# Using stated preference methods to evaluate the impact of water on health: the case of metropolitan Cairo

HALA ABOU-ALI
Environmental Economics Unit, Department of Economics, Göteborg University, P.O. Box 640. SE 40530 Göteborg, Sweden
*Tel: (46) 31-773 4667; Fax: (46) 31-773 4154; e-mail:* Hala.Abou-ali@economics.gu.se

Abstract

This paper analysis the impact of better water quality on health improvements using two stated preference methods: choice experiments and the contingent valuation method. These methods were administered to a random sample of 1500 households living in metropolitan Cairo, Egypt. The results indicate that households living in Metropolitan Cairo have a positive but rather small willingness to pay for reducing health risks owing to water quality.

*Keywords:* Choice experiment; Contingent Valuation Method; Health; Water

*JEL classification:* C25; I10; Q25

## 1. Introduction

The purpose of this study is twofold: i). To estimate the benefits of water quality improvement programs related to health in Metropolitan Cairo. This is important in order to be able to compare these benefits to the cost of a water management program, although cost is beyond the scope of this study, to give insight on the magnitude of these benefits and to show the respondents will and willingness to pay to enhance water quality in the metropolitan Cairo. ii). To compare, evaluate and discusses similarities and differences between CVM and CE.

Increasing deterioration of water quality due to industrial, agricultural, and urban waste as well as insufficient investments in domestic water supply infrastructure is becoming a serious problem in developing countries. The availability of safe drinking water, combined with sanitary facilities and improved hygiene standards, could prevent many diseases. In the Metropolitan Cairo (Egypt), health risks due to drinking water both in the short and long term e.g., diarrhea and hepatitis, respectively, are frequently occurring phenomena. In order to value the benefits of improved water quality two stated preferences (SP) methods are used: the contingent valuation method (CVM) and choice experiments (CE). Some of the reasons for using the two methods are as follows:

(i) The CE includes different attributes and levels that are varied in an experimental design, which requires respondents to make repeated choices. This set up focuses on respondents' trade offs between several different attributes.

(ii) Using only CVM would restrict the respondent's choice to merely one quality where the quality of drinking water may differ from a district to another. One could argue for the use of repeated CVM approach with many scenarios but this could be rather costly.

(iii) The National Oceanographic and Atmospheric Administration (NOAA) have issued guidelines on the design of CVM studies in environmental damage suits (Arrow et al. (1993)). Among those are that CVM results should be calibrated against experimental or actual market findings.

(iv) CE may avoid some of the response difficulties in CVM. For example, dichotomous choice designs in CVM may still be subject to yea-saying despite improvements in design standards (Blamey et al. (1999)). On the other hand CE does not explicitly ask about money values so it is argued that CE is easier for the respondent to understand than CVM.

(v) Carson et al. (1999) argue that, given a consequential survey, a CVM with a binary discrete choice is incentive compatible while any other elicitation format is not.[1]

(vi) The use of CE in the context of environmental and health issues is more recent than that of CVM. Therefore, Bateman et al. (2002) argue that a larger literature using CE approaches and further evidence about their results is required before being confident about implementing CE approaches. (For an extensive discussion on the advantages and disadvantages of CE relative to CVM the reader is referred to Bateman et al. (2002).

The literature comparing SP methods encompasses only a few studies, giving room for additional investigation. Boxall et al. (1996) compare CE and CVM applied to the

[1] A consequential survey is defined one that is perceived by the respondents as something that may potentially influence agency action. Furthermore, the respondent is required to care about the outcome of that action.

effect of environmental quality changes arising from forest management practices on recreational moose hunting. They found significant differences in the welfare measures from a 'typical' application of two different SP methods. The differences between welfare estimates of the hypothetical environmental quality change at the site were significant. The CVM estimate was higher than the alternative SP experimental choice estimate by a factor of 20. In order to fully evaluate their results, they emphasize the need for further testing of SP on other goods and services. However, different results may be obtained if different models e.g., spike model and/or a set of bounded CVM questions are applied. The spike models provide a richer set of information especially when the distribution of the willingness to pay (WTP) is asymmetric and when a sizeable fraction of the respondents has a zero WTP for the good in question (see e.g. Kriström (1997)). According to Hanemann et al. (1991) the double bounded model gives tighter confidence intervals of the WTP and tends to yield a lower point estimate. Hanley et al. (1998) reports results from a study of the economic value of the conservation benefits of Environmentally Sensitive Areas in Scotland using CVM and CE. The welfare estimates obtained using both methods were fairly similar, although in their case the welfare estimates obtained from the CE were sensitive to functional form choice.

The paper is organized as follows: Section 2 includes a description of the implemented survey and the collected data, Section 3 describes the model and the estimation methodology, and Section 4 sketches the socio-economic determinants of the willingness to pay. Section 5 discusses the welfare estimates and Section 6 draws conclusions.

## 2. The survey

In January 2002, an in person survey concerning water borne illness and the value of clean water was administered to about 1500 households in metropolitan Cairo. The goal of the questionnaire was to let households evaluate reductions in health risk due to water quality. To define the short run scenario, the household was asked to recall the number of diarrhea illnesses during the past year in the household and to evaluate its severity. The long run health effect, which involved risk of contracting a dangerous disease in the future, a bundle of diseases such as hepatitis and cholera were mentioned.

Each of the CVM and CE questionnaires was administered to a random sample of around 750 households living in metropolitan Cairo. Metropolitan Cairo was defined as the urban districts of the Cairo, Giza and Kalyubia governorates lying within the ring road. In order to meet a target of 1500 households, a random sample of 1680 was drawn to allow for non-response. The study used a random sample weighted by population drawn from the sample design of the 2000 Egyptian Demographic and Health Survey (2000 EDHS), which is based on a three-stage probability sample.[2] The repartition of the sample in the three governorates was 66, 25.45 and 8.55 percent, respectively.

