these inputs per month. For households who use a ceramic filter, variable cost 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 who consume bottled water, variable cost is given by the average cost of purchasing water each month. Variable cost is associated with a specific avoidance method and is provided only for households that use the method. For the other households who improve drinking water quality, they are associated the average variable cost calculated over the entire sub-sample of households using the avoidance method. Total cost is equal to the sum of variable cost and opportunity cost of time spent treating water. This opportunity cost is given by the average time (in hours) spent every month to improve water quality multiplied by the head of the household's hourly income.[6] The head of the household's hourly income is obtained by dividing his monthly income by his/her monthly work time (in hours). Assuming that people work averagely for 35 h a week,[7] the monthly work time is equal to $35 \times 4 = 140$ h.

For households who use bleach, chlorine or cotton to treat their water, the 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 who consume mineral water, this time is determined by the average time spent going to and from the usual point of purchase multiplied by the average number of trips made per month. Since people were explicitly and exclusively questioned about the time spent fetching bleach/chlorine, cotton or mineral water, it is assumed that trips are specially made to purchase bleach/chlorine, cotton or mineral water.[8] That is, there are no multi-purpose trips. For households who boil water, the average time spent treating water is calculated by the average time spent boiling water each time multiplied by the number of times the water is boiled in a month. For households who use an ordinary filter, the opportunity cost is zero.

[6] In most of the surveyed households, several members are involved in water activities (household heads, kids, stay-at-home mothers, etc.) such that it becomes very complex to compute an aggregate household hourly income taking into account the hourly income of each member weighted by its share in the total water activities.

[7] The labour code in Cameroon states that people should not work more than 40 h a week in non-farm sectors. Given that work in Cameroon officially starts at 7:30 am and ends at 3:30 pm and that Saturday and Sunday are not working days, it turns out that most people work averagely for 35 h a week. This is the reason why the average of 35 h of work per week is usually used in studies carried out in the country like those of the National Institute of Statistics.

[8] The questions were: "*What is the average time spent on a trip between home and the main point of purchasing bleach/chlorine or cotton?*" and "*What is the average time spent on a trip between home and the main point of purchasing bottled water*?" with a subsidiary question about the average number of trips per month.

The opportunity cost of time associated with a specific coping strategy is defined only for households who use the strategy. For the other households who improve their drinking water quality, they are associated the average opportunity cost calculated over the entire sub-sample of households using the coping strategy. The table in Appendix 2 summarises the variables used in the study.

Empirical results

Descriptive statistics

The data collected show that different avoidance methods are used by the surveyed households. The following question was asked to the respondent: ‘In your household, do you usually undertake averting actions (filtering, boiling, purchasing bottled water, etc.) to have a better drinking water quality in order to reduce associated health risks?’ For the respondents who answered yes to the question, an additional question was asked: ‘What is the main averting action usually undertaken to have better water quality?’ with the following proposed answers ‘boiling, filtering with cotton, filtering with ceramic filter, use of chemicals (bleach or chlorine), purchasing and consumption of bottled water, solar disinfection, others (mentioned)’. The full questionnaire is available in Appendix 3.

Table 1 below provides the distribution of surveyed households by avoidance method.

It is observed from Table 1 that the use of ceramic filters remains the main avoidance method used by the surveyed households. They are used by 36% of households (33 and 41% respectively in Douala and Yaoundé). Filtering of water with cotton is also a coping strategy widely used. The proportion of surveyed households filtering water with cotton is 34, 23 and 30% respectively in Douala, Yaoundé, and the total sample.

Table 1 Distribution of households by avoidance method

Avoidance methods	Douala		Yaoundé		Total	
	Number	Frequency (%)	Number	Frequency (%)	Number	Frequency (%)
Boiling	25	9.8	12	8.1	37	9.2
Use of chemicals	37	14.6	27	18.2	64	15.9
Filtering with cotton	87	34.2	34	23	121	30.1
Filtering with ceramic filter	84	33.1	60	40.5	144	35.8
Bottled water	19	7.5	12	8.1	31	7.7
Solar disinfection	0	0.0	3	2	3	0.8
Others[a]	2	0.8	0	0.0	2	0.5
Total	254	100	148	100	402	100

[a] They refer to the other avoidance methods reported by respondents but which were not explicitly proposed in the questionnaire

'Solar Disinfection' and 'others' are the least used methods with a percentage of 0.8 and 0.50%, respectively. These two methods are not considered in the econometric analysis. The consumption of bottled water is marginal among the surveyed households (8%). In developing countries in particular, bottled water is reserved for the few fortunate households. Table 2 provides descriptive statistics of the different explanatory variables used in the econometric analysis.

