Demand for Environmental Quality: Evidence on Drinking Water from Kathmandu, Nepal

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Abstract

This paper examines the demand for environmental quality, clean drinking water in particular, in Kathmandu, Nepal. Water supply is inadequate, unreliable and, low quality and is not directly potable. Kathmanduities engage in several strategies to cope with the unreliable and low quality of water supplies. Some of the major coping strategies are hauling, storing, boiling, and filtering. A Report on Water Survey of Kathmandu Valley 2005 observes that, over 45 per cent of households in Kathmandu valley filter water to make it potable. Similarly, about 39 per cent of households boil to make water safe. Use of Uro Guard and Solar Disinfection System (SODIS) are some of the other purification methods. To date, there has been little empirical analysis of such purification behaviors. This paper investigates these purification behaviors and factors influencing these behaviors. We consider different types of treatments as demand for environmental quality. Using Water Survey of Kathmandu, we estimate the effect of education level of household head, exposure to media, gender, caste, ethnicity and opinion of water quality on drinking water purification. Our result shows that people tend to increase boiling and filtering both instead of only one method if they are wealthier. In addition, household boil and then filter instead of boiling only and filtering only if they think that water delivered to the tap is dirty. Exposure to media has strongest effect in general for the selection of all available treatment modes.

Keywords: drinking water quality, demand for environmental quality, coping strategy

1. Introduction

Access to adequate and good quality of drinking water is a basic need. Unsafe drinking water threatens health of people and is one the most serious challenges for developing countries. The rapid urbanization and growth have made these developing cities unable to meet the increased demand and the situation is worsened by ever increasing population. One of the major problems that most of the developing cities face is to provide enough and good quality of drinking water. Kathmandu is no exception to this. Water is not supplied round the clock, pressure is insufficient to pump it to the tap and the amount of water made available to the public, whatsoever, is not directly potable.

An ongoing survey initiated by NGO Forum for Urban Water and Sanitation (NGOFUWS) finds zero Free Residual Chlorine (FRC)[1] in 47 per cent of piped water samples collected from 120 places of the valley (NGOFUWS). In another study, 82.6% and 92.4% of drinking water samples were found to cross the WHO guideline value for total plate and coliform count for drinking water (Prasai et al. 2007). Poor quality of water supplied is one of the major reasons for water born diseases. Admission of 1,360 diarrheal patients to the Sukraraj Tropical Infectious Disease Hospital between May 2nd and 21st, 2004 (NGOFUWS 2005), shows the seriousness of the water borne diseases in

[1] FRC is chlorine left free in the water after all reactions. According to WHO, 0.2mg to 0.5mg FRC per liter of water is safe. Nepal Drinking Water Quality Standard 2006 also follows the WHO guideline. Amount of FRC in water is the indicator that the water is free from germs. Less than 0.2mg per liter FRC means incomplete destruction of germs.

the valley. People from Kathmandu face a dire situation with unreliable and unsafe drinking water supplies.

To combat the poor quality, households in Kathmandu apply several interventions to make water safe for drinking. Some of the major coping strategies are boiling, filtering and use of tablets. A Report on Water Survey of Kathmandu Valley 2005 suggests that, over 45 per cent of households in Kathmandu valley filter water to make it potable. Similarly, about 39 per cent of households boil to make the water safe. Use of Uro Guard and Solar Disinfection System (SODIS) are some of the other purification methods. Many households still don't treat water and exposed to health risk. Low supply for long time period and lower income may be the principal reason for the low demand of potable water. However, several other factors such as education level, information, social, religious or personal opinion on quality of water can also influence the demand.

Goal 7, target 10 of Millennium Development Goal (MDG) aims at reducing the proportion of people without sustainable access to safe drinking water and basic sanitation to half by 2015 (Millennium Development Goal Report 2007). Thus, household water supply has become an important public policy issue. Designing policy requires careful study of the demand of safe water and demand for the purification behavior if water is not safe. The analysis of demand for different types of purification behavior can be helpful in minimizing the water borne diseases by influencing the behaviors through policy implications. Whether it be a private or public institution, information on willingness to pay and averting expenditure on water supply is important information for the sustainable management of water supply services. Especially, the demand side analysis of quality of water is significant in the context of restructuring and reformation of water supply services. Thus households demand for safe drinking water and purification behavior are important in designing policy for water services. However, the demand for these purification behaviors has hardly been examined.

