Willingness to pay for insecticide treated nets: Alternative models for construct validity of the bidding game, binary with follow-up method and a novel haggling technique

Obinna Onwujekwe, Kara Hanson and Julia Fox-Rushby
Health Policy Unit, London School of Hygiene and Tropical Medicine, London WC1E 7HT
Obinna.Onwujekwe@lshtm.ac.uk

ABSTRACT:

Objectives: To compare the construct validity of three contingent valuation elicitation techniques used to determine the willingness to pay (WTP) for insecticide-treated nets (ITNs) in Nigeria. Secondly, to determine the performance of different econometric models for the WTP estimates.

Methods: WTP was determined from 810 randomly selected household heads or their representatives in three malaria endemic villages, using the bidding game, the binary-with follow-up (BWFU) method and a novel haggling technique. Since the elicited WTP amounts were censored at zero, the Tobit model was compared to the Heckman's selection model estimated by two-step and maximum likelihood estimation (MLE). Ordinary-least-squares (OLS) and truncated regression were compared for the positive WTP. The models were subjected to diagnostic tests of normality, functional form, heteroscedascticity and predicted WTP.

Findings: The Heckman selection model estimated with MLE was the best model in all the elicitation techniques. RESET showed that the Tobit model was mis-specified in the bidding and haggling techniques, but the Heckman models were all correctly specified. The OLS was better than the truncated regression for modelling the positive responses. Overall, WTP elicited using the BWFU method had the best regression diagnostic outcomes.

Conclusion: Reasonable stated WTP for ITNs exist. However, the construct validity of the WTP determined from different elicitation methods were different depending on the econometric models. Also, different econometric models when applied to the same data set gave different outcomes. Thus, criterion for choosing the appropriate parsimonious model(s) was the information from the regression diagnostics. There should be diagnostic testing of regression models used for construct validity if the results are to be credible.

INTRODUCTION:

The willingness to pay technique is grounded in welfare economics, with the measurement of consumer surplus being the major theoretical underpinning. In the effort to empirically ascertain the Hicksian surplus or willingness to pay (WTP), the contingent valuation method (CVM) is often employed (Golan and Shechter, 1993).

Nevertheless, the validity of peoples stated WTP responses have been questioned (Diamond and Hausman, 1994) following identification of bias (Mitchell and Carson, 1989; Liljas and Blumenschein, 2000). Construct validity examined through econometric modelling of WTP is the major test of validity that has been used by most studies. This refers to whether the measurement corresponds to theoretical concepts (Klose, 1999).

Construct validity must be investigated whenever no criterion or universe of content is accepted as entirely adequate to define the quality to be measured (Cronbach and Meehl, 1955). It is established experimentally to demonstrate the extent to which a measure distinguishes between people who do and do not have certain characteristics (Fink, 1993). Thus, hypothetical constructs are proposed as underlying factors for peoples' observable behaviours (Streiner and Norman, 1995).

A key to generating valid WTP estimates is through the use of appropriate CVM questioning formats and elicitation methods. A valid and reliable WTP elicitation method would help to overcome some of the problems with CVM. However, there is still no consensus on the best elicitation method to use in the health sector (Onwujekwe, 2001).

The recommendation by NOAA (1993) that the dichotomous choice format should be used in preference to the open-ended method should be reconsidered. Lunander (1998) and Smith (2000) both point to the biases of the dichotomous choice method, and studies that have compared stated and actual WTP found that different elicitation methods yielded similar results (Brown et al, 1996; Loomis et al, 1997; Frykblom, 1997; and Onwujekwe, 2001).

Elicitation methods need to be specific to the context in which they will be used in order to increase the realism of the contingent valuation method, and thereby the validity of WTP information (Onwujekwe, 2001). Thus, the ideal WTP elicitation format in the Nigerian context for good like Insecticide-treated nets (ITNs), will be one that mimics the haggling technique that is normally used in the markets.

The use of appropriate models for investigating the construct validity of the WTP estimates is as important as having appropriate elicitation methods. The existing evidence of the theoretical validity of the CVM comes from econometric models believed to be parsimonious. However, since most of these models were presented without regression diagnostic tests, one can not confidently attest to the theoretical validity of the CVM in most cases as these models could have been mis-specified and spurious.

Donaldson et al (1998) noted that the appropriate technique for econometric analysis of WTP data had not been addressed in many studies of WTP for health and health care. They recommended that the regression techniques used in analysis of WTP data should reflect the way data have been collected or measured and any underlying theoretical considerations.

Studies that have used different econometric models to analyse the same WTP data set found that the models yielded different outcomes. Donaldson et al (1998) found that the Heckman's selection model was better than the OLS and Tobit models for the construct validity of WTP elicited using an open-ended question. Whittington et al (1992) found that the magnitude of the impact of the explanatory variables was larger with either the OLS or the Stewart Maximum likelihood estimator than with the probit model. Also, Dalmau-Matarrodona (2001), in comparing the Tobit and Double-Hurdle (DH) models, found significant differences between the models.

The use of different models to analyse the same data set would determine the robustness of the parameters and point to differences and similarities between estimators. They would also show their appropriateness for determining the construct validity of WTP generated by different elicitation methods. This is because different elicitation techniques generate different WTP distributions, which may be amenable to different econometric models. Most importantly, the models would signal the best elicitation methods to be used in particular-contexts.

Thus, we determined the performance of different econometric models for the construct validity of WTP for insecticide-treated nets (ITNs), generated using three elicitation methods. The elicitation methods were the bidding game (BG), the binary with follow-up (BWFU) and a novel structured haggling technique (SH). The last method was designed to better mimic the usual price-taking mechanism among the Igbo people of Nigeria. Thus, part of the objective was also to assess the relative construct validity performances of the different elicitation methods.