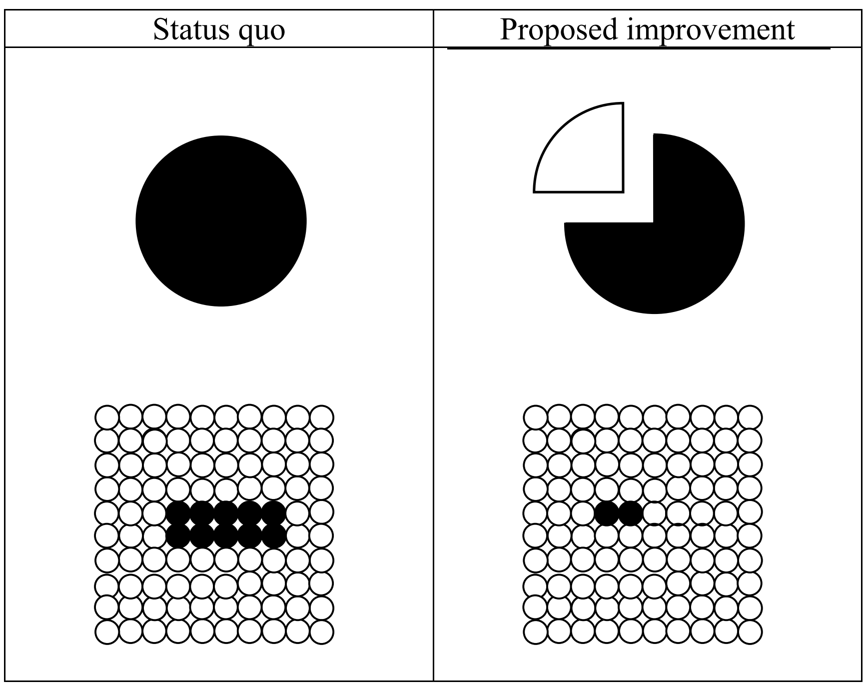
## 2.1 Design of the CV survey

The contingent valuation study was based on a three stages principle, beginning with focus groups, proceeding with a pilot study and finally implementing the main study. The format of the valuation question was a referendum question, and the payment vehicle used was a proposed increase in the water bill. The scenario began with a brief text segment describing the proposed health program. The interviewer first read the text and then asked the respondent to describe how the program would affect the household health. After eliciting perceived impacts, the referendum portion of the question detailed the resulting outcomes (services to be obtained) from the program. Respondents were asked for any questions they might have about the project. The interviewer then gave a brief list of reasons in order to remind the respondents of the health tradeoffs and the budget constraints involved in a voting decision. Moreover, the respondents were asked whether to go ahead with the program or not. The respondents were also informed about the fact that "some people we had talked to previously" voted for the program and others voted against it. This is done in order to remove the chance of biasing the votes such as in Hoehn and Krieger (1998). Then the change in health was presented using visual aids, shown in Figure 1, this illustrates the suggested improvement, which is a decrease in the short run health effect due to

[2] For details on the 2000 EDHS sample design see El-Zanaty et al. (2001) pp.219-234.

poor quality water by 25% and a reduction to 2% of the probability of contracting water born diseases in the long run. In the CVM format depicted in Figure 2, the respondents were first asked if they would be willing to pay anything, even a small amount for the health improvement shown to them by the aid of Figure 1 i.e., *Q43* of Figure 2. This established three groups of respondents; potential payers, non-payers and protesters. The proportion of households willing to pay in principle was around 50 percent. Non-payers accounted for 43 percent of the respondents, and protesters 7 percent. Most common motives for protesting were disagreement related to the fact of paying more expenses and that the water-works are unable to provide the proposed improvement. Then an initial Dichotomous Choice (DC) format of the valuation question was asked (i.e. *Q44* of Figure 2), contingent on the answer of that question the respondent was offered a second closed ended valuation question (i.e. *Q45* or *Q46* of Figure 2). Finally an open-ended follow up question was offered to the respondents (i.e. *Q47* of Figure 2).

**Figure 1:** Visual aid of health improvement suggested in the contingent valuation




The necessity of using visual aid was imposed by the rate of illiteracy in Egypt. According to the World Bank Indicators, in year 2001 the illiteracy rate of the Egyptian females and males was 55 and 33 percent, respectively. Hence, the use of visual materiel was applied in order to facilitate the task of the respondents in understanding the trade offs they are making when making a choice. A number of risk communication tools have been developed in the literature to assist respondents in comprehending the magnitude of risk reduction. For instance Corso et al. (2001) show not just the importance of visual aids in conveying risk but there type also matter. They test the effects of visual aids on WTP responses and find that communicating risk using an array of dots enhances the sensitivity of estimated WTP to the magnitude of risk reduction, yielding CV estimates that are more consistent with economic theory. Loomis and duVair (1993) have also tested the effect of different visual aids on WTP. Based on this evidence together with the use of focus groups and pilot testing it was chosen to describe the short run health effect by the mean of pie charts where the black circle indicates the number of ill days per year. And the offered improvement was illustrated by the white part in the pie chart. The long run risk is represented by the aid of an array of dots where black dots indicate the risk of contracting a disease.

**Figure 2:** The valuation question

*Q43. Supplying an improved health through better water quality is a program that costs money and we are however uncertain about the exact cost. The water agency cannot afford to implement the program unless it collects enough money to cover the costs. Every household in your heta will pay its share of the costs of supplying an improved health through better water quality. The water agency wants to know whether households like yours are willing to pay any thing to reduce by 25% the number of days you are affected by diarrhea and the probability of contracting a water borne disease in the long run as cholera, typhoid, hepatitis and kidney failure will also be reduced to 2%.*

*YES…………………………………………………1*

*NO…………………………………………………2 (Skip to 48)*

*Q44. The water agency wants to know whether households like yours are willing to pay any thing additional to the water bill to reduce by 25% the number of days you are affected by diarrhea and the probability of contracting a water borne disease in the long run as cholera, typhoid, hepatitis and kidney failure will also be reduced to 2%.if it costs you LE ☻ increase in the water bill.*

*If the supply of an improved health through better water quality costs your household an extra ☻ pounds per bill, would your household want this health improvement or not?*

*YES, WANT IT AT LE ☻/BILL…………………1*

*NO, DO NOT WANT IT AT LE ☻ /BILL…….. 2 (Skip to 46)*

*Q45. Suppose the actual increase in water bill is higher and it turned out to be ☺ pounds per bill instead of ☻ pounds per bill. If better health costs your household ☺ pounds per bill, would your household be willing to pay for better health or not?*

*YES, WANT IT AT LE ☺/BILL…………………1 (Skip to 47)*

*NO, DO NOT WANT IT AT LE ☺/BILL……....2 (Skip to 47)*

*Q46. Suppose the actual increase in water bill is lower and it turned out to be ☼ pounds per bill instead of ☻ pounds per bill. Now suppose better health would cost your household ☼ pounds per bill, would your household be willing to pay for better health or not?*

*YES, WANT IT AT LE ☼/BILL …………………1*

*NO, DO NOT WANT IT AT LE ☼/BILL………2*

*Q47. The water agency wants to know what is the maximum willingness to pay for a households like yours per bill to reduce by 25% the number of days you contract diarrhea and the probability of* *contracting a water borne disease in the long run as cholera, typhoid, hepatitis and kidney failure will also be reduced to 2%?*

_________________ *AMOUNT PER BILL*

Sequential design was used to determine the starting bid (cost) values. The pre-testing on a sample of 60 households was performed and resulted in a median of 5 Egyptian pound (L.E.).[3] Following Hanemann and Kanninen (1999) where they emphasize that bid values near the center of the WTP distribution are best for obtaining an efficient estimate of median WTP, five starting bid were chosen. The starting bids which were used in the final study were calculated so that they correspond to two lower values and two upper values arrayed symmetrically around the median. Moreover, each bid was distributed evenly on a sub-sample of 168 households in order to meet a target of 150.[4]

Moving from a single- to a double- bounded valuation format create some bias despite the gain in efficiency. This is due to the fact that the responses to the follow up bid are inconsistent with the responses to the starting bid. The bid structure used in this study has separate overlapping sets of bids, for example {starting bid ($B$)= 5; higher bid ($B^u$)= 6; lower bid ($B^d$)= 4} and {$B$=6; $B^u$=7; $B^d$=5}). Meaning that the first set of bids starts with 5L.E. and then either goes up to 6L.E. or down to 4L.E. while the second starts with 6L.E. and then goes up to 7L.E. or down to 5L.E.