Several studies (Whittington et al. 2002, Tiwari 2000, and Pattanayak et al. 2005) have investigated willingness to pay for safe and adequate water in Kathmandu. One of the common conclusions reached from these studies is that households are willing to pay for the improvement of water services significantly higher than what they are currently paying. Coping strategies[2] and averting expenditure are investigated on households' demand on improved water services by Pattanayak et al. 2005. Authors concluded that households engage in five types of coping strategies; collecting, pumping, treating, storing, and purchasing. Coping costs and willingness to pay were found to be statistically correlated.

Perhaps more relevant, there have been a number of studies on averting behavior for the improvement of drinking water quality in the developing world (Larson et al. 1999, Zerah M. 2000, McConnell and Rosado 2000) . Larson et al. (1999), and Zerah M. (2000) examined household demand for averting behavior for drinking water in Brazil and Delhi respectively. Demand for averting behavior was found to be significantly and positively influenced by income, opinion on quality of water, and education level. In another study, using an experiment in Delhi, Jalan et al. found that information provided on quality of

[2] Pattanayak et al. 2005 discuss the averting behavior, averting cost and compare that with willingness to pay for the water services. But these averting behaviors also include hauling and storing water to make the water adequate in addition to different treatment. But our focus in this paper is to investigate demand for quality, specifically purification behavior and factor influencing it.

the water strongly influence the demand for the purification behavior of the households. Authors found that households who were not purifying water and who were told that their water is dirty changed the purification behavior by eleven per cent. Thus, there are several factors that influence the demand for averting behavior and health of the consumers.

Despite of its significance and extensive use, there has been little empirical analysis of such purification behaviors for Kathmandu water supplies. This study, probably, for the first time investigates the purifying behavior and demand for safe and potable water in Kathmandu valley. The specific purpose of this study is to examine the demand for environmental quality, clean drinking water in particular, using purification behavior in Kathmandu, Nepal. We investigate these purification behaviors and the factors influencing these behaviors using household survey of 2000 households in Kathmandu, Nepal. This survey was conducted in 2005. We use logit model to estimate the marginal effect of the variables that influence the demand of these purification behaviors. We consider different types of treatments as demand for environmental quality and estimate the effect of education level of household head, exposure to media, gender, caste/ethnicity and opinion of water quality on demand for purification.

Our result shows that marginal effect of wealth is stronger for the use of boiling and filtering both (5%) as compared to boiling only (3%) and filtering only (4%). It implies that people tend to increase boiling and filtering both instead of only one method if they are wealthier. Household boil and then filter instead of boiling only and filtering only if they think that water delivered to the tap is dirty. Exposure to media has strongest effect in general for the selection of all available treatment modes.

Rest of the paper will proceed as follows. We discuss the background of water supplies situation next section and data and descriptive statistics is discussed in section 3. Opinion on quality of water and different types of purification methods is discussed in section 4 and 5. In section 6, we discuss simple theory related to averting behavior. In section 7, we use binomial and multinomial logit regression and discuss the results. In section 8, we conclude with some policy implications.

2. Background

Kathmandu valley, the only metropolitan and capital city, is the center of sociological and economic development of Nepal. The valley inhibits more than 1.5 million people with 220,000 households (Disaster Risk Management Profile-2005). It includes five major cities: Kathmandu, Lalitpur, Bhaktapur, Kirtipur, and Madhyapur Thimi. In addition to its permanent residence, the valley welcomes thousands of visitors each day. Contradictorily, one of the instructions given to the one, who is coming into the valley, is not to drink water unless it's being treated. Basically, each is instructed to check if water is boiled or filtered before consuming it.