METHODS:

The nature of the good: Insecticide-treated nets (ITNs) form one of the new strategies for malaria control in Nigeria and people are expected to pay for them. It is therefore important to determine the level of peoples' WTP for the nets, using the most valid elicitation method. The information will help to determine the value of the ITNs products to the people and also help to understand the potential demand for the products. The use of ITNs is new in the country. ITNs are cost-effective tools for the control of malaria (Goodman et al, 2001). They are basically normal and private goods.

Study area: This was a combination of three villages with high malaria transmission rates namely; Amaetiti, Ahani and Enugu Akwu in Achi community of Enugu State, Southeast Nigeria. Achi has an estimated population of 45,000 people and is divided into 12 villages. The people are of "Igbo" ethnic group and Christianity is the major religion, with subsistence farming being their major source of livelihood. This project was the first contact of the villagers with ITNs. Bargaining for goods is the norm in the small village markets.

Choice of the elicitation methods to be compared to the novel technique[1]: The two existing elicitation methods were chosen because they mostly closely mimicked the normal price-taking behaviour in South-east Nigeria. Also, the bidding game and binary with follow-through techniques had positive predictive validity of 81.3% and 71.4% in another study in the country (Onwujekwe 2001).

The survey: A mini-census was conducted in the villages to produce the sample list. Sampling size was calculated based on an earlier study in Nigeria. Thus, 300 households were selected from each village using systematic random sampling, by including every 2nd household in the household roster. The household heads or their representatives (if the household head was not available) from the selected household were interviewed. The sample from each village was divided into three equal parts and an elicitation method applied to a third of each village respectively. This was to control for differences in villages' characteristics that might affect the performance of the three elicitation techniques.

Trained field workers selected from within the study villages administered the pre-tested questionnaire to the respondents. Each field worker mastered only one elicitation method in order to ensure expertise and proper conduct of the interviews. Demographic and other information was also collected from respondents. Information on the households' weekly food cost was used as the proxy for income. These variables, their measurements and hypothesised theoretical relationship with WTP for ITNs is shown in appendix 1. The

WTP scenario included showing the respondents a sample of the ITN. A study of content validity was used to select the starting-points for the three elicitation groups.

Descriptive analysis: The data from each elicitation method was pooled from the three villages. The demographic and other characteristics of the respondents were tabulated and compared across the three elicitation groups using Kruskal-Wallis statistics, to see how homogenous the groups were. The mean and median WTP estimates were generated, together with the confidence intervals around them and compared across the three groups. The WTP amounts were expressed in the local currency, the Naira (£1.00 = 170 Naira).

[1] The scenario and elicitation formats are available from the authors on request

ECONOMETRIC MODELLING

Theoretical model: Based on consumer demand theory, it is hypothesised that a respondent's willingness to pay for ITNs (W_i) is a function of the personal and household socio-economic characteristics, malaria/mosquito specific variables and attributes of the nets.

$$W_i = a + F_iB + e_i \quad (1)$$

Where F_i is a vector of the respondent's and household's characteristics and the attributes of the good under valuation, a and B are parameters of the model, and e_i is a random term with a standard normal distribution (Whittington et al 1990). Equation 1 depends on the individuals' utility function

$$U_i = V(Y, P, N, Q) \quad (2)$$

With utility of the individual (U_i), monetary income (Y), the prices of other goods and services expressed as a vector (P), other demographic and economic factors that might influence ability to pay or constrain behaviour (N) and the character of the goods under valuation (Q) (Whittington et al, 1992).

Choice of econometric model(s) :

The Tobit, Heckman selection model estimated by both the Heckman two-step procedure and Maximum Likelihood estimator respectively were used for the test of construct validity of the full sample WTP. The OLS and truncated regression models were compared for the positive WTP.

If the dependent variable is limited in some way, OLS estimates are biased even asymptotically (Kennedy, 1998). The OLS in this case fails to account for the qualitative differences between the limit observations (those with zero WTP) and the non-limit observations (Donaldson et al, 1998). Omitting the limit observations creates bias, ignoring them will be throwing away information, but including them as though they were ordinary observations also creates bias (Kennedy, 1998).

There are several alternative models for limited dependent variables and the easiest is the Tobit model (Kennedy, 1998). Donaldson et al (1998) also recommended the Heckman selection model depending on the underlying assumptions behind the zero responses. They posited that if the zero observations reflect genuine WTP values of zero, the Tobit model is appropriate for the estimation. However, if the zero responses have other than a genuine zero WTP, ranging from reporting errors to protest responses, the Heckman model is better since a more flexible specification of the censoring mechanism is required in that case.

In the case of modelling of positive WTP, a possible failing of the OLS estimation occurs with truncation of data. Such truncation at zero causes the lower tail of the distribution of the error term to also be truncated (Hoddinott, 1992). Thus, the mean of the error term differs from the estimated error term (which by definition is equal to zero) and a necessary condition for OLS estimation that the error term has a mean of zero is violated because of the truncation (Hoddinott, 1992).

However, whether truncated or OLS regression is more appropriate depends on the purpose of the estimation (STATA, 1985-1999). For instance, if one is interested in the mean of a woman's working hours conditional on the sub-sample of market labourers, OLS is appropriate. However, if it is the mean of the woman's working hours regardless of market or non-market labour status, OLS estimates could be seriously misleading (STATA, 1985-1999).

Models' specification approach: The nature of the zero responses was first determined, before the application of the specific models. Various data transformations were done for the continuous variables before the final functional forms used were selected. Regression diagnostic tests were conducted and the best model used for the interpretation of the parameters and for comparing the different elicitation methods.

Nature of the zero WTP responses: This was to determine whether the zeros represented true zero responses. The first step taken was the creation of a dummy variable (WTPbin) with the value 0 if the respondent had a zero WTP and 1 if otherwise. Then there was means testing of WTPbin versus the independent variables and tests of proportions between the two WTPbin groups.

