WILLINGNESS TO PAY TO AVOID HEALTH RISKS FROM PESTICIDES, A CASE STUDY FROM NICARAGUA

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Abstract

A contingent valuation approach to assess the health effects of pesticides among Nicaraguan vegetable farmers is presented. Farmers' valuation of health is measured as willingness to pay (WTP) for low toxicity pesticides. Results show, that farmers are willing to spend about 28% of current pesticide expenditure for avoiding health risks. The validity of results is established in scope tests and a two-step regression model. WTP depends on farmers' experience with poisoning, income variables and pesticide exposure. The results can help in targeting of rural health policies and the design of programmes aiming to reduce negative effects of pesticides.

Keywords

Health risks of pesticides, Contingent Valuation, Nicaragua

1. Introduction

The use of chemical pesticides continues to rise in world agriculture. Their benefits as well as their negative side effects on the environment and human health have been demonstrated in numerous studies. In general farmers and farm labourers are most at risk of pesticide poisoning. In Nicaragua, pesticide poisoning has been well documented (see e.g. CORRIOLS 2002; KEIFER et al. 1996; MURRAY et al. 2002). PAHO (2002) estimated that the number of farmers affected by pesticide poisoning every year is 5.4% of the farming population of Nicaragua. This is comparable to data from other developing countries like Sri Lanka and Malaysia with poisoning rates among farmers of about 7% (JEYARATNAM et al. 1987) and Ivory Cost with 8% (AJAYI 2000). Recent survey data from Nicaraguan vegetable growers revealed that 30% had experienced acute poisoning in their life as farmers. During the year of the survey in 2004, 5.6% of respondents experienced acute pesticide poisoning alone. Chronic effects from long-term exposure however are rarely recognized and documented. Even for acute poisoning a scarce data situation is typical: In Nicaragua, CORRIOLS et al. (2001) estimated that 98% of pesticide poisoning in Nicaragua remained unreported by the official health statistics.

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Economic evaluation of health costs of pesticides is constrained by this lack of data in addition to the methodological challenges resulting from the different value components of human health. The economic value of health includes market components like the cost of illness and non-market aspects like the cost of pain and discomfort. Evaluations of health costs of pesticides so far have focused on the market components, estimating the costs of illness. Different approaches include: accounting for farmers' private expenses for the treatment of acute poisoning, the opportunity cost of labour lost due to illness (AJAYI 2000; HUANG et al. 2000), effects on the productivity of the family labour, effects on the decision making capacity of farmers (CRISSMAN et al. 1998) and estimates of the cost of chronic illnesses based on clinical studies (ROLA et al. 1993). However, a more comprehensive analysis of the health costs of pesticides has to consider also the non-market value. For this purpose, the contingent valuation method (CV) has been proposed in order to obtain a valuation of health based on the individuals' preferences (HIGHLEY and WINTERSTEEN 1992).

This paper presents a contingent valuation approach to assess the health effects of pesticides among vegetable farmers in Nicaragua. The objective is to assess the value of pesticide-related health from the farmers' point of view. This information can contribute to the targeting of rural health policies and the design of programmes aiming to reduce negative effects of pesticides.

2. Theoretical background

In CV, the change in the supply of a non-market good is evaluated with respect to a constant utility for the individuals following the concept of Hicks compensated demand functions. Its theoretical basis is welfare economics (MITCHELL et al. 1989), when public goods or policies are evaluated. In the case of health economics the valued good is mainly of private nature (SMITH 2005), which is evaluated in the framework of household theory.

CV has already widely been applied in human health economics (see e.g. O'BRIEN et al. 1996; DIENER et al. 1998; HANLEY ET AL. 2003). The utility of the farm household (U_0) can be expressed as the sum of health (H_0) and other goods, summarized as income (I_0). If supply with health is improved to H_1, keeping income constant, farmers move to a higher utility level (U_1). The value of the change in supply is measured as that amount of income that the farmer is willing to pay (WTP) in order to be indifferent about the change in health i.e. to remain on his initial utility level, the compensating variation (C).

(2.1) $$U_0 = I_0 + H_0 = I_0 - C + H_1$$

The elicitation of WTP is based on surveys, where respondents evaluate the non-market good in hypothetical market situations.

Few case studies so far have applied contingent valuation to the topic of health effects of pesticides. MULLEN et al. (1997) and BRETHOUR et al. (2001) analyzed the non-market benefits of a program of Integrated Pest Management (IPM) in the US, based on a consumer survey. OWENS ET AL. (1998) and CUYNO ET AL. (2001) studied farmers' WTP for reducing the negative effects of pesticides in the US and in the Philippines, respectively. These studies valued environmental effects of pesticides, considering health as one of several environmental categories. Respondents had to value their WTP in a sequence of scenarios for the different environmental and human health categories. However, this method may complicate the valuation for respondents, who have to process a large quantity of information in order to understand the differences in the described scenarios.