The Nepal Water Supply Corporation (NWSC)[3] fulfills increasing demand of water through 9 major supply systems, 15 water treatment plants and has 132,803 legal

[3] NWSC was responsible for the distribution of water in the Valley when the survey was conducted. But as a part of institutional restructuring (privatization?) of the water supply service, an autonomous body "Kathmandu Upatyaka Khanepani Limited (KUKL)" was formed on February 2008 for the distribution of drinking water in the Valley. The KUKL, a public limited, has undertaken the responsibility of Kathmandu valley drinking water management system since February 2008.

connections including 809 community taps (NGOFUWS, 2005). Many households are not connected to the official water supply network. Total demand for water in Kathmandu valley is more than 200 MLD. At the moment, NWSC is supplying about 80 (MLD) during dry season and 120 MLD during wet season. Much of water, approximately 40% that is produced is lost before it reaches the NWSC's consumers (Whittington et al. 2002). Average number of water available days in a week is 4, and even during those 4 days water is available for only 2.4 hrs. More seriously, whatever water is delivered is not clean and safe to drink.

Due to intermittent, unreliable, and poor quality of water supplies, households spend extra money in coping with these problems. On the one hand, consumers spend significant amount of time fetching and storing water, while on the other significant amount of money is spent for treatment of water. Thus, despite of being access to potable water significant, it is not so in reality because of quality dimension of water. Given the current distribution system, the valley has at work; we can not assume that water quality is adequately safe for consumption.

3. Data and descriptive statistics

We use data from "Water Survey of Kathmandu – 2005" conducted by Central Bureau of Statistics, National Planning Commission Secretariat, Government of Nepal in 2005. The survey was conducted to identify the status of water supply, level of water consumption and demand, water tariff, and willingness to pay in Kathmandu valley. All together 2000 households were surveyed. A multi-stage sampling design was used to select households.

Table 1 reports the descriptive statistics of a household in Kathmandu valley. A typical household of Kathmandu has 4.6 family members. Almost half of the households live in rented house. Of the total, 16 percent household heads are female. Majority of the household heads (88%) in the study area are literate. Household that have access to telephone are 46 per cent and 81 per cent of the households have televisions. Out of 2000 household surveyed, about half of the household have private pipe line. 7 per cent in urban and 46 per cent in rural area does not have any water source in their household premise.

[Table 1 about here]

The survey did not collect detailed information on household wealth or income. However, questions were asked on possession of durable goods. Information collected on possession of durable goods is used to create a proxy for wealth. We create wealth index using first Principal Component of Appropriate variables (PCA)[4]. The variables included in the wealth index are: possession of a refrigerator, radio, computer, television, phone,

[4] PCA is a technique for extracting linear combinations of the variables that best capture the common information. The first principal component is the linear index of variables with the largest amount of information common to all of the variables. In other words, the components are ordered in such a way that the first component explains the largest possible amount of variation in the original data, subject to the constraint that the sum of the squared weights is unity.

washing-machine, and motorcycle. No direct information on household exposure to media is available in the survey. We use radio and television as proxy for the exposure to media for our analysis. A household which possesses either of the media is assumed to be exposed to media. Households with radio and TV are 87 per cent 81 per cent respectively.

Majority of the household heads (88%) in Kathmandu are literate. Average education level of household head is 7.6 years. Newar (27%) and Brahmin (25%) are major caste/ethnic groups in Kathmandu in terms of population size followed by Kshetri (18%). About 11 per cent of household reported that water delivered to their household is dirty.

4. Drinking water supply and its quality

Like any other developing cities, the Kathmandu water supply suffers from several problems. Because of old and poorly maintained distribution system, the service is not efficient. Water is not supplied round the clock, pressure is insufficient to pump it to the tap and the amount of water made available to the public, whatsoever, is not directly potable. Table 2 summarizes some of the major problems, based on the information collected from household survey.

[Table 3 about here]

Low discharge and intermittent supply is one of the most serious problems of Kathmandu water services. Distribution is not regular at all. Majority of the household in urban areas

(35.5%) have either low discharge or no discharge of water at their tap. Most important, about 11 percent households think that water flowing out of their tap is dirty.

There are several reason associated with the poor quality of water delivered to the households. Not all water distributions have appropriate treatment facilities. Either, water is improperly disinfected or not disinfected at all. Because of intermittent supply and leakages, negative pressure often draws contaminated material from the surface. Even good quality of water delivered from the source gets polluted due to infiltration of contaminated water through leakage points. The problem is worsened by the old distribution network.

5. Purification methods

Because of the severity of the quality of the water, several purification behaviors been applied to make water potable in the valley. Casual observation shows that boiling, filtering, use of tablets, use of Uro guard, SODIS and purchasing mineral are some of the common averting behavior. The survey provides data on different types of averting behavior that is being applied by each household (Table 2). More than 34 per cent of households in Kathmandu valley boil water to make it safe. It is interesting to note that percentage of households who boil water is higher in urban area (44.3%) as compared to rural households (19.0%).