Households were randomly assigned a set of bids. However, a non-parametric consistency test of the responses suggested by McFadden and Leonard (1993) is implemented in order to check certain relationships between the response probabilities. For instance, two estimates of the probability Pr $\{5 \leq \text{WTP} \leq 6\}$ were compared. One estimate takes the respondents who received the first set of bids and calculates the yes/no proportion. The other calculates the no/yes response's proportion of the second set of bids. This example is taken for the sake of illustration but all possible relationships were tested (see Appendix Table A2). In most cases the consistency test of the responses failed. However, it was decided to continue pooling

[3] 1 USD = 4.5 L.E. in September 2002.

[4] The heterogeneity in the sample distribution of the bids that resulted was due to two reasons: 1. Non-existence of households since they had either, moved, were unavailable at the time of the survey, or simply refused to participate (For the sample distribution of the bids see Appendix Table A1.). 2. The willingness to participate to the program, since the bid was only offered to those willing to participate.

the responses to the first and second bid despite the inconsistencies. It is believed that the gains in efficiency in the estimation outweigh the inconsistencies (see Alberini (1995) for more details). A finale caveat should be made about the bid distribution applied in this study concerning the high proportion of the sample saying 'yes' to the highest bid value. This reflects a problem in the bid design, since no information about the tail of the bid distribution is collected. This accentuates the sensitivity of the WTP estimates with regard to the treatment of the upper tail of the distribution. This problem arouse in the estimation of a single bounded model were the welfare estimates were very sensitive to the model specification and the assumptions made about the tail of the distribution.

### 2.2 Design of the choice experiment

The development of the choice experiment implemented here follows Ryan and Huges (1997) where the procedure starts by the determination of the attributes and assigning their levels, then moving to the construction of the choice sets by combining the attribute levels in each of the alternatives. The next stage consists of collecting responses and finally proceeding to the econometric analysis of the data. This section concentrates on the first three stages.

**Table 1:** Attributes and levels of the choice experiment

| *Attribute* | *Level* |
|---|---|
| Short run health effect | Same as today, 5, 25, and 50 percent decrease |
| Long run health effect | 10% risk of contracting a disease<br>7% risk of contracting a disease<br>5% risk of contracting a disease<br>2% risk of contracting a disease |
| Price (suggested increase in water bill) | 0, 2.5, 10, and 20 Egyptian pounds (L.E.) or 0, 5, 20, and 40 L.E. |

Focus groups and pre-testing with a sample of individuals were used to determine some measurable attributes associated with the effect of the quality of drinking water on health. These attributes were:

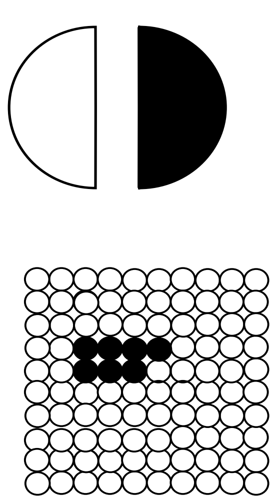
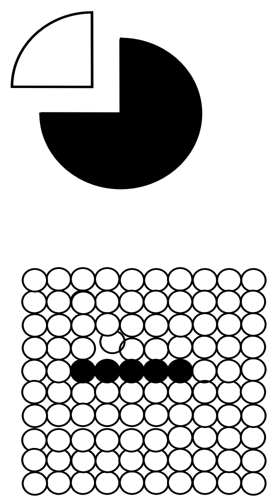
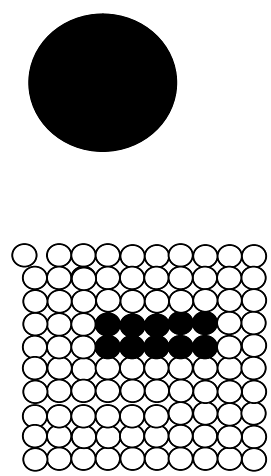
1. Short run health effect included the number of ill days caused by water born diseases during the year -e.g., diarrhea-. The design was constructed as such to allow

households to reveal their own level of status quo of this attribute. Henceforth, a proposed decrease was offered.

2. Long run health effect involved the risk of catching a dangerous disease in the future where a bundle of diseases such as hepatitis and cholera were mentioned.

3. Prices were formulated such as a proposed increase in the water bill due to the program. Hence, two different sets of prices were prepared and offered according to the current water bill, which is paid every two month by most of the households. Those with water bill less than 20 L.E. were offered a lower set of prices than households with higher bills. Eight price levels were used, based on the distribution of the open-ended CVM. This is to avoid the drawbacks of the concentration of the bids around the mean previously encountered in the CVM.

**Figure 3:** Example of one of the 4 choice sets in the choice experiment task

| Option A | Option B | Status quo |
|---|---|---|
|  7% |  5% |  10% |
| 2.5 L.E. | 20 L.E. | No increase in the bill |

The discussion also helped in the specification of the levels of each of these attributes. The attributes as well as the levels used in the choice experiment are described in Table 1. Given this set of attributes and levels, a linear D-optimal design method was used to structure paired choice sets. Carlsson and Martinsson (2003) recommend this type of design. The set of attributes and levels presented in Table 1 were used to create choice sets using a ($4^3 \times 4^3$) orthogonal main effects design, which produced 24 choice sets. These in turn were blocked into six versions of 4 choice sets each, using a D-optimal criterion. Focus group work showed that respondents could cope with up to 4 choice triplets each. This gave a finale sample size of 757 households. In the survey, each household was randomly assigned to one version.[5] Each household therefore evaluated 4 triplets of descriptions of different health risk situations i.e., A, B and the status quo. An example of one of the choice sets is presented in Figure 3. This procedure would imply a trade off between side effects and an increased water bill. The side effect described to the respondents represented the most frequently occurring water borne diseases in the short and long run. At this stage, it is worth noting that the wording describing the program to the respondent prior to the choice sets was similar to the one used in the CVM.

Figure 3 depicts an example of a choice set out of four given to the respondent in the CE. It should be noted that the communication of risk offered to the respondent is similar to the CVM with the distinction that the latter only offered the *status quo* and one proposed improvement of 25 percent reduction in the short run effect and a two percent risk of contracting a disease in the long run. All interviews were carried out face-to-face using the information packs used in the CVM to provide background information. Although no participation question was asked here a form of protesting or non-participation may still be tractable by the proportion of respondent always choosing the states quo. 40 percent of the sample chooses the states quo in the four offered choice sets.