Table 2 also shows that about 10% of heads of households have gone through at most the primary education, 47% the secondary education and 43% the higher education. Regarding the heads of households' gender, statistics show that about 80% of households are headed by men. As far as children are concerned, the survey shows that about 60% of households do not have at least one child below five. Concerning wealth index, it has been categorised into four dummies. The average wealth score of households is 0.25 with the maximum value of 1 and the minimum value of 0. A higher value of the index indicates a wealthier household.

Concerning the respondents' perception of the water quality after treatment, Table 2 shows that about 86% of the respondents are satisfied with the overall quality of water. This percentage is 87% when water quality in terms of health safety is considered. Regarding avoidance expenditures, statistics reveal that the average variable cost of water treatment is 3656 FCFA per month. These costs vary from a minimum value of 0[9] to a maximum value of 56,000 FCFA. When the opportunity cost of time spent improving water quality is added to costs, the average total cost becomes 4651 FCFA per month. This total cost represents about 3% of the average monthly income of the households which is 158,000 FCFA.

Estimation results

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 on each variable is six per household.[10] Estimates therefore involved $769 \times 6 = 4614$ observations. The results of the first estimation carried out are reported in Table 3.

Several tests were further conducted in order to check the robustness of the results. The results of two alternative specifications are reported in Table 4. The first alternative model is model 1 which 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 inversely, the low level of health risk), is incorporated into the model as an explanatory variable instead of the overall water quality. The results are not significantly different from the previous ones. They suggest that a favourable opinion about the effectiveness of an avoidance method increases its probability of adoption.

Column 3 of Table 4 presents the results of the estimation of the second alternative specification. In model 2, 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 method on its probability of adoption. The second alternative model thus

[9] For households who are not involved in averting actions.

[10] Due to the existence of six possible choices: the choice of one of the five avoidance methods or the option "does not improve water quality".

Table 2 Descriptive statistics of explanatory variables

	Mean	Standard deviation	Minimum	Maximum
Wealth	0.25	0.20	0.00	1.00
Primary education	0.10	0.30	0.00	1.00
Secondary education	0.47	0.50	0.00	1.00
Higher education	0.43	0.50	0.00	1.00
Male	0.79	0.41	0.00	1.00
No Child	0.60	0.49	0.00	1.00
Overall water quality	0.86	0.20	0.00	1.00
Water safety	0.87	0.17	0.00	1.00
Monthly variable cost (in CFA franc)[b]	3656	5883	0.00	56,000
Monthly total cost (in CFA franc)	4651	6469	0.00	61,964

[a] Euro 1 = CFA 655,957

incorporated the variable cost and the degree of safety. Once more, results are not different from those presented in Table 3. In conclusion, the results of the different alternative estimations 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 robustness of the findings.

Table 3 Estimation 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	
Total cost/1000	− 0.277*** (0.058)
Overall water quality	5.809*** (0.789)
First level of decision: improved/not improved	
Third wealth quartile	− 1.037*** (0.230)
Second wealth quartile	− 1.323*** (0.252)
Lower wealth quartile	− 1.123*** (0.261)
Primary education	− 0.568* (0.321)
Secondary education	− 0.094 (0.199)
Male	− 1.201*** (0.193)
No child	− 0.635*** (0.166)
Inclusive value	
Treat	0.680*** (0.081)
Do not treat	1***
Observations	4614