[Table 2 about here]

Filter is the most common household practice of water purification method used in the valley. Percentage of household who use filter to make water potable is higher than that of percentage of households who boil it. Forty per cent households in Kathmandu (48 % in urban and 29 % in rural areas) filter water to make it potable. Significant number households think that only boiling or only filtering is not enough to make water safe. So they use both methods consecutively to avoid the risk of unsafe water. About 19 per cent households in Kathmandu (25 % in urban and 9 % in rural areas) boil as well as filter. Uro guard is comparatively expensive electronic filter and used by hotels and other institutions serving more people. Since the survey does not include such institutions, the number of households using Uro guard is significantly low (1%). There are other some purification methods such as SODIS[5], use of tablets[6] that have been used in Kathmandu. On average eight and half per cent use these methods. Percentage of households in rural area is higher (14.1%) than percentage of household in urban areas (4.7%). There are still significant percentages of households that do not use either of these purification methods. Thirty five per cent households consume water without any treatment (27 per cent in urban areas and 47 per cent in rural areas). This percentage may not look significant at glance. However, since these behaviors are not temporary (for example due to sudden problem on water supply) but permanent, have significant impact on health and overall welfare to the society.

[5] SODIS is a simple water treatment technology that uses plastic bottles and sunshine. Water is disinfected by exposing the bottles to sunshine for five to eight hours

[6] Piyush, aquatabs (chlorine tablet) are some of the tablets used for point of use purification of drinking water in Kathmandu.

6. Theoretical framework of purification behavior

To cope with low environmental quality households undertake several strategies to avoid health risk associated with poor quality. Specifically in case of drinking water, several avoidance measures are undertaken to improve the quality of water so that it is safe and potable. If available water is not safe, households avoid the risk by purifying at point of use. Household health production theory provides a theoretical basis for the avoidance behavior (Bartik 1988, Abdalla et al. 1992). If available water is not safe, household use other inputs to make it safe. Consumption goods, safe water in this case, is produced by using either one or combination of different purification behaviors. Following Bartik (1988), Larson et al. (1999), the household production function is given by,

$$S = S(A, Q) \qquad [1]$$

where S is perceived quality of water, Q is opinion on water quality, A is averting behavior.

Given the production function, household minimizes expenditure based on opinion on initial quality of water Q to achieve intended water quality S.

$$\underset{\{A\}}{Min}\; pA$$

$$\text{Subject to } S = S(A, Q) \qquad [2]$$

where p is price of averting behavior.

Above minimization problem can be solved for minimum expenditure. Let $E = E(p, S, Q)$ be the min expenditure on avoidance measure required to obtain intended quality S, given the initial quality Q.

With the consumption of intended quality (S) of water and other composited goods, household maximizes its utility given the budget constraint.

$$\underset{\{S,Z\}}{Max} U(S, Z : \beta)$$

Subject to $pA + Z \leq I$ [3]

Z is composite goods and I is income available to the household, β is vector of household characteristics. The two stage problem of minimizing expenditure given the production function and maximizing utility given the budget constraint can be combined as,

$$\underset{\{S,Z\}}{Max} U(S, Z : \beta)$$

Subject to $E(p, S, Q) + Z \leq I$ [4]

Above utility maximization problem can be solved to obtain an indirect utility function V,

$$V^* = V(p, I; S, \beta)$$

Optimal averting behavior can be obtained by above indirect utility using envelope theorem,

$$A^* = \frac{\partial V / \partial p}{\partial V / \partial I} = \frac{\partial E}{\partial p} = A(p, Q, S^*(p, I, Q, \beta)) \qquad [5]$$

A^* is optimal avoidance behavior which maximizes utility and minimizes the averting expenditure. Equation (5) shows that optimal averting behavior depends on four types of variables in general: the price of avoidance represented by p; income represented by I; the household's opinions of tap water represented by Q; and other household characteristics β. Thus, we can estimate the optimal avoidance behavior based on explanatory variables; price of avoidance behavior, income, opinion on initial quality of water and households characteristics.