Logistic regression of WTPbin versus the explanatory variables was also done to shed more light on the groups' characteristics, and determine variables that will be included in Heckman's selection equation. A general to specific modelling approach was used in order to arrive at the best model. The goodness of fit measures assessed were the log-likelihoods, the chi-squared (which uses the log-likelihood to test the over all significance of the model) and the proportion of correct predictions made by the estimated model.

The independent variables with the smallest t-statistic, and whose removal does not adversely affect the other coefficients nor the prediction of the models were removed sequentially. The F-test for the hypothesis that coefficient of that variable is zero was used to decide whether the variable will be finally dropped or re-entered into the regression (Ryan et al, 1996). The variables were finally dropped if the probability associated with the F-test was more than 0.10.

Modelling of the estimators. Full and specific models were estimated using the approach in the logistic regression. However, since there is no existing guideline on the variables that should be in the Heckman's selection equation, three different selection equations based on the result of the logistic regression were used for comparison purposes and the best selected.

Thus, the models used in the Heckman selection equation were; (1) Only the variables that were significant in the logistic model and that also obeyed the set hypotheses in this study. (2) All the statistically significant variables in the logistic model. (3) All the variables in the reduced logistic model. Sex was the used as the identifying variable in all the selection equations other than one, where status in the household was used. According to Manning et al (1987), if one does not know the correct specification, data could be used to find a satisfactory specification. Both the Heckman two-step consistent estimator and the MLE estimator were used for comparison purposes.

Regression diagnostics: Generalised residuals were used to check for heteroscedasticity and normality Donaldson et al, 1997). The Ramsey RESET test was used to check for functional mis-specification. Scatter plots of the residuals versus the predicted values were used to check for heteroscedasticity. In addition, Cook-Weisberg test for heteroscedasticity was also used for the OLS models. The numbers of statistically significant hypotheses obeying variables, together with the predicted WTP values were used as additional criteria for comparing the models and elicitation methods.

Comparison of the econometric models within and across the different elicitation methods: The regression diagnostics were used to compare the econometric models within each elicitation method in order to determine how good they were for explaining WTP using the same data set. The comparisons across elicitation methods were used to determine the overall better performing models and elicitation techniques.

RESULTS:

Descriptive statistics: The usable numbers of questionnaires for the analysis were 261, 267 and 273 for the bidding game, Binary with follow-up (BWFU) method and the structured haggling technique respectively. Chi-square tests showed that the three groups of respondents were similar for almost all the demographic variables except for status of the respondent, the person's years of formal schooling, food cost and the number of household residents. Less than 2.5% of the respondents had ever heard about ITNs before the survey, and none had ever purchased the net.

Stated WTP: More than 75% of the respondents in all three groups stated a positive willingness for the ITNs (Table 1). The decision about WTP was not statistically different across the elicitation methods' groups (chi-square = 2.93; p=0.231). The distributions of level of WTP across the three groups were statistically different (chi-square = 10.04; p=0.007). The data generated by the BWFU method was normally distributed. Conversely, the data generated by both the bidding and haggling methods were not normally distributed and so were transformed to their natural logarithms before the modelling.

Nature of the zero WTP responses: In general, the respondents who were unwilling to pay were more likely to belong to the lower socio-economic groups since they spent less money on food and health care. The people that were willing to pay also had more incidences of malaria and expenditures to both prevent and treat it and had previously purchased more untreated nets. These latter groups of respondents also had more household assets. Nevertheless, amongst other variables, food cost was uniformly different between the respondents that were willing to pay and others in the three elicitation groups ($p<0.01$), confirming that income was the major determinant on the decision to buy a net. However chi-square tests showed that not all the differences between the two groups were statistically significant.

In the logistic regression[1], the log of food cost was the only variable that was uniformly significant across all elicitation methods. Few variables were, however, statistically significant and not all the statistically significant variables had the hypothesised signs. The logistic regressions nevertheless confirmed the findings of the bivariate analysis that higher socio-economic groups and those with more malaria exposures were more willing to pay for the ITNs. The reduced models for the three elicitation methods were all statistically significant ($p<0.01$) and were able to correctly predict more than 80% of the observations.

[1] The result is available from the authors on request

COMPARING THE ESTIMATORS WITHIN THE DIFFERENT ELICITATION METHODS[1]:

The Heckman's two-step versus Heckman's MLE procedure and the Tobit from the bidding game data: The diagnostics showed that the residuals from Heckman's MLE and the 2-step models were normally distributed. The RESET test failed to reject the null hypothesis of correct specification, while the Tobit was the wrong functional form with a t-statistic of 3.28 for the RESET test ($p<0.05$) (Table 2). A plot of the residuals versus the fitted values of WTP showed no evidence of heteroscedascticity in either model.

The Heckman MLE predicted raw WTP, better than the 2-step. Thus, all these results show that Heckman MLE is a better estimator than the 2-step. Furthermore, within the Heckman MLE, the model that used only the statistically significant and hypotheses obeying variables from the logistic model as the selection equation had the best Ramsey RESET value (No 1) and was selected as the best estimator for the bidding game data.

The Heckman two-step versus Heckman MLE procedure and the Tobit from the BWFU data: The residuals from both Heckman MLE and the 2-step models were normally distributed and the RESET showed that they were both correctly specified (Table 3). Plots of the residuals versus the fitted values of WTP showed no evidence of heteroscedascticity in both models.

The Heckman MLE had better Ramsey RESET values and also predicted raw WTP better than the 2-step. Thus the Heckman MLE was a better estimator than the 2-step procedure. Furthermore, as in the Bidding game data, within the Heckman MLE, the model that used only the statistically significant and hypotheses-obeying variables from the specific logistic model as the selection equation had the best Ramsey RESET value.

The residuals from the Tobit model were normally distributed and had the right functional form. The plot of the residuals versus the fitted values revealed no evidence of heteroscedascticity in the model. However, the Heckman MLE had better Ramsey RESET values and predicted raw WTP better than the Tobit model. Therefore, for the BWFU method, the Heckman MLE is the preferred model for construct validity tests.