### 2.3 Questionnaire development

This phase lasted several weeks, consisting of focus group sessions, open-ended questioning on specific issues and a pilot test of the full questionnaire. Careful attention was also given to the structure and ordering of questions to ensure that concepts which potentially impact upon the valuation issue are introduced in a logical sequence to minimize the degree to which respondents may be influenced by the questions posed. The pilot test, involving a sample of 60 households, served to decide the bid vector and the price level -for the CVM and CE, respectively-, to check any

[5] The six sets were offered under the form of different questionnaires. Each questionnaire was randomly assigned to a sample ranging from 124 to 130 households.

potential problem areas in the questionnaire e.g., miss-understanding of the questions and to include more questions to enhance the survey. The study included two questionnaires: the first one dealt with the CVM approach and the other one was about the CE. The questionnaires were made in Arabic to ease understanding for the respondents.[6]

Each questionnaire consisted of 10 parts or sections. It started with a series of questions on the source of drinking water and its characteristics, and then followed by questions about the cost and the reliability of water. The respondents were also asked questions about their household composition and their health status, pursued by a section describing the program proposed to reduce health risks from drinking water. In this section the information necessary for the respondents to make a reasoned decision without biasing their responses is offered. Followed by the valuation question or the choice sets for the CVM and CE, respectively. The succeeding section consisted of a set of debriefing questions concerning the health improvement program. The seventh and eighth sections gathered information on the characteristics of the household building and household possessions such as the type of dwelling, availability of electricity and household income. Subsequently information about the male and female household heads is collected including age, work status and education. The last section collected information about the respondent general environmental awareness and concerns.

### 2.4 Descriptive statistics

Throughout this section whenever there is a difference in magnitude between CE and CVM variables the latter related value appears in parenthesis. For the choice experiment (CVM) approximately 757 (732) households responded to each of the corresponding questionnaires as shown in Table 2.[7] Respondents were split evenly as much as possible between male and female heads of the households in order to allow for testing differences of gender on the response but no significant differences were found. The mean age of the respondent was around 45 (46.6). The mean household size was around 4.3 people with a mean of 1.25 (1.15) persons under 15 years of age.

[6] Whilst both questionnaires were conducted in Arabic, an English version is available from the author.
[7] For an extended table of descriptive statistics see Appendix Table A3.

Around 14 (13) percent of the households had a female head where the mean age of the household head was around 48 (49) years. 19 percent had completed preparatory education and around 28 (24) percent had completed a university degree. The average household monthly income was around 700 (600) Egyptian pounds for the CE and CVM, respectively. Around 72 percent of the respondents perceived the subjective health of their households as being good or very good. As for the existence of water born diseases in the household the CE and the CVM sample prevalence is 41 (24) percent.

**Table 2:** Description of the sample and variables used in the analysis

| *Variables* | *Choice experiment* | | | | *Contingent valuation* | | | |
|---|---|---|---|---|---|---|---|---|
| | Mean | Std. | Min | Max | Mean | Std. | Min | Max |
| Household income (Egyptian pound / month) | 698 | 832 | 55 | 9000 | 601.8 | 774.5 | 38 | 8000 |
| Good health (subjective health of the household 1= very good and good, 0=fair, poor and very poor) | 0.71 | 0.45 | 0 | 1 | 0.73 | 0.44 | 0 | 1 |
| Diseases in the household (1=diseases, 0=no diseases) | 0.41 | 0.49 | 0 | 1 | 0.24 | 0.43 | 0 | 1 |
| *Household Head's characteristic* | | | | | | | | |
| High education | 0.28 | 0.45 | 0 | 1 | 0.24 | 0.43 | 0 | 1 |
| Medium education | 0.25 | 0.43 | 0 | 1 | 0.27 | 0.44 | 0 | 1 |
| Low education | 0.19 | 0.39 | 0 | 1 | 0.19 | 0.39 | 0 | 1 |
| No education | 0.28 | 0.45 | 0 | 1 | 0.26 | 0.43 | 0 | 1 |
| Head employment (1=employed, 0=else) | 0.73 | 0.44 | 0 | 1 | 0.72 | 0.45 | 0 | 1 |
| Sample size (*N*) | 757 | | | | 732 | | | |

Furthermore, 90.9 (96) percent of the respondents paid a cash amount for water services, where 86 (90) percent of them paid in the form of a bimonthly bill, the remainder paid a variation of monthly, quarterly, half a year and yearly bill. In addition, 1.2 (1) percent paid for water as a part of a rental payment and 7.9 (3) percent did not pay for water. The mean cash payment was 13.15 (15.19) L.E. per household per bill. The mean addition to rent paid for water service was 7.25 (7.66) L.E. per household per month.

Table 3 brings together reasons for the respondents' choices. Around 26 percent of the CE and the CVM participants supported the positive short run effects of better water quality. In the long run 51 percent of the CE respondents and 69 percent of those willing to participate in the program believed on reducing long run health effects if water quality were enhanced. Since better water quality may lead to better health around 26 and 36 percent of the CE and the overall CVM respondents, respectively, are willing to contribute to the program.

**Table 3:** Reasons of the choice made by the respondents†

| *Reason* | *Method* | | | |
|---|---|---|---|---|
| | Choice experiment | Contingent valuation | | |
| | | Overall | Yes participation | No participation |
| Reduce short run problems | 25.46 | 15.71 | 27.2 | |
| Reduce the probability of diseases in the long run | 50.79 | 39.21 | 68.5 | |
| Better health worth the cost (instead of going to the doctor) | 26.12 | 35.66 | 62.5 | |
| No short run problems | 4.62 | 7.24 | | 16.5 |
| Don't believe in long run effects | 1.72 | 5.33 | | 11.43 |
| Can't pay more expenses | 40.5 | 31.56 | | 72.7 |
| Water-works can't provide the service | 1.98 | 4.23 | | 10 |

† Values in the table are percentages if not else indicated.

In the view of the fact that enhancing water quality is not free of charge, some respondents in both studies revealed their inability to pay more expenses. However, the proportion of the respondents not believing in the relation between enhanced water quality and better health in both the short and long run is relatively small.

## 3. Model and estimation methodology

The Random Utility Model (RUM) is a link between a statistical model of observed data and an economic model of utility maximization. RUM is used in this study since it serves to analyze both the CE and the CVM data (Hanemann (1984), Mitchell et al. (1989), McFadden (1974) and Ben-Akiva et al. (1985)). The use of the same theoretical foundation permits direct comparison of the welfare estimates from each method.

In this setting each household *h* is assumed to have a utility function associated with each alternative *i* of the choice set *t*:

$$U_{hit} = V_{hit}\left(X_{it}, Z_h, y_h - p_{it}\right) + e_{hit} \tag{1}$$

where in the choice experiment $U_{hit}$, $i=1,2...n$ is the utility of each of the $n$ alternative health improvement profiles and $U_{h0}$ is the subject's status quo. This utility function is composed of a deterministic part $V_{hit}(.)$ and a stochastic part $e_{hit}$. According to Ben-Akiva and Lerman (1985), $e_{hit}$ is attributed to unobserved taste variations, unobserved attributes, measurement errors and the use of instrumental variables rather than the actual variables that appears in the utility function. $V_{hit}(.)$ is the household's indirect utility function that is considered to be a function of the attributes and the socio-economic and demographic characteristics. These are incorporated in order to account for the observed taste variation among the respondents. The indirect utility function is assumed to take the following form:

$$V_{hit} = \alpha_{hi} + \beta X_{it} + \gamma Z_h + \delta_h \left(y_h - p_{it}\right) \tag{2}$$

where $\alpha_{hi}$ captures the household's intrinsic preference for alternative $i$, $\beta$ is a vector of attribute parameters, $X_{it}$ is a vector of health risk attribute levels in the profile $it$, where each decision set is indexed by $t$. $\gamma$ is a vector of parameters, $Z_h$ is a vector of socio-demographic characteristics, $\delta_h$ is the marginal utility of money, $y_h$ is household income, and $p_{it}$ is the cost attribute.