7. Econometric analysis

Each household choose whether or not to avoid and select between different avoidance behaviors based on number of explanatory variables. Optimal averting behavior, based on utility maximization and household production function is given by

$$A^* = A(p, Q, S^*(p, I, Q, \beta)$$

Independent variables are the price of avoidance; income represented by wealth index; the household's opinions of tap water represented; and other household characteristics β.

$$Y(X;\beta)_i = Y(p, Q, S^*(p, I, Q, \beta)$$

$$Y(X;\beta)_i = Y(p, Q, I, \beta)$$

$$Y(X;\beta)_i = \alpha p + \theta Q + \gamma I + \beta H \qquad [6]$$

Under the assumptions that the avoidance behavior is a normal good, we would expect that higher the price of avoidance behavior, less the choice of avoidance behavior.

$$\frac{dA^*}{dp} < 0$$

The implication of this hypothesis is that, all else equal, household will use cheaper avoidance given the choice of several avoidance options. For example filtering can be cheaper as compared to boiling and other avoidance. If that is the case, maximum number of household will choose filter. Similarly, we also expect that, wealthier household will use more expensive avoidance behavior[7].

[7] Avoidance behavior, in general is normal good, given that more avoidance behavior gives more utility to the households. However, if we consider some particular avoidance, filtering for example, household can treat as the behavior as an inferior good. Wealthier household may start filtering less and use other expensive avoidance measure instead of filtering.

$$\frac{dA^*}{dI} > 0$$

Opinion on initial quality of water is also an important explanatory variable for avoidance behavior. According to Larson et al. (1999), economic theory does not suggest an unambiguous relation on initial water quality and the level of avoidance. But if household think that they benefit from avoidance, households increase avoidance behavior according to the opinion on initial quality of water i.e.

$$\frac{dA^*}{dQ} > 0$$

Along with price, income and the initial quality of water, there are several household characteristics that are expected to influence the demand for environmental quality. We expect that education level of the household head, exposure to media, gender of the household head, and caste/ethnicity will also influence the demand for avoidance behavior.

In the following section we analyze these behavior and test above mentioned hypotheses using bionomial and multinomial logit regression model. Each household decision on whether to treat the water to make it safe will be estimated. Using bionomial logit model we also estimate the marginal effect of explanatory variables on households' decision to treat or not. We then estimate the effect of explanatory variable on the choice made by households for a particular avoidance behavior over other behaviors. We use multinomial logit model to analyze the choice of treatment mode.

7.1. Who purifies and who does not? Bionomial logit regression analysis of purification behavior

In this section we investigate the factors that influence the demand for purification behavior of households. The survey results show that household engages in several types of purification behavior; boiling, filtering, SODIS, Uroguard, purchasing mineral water and nothing. Since the variable of our interest (whether or not the household purify or not) is a discrete variable, it can not be analyzed using linear regression model. We use discrete choice binomial logit model to analyze the purification behavior. Using logit model, we estimate the probability of household adopting at least one strategy and marginal effect of explanatory variables to purification behavior. In our logit model, the dependent variable is defined as 1 if at least one of the purification is used and 0 otherwise. This is consistent with a situation that household chose the optimal averting behavior which brings the highest utility level.

Let Y_i be the *i*th household's utility if the household took at least one averting action and 0 if no action are taken. The observed choice of the averting action taken by the *i*th household can be expressed as:

$Y_i = 1$ if at least one purification method is applied

= 0 if no action are taken [7]

$$Y_i^* = Y(X;\beta)_i + \varepsilon_i$$

First part of the above equation is deterministic and the error term is stochastic. ε_{ij} is a random error term. This error term captures the errors arising from unobservable component from household characteristics. X is a vector of explanatory variables for household i. It is the vector of income represented by wealth index; the household's opinions of tap water represented by Q; and other household characteristics, β is a vector of parameters.. Under the assumption that error terms ε are independent and randomly distributed and follow a type I extreme value distribution, above probability function can be written as binomial logit and is estimated by using maximum likelihood procedure.