The Heckman two-step versus Heckman MLE procedure and the Tobit from the structured haggling technique data: The diagnostics showed that the residuals from both models were slightly not normally distributed, though the RESET test was consistent with correct specification (Table 4). Plots of the residuals versus the fitted values of WTP showed no evidence of heteroscedascticity in both models.

[1] The results not presented in this paper are available from the authors on request

However, the Heckman MLE predicted raw WTP better than the 2-step and in general had the better RESET values. The Tobit was the wrong functional form with a t-statistic of 4.84 ($p<0.05$). Furthermore, as with the previous elicitation methods, the Heckman MLE model that used only the statistically significant and hypotheses obeying variables from the logistic model as the selection equation (No 1) had the best Ramsey RESET value and was the best model of the structured haggling data.

OLS and Truncated regression for all elicitation techniques: The OLS had better outcomes than the truncated regression in both the bidding group and BWFU data. However, both were indistinguishable in the structured haggling group. Thus, the OLS was selected as the better estimator of positive WTP.

COMPARING THE HECKMAN MLE AND OLS ESTIMATORS ACROSS THE DIFFERENT ELICITATION METHODS:

The Heckman selection models: The actual incidence of malaria was statistically significant across the three elicitation methods, and had the hypothesised positive sign (Table 5). In the selection equation, all the variables that were significant in the logistic model were also significant in all selection equations except for ownership of a grinding machine which was not significant in the Bidding game and Haggling models. Sex became statistically significant in the BWFU model, while it was insignificant in the logistic model.

Six out of the seven statistically significant variables had the expected hypothesised signs in the Bidding group. These variables were sex ($p<0.10$), marital status ($p<0.01$), actual incidence of malaria ($p<0.10$), dummy of the expenditure to prevent malaria ($p<0.10$), dummy of the expenditure to treat other illnesses ($p<0.01$) and ownership of grinding machine ($p<0.05$). Only the ownership of motor car ($p<0.05$) had a negative sign instead of the hypothesised positive sign.

In the BWFU group, just four out of the eight statistically significant variables had the expected signs. These were the numbers of years of schooling, previous purchase of nets and food cost. Conversely, ownership of grinding machine, ownership of motorcycle, and occupational groups 4 and 5 had unexpected signs. Only 3 variables were statistically significant in the Haggling group, and one of them (marital status) had an unexpected sign. Status in the household and actual incidence of malaria had the expected signs.

The chi-square of tests of independent equations showed that while the Bidding and BWFU groups' two equations were independent, that of the Haggling group was not. This is confirmed by the coefficient of correlation (rho). However, models all the three elicitation groups were statistically significant ($p<0.015$).

The RESET test failed to find evidence of misspecification.. The model for the haggling group predicted raw WTP better than the others. Plots of the residuals versus fitted values showed the absence of heteroscedasticity in all models. While the residuals in the bidding and BWFU models were normally distributed, those in the haggling group deviated slightly from normal.

Apart from the number of statistically significant variables that obeyed set hypothesis, other criteria comparing the performance of the three elicitation methods include the goodness of fit measure which is the magnitude of the chi-square test and the magnitude of the chi-square of independent equations. Thus, Heckman selection regression best fits the data generated using the BWFU method.

OLS models: Most of the statistically significant variables had the expected hypothesised signs. The log of food cost was uniformly statistically significant across the three elicitation methods and also had the expected positive sign. The incidence of malaria was uniform in the BWFU and Haggling groups and had the hypothesised positive sign. Also, there were six statistically significant variables in the bidding game that had the hypothesised signs, four in the BWFU group and three in the haggling group.

The coefficients showed that as food cost increased, the respondents were more likely to state a larger positive WTP. The economic effects of number of years of schooling, incidence of malaria and ownership of radio were considerable. The result showed that a unit increase in the value of any of these variables would lead to a substantial increase in the level of WTP.

A variable that contradicted theoretical expectations in the bidding group was ownership of a car ($p<0.01$). Instead of being positively related to WTP, it had a negative sign. A unit increase in ownership of a car will decrease the level of WTP for an ITN by 0.29 (all other variables being held constant in each case). In the BWFU, belonging to occupational groups 4 and 5 had massive effects as they would each decrease the level of WTP by 103.4 Naira and 126.6 Naira per any unit increase respectively.

The OLS explained about 17% of the variation in WTP in both the Bidding and Haggling groups, and about 20% in the BWFU group. The reduced models were all statistically significant ($p<0.01$). The models in the bidding and BWFU groups were both homoscedastic and normally distributed, while the haggling was heteroscedastic and not normally distributed. However, the Ramsey RESET test failed to find evidence of misspecification.

DISCUSSION:

The decision about whether to pay a positive amount was expectedly similar across the three elicitation mechanisms. However, the statistically significant differences in the mean levels of WTP generated by the elicitation methods showed that the elicitation methods possibly acted in different ways on the respondents' thought processes. The greatest variability was observed in the data from the haggling elicitation method. This may be a reflection of the many steps involved thus giving rise to more varied responses.

However, considering the distributions of the level of WTP, the BWFU and haggling data were similar, while the bidding was only similar to the haggling data. Though the BWFU has fewer iterations, both haggling and BWFU have a step which ensures that respondents whose WTP were lower than the intended sales price was aware of this. This could have led to the homogeneity between the two groups.

Nature of zero values: The decision to pay for an ITN was propelled by need and enhanced by better income status. The question becomes whether those that stated zero WTP amounts also represented negative WTP or low positives. Johannesson and Johansson (1997) have argued that it is impossible to have negative WTP for private medical commodities, since the consumer is free to accept or reject to 'buy'. Thus, the zero WTP values can be interpreted as true zeros. This was confirmed by the findings of the logistic regression, as food cost was statistically significant in the three elicitation groups. It also had the hypothesised positive sign showing that as food cost rises, the decision to pay for ITNs also increases.