The probability of a household $h$ choosing an alternative $i$ from the choice set $t$ is:

$$P_h(it) = \Pr\{(\alpha_{hi} + \beta X_{it} + \gamma Z_h + \delta_h(y_h - p_{it}) + e_{hit}) > (\alpha_{hj} + \beta X_{jt} + \gamma Z_h + \delta_h(y_h - p_{jt}) + e_{hjt})\},\ \forall i \neq j .$$

Assuming that the random term $e_{hit}$ follows a type one extreme-value with scale parameter μ, the probability of choosing alternative $i$ from the choice set $A_t$ can be estimated using the conditional-logit model (McFadden (1974) and Maddala (1983));

$$P_h(it) = \frac{\exp(\mu V_{hit})}{\sum_{j \in A_t} \exp(\mu V_{hjt})}$$

The analysis of CVM responses can also be based on the RUM and the responses are analyzed in a similar manner. Hence, the model in (1)-(2) is used but the household is asked three questions starting with if the household would want or not to contribute in a project offering health improvements. This will be referred to as the participation question. This question is included in order to introduce a spike into the model. The essence of spike models is that they allow for a non-zero probability of zero WTP.[8] Two consecutive bids are offered to the participating household where the level of the second bid is contingent upon the response to the first one.[9] The cost $p$ takes the form of a starting bid, a higher bid and a lower bid that will be denoted by $B_h$, $B_h{}^u$ and $B_h{}^d$, respectively. The household then chooses between two alternatives where the first one is an improved state *1* with three potential costs that derive the utility $U_{h1}$. The second alternative is the status quo case $U_{h0}$ where $p_0$ equals zero. If the respondent answers "no" to the participation question then his/her WTP is assumed to be zero with a positive nonzero probability $a$. On the other hand if the answer is "yes", four possible outcomes arise with different probabilities of occurrence,

(i) both answers are "yes" $P_h^{yy}$ ,

(ii) a "yes" followed by a "no" $P_h^{yn}$ ,

(iii) a "no" followed by a "yes" $P_h^{ny}$ , and

(iv) both answers are "no" $P_h^{nn}$ .

If for instance, a household accepts the bid this is an indication that the utility in the case of an improvement is higher than in the status quo case. Further, the participating household after an acceptance or rejection of the bids is offered a follow up question asking about his/her maximum WTP. The answer to this question is referred to as a result of the open-ended procedure.

This structure of the CVM questions generates various possibilities of models to be estimated. For example, a spike model using the participation question together with the starting bid may be estimated, and a spike model with double bounds may also be estimated using the full structure of the referendum CV question. Following (Kriström (1997)) to estimate the spike model, the household is faced with two questions. The first one asks whether or not they would want to contribute to the project. The second suggests a price. For a household $h$ let $S_h=1$ if WTP>0, and zero otherwise. The following formula depicts the sample log-likelihood function,

$$\ln L = \sum_{h=1}^{N} \left[ S_h I \ln(1 - G(B_h)) + S_h I \ln(G(B_h)) + (1 - S_h) \ln(1 - G(0)) \right]$$

[8] For an extensive discussion on the spike models see Kriström (1997).
[9] This is the standard double bounded model see Hanemann et al. (1991)

$N$ is the sample size, $I$ is an indicator that equals one when the response to the second question is yes, and zero otherwise. $G(0) = a \in (0,1)$ and the probability of a "yes" response (i.e., that the household accepts the bid ($B_h$) is assumed to be logistically distributed:

$$\Pr(yes) = \frac{\exp(V_1 - V_0)}{1 + \exp(V_1 - V_0)} = 1 - G(B_h)$$

This estimation is extended following the method proposed by Reiser et al. (1999), in order to allow the estimation of a double bounded model with a spike and the incorporation of explanatory variables. Their method suggests breaking up the likelihood function into two separate parts. In the first one the spike is estimated using a logistic regression where the dependent variable $c$ for each household is $1$ or $0$ according to whether the WTP is greater or equal to zero.

$$\operatorname{logit} c_h = \log(c_h / 1 - c_h) = \alpha + \gamma Z_h$$

The second part consists of optimizing the cumulative distribution function $F(B_h)$ of the sub-population that is willing to pay anything. In this estimation the following log-likelihood function is estimated,

$$\ln L = \sum_{h=1}^{N} \left[ I_{yy} \ln P_h^{yy} + I_{yn} \ln P_h^{yn} + I_{ny} \ln P_h^{ny} + I_{nn} \ln P_h^{nn} \right]$$

where $I_{qw}$ are indicators that equal one when the two responses are $qw$, and zero otherwise. $P_h^{yy} = 1 - G\left(B_h^u\right)$, $P_h^{yn} = G\left(B_h^u\right) - G(B_h)$, $P_h^{ny} = G(B_h) - G\left(B_h^d\right)$ and $P_h^{nn} = G\left(B_h^d\right)$. In addition, the bid distribution is assumed to be log-logistic having the following form

$$1 - G(B_h) = F(B_h) = \frac{\exp(\eta_h)}{1 - \exp(\eta_h)}$$

where $\eta_h = \alpha_0 + \alpha_1 \log B_h + \gamma Z_h$ .

## 4. Socio-economic determinants of the willingness to pay

### 4.1 Contingent valuation results

Several explanatory variables were candidates in the preliminary estimations. Variables used in the estimation equation are the ones producing the best fit. Variable choice was based on a likelihood ratio test between various specifications. Table 4 presents the final results where most estimates are in accord with economic theory and prior expectation. The first column depicts the results of the spike model. The dependent variable in the spike logit, the second column, is simply 1 or 0 according to whether the household's WTP is greater or equal to zero. It could be seen that household income, the existence of diseases in the household and head employment state are the main factors that derive the household decision to participate or not to the proposed health program. The last column depicts the results of the double bounded estimation.

**Table 4:** Estimations results of the CVM†

| *Variables* | *Spike model (logit)* | *Double bounded* | |
|---|---|---|---|
| | | The spike (logit) | Participant (logit) |
| Intercept | 0.726** | -0.865** | 3.02** |
| | (0.194) | (0.215) | (0.432) |
| Price | -0.1** | | -0.59** |
| | (0.01) | | (0.046) |
| *Socio-economic and demographic variables* | | | |
| Household income (1000 Egyptian pound per month) | 0.4** | 0.27* | 0.86** |
| | (0.106) | (0.135) | (0.236) |
| Good health | 0.442** | 0.268 | 0.3 |
| | (0.171) | (0.176) | (0.236) |
| Disease in the household | 0.32 | 0.458* | -0.04 |
| | (0.175) | (0.187) | (0.229) |
| High educate head | 0.61** | 0.41 | 1.24** |
| | (0.212) | (0.228) | (0.321) |
| Medium educated head | 0.777** | 0.639** | 0.642** |
| | (0.195) | (0.207) | (0.258) |
| Low educated head | 0.249 | 0.131 | 0.377 |
| | (0.215) | (0.222) | (0.287) |
| Head employment | | 0.552** | -0.302 |
| | | (0.174) | (0.257) |
| *N* | 732 | 732 | 417 |
| *Log-likelihood* | -684.66 | -476.64 | -497.6 |
| *Restricted log-likelihood* | | -500.53 | -212.22 |
| *Akaike information criteria* | | 1.324 | 0.93 |

† Standard errors are in parenthesis
** if significant at 99% level
* if significant at 95% level

The negative coefficient of the price variable indicates that giving the respondents a higher price reduces the probability that a respondent will say 'yes'. The result shows that household income has a statistically significant effect on household willingness to pay (WTP); households with larger incomes are willing to pay more for the improved health service than households with lower incomes. Hence, if monthly household income increases by 1000 L.E., the household's WTP will increase by about 1.5 L.E. per month. High and medium educated heads had a positive and significant effect on WTP.