Robust standard errors in parentheses

***$p < 0.01$; **$p < 0.05$; *$p < 0.1$

Table 4 Results of the robustness checks

Variables	Model 1	Model 2
Second level of decision: boiling, using chemicals, filtering with cotton, filtering with a ceramic filter, bottled water		
Total cost/1000	− 0.326*** (0.070)	
Variable cost/1000		− 0.283*** (0.060)
Water safety	7.364*** (0.975)	6.844*** (0.911)
First level of decision: improved/not improved		
Third wealth quartile	− 1.189*** (0.236)	− 1.145*** (0.234)
Second wealth quartile	− 1.475*** (0.256)	− 1.390*** (0.252)
Lower wealth quartile	− 1.261*** (0.273)	− 1.178*** (0.270)
Primary education	− 0.734** (0.333)	− 0.658** (0.329)
Secondary education	− 0.210 (0.205)	− 0.143 (0.203)
Male	− 1.346*** (0.202)	− 1.459*** (0.207)
No child	− 0.622*** (0.169)	− 0.642*** (0.169)
Inclusive value		
Treat	0.687*** (0.095)	0.610*** (0.0881)
Do not treat	1***	1***
Observations	4614	4614

Standard errors in parentheses

***$p < 0.01$; **$p < 0.05$; *$p < 0.1$

The estimated parameter of the inclusive value in the branch 'improve' is equal to 0.68. This means that the five avoidance methods 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 be 1 because it is a degenerated branch (or single option). In addition, the likelihood ratio test indicates that the null hypothesis of the dissimilarity parameters equal to 1 is rejected at the 1% level, justifying the appropriateness of the nested logit model used.

Discussion

The study explores the effect of wealth on the decision to improve drinking water quality. The coefficients of the different wealth dummies are negative and statistically significant (the top wealth quartile is used as reference). 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 methods for some households involve significant costs, such that the income constraint becomes a factor that limits their choices. Such a result is not new in the literature. Previous studies such as that of Jalan et al. (2009) discussed the influence of wealth on the likelihood of treating water.

As expected, Primary education and Secondary education variables have a negative coefficient (however, the coefficient of Secondary education is not significant). These findings suggest that as compared to households with heads that have gone through higher education, households with less educated heads are less likely to improve the quality of their drinking water. The reason is probably that income varies with the level of education. The education effect could therefore be correlated with the wealth effects. Furthermore, less educated households' heads are possibly less aware of the detrimental effects of consuming contaminated water. As suggested in the literature, a low level of education limits understanding of the issues related to the availability of drinking water at home such as health benefits for instance (Briand and Loyal 2013). Actions of education and sensitization of the population on the health effects of unsafe water consumption should thus be undertaken 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 (Rosenstock 1974), which suggests that warnings or sensitization campaigns about health issues serve as a signal that triggers the perceived threat and the likelihood of the action. As stated by Figueroa and Kincaid (2010), several studies confirmed the positive effect of the different communication channels used by water treatment interventions for disseminating water treatment and hygiene messages, especially mass media (radio and television), community participation (health clubs, schools, water committees), entertainment education (local theatre, videos) and interpersonal communication. Also, in a study conducted by Jalan and Somathan (2008) about the extent to which information affects the demand for environmental quality, authors found that households initially not purifying their water and told that their drinking water was possibly contaminated were 11% more likely to begin some form of home purification in the next 8 weeks than households that received no information. Moreover, an additional year of schooling of the most educated males in the households is associated with a 3% rise in the probability of initial purification.

This study also tested the effect of the gender of the households' heads on household avoidance behaviour. The result is consistent with those of many other existing studies like McConnell and Rosado (2000) who found that female-headed households are more likely to adopt averting behaviour as compared to male-headed households. The negative coefficient of the variable *Male* might be explained by the fact that women in general are in charge of taking care of sick persons in a household. Therefore, they are more concerned about the health detrimental effects of consuming unsafe water than men to the extent that in case of sickness, the time that they would have invested in productive and remunerative jobs, education of children or the preparation of meals will be reallocated to sick persons. Furthermore, studies on intra-household bargaining power such as the one of Schmidt (2012) provided supportive evidence of the positive impact of women power on health outcomes and thus, on the demand for water quality.

The findings of the study also suggest that a household without at least one child less than five is less likely to adjust the quality of water than a household with young children. Indeed, since children are more vulnerable to health risks from unreliable water than adults, households' members seem to be less sensitive to water quality issues in the absence of children. The impact of the presence/absence of children on the choice to purify water or to consume bottled water has been shown by many authors (McConnell and Rosado 2000; Nauges and Van Den Berg 2009; Johnstone and Serret 2012; etc.).