Parameters of asset holdings like ownership of motor car (Bidding group) and ownership of motorcycle (Haggling group) though statistically significant had negative signs, instead of the hypothesised positive signs. An explanation for the divergence from the expected could be that because these people are mobile, they felt that they could easily drive to the major cities and purchase the nets, maybe, at presumed lower prices.

Heckman selection model: The BWFU method generated the best data for the Heckman selection model. The incidence of malaria was the only statistically significant variable across the three elicitation methods. It also had the anticipated positive sign. This further confirms the results of other models that the level of WTP increases as the numbers of malaria attacks increase.

The variables that had the wrong hypothesised signs include ownership of motorcycle and car in the bidding group, occupational groups 4 and 5 and ownership of grinding machine in the BWFU group, and marital status in the haggling group. Some explanations for these divergences have been already discussed in the models previously presented.

Thus, some asset variables may not indicate a household's current socio-economic status since such assets could have been acquired when the households had money. More intriguing was the behaviour of the two occupational groups that were supposed to signify higher socio-economic groups. Unravelling the cause of their divergences from the hypothesised requires further study.

Tobit model: The Tobit model did not fit the data generated by the haggling and bidding game methods. Nevertheless, most of the statistically significant parameters in the three elicitation methods had the correct hypothesised signs. Food cost was the only variable that was statistically significant across the three elicitation groups, and with the right positive sign, thus amplifying the positive effect of income on WTP.

OLS and Truncated regression models: The OLS provided the best fit of the data generated from BWFU, while the truncated regression model was the best fit for the bidding game and structured haggling technique. In the truncated regression, the bidding method had the highest numbers of hypothesis-obeying statistically significant variables, the best predictions of WTP and the most correctly specified functional form.

The majority of the statistically significant parameters in both the OLS and Truncated regression models across all elicitation methods had the hypothesised signs. Notable exceptions were car ownership in both the OLS and truncated regression models in the biding game, ownership of grinding machine in truncated regression of the BWFU method and marital status in both the OLS and truncated regression models in the haggling method. Car ownership, being indicative of a higher socio-economic group, was hypothesised to be positively related to WTP, but it was negative here. The explanation is as in logistic regression where it also had a negative sign.

The fact that food cost was statistically significant across all the models and elicitation groups other than the truncated regression in the BWFU group showed that income is a major determinant of the amount that people would pay for nets. Actual malaria incidence, being statistically significant in 3 out of the six models also confirmed the characterisation of the zero WTP, that higher malaria incidences would lead to higher stated willingness to buy nets for prevention of malaria.

Though Hoddinott (1994) argued in favour of the truncated regression models, the OLS models in this study proved to be a better specification and were more efficient than the truncated regression models based on the diagnostic tests. Compared with the adjusted R2 obtained in previous studies, the OLS models in the elicitation methods performed well in explaining variation in WTP..

Comparison of the models: The Heckman models showed some measures of homogeneity with the Tobit models in the three elicitation methods. The Tobit models generally had fewer statistically significant, especially the hypotheses obeying statistically significant variables than the Heckman models. Nevertheless, 2 out of 5 statistically significant variables in the bidding game, 3 out of 4 statistically significant variables in the BWFU, and 1 out of 2 hypotheses obeying statistically significant in the Haggling techniques were similar in the Tobit and Heckman models.

The Heckman models were generally better than the Tobit model, especially viewed from the fact that RESET test showed that the Tobit was the wrong model in the bidding and haggling groups. Donaldson et al (1998) also found that Heckman's model was better than the standard Tobit model. These consistent variables between the two models were the expenditure to prevent malaria and ownership of grinding machine in the bidding game.

The problem with the Heckman model was the lack of guidance, on the variables to be included in the first part of the model. In this study we used the a priori logistic regression result of the decision to state a positive WTP to select these variables. The variables that were statistically significant in the logistic model were also statistically significant in the first stage of the Heckman estimation.

The OLS models also mirrored more closely the models used to estimate limited dependent variables from the comparisons of the OLS model and Heckman MLE. Most variables had the same constructs in the two models per elicitation group. However, as was also found by Donaldson et al (1998), the Heckman model was better than the OLS. The truncated and OLS models were very similar to each other within elicitation methods, but greater measures of heterogeneity between different elicitation methods.

The ultimate criterion for selecting the best models rests on regression diagnostics. However, a structured approach is needed for determining the performance of the elicitation methods for easy comparisons and generalising of findings. Previous attempts to classify the performance of models have not used a structured regimen. Johanesson et al (1991) used indicators of goodness of fit and Donaldson et al (1998) used regression diagnostic tests determine the performance of different models.

Modelling estimated WTP using different regression estimators is an excellent search process for determining the best models to use in interpreting the parameters. The robustness of the different parameters across different models strengthens the interpretations and conclusions on the effect of the variables on WTP. Qualitative studies could also be used to understand why some variables deviate from the logical set hypotheses.

Although the Heckman selection model was consistently the best performing model for limited dependent variables, no single model is perfect for all data sets. Also, different elicitation methods generate different distributions of WTP, thus accounting for differences in the econometric models used to model them. The mechanisms leading to the generation of different WTP by the different elicitation groups is not clear and requires further investigation.

The fact that the data generated by BWFU proved to be most amenable to modelling may challenge the rationale for having better context-specific methods like the structured haggling technique. However, the BWFU was also improved to better mimic price-taking in the study area before the survey. It was possible that the relative ease of administering the BWFU questions contributed to its performance. In addition, the field-workers that administered the BWFU questionnaires could have been more proficient than others.

Further tests of construct and criterion validity are needed before conclusive evidence on the performance of the elicitation methods in rural Nigeria can be made. Like all CVM studies, a limitation is whether the scenario presented enough information to the respondents. The tests of content validity and pre-testing done before the survey suggested that it did. However the difficulty is that it is not easy to convey enough information in a short survey (Phillips et al 1997).