$$\Pr_i(y_i) = \frac{e^{Y(X;\beta)_i}}{1+e^{Y(X;\beta)_i}} \quad [8]$$

The Log likelihood function is;

$$LogL = \sum_{i=1}^{n}(d_i.Log\Pr_i + (1-d_i)Log(1-\Pr_i)) \quad [9]$$

$d_i = 1$ if individual applies at least one treatment; 0 otherwise

As explained by theory, the purification behavior is assumed to depend on income, education level, and exposure to media, caste/ethnicity, opinion on water quality, and other household characteristics. In our logit model dependent variable is one if household engage in at least one of the treatment and 0 otherwise. Independent variables are; wealth index (WEALTH), education level of household head (EDU), and exposure to media (MEDIA). Also included in the model as dummy variables are; gender (MALE), caste/ethnicity (BRAHMIN), area (URBAN) and quality of water (DIRTY). Table 4 reports marginal effect of a logit model for purification behavior. Sign of marginal effect of all explanatory variables are as expected and significant at less or equal to 1% significance level.

[Table 4 about here]

Wealth, as expected by economic theory, has positive effect on making decision whether or not to treat water. 1 per cent increase in wealth from mean, increases the probability of using at least one treatment method by 11 per cent. Education level of household has also positive effect on household decision to treat water before drinking. One additional year of schooling results in 3 per cent increase in purification. Exposure to media has also strong effect. Result shows that household exposed to media increases their purification behavior by 20 per cent, if their exposure increases by 1 percent.

It is interesting to note that caste/ethnicity also plays a significant role on decision making. Being Brahmins as compared to other caste (especially Newar and Kshetri) increases the probability of purifying water by 11 percent. As expected, households are less likely to purify water if household head is male. The probability decreases by 12 percent. Household who own their house are less likely to purify water as compared to household who rent it. This might be correlated with owner being more Newar and the one who rent being Brahmin and Kshetri.

Opinion on quality of water delivered at the tap has strong and significant impact on purifying water. Households, who think that water is dirty, are more likely to purify and it increases by 20 per cent. Although theory does not suggests an unambiguous sign for this, this is as expected, given the structure of the survey. Bionomial logit model gives the impact of explanatory variable on purification, but it does not tell us what types of treatment are more affected by different variables. To investigate the impact of these explanatory variables on mode of treatment (e.g. boil vs filter etc), we use multinomial logit model. We discuss the multinomial logit model in the following section.

7.2. What purification method? Multinomial logit regression analysis for choice of purification behavior

There are several options available in market for the point of use purification of water in Kathmandu. Boiling, filtering, using tablets, SODIS, Uroguard etc. are frequently used to make water safe. Each treatment differs in effectiveness as well as cost. Each household decides whether or not to purify water and which methods to use to make it safe. In addition to opinion on quality of water, given the cost of purification methods, we expect that the decision made by the households is influenced by households' characteristics such as income, education level, caste etc. We use multinomial logit model to investigate the decision made by the household for different purification method.

Household receives utility Y_{ij} by making the j^{th} avoidance choice for j = 1,2,3,4,5,6 where $j=1$ for boiling, $j=2$ for filtering, $j=3$ for boil and filter both, $j=4$ for other (SODIS, Uroguard and Tablets), $j=5$ for purchasing mineral water $j=6$ for not treating water at all. The observed choice of j^{th} over other purification methods used by the i^{th} household is given by;

$$Y_{ij} = 1 \text{ if } Y_{ij}^{*} > Y_{ik}^{*}; \forall j \neq k$$

$$= 0 \text{ if no action are taken} \qquad [10]$$

$$Y_{ij}^{*} = Y(X;\beta)_{ij} + \varepsilon_{ij}$$

First part of the above equation is deterministic and the error term is stochastic. ε_{ij} is a random error term which is known to the household but unobservable to the researcher. This error term captures the errors arising from unobservable component from household characteristics. X is a vector of explanatory variables for of a household and β is a vector of parameters. Under the assumption that error terms ε_{ij} are independent and randomly distributed and follow a type I extreme value distribution, above probability function can be written as Multinomial Logit Model (MNL).

$$\Pr_{ij}(y_i) = \frac{e^{\mu Y(X;\beta)_{ij}}}{\sum_{k=1}^{M} e^{\mu Y(X;\beta)_{ik}}} \qquad [11]$$

The Log likelihood function is;

$$LogL = \sum_{i=1}^{n}\sum_{j=1}^{M} d_{ij}.Log\Pr_{ij} \qquad [12]$$

where d_{ij} is binary indication such that:

$d_{ij} = 1$ if individual selects alternative *j*; 0 otherwise

The MNL function is estimated by using maximum likelihood procedure. We estimate the multinomial logit model using STATA. We use five different choices for treatment of water (TREAT_MODE); Boiling (1), filtering (2), boiling and filtering both (1.5), others (3)[8], purchasing bottled water (4), and no treatment (0 as “base category”) as dependent variables in multinomial logit model. Unlike bionomial logit model, in multinomial logit model we expect different explanatory variables affect the choices in different ways. Table 5 shows marginal effect of different explanatory variables on different choices of purifications (TREAT_MODE). Marginal effect of different variables on probability of choosing different treatment modes are evaluated at the means of rest of the variables.

[Table 5 about here]

[8]There are very few observations for different treatment such as use of tablets, SODIS. So we clustered them and created another treatment mode and called it others.

Result shows that probability of boiling is found to be positively influenced by wealth, education level of the household head, exposure to the media, and opinion on quality of water. Household head who owned his house and male is found to negatively influence the probability of boiling. The same is true for almost other treatment modes as expected by our previous regression model. Marginal effects of almost all the variables are insignificant for the selection of "other" treatment method. In general, the estimation for the use of at least one purification method using bionomial logit model and estimation for the choice of treatment methods using multinomial logit model exhibit the same pattern.

More interesting is quantitative difference in marginal effect of different explanatory variables on the selection of particular method. Marginal effect of wealth is significant ($p<0.05$) for boiling, filtering, boiling and filtering both and, other as well. But marginal effect is stronger for the use of boiling and filtering both (5%) as compared to boiling only (3%) and filtering only (4%). It implies that people tend to increase boiling and filtering both instead of only one method if they are wealthier.

One additional year of education is found to increase the probability of boiling by 2 per cent, filtering by 1 per cent, boiling and filtering both by 2 per cent and, has no effect on the use of "other" purification methods. Exposure to media has strongest effect in general, as was in case of using at least one treatment method. Marginal effect of exposure to media is strongest for filtering (21%) relative to boiling (6%) and boiling and filtering both (12%). Brahmins in general, tend to use all treatment method as compared to other caste. As already shown by previous logit model, the probability of using all methods in general decreases if household head is male. As compared to other explanatory variables, it is worth commenting on marginal effect of opinion on quality of water on the selection of treatment mode. Marginal effect is significantly higher for boiling and filtering both (12%) as compared to boil only (7%) and filter only (9%) for opinion on quality of water. Household boil and then filter instead of boiling only and filtering only it they think that water delivered to the tap is dirty. It is consistent with our theoretical model i.e. if people think that water delivered to the tap is dirty, they use more than one and stronger method to ensure the quality of water so that it is safe to drink.

Our result from bionomial logit and multinomial logit model are significant and consistent with theory. However, there are certain limitations as well. Survey provides data only on households' level, so some institutional purifying behavior such as used by school, colleges and hospital could not be included in our analysis. In addition, because of the small population of households who purchase water, we are not able to analyze the purchasing behavior.

8. Conclusions and policy implications

Environmental sanitation is prerequisite for good health. Enough and safe quality of water constitutes a satisfactory water supply. Poor quality of drinking water increases the health risk of water use. In other words, drinking water has quantity as well as quality dimension. But drinking water in Nepal, confined to urban settings, does not guarantee enhanced health outcomes. Because of poor quality delivered to the household, drinking water quality is a major issue not only in rural areas but for Kathmandu valley as well. Households affected by poor water quality take measures to reduce or eliminate the risk. We examined the demand for purification behaviors of household in Kathmandu. Our result shows that significant percentage of household use either one or more than one method to treat water to make it safe for drinking. Household wealth, education level of the household head, exposure to media, and gender play significant role in purification behavior. Results are robust and significant. This can have two policy implications in general. First, given the poor quality of water distributed, behavior of households can be influenced by policy implementations. In addition to income, information and education level are important to reduce the health risk poor quality of water. For example, increasing education level and providing information through media can significantly reduce the health risk by influencing purification behavior. Second, despite the smaller current payment for water, a significant amount of money is being spent for purification by major portion of the population in the Valley. As explained by economic theory of averting behavior, household are willing to pay more for drinking water if household are ensured about the quality of water. To conclude, study suggests that, households from Kathmandu are paying significantly higher amount of money to purify water than what they are paying as current tariff and hence water utility levies can be increased to improve the quality of water. Until the quality of water is ensured, policy should aim in reducing health risk of poor quality of water by influencing the purifying behavior of people in the Valley.