The findings also show that the estimated cost of improving water quality has a negative and statistically significant coefficient, indicating that the more an avoidance method is expensive, the less likely it will be chosen. This result is consistent with the demand theory which states that as the price of a good increases, its demand decreases, ceteris paribus. The negative impact of the cost of water treatment on household choice is also highlighted in the study by McConnell and Rosado (2000).

As to the impact of the respondents' opinion on the quality of drinking water, findings show that the coefficient of water quality is positive and statistically significant at 1%. This result suggests that the more respondents consider an avoidance method to be efficient (that is, it produces better water quality), the more likely they will adopt it. This result is consistent with expectations.

Conclusion

Based on 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 avoidance behaviours to cope with unsafe drinking water in the cities of Douala and Yaoundé in Cameroon. The regressions carried out suggest robustness of the findings. In particular, results reveal that the probability of adopting avoidance methods decreases with their costs and increases with their perceived efficiency (favourable opinion on the quality of water after treatment). The implementation of policies that aim at making averting methods more affordable, as well as, the sensitisation of the public about the efficiency of water treatment as a means to improve the quality of water and reduce waterborne diseases are recommended. Priority should be given to the promotion of the most efficient methods. At the same time, the public should be sensitised (through mass media for instance) about the detrimental health effects of consuming unsafe and unreliable water. This sensitisation should be permanent and not only conducted during periods of cholera outbreaks, as it used to be the case. Moreover, authorities should put in place appropriate measures to make averting technologies more affordable for the public. They should specifically intervene on the supply side by facilitating the setting up of companies that produce averting technologies (ceramic filter for instance). Such policies could take the form of tax exonerations on the production or the importation of the inputs. It is really surprising to observe that till date, no company producing ceramic filters is present in the country and there is no official policy that supports such local production. The local production of coping technologies should result in the increase of the supply and the reduction of the prices. The drop in the prices of bottled water in the country that arises from the current development of companies producing bottled water is appreciable and will probably increase the rate of consumption of bottled water that remains very low in the country.

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Appendix 1

Table 5 Selected papers from the literature

Authors	Country/city	Aim	Methodology	Main results
Abdalla et al. (1992)	Southeastern Pennsylvania, USA	To analyse the economic costs of groundwater degradation to households	A two-step process with the estimation of logit regression models at the first step for decision regarding whether actions should be taken to reduce exposure to water contamination and OLS estimation at the second step for decision regarding the intensity of averting action undertaken	Averting expenditures were estimated to range from $61,313.29 to $131,334.06 during an 88-week trichloroethylene contamination period. Qualitative risk perception, knowledge of contamination and the presence of children determined households' decisions to undertake averting behaviours, while the presence of children and income levels determined the level of averting expenditures
McConnell and Rosado (2000)	Brazil	To estimate the non-marginal benefits from improvements in drinking water quality using defensive input	The nested logit model is used here to yield parameters of a preference function for four methods of treating potentially unsafe water. This preference function is used to find a lower bound estimate of the willingness to pay for relatively riskless water	Presence of children, income, school instruction, relatively better occupation and gender (1 = female) of the household head positively affect the likelihood of treating water. The choice of treatment methods is positively affected by choice-specific indicators and negatively by treatment costs. Households are willing to pay on average, $3 per month to have safe drinking water
Jalan et al. (2009)	India	To estimate the effects of the health hazards from drinking contaminated water on home water purification	Probit and multinomial models are estimates to measure the impact of awareness on the choice of purifying water and the choice of adopting any given method respectively. Education, exposure to mass media and occupation are used as measures of	The measures of awareness have a positive and significant impact on the adoption of some home purification methods. Estimates indicate that expected expenditure, a lower bound for willingness to pay for safe water, more than triples from

Table 5 (continued)