In conclusion, depending on the econometric model, different elicitation methods will perform differently. Some perform better with some methods, while performing badly in other models. Improving tests of construct validity will include better ways of: measuring the variables, administering the questionnaires, as well as training and supervising field workers. Asserting the construct validity of WTP requires the diagnostic testing of different econometric models.

ACKNOWLEDGMENTS: This study received financial support from the UNDP/World Bank/WHO Special Programme for Research and Training in Tropical diseases.

References:

1. Brown TC, Champ PA, Bishop RC and McCollum DW (1996). Which response format reveals the truth about donations to a public good? *Land Economics;*72(2):152-66.
2. Cronbach, L.J. and Meehl, P.E. (1955). Construct validity in psychological tests. *Psychological Bulletin* 52:281-302.
3. Dalmau-Matarrodona, E. (2001) Alternative approaches to obtain optimal bid values in contingent valuation studies and to model protest zeros. Estimating the determinants of individual's willingness to pay for home care services in day care surgery. *Health Economics*; 10:101-118.
4. Diamond, P. and Hausman, J. (1994). Contingent valuation: Is some number better than no number? *Journal of Economic Perspectives;*8(4): 45-64.
5. Donaldson, C., Farrar, S., Mapp, T., Walker, A. and McPhee, S. (1997). Assessing community values in health care: is the 'willingness to pay' method feasible? *Health Care Analysis*;5:7-29.
6. Donaldson, C., Jones, A.M., Mapp, T.J. and Olson, J.A. (1998). Limited dependent variables in willingness to pay studies: applications in health care. *Applied Economics*, 30:667-677.
7. Fink A (1993). *Evaluation Fundamentals: Guiding Health Programs, Research and Policy.* London: Sage Publications.
8. Frykblom, P. (1997). Hypothetical question modes and real willingness to pay. *Journal of Environmental Economics and Management*; 34(3):275-287.
9. Golan, E. H. and Shechter, M. (1993). Contingent valuation of supplemental health care in Israel. *Medical Decision Making*;13(4): 302-10.
10. Goodman CA, Mnzava AE, Dlamini SS, Sharp BL, Mthembu DJ, Gumede JK. (2001). Comparison of the cost and cost-effectiveness of insecticide-treated bednets and residual house-spraying in KwaZulu-Natal, South Africa. *Tropical Medicine and International Health*;6(4):280-95.
11. Hoddinott, J. (1992) Modelling remittance flows in Kenya. *Journal of African Economies*; 1(2):207-232.
12. Johannesson, M., Jonsson, B. and Borgquist, L. (1991). Willingness to pay for anti-hypertensive therapy: results of a Swedish pilot study. *Journal of Health Economics;* 10(4):461-474.
13. Johannesson, M. and Johansson, P. (1997). The value of life extension and the marginal rate of time preference: a pilot study. *Applied Economics Letters;* 4:53-55.
14. Kennedy, P. (1998). *A guide to econometrics.* 4th ed. Oxford: Blackwell publishers.
15. Klose T.(1999). The contingent valuation method in health care. *Health Policy;* 47:97-123.
16. Liljas, B. and Blumenschein, K. (2000). On hypothetical bias and calibration in cost-benefit studies. *Health Policy*; 52:53-70.

17. Lunander, A. (1998). Inducing incentives to understate and overstate willingness to pay within the open-ended and the dichotomous-choice elicitation formats: An experimental study. *Journal of environmental economics and management*; 35(1):88-102.
18. Loomis, J., Brown, T., Lucero, B. and Peterson, G. (1997). Evaluating the validity of the dichotomous choice question format in contingent valuation. *Environmental and Resource Economics*; 10(2):109-123.
19. Manning WG, Duan N and Rogers WH (1987). Monte Carlo evidence on the choice between sample selection and two-part models. *Journal of Econometrics* 35:59-82.
20. Mitchell, R.C. and Carson, R.T. (1989). *Using surveys to value public goods: the contingent valuation method.* Washington D.C.; Resources for the future.
21. Phillips, K., Homan, R., Luft, H., Hiatt, P., Olson, K., Keraney, T., and Heard, S. (1997). Willingness to pay for poison control centers. *Journal of Health Economics;*16:343-357.
22. Ryan M. (1996). Using willingness to pay to assess the benefits of assisted reproductive techniques. *Health Economics*; 5:543-558.
23. Smith, R.D. (2000). The discrete-choice willingness to pay question format in Health economics: Should we adopt environmental guidelines? *Medical Decision Making*; 20:194-206.
24. STATA *manual version 6* (1985-1999); Texas. Stata Press.
25. Streiner, D.L. and Norman, G.R. (1995). *Health measurement scales. Practical Guide to their Development and Use.* Second edition. New York; Oxford University Press.
26. Onwujekwe OE (2001). Searching for a better contingent valuation elicitation method in rural Nigeria. The Binary question with follow-up versus the bidding game technique. *Health Economics*; 10:147-158.
27. Whittington, D., Briscoe, J., Mu, X., and Barron, W. (1990). Estimating the Willingness to Pay for Water Services in Developing Countries: a Case Study of the Use of Contingent Valuation Surveys in Southern Haiti**.** *Economic Development and Cultural Change;* 38(2): 293-312.
28. Whittington, D., Smith, K., Okoroafor, A., Liu, J.L. and McPhail, A. (1992). Giving respondents time to think in contingent valuation studies: A developing country application. reliability of contingent values: A comparison of on-site users, off-site users, and non-users. *Journal of environmental economics and management;22(3):205-225.*