While estimating a Heckit model for the open-ended data the only variable with a significant effect was the starting bid. This indicates that the open-ended data suffer from starting point bias or anchoring effect (see Mitchell and Carson (1989) for more details). The presence of anchoring effect here is in the sense that the values of the open-ended WTP are not independent of the bids that were randomly distributed among households. Since it is found that increasing the starting bid by one L.E. results in a 0.86 L.E. increase in the open-ended WTP. This result reveals that the estimated coefficient of the starting bid is positive and significantly different from zero. The presence of the anchoring effect suggests that the bids themselves were often important influences on what WTP the respondents stated. This may indicate some uncertainty among households about their true preferences for the proposed health improvement program. For instance the open-ended data in a study of the benefits of groundwater protection by Press and Söderqvist (1998) also suffered from anchoring effect. This is similar to Lauria et al. (1999) where in their study on household demand for improved sanitation services in the Philippines they also found evidence of starting point bias.

## 4.2 Choice experiments results

The conditional-logit model makes use of 3028 observations. Two different specifications of the attributes are used. First, the attributes are used as continuous variables entailing the assumption that all the attributes are quantitative. As a second specification, the qualitative attributes of the health risk were described using effects codes. These codes were constructed for a four level attribute by coding the first 3 levels as dummy variables and coding the fourth as "-1". For example, an effect code *Level 2* is created such that if the treatment contains the second level selected, i.e., 5 percent reduction in the short run attribute and 7 percent risk of contracting a disease in the long run attributes, *Level 2 = 1*, if the treatment contains the fourth level, *Level 2 = -1*, otherwise *Level 2 = 0*.The outcome of this procedure is that the coefficient on the fourth level is the negative sum of the coefficients of the other 3 levels. Notice that *Level 1* represents the *status quo* level of each attribute and *Level 2* to *Level 4* moves from the lowest to the highest reduction offered. These codes are advantageous in experimentally designed research for a number of reasons. For instance, in contrast to dummy variable specification, effect codes are uncorrelated with the intercept in the model. On the other hand, using effect codes is equivalent to calculating the marginal effects of the levels of each attribute. For more details on these issues consult Adamowicz et al. (1994), Louviere (1988) and Louviere et al. (2000).

The models estimated in Table 5 were investigated pair wise using a likelihood ratio test which resulted in that the model presented in the last column is the most preferred. Looking at the adjusted $R^2$ the same result may be concluded since the statistical fit of the latter is better. The variables included in the estimation of the CE (Table 5) are similar to those used in the CVM in order to ease comparison. Many of the covariates operate as expected. The effect of the constant is negative and statistically significant at the 99 percent level, indicating that everything else held constant, it is more likely that the household will choose the *status quo*. The coefficient of the price attribute is negative and statistically significant. Indicating that for each one L.E. increase in the water bill, the probability of choosing an option other than the status quo decreases by 0.068. The coefficients of the long run health risk variables suggest rising utility with reduction in the probability of contracting a bad disease. Suggesting that the most preferred long run health risk is 2 percent i.e. the lowest level of this attribute, and the least preferred is the status quo. The coefficient of the short run attribute has a positive effect on the utility up to the second level. Consequently, an ambiguous effect is obtained since the coefficient of the higher level is not significant. Telling, that health program choice is unaffected by the short run risk. Turning to the socio-economic and demographic covariates most of them show a significant effect on the WTP. Households with higher income as well as household's head with higher education are more prompted to choose an alternative that is not the status quo.

**Table 5:** Estimation results of the choice experiment†

| *Variables and attributes* | *Attributes* | *Covariates* | *Effect codes* | *Effect codes & covariates* |
|---|---|---|---|---|
| Intercept | -0.78** | -2.49** | -1.047** | -2.78** |
| | (0.082) | (0.142) | (0.119) | (0.168) |
| Price | -0.064** | -0.068** | -0.064** | -0.068** |
| | (0.0046) | (0.0048) | (0.0047) | (0.0048) |
| Short run | -0.002 | -0.0013 | | |
| | (0.0016) | (0.00165) | | |
| Level 1 | | | -0.156** | -0.18** |
| | | | (0.061) | (0.064) |
| Level 2 | | | 0.219** | 0.227** |
| | | | (0.051) | (0.053) |
| Level 3 | | | -0.043 | -0.039 |
| | | | (0.053) | (0.055) |
| Level 4 | | | -0.017 | -0.004 |
| | | | (0.054) | (0.055) |
| Long run | 0.175** | 0.184** | | |
| | (0.011) | (0.011) | | |
| Level 1 | | | -0.751** | -0.789** |
| | | | (0.066) | (0.068) |
| Level 2 | | | -0.115* | -0.131* |
| | | | (0.054) | (0.056) |
| Level 3 | | | 0.146* | 0.166** |
| | | | (0.058) | (0.06) |
| Level 4 | | | 0.718** | 0.753** |
| | | | (0.049) | (0.05) |
| *Socio-economic and demographic variables* | | | | |
| Household income (1000 Egyptian pound per month) | | 0.4** | | 0.4** |
| | | (0.0678) | | (0.0678) |
| Good health | | 0.345** | | 0.344** |
| | | (0.091) | | (0.091) |
| Disease in the household | | 0.66** | | 0.667** |
| | | (0.083) | | (0.083) |
| High educated head | | 1.24** | | 1.234** |
| | | (0.12) | | (0.12) |
| Medium educated head | | 0.929** | | 0.924** |
| | | (0.11) | | (0.11) |
| Low educated head | | 0.756** | | 0.75** |
| | | (0.12) | | (0.118) |
| Head employment | | 0.316** | | 0.32** |
| | | (0.093) | | (0.0925) |
| *N* | 3028 | 3028 | 3028 | 3028 |
| *Log likelihood (coeff)* | -2926.34 | -2728.7 | -2916 | -2718.5 |
| *Log likelihood (nocoeff)* | -3328.8 | -3328.8 | -3328.8 | -3328.8 |
| *Adjusted*$R^2$ | 0.12 | 0.178 | 0.122 | 0.181 |

† Standard errors are in parenthesis
** if significant at 99% level
* if significant at 95% level

## 5. Welfare analysis

The objective of the SP task and the associated model estimates was to understand the economic impact of changing attributes of different health programs. In economic terms this is known as welfare measurement, which refers to the amount individuals, households in this case, are willing to pay for quality or quantity changes. In this study, welfare measures refer to the amounts that households are willing to pay in addition to the bimonthly water bill for health improvements through an enhanced water quality. This provides a way to monetise the benefits of health improvements to measure based on the same scale and to compare them to other health improvements already measured in monetary term.