Authors	Country/city	Aim	Methodology	Main results
			awareness. Expected averting expenditure is also computed by multiplying the cost of a purification method by its conditional probability of adoption	Rs. 48 (5.10 USD at PPP) per household per year to Rs. 162 (USD 17.23) when the schooling of the most educated adult (conditional on her being female) rises from no schooling to 15 years
Jakus et al. (2009)	USA	To examine the impact of perceived risk of tap water contamination on the purchase of bottled water	Heckman model for decisions on consuming bottled water and bottled water expenditures. Perceived risks are instrumented	Findings show that the general issue of water quality dominates the role of perceived risk in the decision to buy any bottled water. However, perceived risk is a statistically significant determinant of the amount of bottled water to buy, given that a person has decided to buy bottled water
Nauges and Van Den Berg (2009)	Southwest Sri Lanka	To study the determinants of the perception of risk related to water consumption and its impact on household's decision to treat water before drinking	The ordered probit model is used to model the determinant of risk related to water consumption and bivariate probit models to model the simultaneous choices of water treatment and water sources	Findings suggest that water aesthetic attributes (taste, smell and colour), household's education and information about hygiene practices determine household's assessment of safety risk. Moreover, a higher perceived risk increases the probability of boiling or filtering water before drinking
Totouom et al. (2012)	Cameroon	To identify factors driving households' decision to purify drinking water	A bivariate probit model is used to account for potential simultaneity of the source of drinking water and that of purifying water	Education, wealth quintile, health status and number of children less than 5 years strongly and positively affect households' decision to purify water
Katuwal et al. (2015)	Kathmandu, Nepal	To analyse the determinants of water treatment behaviour	Binary probit model to examine the adoption of at least one treatment method and a multinomial probit	Knowledge about waterborne diseases, exposure to water quality information campaigns,

Table 5 (continued)

Authors	Country/city	Aim	Methodology	Main results
			model to examine the determinants of specific treatment methods	participation in community organisations, education, income and connection to municipal system, belonging to the Newar caste, have a positive significant effect on drinking water treatment behaviour, while the impact of household size and number of years living in the community is negative. In general, these variables have similar effects on each specific treatment
Vásquez et al. (2015)	León, Nicaragua	To analyse household perceptions of water quality and associated averting behaviours	Seemingly unrelated instrumental variable probit models are estimated to take the potential endogeneity of water quality perceptions and the relationship between different averting behaviours into account	Averting behaviours (i.e. consumption of bottled water and in-home water treatments), or lack thereof, are primarily driven by the perceived quality of tap water. Findings also indicate that perceptions of water quality are associated with service performance and assessment of water quality relative to peers
Bontemps and Nauges (2016)	Australia, Canada and France	To measure the influence of the perceived health impacts of tap water on a household's decision to drink water directly from the tap instead of bottled water or tap water that has been purified, filtered, or boiled	Bivariate probit model and a special regressor model are used, whereby the endogeneity of perceived health impacts of tap water is taken into account. The proportion of households that drink water from the tap and the average level of concern about water pollution in general are used as instruments	Perceived health impacts of tap water affect households' decisions to drink water from tap. Individuals' perceptions are found to be statistically significant for all the models, but the estimated marginal effect is sensitive to the chosen model.
Beaumais and	France	To examine the determinants of	Combination of a scaled multinomial Logit	The level of satisfaction is a strong

Table 5 (continued)

Authors	Country/city	Aim	Methodology	Main results
Veyronnet (2017)		individual choices of drinking water supply with main focus on the perceived quality of tap water	where the modalities are tap water (reference), bottled water or purified tap water and the correction of the endogeneity of the perceived quality of tap water by two-stage residual inclusion. The objective physicochemical quality of water is used as instrument for perceived quality	determinant of individual drinking water supply choices. Findings also show that the correction of the problem of endogeneity significantly changes the results about the sources of the heterogeneity of individual preferences in the choice of drinking water supply. For instance, in the absence of correction of endogeneity, the estimation of a multinomial logit model could have led to a false conclusion of the presence of random unobserved heterogeneity which cannot be related to the observed characteristics of individuals. The results suggest that this is not the case
Lanz and Provins (2017)	England and Wales	To estimate the demand for qualitative aspects of tap water supply (water hardness and aesthetic quality in terms of taste, smell and appearance) using averting expenditures	Tobit model where the dependent variable is total expenditures on substitutes for water hardness and aesthetic quality only where these are explicitly reported to be due to a service failure. The endogeneity of perceived quality is taken into account and modelled as a function of objective quality	For water hardness, about 14% of households employ at least one water softener device, with mean and median yearly expenditure around £95 and £50, respectively. Overall, 39% of respondents report to use at least one of the substitutes for the aesthetic quality of tap water (bottled water, water filter devices, or adding squash or cordial before drinking) with mean and median yearly expenditure around £92 and £60, respectively. Findings from regressions carried out show that