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Table 1

Descriptive statistics

Variables	Mean
Household size (number of people)	4.6
Education of household head, years	7.8
Wealth (index)	-0.000365
Percentage of respondents who are homeowners	58.9
Percentage of respondents who are male	84.8
Percentage of respondents who are Brahmin	23.8
Percentage of respondents who are exposed to media (Radio or TV)	88.8
Percentage of household in Urban Area	60
Percentage of households who reported water to be dirty	10.55

Table 2

Treatment method based on household characteristics

Households Characteristics	Percentage of Households*						Number of household
	Boil	Filter	Boil and Filter	Mineral water	Other[†]	Nothing	
Urban	19.1	21.8	24.9	1.00	2.42	30.75	1200
Rural	10.4	20.4	8.4	0	1.13	59.75	800
Total	15.6	21.3	18.3	.6	1.9	42.35	2000

*There are several households that use more than a single treatment method. For example a household which is using boiling is also using filtering and other purification methods.

[†]Other treatments are use of tablets, Uroguard and SODIS.

Table 3

Households by their problem on water distribution system

Background characteristics	Percentage of households with their views on current water distribution system of pipeline*					Number of households
	Low discharge pressure	Inappropriate time distribution	Dirty water flow	Poor service	No problem	
Urban	35.5	9.6	15.8	1.9	36.5	1200.0
Rural	7.4	1.3	2.6	2.0	24.0	800.0
Total	24.3	6.3	10.6	2.0	31.5	2000.0

*There are several households that that have more than a single problem. For example a household which is facing low discharge pressure also have inappropriate time distribution and dirty water.

Table 4
Marginal effects of bionomial logit regression for use of at least one purification method

y_i =1 if household adopts at least one treatment method; = 0 otherwise

Variables	Coefficient	Marginal effect
CONSTANT	-0.19	-0.20
	(.28)	(.02)***
WEALTH	0.52	0.11
	(.52)***	(0.01)***
EDU	0.14	0.029
	(0.01)***	(0.00)***
MEDIA	0.93	0.21
	(0.20)***	(0.05)***
BRAHMIN	0.60	0.11
	(0.14)***	(0.02)***
MALE	-0.67	-0.12
	(0.17)***	(0.03)***
DIRTY	1.27	0.20
	(0.26)***	(0.02)***
OWN	-1.05	-0.20
	(0.12)***	(0.02)***
URBAN	0.13	0.03
	(0.12)	(.03)
n	2000	2000
Pseudo R^2	0.2501	
Wald Chi^2	398.45	

Note: Standard errors reported in parentheses.
***=.01, **=.05 and *=.10

Table 5
Marginal effects of multinomial logit regression for choice of purification behavior

y_{ij} =1 if household *i* adopts *j*th treatment method; = 0 otherwise

Variables	Marginal effect			
	Boil	Filter	Boil & Filter	Other
WEALTH	0.03	0.04	0.05	0.01
	(0.01)**	(0.01)***	(0.01)**	(0.00)***
EDU	0.02	0.01	0.02	0.00
	(0.00)***	(0.00)***	(0.00)***	(0.00)**
MEDIA	0.06	0.21	0.12	-0.01
	(0.04)	(0.03)***	(0.02)***	(0.03)
BRAHMIN	0.06	0.07	0.07	-0.00
	(0.01)***	(0.03)**	(0.02)***	(0.00)
MALE	-0.07	-0.05	-0.06	-0.00
	(0.03)**	(0.03)	(0.03)**	(0.00)
DIRTY	0.07	0.09	0.12	-0.07
	(0.04)*	(0.04)**	(0.03)*	(0.01)
OWN	-0.08	-0.11	-0.03	-0.00
	(0.02)***	(0.02)***	(0.02)*	(0.00)
URBAN	0.07	0.03	0.09	0.01
	(0.02)***	(0.03)	(0.02)***	(0.00)
n	2000			

Note: Standard errors reported in parentheses.
***=.01, **=.05 and *=.10