The results of the SP models can be used as a guideline for the policy makers on how the households trade different health risks while considering various possible health programs with diverse outcomes. And could also serve as an indication of the benefits of improving water quality, thought comparing cost and benefits is beyond the scope of our study.

### 5.1 Contingent valuation welfare estimates

The welfare measures are evaluated using various models where the results vary with model specification. Starting with the open-ended approach, the mean and median WTP for the health improvement is estimated to be 6.8 and 5 L.E./bill, respectively. In the spike model without covariates the mean WTP is 9.02 L.E./bill. As concerns the double bounded without a spike the mean and median willingness to pay are estimated to be around 5 and 7 L.E./bill, respectively. The counterparts of the welfare estimates generated when introducing a spike to the double bounded model are lower, scoring 4.8 and 2.9 L.E./bill, respectively. Tables 6 presents the welfare estimates at sample mean, mean of the sample and for a specific household. The 95 percent confidence intervals (CI) are also depicted. As expected the double bounded give lower point estimates and tidier CI.

**Table 6:** CVM welfare estimates and their confidence intervals in Egyptian pounds

| | *Spike* | *Double bounded without spike* | *Double bounded with a spike* |
|---|---|---|---|
| Mean without covariates | 9.02 | 6.96 | 4.797 |
| | [7.29, 10.75] | [6.58, 7.34] | [4.21, 5.38] |
| Mean with covariates | 7.97 | 6.2 | 3.87 |
| | [5.42, 10.52] | [5.08, 6.95] | [3.03, 4.71] |
| Mean average household with covariates | 8.99 | 6.68 | 4.4 |
| | [6.28, 11.7] | [5.86, 7.5] | [3.56, 5.24] |
| Mean specific household with covariates† | 10.51 | 6.51 | 4.27 |
| | [7.16, 13.87] | [5.56, 7.46] | [3.33, 5.21] |

†The mean for the specific household is based on a household with an average income, contaminated with diarrhea, the household head has a medium education and is employed.

### 5.2 Choice experiment welfare estimates

In order to compare welfare measures from each model, the choice experiment is restricted to estimate the welfare impact of the same improvement offered in the CVM. For the choice experiment changes of a proposed health improvement through a better water quality is calculated using the following expression (Hanemann (1999)):

$$W = \frac{1}{\delta}\left[\ln\sum_{h\in A} e^{V_{h0}} - \ln\sum_{h\in A} e^{V_{h1}}\right] \qquad (3)$$

where $W$ is the compensating variation, $d$ is the marginal utility of income -which is considered to be the coefficient of the price attribute-, $V_{h0}$ and $V_{h1}$ represent the utility before and after the change. $A$ is the choice set of the household. Using the CE model the value of health improvement similar to the CVM offered to an average household in the sample is estimated to be around 6.8LE/bill.

Table 7 depicts the welfare estimates for the CE model with a proposed improvement in the short run of 25 percent and 2 percent risk in the long run. The 95 percent CI for the estimates are also calculated. The mean with covariates of the effect codes estimates is the one to rely on since this model explains the data better than the others since it has a better statistical fit. A finale caveat is that the reader should be aware of the fact that the attributes of alternatives can be varied in expression (3) and the impact of changing any one or a combination of attributes can be examined. This provides the decision makers with the information they need to compare the impacts of various alternatives.

**Table 7:** The CE welfare estimates and their confidence intervals in Egyptian pounds

| | *Attribute* | *Effect codes* |
|---|---|---|
| Mean without covariates | 8.92 | 8.35 |
| | [7.32, 10.52] | [6, 10.71] |
| Mean with covariates | 10.28 | 9.712 |
| | [6.68, 13.89] | [5.73, 13.7] |
| Mean average household with covariates | 6.8 | 6.18 |
| | [3.55, 10.54] | [2.47, 9.89] |
| Mean specific household with covariates† | 15.45 | 15 |
| | [11.96, 18.94] | [11.14, 18.81] |

†The mean for the specific household is based on a household with an average income, contaminated with diarrhea, the household head has a medium education and is employed.

### 5.3 Comparing the methods

Welfare effects of changes in health through a change in water quality is estimated and compared. Although two different methods are used, comparison is still feasible due to the common basis of the utility theory, as previously discussed. Note that the choice experiment model allows estimation of welfare impacts for different levels of the attributes. As for the CVM only one change can be examined where the suggested improvement is a decrease in the short run health effect due to poor quality water by 25% and a reduction to 2% of the probability of contracting water born diseases in the long run. Thus, in order to compare welfare measures from each model, the choice experiment is restricted to estimate the welfare impact of the same improvement offered in the CVM.

The welfare measures estimated for the CVM have exhibited differences in magnitude depending on the econometric specification. Nevertheless, it should still be noted that the welfare values given by the CE are quite similar to the ones calculated for the CVM. The results obtained here are opposite to Boxall et al. (1996) were the CVM estimate was higher than the CE estimate by a factor of 20. One of the reasons that could have driven their result is the method used in estimating the CVM results where the single bounded usually produces higher welfare measures. Those measures are also sensitive to the selected model. Moreover, Boxall et al. asked the respondents that currently hunted and few were likely to hunt in the site. The latter group of the respondents may never hunt in the site at all and thus the probability of use of the good does not differ between the two choices of their CVM exercise. Hence, any response has the same impact on the respondent's utility implying a violation of the incentive compatibility constraint. Consequently, this group of respondents may have driven a portion of the result to higher CVM welfare estimates. On the other hand, Hanely et al. (1998) find that the welfare estimates calculated from a quadratic CE are comparable to the CVM estimates while the CE estimate is greater than either of these. Whilst the results obtained in this paper suggest that the estimates are similar. It is difficult to draw firm conclusions about the relationship between the welfare estimates of the CVM and CE from this limited set of studies, since the direction of the relation varies from study to study. However, Hanely et al. point out the usefulness of the CE approach as opposed to CVM in offering greater potential for benefit transfer, together with the fact that CE seems best suited to value individual characteristics that make up a policy and CVM to value an overall policy package. Since in the former the attributes of alternatives can be varied and the impact of changing any one or a combination of them can be examined.

## 6. Discussion and conclusion

This paper presents an application of the CE and CVM analysis of health improvements through better water quality. The methods were administered to a sample of 1500 households living in Cairo, Kalyubia and Giza governorates. No considerable difference is found between the estimated values of the changes in health risk derived from both methods. However, it still could be concluded that the household living in Metropolitan Cairo have a positive WTP for reducing health risks owing to water quality. This WTP is around 1% of mean income for a decrease in the short run health effect due to poor quality water by 25% and a reduction to 2% of the probability of contracting water born diseases in the long run. The one percent of mean income results in very little value due to the fact that Egypt is a rather poor country. Although, study of costs are beyond the scope of this study it is worth noting that water infrastructure are typically expensive and the value of benefits found appears to be far from cost recovery. Though this low WTP indicates that it is economically not worth implementing this health program, the author is reluctant to draw such conclusion since the respondents may not have taken the externalities involved such as spread of the diseases into account. Hence, taking such externalities into account the program could still be potentially worthwhile from a social perspective. Moreover, this low WTP could possibly be attributed to limitations in understanding health problem resulting from different sources. Alternatively, they may reflect a psychological defense or miss-information, or respondents' beliefs that such problems are beyond their control. Furthermore, the size of the large health reductions in the scenarios may have been difficult to comprehend, implying that the respondents might have been valuing a risk change different (and smaller) from the one stated in the survey, which may be seen as a form of scenario rejection (cf. Mitchell and Carson, 1989).