Table 5 (continued)

Authors	Country/city	Aim	Methodology	Main results
				a 10% reduction in water hardness is associated with a £1.50 reduction in averting expenditures and a one fifth increase in the rating of water taste is associated with a £19 reduction in yearly expenditures

Appendix 2

Table 6 Description of the variables

Variables	Variables description
Dependent variables	
P_i	Dummy variable: 1 if the household undertakes any actions to have better water quality and 0 otherwise
$P_{j/i}$	Dummy variable: 1 if the household uses method j to have better water quality and 0 otherwise
Independent variables	
Wealth	Categorical variable giving households' wealth index. The variable is represented by 4 quartiles
Primary education	Dummy variable: 1 if the household head has gone at most through primary education and 0 otherwise
Secondary education	Dummy variable: 1 if the household head has gone at most through secondary education and 0 otherwise
Higher education	Dummy variable: 1 if the household head has gone through higher education and 0 otherwise
No child	Dummy variable: 1 for households that do not have at least one child under 5 and 0 otherwise
Male	Dummy variable: 1 if the household head is a male and 0 otherwise
Overall water quality	Continuous variable: household's opinion on the general quality of water after improvement of its quality using each of the avoidance methods
Water safety	Continuous variable: household's opinion on water safety after improvement of its quality with each of the avoidance methods
Variable cost	Continuous variable: variable cost associated with acquisition and use of each avoidance method.
Total cost	Continuous variable: total cost associated with averting actions. It is equal to variable cost + opportunity cost of time associated with a coping strategy

Appendix 3. Questionnaire

IDENTIFICATION	
CITY………………………………………………|___|___| MUNICIPALITY…………………………………|___|___| QUARTER…………………………………………|___|___| COUNTING ZONE NUMBER…………….........|___|___|___|	INTERVIEWEE'S RELATIONSHIP WITH THE HOUSEHOLD HEAD ………………………………..………|___| 1- Head of household 2- Spouse of the head of household 3- Son / daughter of the head of household 4- Parent of the head of household or spouse 5- Niece / nephew of head of household or spouse 6- Not related to head of household or spouse 7- Other (to specify)………………………
DATA COLLECTION AND ENTRY	
INTERVIEWER ……………………………………. |___|___| DATE OF INTERVIEW ………………|__|__| |__|__| |__|__|	DATA ENTRY AGENT…………………………………………|___|___| DATE OF DATA ENTRY………………………………………. |___|___|

Part I—Socioeconomic and demographic profile of the household

Section 1 Information on the head of the household and the interviewee			
N°	**Questions and Answers**	**Codes**	
		Household Head	Interviewee *(Do not fill in this column if the respondent is the head of the household)*
1101	Sex 1-Male 2-Female	|___|	|___|
1102	Age (in years gone by)	|___|___|	|___|___|
1103	Marital status 1- Married 3- Widower/widow 5- Free union 2-Single 4- Divorced / Separated	|___|	|___|
1104	Region of origin 1-Far North 4-Center 7-West 10-Littoral 2-North 5-South 8- North-West 3-Adamaoua 6-East 9- South-West	|___|	|___|
1105	Religious Affiliation 1-Catholic 5- Animist 2-Protestant 6- Atheist 3- Pentecostal 7- Other (to specify)….. …………….....……….. 4- Muslim	|___|	|___|
1106	Highest level of education attained 1-None 5- Higher- First degree 2- Primary 6- Higher -Master's degree 3-Secondary 1st cycle 7- Higher- Doctorate 4- Secondary 2nd cycle	|___|	|___|
1107	Professional status 1- Public Sector Employee 5- Invalid 2- Private Sector Employee 6- Student 3- Self-Employed 7- Unemployed 4- Retired 8- Other (to specify) ………………….…	|___|	|___|
1108	Average monthly income (including other sources of income other than the salary) Amount in FCFA of the household head ……|___|___|___||___|___|___||___|___| Amount in FCFA of the interviewee ……..……|___|___|___||___|___|___||___|___| Income class 1-Lower than 28,500 6-Between200,001 and 250,000 2-Between 28,501 and 50,000 7-Between 250,001 and 300,000 3-Between 50,001 and 100,000 8-Between 300,001 and 350,000 4-Between 100,001 and 150,000 9-Between 350,001 and 400,000 5-Between 150,001 and 200,000 10-400,001 and plus	|___|___|	|___|___|