Table 1: Stated WTP

Variable	Definition and measurement	Bidding	Binary	Haggling	χ^2 (p value)
Whether WTP	1 = Yes 0 = No Total	196 (75.1%) 65 (24.9%) 261 (100%)	215 (80.5%) 52 (19.5%) 267 (100%)	206 (75.5%) 67 (24.5%) 273 (100%)	2.93 (p=.231)
WTP amount (Naira)	Mean (S.D.) [95% CI] Median	162.0 (137.8) [145.2-178.9) 150.0	195.1 (136.2) [178.7-211.5] 200.0	190.4 (162.7) [170.9-209.9] 200.0	10.04 (p=0.007)

Table 2:Comparison of bidding game models

	Predicted values	Normality (χ^2 critical value at 0.95 = 5.991)	RESET ($t_{0.05} \cong 2$)
OLS LnWTP	5.18	5.70	0.325
Truncated regression	5.18	11.25*	0.312
Tobit	3.65	2.44	3.278*
Heckman (2step)			
1. Stat sig hypothesis obeying in logit model	5.78	1.19	0.305
2. All stat sig variables in logit model	5.64	10.31*	1.403
3. All variables in logit model	5.55	8.25*	0.760
Heckman (MLE)			
1. Stat sig hypothesis obeying in logit model	5.41	5.86	0.315
2. All stat sig variables in logit model	5.40	6.50*	0.845
3. All variables in logit model	5.40	5.27	0.753

***p<0.05; Mean of raw Log WTP = 5.21 and Log +1 WTP = 3.97**

Table 3:Comparison of the BWFU models

	Predicted values	Normality (χ^2 critical value at 0.95 = 5.991)	RESET ($t_{0.05} \cong 2$)
OLS	195.07	0.92	0.26
Truncated regression	232.14	6.51*	0.86
Tobit	178.77	4.85	1.89
Heckman (2step)			
1. Stat sig hypothesis obeying variables in logit model	230.03	0.45	0.84
2. All stat sig variables in logit model	228.35	0.43	1.00
3. All variables in logit model	235.10	0.47	0.86
Heckman (MLE)			
1. Stat sig hypothesis obeying variables in logit model	203.20	0.46	0.24
2. All stat sig variables in logit model	203.61	0.37	0.74
3. All variables in logit model	242.93	0.89	0.91

***p<0.05; Mean of raw WTP = 195.07**

Table 4:Comparison of the structured haggling models

	Predicted values	Normality (χ^2 critical value at 0.95 = 5.991)	RESET ($t_{0.05} \cong 2$)
OLS LnWTP	5.29	6.12*	1.33
Truncated regression	5.29	6.12*	1.31
Tobit	3.79	1.11	4.84*
Heckman (2step)			
1. Stat sig hypothesis obeying in logit model	5.44	6.84*	1.09
2. All stat sig variables in logit model	5.46	6.54*	1.90
3. All variables in logit model	5.37	7.11*	1.90
Heckman (MLE)			
1. Stat sig hypothesis obeying in logit model	5.33	6.28*	1.13
2. All stat sig variables in logit model	5.35	6.30*	1.86
3. All variables in logit model	5.31	6.47*	1.53

***p<0.05; Mean of raw log WTP = 5.36 and log + 1 WTP = 4.10**

Table 5: Heckman selection model

	Bidding		BWFU		Haggling	
Variables	**Full Model Coeff. (SE)**	**Reduced model Coeff.(SE)**	**Full Model Coeff. (SE)**	**Reduced model Coeff.(SE)**	**Full Model Coeff.(SE)**	**Reduced model Coeff. (SE)**
Status in the household			-11.27 (19.42)		.26 (.10)***	.29 (.08)***
Number of household residents	-.03 (.02)*	-.02 (.02)	-.40 (3.17)	1.62 (2.99)	.02 (.02)	.02 (.017)
Sex	.16 (.09)*	.17 (.08)**				
Age	-.001 (.002)		-.20 (.59)		.002 (.003)	
School years	-.01 (.01)		7.32 (2.25)***	9.04 (2.09)***	.01 (.01)	
Marital status	.31 (.12)**	.33 (.12)***	-8.72 (21.92)		-.23 (.12)*	-.24 (.11)**
Perceived incidence of malaria	-.05 (.11)		.51 (18.37)		.03 (.09)	
Actual incidence of malaria	.18 (.09)*	.15 (.09)*	16.16 (16.59)	26.15 (15.59)*	.13 (.06)**	.14 (.06)**
Dummy of exp. to treat malaria	-.22 (.14)	-.17 (.13)	-31.68 (28.04)	-25.35 (26.22)	-.16 (.13)	-.16 (.12)
Dummy of exp. to prevent malaria	.16 (.10)	.18 (.10)*	-17.46 (15.21)	-17.30 (14.17)	.08 (.11)	
Actual incidence of other illnesses	.0003 (.10)		-9.18 (11.71)	-8.45 (7.72)	.01 (.07)	
Dummy of exp. to treat other illnesses	-.25 (.14)*	-.25 (.07)***	.017 (21.59)		.01 (.13)	
Previous purchase of nets	.06 (.10)		35.84 (19.61)*	34.46 (19.60)*	-.04 (.11)	
Ownership of radio	.09 (.09)		29.29 (19.75)	26.13 (18.34)	.15 (.10)	.15 (.10)
Ownership of bicycle	-.04 (.09)		16.97 (16.15)	13.30 (15.19)	-.08 (.09)	-.09 (.08)
Ownership of grinding machine	.23 (.11)**	.22 (.11)**	-42.55 (21.82)*	-49.21 (20.20)**	.08 (.11)	.10 (.11)
Ownership of motorcycle	.13 (.10)	.15 (.10)	-30.97 (17.45)*	-25.59 (16.78)	-.04 (.11)	
Ownership of car	-.37 (.18)**	-.35(.16)**	22.24 (25.80)		.10 (.14)	.09 (.13)
Log of Food cost	-.06 (.08)	-.03 (.07)	10.77 (13.87)	32.66 (12.03)***	.09 (.07)	.10 (.08)
Occup2	.09 (.23)		-63.06 (40.47)	-59.55 (37.39)	-.15 (.16)	-.16 (.16)
Occup3	.23 (.23)		-50.56 (40.43)	-47.50 (38.45)	-.13 (.19)	-.12 (.17)
Occup4	.23 (.25)		-140.56 (47.35)***	-124.55 (45.27)***	-.19 (.23)	-.13 (.18)
Occup5	.26 (.32)		-140.28 (55.17)**	-135.24 (52.64)**	.19 (.23)	.22 (.23)
Constant	5.28 (.58)***	5.35 (.51)***	220.89 (117.62)*	-20.35 (86.75)	4.49 (.60)***	4.65 (.64)***
Select	Status	Status	Sex	Sex	Sex	Sex
Sex or Status	-.09 (.15)	-.04 (.15)	.45 (.20)*	.29 (.17)*	.25 (.20)	.27 (.21)
Log of food cost	.55 (.14)***	.54 (.14)***	.49 (.14)***	.37 (.13)***	.70 (.13)***	.69(.13)***
Years of schooling			.05 (.03)*	.06 (.02)**	.05 (.03)*	.05 (.03)*
Dummy of Mal.prev			.48 (.15)***	.45 (.14)***		.55(.39)
Grinding machine	.28 (.22)	.24 (.22)			.57 (.39)	-
Constant	-2.90 (.90)***	-2.87 (.89)***	-3.05 (.91)***	-2.24 (.87)**	-4.21 (.80)***	4.17 (.81)***
/arthro	-1.71 (.30)***	-1.58 (.27)***	-.16 (.51)	1.54 (.33)***	-.11 (.33)	-.22 (.39)
/lnsigma	-.45 (.06)***	-.45 (.06)***	4.58 (.06)***	4.73 (.06)***	-.65 (.05)***	-.64 (.06)***
Rho	-.94 (.04)	-.92 (.04)	-.16 (.51)	.91 (.06)	-.11 (.32)	-.22 (.37)
Sigma	.64 (.04)	.64 (.04)	97.47 (5.38)	113.31 (6.84)	.52 (.03)	.53 (.03)
Lambda	-.60 (.06)	-.59 (.06)	-15.78 (50.29)	103.42 (11.15)	-.06 (.17)	-.12 (.20)
Test of indep. eqns	12.85***	11.30***	0.05	9.30***	0.12	0.42
Chi2	52.20***	45.21***	43.22***	64.14***	47.24***	41.76***
Log likelihood	-271.818	-274.789	-1389.875	-1392.002	-266.938	-268.373
Predicted values		5.41		203.20		5.33
Ramsey RESET		0.32		0.24		1.13