However, the results of this study are nevertheless of interest for various reasons: The study asked the households to value a health risk that they had actually experienced (i.e., the short run effect) together with a "synthetic" illness that the interviewers described to them. This provides information that could be used to value the benefits of water quality improvement or other health programs in Metropolitan Cairo. Further, from a methodological point of view it allows comparison of values that people place on avoiding illness using two different SP methods, CE and CVM, in a developing country perspective. The results show that one should be hesitant in concluding that one method provides larger valuations than the other, and that the specific survey design and functional forms may be more important for such differences.

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**Appendix A**

**Table A1:** The distribution of the bids on the sub-sample and the number of yes/no saying

| *Lower, starting and upper bids* | *Bids value* | *Number of households asked*[a] | *Yes* | *No* |
|---|---|---|---|---|
| Lower bid ($B_h^d$) | 2 | | 6 | 9 |
| Starting bid ($B_h$) | 3 | 81 | 66 | 15 |
| Upper bid($B_h^u$) | 4 | | 41 | 25 |
| $B_h^d$ | 3 | | 2 | 11 |
| $B_h$ | 4 | 84 | 71 | 13 |
| $B_h^u$ | 5 | | 55 | 16 |
| $B_h^d$ | 4 | | 8 | 11 |
| $B_h$ | 5 | 93 | 75 | 19 |
| $B_h^u$ | 6 | | 49 | 26 |
| $B_h^d$ | 5 | | 9 | 9 |
| $B_h$ | 6 | 76 | 58 | 18 |
| $B_h^u$ | 7 | | 40 | 18 |
| $B_h^d$ | 6 | | 10 | 11 |
| $B_h$ | 7 | 82 | 61 | 21 |
| $B_h^u$ | 8 | | 51 | 10 |

[a] This is the number of households from the sample that was given a price after they had agreed to participate to the project.

**Table A2:** Consistency test of the bids

| *Probability* | *Proportions* | |
|---|---|---|
| | Yes/no | No/yes |
| Pr $\{3 \leq WTP \leq 4\}$ | 2.7 | 6.5 |
| Pr $\{4 \leq WTP \leq 5\}$ | 4.4 | 2.4 |
| Pr $\{5 \leq WTP \leq 6\}$ | 2.7 | 2 |
| Pr $\{6 \leq WTP \leq 7\}$ | 3.2 | 2.1 |

**Table A3:** Description of the sample and variables used in the analysis

| *Variables* | *Choice experiment* | | | | *Contingent valuation* | | | |
|---|---|---|---|---|---|---|---|---|
| | Mean | Std. | Min | Max | Mean | Std. | Min | Max |
| Household size | 4.29 | 1.77 | 1 | 11 | 4.33 | 1.84 | 1 | 13 |
| Female household head | 0.14 | 0.35 | 0 | 1 | 0.13 | 0.34 | 0 | 1 |
| # people working for money | 1.18 | 0.75 | 0 | 5 | 1.14 | 0.73 | 0 | 4 |
| # children under15 | 1.25 | 1.35 | 0 | 10 | 1.15 | 1.25 | 0 | 5 |
| # children between 5 and 15 years | 0.87 | 1.08 | 0 | 5 | 0.81 | 1.03 | 0 | 4 |
| # children under 5 | 0.42 | 0.7 | 0 | 4 | 0.34 | 0.65 | 0 | 3 |
| *Overall household subjective health* | 2.11 | 0.87 | 1 | 5 | 2.15 | 0.86 | 1 | 5 |
| Very good | 0.25 | 0.43 | 0 | 1 | 0.2 | 0.4 | 0 | 1 |
| Good | 0.47 | 0.5 | 0 | 1 | 0.53 | 0.5 | 0 | 1 |
| Not bad | 0.22 | 0.42 | 0 | 1 | 0.203 | 0.4 | 0 | 1 |
| Bad | 0.06 | 0.23 | 0 | 1 | 0.044 | 0.2 | 0 | 1 |
| Household member previously ill due to water | 0.06 | 0.23 | 0 | 1 | 0.045 | 0.21 | 0 | 1 |
| *Diseases in the household* | 0.41 | 0.49 | 0 | 1 | 0.24 | 0.43 | 0 | 1 |
| Diarrhea | 0.39 | 0.49 | 0 | 1 | 0.22 | 0.41 | 0 | 1 |
| Cholera | 0.005 | 0.07 | 0 | 1 | 0.001 | 0.04 | 0 | 1 |
| Thaiphoid | 0.011 | 0.1 | 0 | 1 | 0.014 | 0.12 | 0 | 1 |
| Hepatitis | 0.03 | 0.16 | 0 | 1 | 0.007 | 0.082 | 0 | 1 |
| Visited a Doctor | 0.24 | 0.43 | 0 | 1 | 0.21 | 0.4 | 0 | 1 |
| Expenses of Medical support | 4.44 | 17.38 | 0 | 250 | 4.36 | 25.09 | 0 | 600 |
| *Household Head's characteristic* | | | | | | | | |
| Age | 48 | 13 | 10 | 95 | 49.13 | 12.81 | 21 | 95 |
| High education | 0.28 | 0.45 | 0 | 1 | 0.24 | 0.43 | 0 | 1 |
| Medium education | 0.25 | 0.43 | 0 | 1 | 0.27 | 0.44 | 0 | 1 |
| Low education | 0.19 | 0.39 | 0 | 1 | 0.19 | 0.39 | 0 | 1 |
| Employed | 0.73 | 0.44 | 0 | 1 | 0.72 | 0.45 | 0 | 1 |
| *Respondent's characteristic* | | | | | | | | |
| Female | 0.59 | 0.49 | 0 | 1 | 0.58 | 0.5 | 0 | 1 |
| Age | 45.06 | 13.8 | 10 | 95 | 46.62 | 13.27 | 20 | 95 |
| High education | 0.24 | 0.43 | 0 | 1 | 0.212 | 0.41 | 0 | 1 |
| Medium education | 0.26 | 0.44 | 0 | 1 | 0.255 | 0.44 | 0 | 1 |
| Low education | 0.19 | 0.39 | 0 | 1 | 0.184 | 0.39 | 0 | 1 |
| Employed | 0.42 | 0.49 | 0 | 1 | 0.42 | 0.49 | 0 | 1 |
| *Water characteristics in the household* | | | | | | | | |
| Bad odor | 0.25 | 0.43 | 0 | 1 | 0.21 | 0.41 | 0 | 1 |
| Frequency of bad odor | 0.103 | 0.304 | 0 | 1 | 0.1 | 0.29 | 0 | 1 |
| Dirty | 0.42 | 0.49 | 0 | 1 | 0.34 | 0.48 | 0 | 1 |
| Frequency of dirtiness | 0.18 | 0.39 | 0 | 1 | 0.2 | 0.4 | 0 | 1 |
| N | 758 | | | | 732 | | | |