Section 2 : Information about other household members			
	Questions	**Answers and codes**	**Instructions**
1201	What is the total number of people living in the household?	Number of people…………………|___|___|	
1202a	Are there children under the age of 5 years in the household?	Yes …………………………………………..1 No ……………………………………………..2	If 2 go to 1203a
1202b	How many?	Number of children …………………...|___|___|	
1203a	Is any member of your household currently suffering from or has suffered from water-related diseases in the past 30 days?	Yes ……………………………………………..1 No ……………………………………………..2	If 2 go to section 3
1203b	Which one (s)?	Typhoid…………………………………………...1 Diarrhea ……………………………………...2 Cholera…………………………………………...3 Intestinal worms ………………………...…..4 Other (to specify) ……..…………………… …..5	

Section 3: Housing and Equipment			
Nº	**Questions**	**Answers and codes**	**Instructions**
1301	What is the total number of rooms of your housing?	Number of rooms……………….…….|___|___|	
1302	What is your occupational status in your housing?	Owner…...…………………………………….……1 Renting…..……...……..…………………..……..2 Rent-purchase..…………………………….…….3 Accommodated by a parent/brother……...…...4 Accommodated by the employer…...…...……..5 Others (mention)….……………………...…….6	
1303	What type of material was used to build your house?	Local material.........……………………... ……1 Modern material………………………………2	
1304	Is your house connected to electricity network?	Yes….…………………………………...…….. 1 No.. …………………………………... ………2	
1305	What type of latrines do you have in your house?	Latrines with toilet flush…………….....………1 Improved latrines…..…………………………..2 Unimproved latrines……..…… ………………3 No latrines.…………………… ………………4	
1306	In your home, do you have: A washing machine? A radio? A TV? A digital/parabolic antenna ? A computer? An air conditioner? A mobile phone ? A fix phone ? a CT phone ? A freezer ? Gas plate ? A fan ? Access to internet ?	Yes No washing machine......................... 1 2 radio……..................................... 1 2 Television .... 1 2 Digital/parabolic antenna………..1 2 computer .... 1 2 air conditionner.............................1 2 mobile phone................................ 1 2 fix phone.......................................1 2 CT phone...................................... 1 2 freezer……................................... 1 2 gas plate……. ....….. 1 2 fan…………….............................. 1 2 internet.…..................................... 1 2	
1307	Does a member of your household own a car?	Yes…………………………………………..1 No.. ……………………………………………2	

Part II – Relation with drinking water

Section 1 General Information			
N°	Questions	Answers and codes	Instructions
2101	Does the quality of the water you consume seem to you to be a major concern?	Yes …… 1 No …… 2	
2102	What is the main source of drinking water used in your household ?	Piped into dwelling…… 11 Piped to yard/ plot…… 12 Public Tap/ standpipe…… 13 Piped neighbour …… 14 Tube Well/borehole …… 21 Protected well …… 31 Unprotected well…… 32 Protected spring …… 41 Unprotected spring …… 42 Rainwater collection …… 51 Vendors…… 61 Surface water …… 71 Others …… 96	
2103	How do you perceive the overall quality of water from the main source of drinking water used in your household?	Very bad …… 11 Bad …… 12 Acceptable…… 13 Excellent…… 14	
2104	What is your perception of the quality of water from the main source of drinking water used in your household in terms of ...?	Health risk Very high risk …… 11 high risk …… 12 Moderate risk …… 13 No risk …… 13 Taste Very bad taste …… 21 Bad taste …… 22 Acceptable taste …… 23 Without flavor …… 24 Color Very dirty…… 31 Dirty …… 32 Acceptable color …… 33 Colorless …… 34 Odour Very bad smell …… 41 Bad smell …… 42 Odor acceptable …… 43 Odorless …… 44	
2105a	In your household, do you REGULARLY do something to make the drinking water more salubrious (filter, boil, buy and consume mineral water, etc.) and thus reduce the health risks to which you may be exposed?	Yes …… 1 No …… 2	If 1 go to section 2 If 2 go to 2105b then to section 3
2105b	For what reasons ?	No time to do it …… 1 No financial means to do it …… 2 It does not present a major health risk …… 3 I do not know …… 4 Other (to specify) …… 5	