*** <0.10, **<0.05, ***<0.01**

Appendix 1: The independent variables: measurement and hypotheses

Variables	Measurement	Hypotheses (relationship with WTP)
Status in the household	1 = household head 0 = otherwise	Household heads being the ones that control the purse strings will be more willing to pay than others
Number of household residents	Continuos quantitative measure	The more the number, the more willing a household will be, because they will have more resources to pool
Sex	1 = male 0 = female	Males will be more willing to pay since they usually control purse strings and are the key decision makers
Age	Continuous measure in years	The active workforce will be more willing to pay since they have more money, thus the under 60s will have more WTP
Square root of age	Ditto	
Number of years of formal schooling	Ditto	Education increases level of awareness. Thus increased education will lead to increased WTP
Marital status	1 = married 0 = never married	Married people will be more WTP, because they'll like to protect their spouses and children
Perceived incidence of malaria	1=perceived occurrence 0 = perceives no occurrence	The more the perceived incidence, the more WTP
Actual incidence of malaria	Continuous data on occurrence of malaria in last month	The more the actual incidence, the more the WTP
Last month's expenditure to treat malaria (maltreat.)	Continuous monetary measure	The more the expenditure, the more the WTP
Dummy of maltreat	1 = made expenditures 0 = made no expenditure	Ditto
Last month's expenditure to prevent malaria (malprev.)	Continuous monetary measure	Ditto
Dummy of malprev.	1 = made expenditures 0 = made no expenditures	Ditto
Actual incidence of other illnesses	Continuous count o occurrence of other illnesses in last month	This may lead to depletion of household resources, thereby decreasing WTP
Last month's expenditure to treat other illnesses (illtreat.)	Continuous monetary measure	Ditto
Dummy of exp. to treat other illnesses	1 = made expenditures 0 = made no expenditure	Ditto
Previous purchase of nets	1 = ever purchased any type of net 0 = otherwise	People who have ever purchased nets will be more WTP since they had earlier decided that they are important
Ownership of radio	1 = household owns a radio 0 = otherwise	It shows enhanced socio-economic status and will lead to increased WTP
Ownership of bicycle	1 = household owns a bicycle 0 = otherwise	It shows enhanced socio-economic status and will lead to increased WTP
Ownership of grinding machine	1 = owns a grinding machine 0 = 0therwise	It shows enhanced socio-economic status and will lead to increased WTP
Ownership of motorcycle	1 = owns a motorcycle 0 = otherwise	It shows enhanced socio-economic status and will lead to increased WTP
Ownership of car	1 = owns a car 0 = otherwise	It shows enhanced socio-economic status and will lead to increased WTP
Last week's Food cost (expenditure + home produced)	Continuous monetary measure	This is the proxy for income. Thus, the more the food expenditure, the more WTP
Occup1	1=unemployed/unskilled lab. 0 = otherwise	This group will have negative WTP since they don't have money
Occup2	1 = farmer 0 = otherwise	They will have negative WTP because of lack of disposable cash
Occup3	1 = skilled labourer/trading 0 = otherwise	They will have a positive WTP since they have disposable cash
Occup4	1 = Formally employed 0 = otherwise	They will have a positive WTP since they have disposable cash
Occup5	1 = professionals & mid/big time business 0 = otherwise	They will have a positive WTP since they have disposable cash