Section 2 Strategies of improving water quality (households usually undertakes averting actions to have a better drinking water quality)			
Nº	Questions	Answers	Instructions
2201	In your household, what is the main averting action usually undertaken to have a better water quality for the purpose of drinking.	Boiling……………………………………………… 1 Adding chemicals (bleach/chlorine)……………… 2 Filtering with cotton…………………………………3 Filtering with ceramic filter……………………….. 4 Purchase and consumption of mineral water……..5 Solar disinfection……………………………….. 6 Others (mention)……………………………… …7	If 1, move to 2202-2206 If 2 or 3, move to 2207-210 If 4, move to 2211-2215 If 5, move to 2216-2220 If 6 or 7, move to 2221
2202	What type of combustible is used for boiling purpose ?	Domestic gas……………………………… …1 Charcoal…………………………………………2 Fire woods………………………………………3 Petrol……………………………………………4 Others (mention)…………………………… …5	
2203	How much do you estimate the average monthly cost of purchasing combustible for boiling water?	Cost in CFA franc……………|___|___|___|___|___|___| *999 if it is free of charge*	
2204	What is the average time spent for boiling water each time?	Number of minutes…………………………|___|___|___|	
2205	What is the average quantity of water boiled each time ?	Volume in meter cubic…………………|___|___|___|___|	
2206	In average, how many times per month do you used to boil water in your household ?	Number of times……………………………|___|___|___|	
2207	How much do you estimate the average monthly cost of beach/chlorine purchase for treating water ?	Cost in CFA franc……………|___|___|___|___|___|	
2208	How long is the main place of purchasing bleach/chlorine or cotton from home ?	Distance in meters……………………|___|___|___|	
2209	What is the average time spent in a trip between home and the main point of purchasing bleach/chlorine or cotton?	Number of minutes…………………………|___|___|___|	
2210	On average, how many times do you purchase bleach/chlorine or cotton per month?	Number of times……………………………|___|___|	
2211	How much did the ceramic filter used at home cost?	Cost in CFA franc……………|___|___|___|___|___|	
2212	How long has the filter been purchased ?	Number of years…………………..|___|___|___|___|	
2213	Since the purchasing of the filter, have you ever changed its candle?	Yes…………………………………………….. 1 No…………………………………………… 2	If 2, move to 2221
2214	Since the purchasing of the filter, how many candles have been bought to replace the older ones?	Number of candles…………………………|___|___|	
2215	What is the unit price of the candle ?	Price in CFA franc………………|___|___|___|___|	
2216	On average, how many bottles of mineral water do you purchase for the household per month?	Number of bottles………………|___|___|___|___|	
2217	What is the unit price of a bottle ?	Amount in CFA franc……………………|___|___|___|	
2218	How long is the main place of purchasing bottled water from home ?	Distance in meters……………………|___|___|___|	
2219	What is the average time spent in a trip between home and the main point of purchasing bottled water?	Number of minutes…………………………|___|___|___|	
2220	On average, how many times do you purchase bottled water per month?	Number of times……………………………|___|___|	
2221	Who are those in charge of water treatment activities (or purchasing bottled water) in your household?	A parent……………………………………… 1 An adult (man/woman……………………….. 2 A kid (less than 15)……………………………. 3 A servant………………………………………. 4	

Section 3 Perception of the water quality after treatment								
Nº	Questions and answers	Codes						
		Water from the main drinking water source (without treatment)	Water after boiling	Water after treatment with chemicals (bleach/chlorine)	Water after filtering with cotton	Water after treatment with ceramic filter	Bottled water	Water after solar disinfection
2301	What is your opinion on the overall quality of … ? 1-Too bad 2-Bad 3-Good 4-Excellent	|___|	|___|	|___|	|___|	|___|	|___|	|___|
2302	What is your opinion on the health risk of … ? 1-very high risk 2-high risk 3-moderate risk 4-No risk	|___|	|___|	|___|	|___|	|___|	|___|	|___|

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