The CV method has been criticized for relying on stated preferences instead of observable behavior (HAUSMAN 1993). Therefore, CV studies have to provide evidence on the validity of the results. MITCHELL AND CARSSON (1989) categorize three main types of validity assessments. Content validity refers to the design of the survey instrument. Is the good defined in a way that the correct value can be measured? Are respondents provided with sufficient and plausible information? Is the proposed way of payment acceptable and scenarios plausible? Careful survey design, pre-tests and focus group discussions are tools to enhance content validity. Convergent validity compares valuations of the same good obtained by different measures. If the measures are correlated and tend to converge, they are assumed to be valid. However in a specific application, it may be difficult to obtain other measures, as CV usually is applied in cases where e.g. market based prices are not available. The theoretical validity test applies the idea that the demand for non-market goods follows the same rules as the demand for market goods. The valuation should be sensitive to the quantity of the good and WTP should vary with income and attitudes towards the good. Attitudes towards the good, e.g. concerns about pesticide poisoning and experience of illness, as well as budget constraints and risk measures like intensity of pesticide use are expected to have an impact on farmers' valuation of pesticide-related health. This can be analyzed in regression models on WTP.

In general, CHAMP et al. (2003, p. 155) state that the reliability of the CV "is not an issue of concern", but stress the importance of tests on the validity of the results for the assessment of the quality of particular CV studies. For the evaluation of health effects of pesticides CV is an appropriate methodology, because it allows the valuation of non-market values based on individual preferences.

In the following section, the design and the conduct of the CV survey with Nicaraguan small-scale vegetable farmers is described. A description of establishing evidence of validity is provided.

3. Methodology and Model

The reliability of CV applications depends highly on the design of the survey instrument and the implementation of validity tests. The design of the questionnaire therefore was guided by the data requirements for the elicitation of WTP and the tests on the validity. Table 3.1 gives an overview of the validity criteria, their implementation in the survey and the methods of assessment of each criterion included in the study.

The description of health for the valuation scenario was based on the approach used by Cuyno et al. (2001). Health was represented as an attribute of a pesticide, which was offered in a hypothetical purchase situation. In order to increase the farmers' familiarity with the good, for each respondent his most used pesticide was taken as a reference with respect to pest control efficiency. The price premium he would be willing to pay for a pesticide with the same characteristics except the health risks of the product was then established as the WTP for the health attribute. Other possible descriptions of the good "health" would have included e.g. the willingness to invest in IPM or the purchase of protective equipment. However, discussions with farmers showed, that especially in vegetable production IPM is only vaguely defined. Protective equipment however is often perceived as inconvenient and of questionable effectiveness in avoiding pesticide exposure, which would have reduced the plausibility of this scenario for the farmers. Thus the most practical description were chemical pesticides which farmers are very familiar with, rendering the "low toxicity pesticide option" as the most feasible one for the CV survey.

Table 3.1: Validity test in the implementation of the CV survey

<table>
<tr><th>Validity</th><th>Implementation in survey</th><th>Method of assessment</th></tr>
<tr><td>Content validity</td><td></td><td rowspan="5">Response rates
Analysis of comments of respondents with zero-bids.</td></tr>
<tr><td>Definition of the good</td><td>Pesticide without health risks</td></tr>
<tr><td>Payment vehicle</td><td>Pesticide price</td></tr>
<tr><td>Familiarity</td><td>Purchase of pesticide,
Farmers' most used pesticide according to production recall questions</td></tr>
<tr><td>Acceptance of the questionnaire</td><td>Modifications after pre-tests</td></tr>
<tr><td>Construct validity</td><td></td><td></td></tr>
<tr><td>Convergent validity</td><td>Costs of acute poisoning

Adoption of IPM practices</td><td>Compared to stated WTP – lower bound of WTP
Frequency of IPM adoption</td></tr>
</table>

Theoretical validity	Valuation in two scenarios Questions on ❑ Household characteristics ❑ Income variables ❑ Pesticide exposure and health	Scope test: less benefits = less WTP? Logistic regression: Payer / Non-payer Regression model on WTP

Source: own presentation

In order to compare WTP to related measures of health costs of pesticides, the costs of acute poisoning and general health costs of the household were collected in the survey as well. For a test on scope sensitivity as part of the theoretical validity, two scenarios were designed for valuation: In a first scenario, a pesticide was evaluated which was safe with respect to chronic health risks, but still possibly causing acute symptoms. The second scenario presented a pesticide which was safe with respect to acute and chronic health risks, i.e. completely safe for human health. The expectation was, that WTP for the second scenario should be higher or equal to the first scenario, as benefits are higher as well. This was assessed using t-tests to compare the mean WTP for the scenarios. Theoretical validity was assessed in a two-step methodology, first identifying the factors determining whether a respondent has a positive WTP, then analysing the variation WTP amounts. In the first step, a binary logistic regression was applied, where the probability of a positive WTP (p) is regressed on explaining variables (x_i), following a logistic probability distribution:

$$(3.1) \quad p = \frac{e^{\alpha+\beta_1 x_1}}{1+e^{\alpha+\beta_1 x_1}},$$

For an interpretation similar to the linear regression model, in the logistic regression, the odds ratio of the probabilities for the two possible outcomes of the dependent variable is calculated, which in its logarithmic transformation is a linear function of the explaining variables, α representing the intercept and β' the vector of coefficients of the explaining variables (ZANDER et al. 2005):

$$(3.2) \quad \text{logit}(p) = \ln\left(\frac{p}{1-p}\right) = \alpha + \beta' x.$$

Since the distribution of positive WTP values was skewed, as frequently observed in health care data (MANNING et al. 2005), a semilog or log-linear regression model (GUJARATI 1995 p. 169) was used for the analysis.

$$3.3 \quad \ln(Y) = \alpha + \beta' x_i$$

The explaining variables (x_i) include personal and household characteristics, socio-economic, health-related and pesticide exposure related variables. Attitudes towards health are expected to be the most important explaining variables determining WTP. These are defined as previous experience with pesticide poisoning, the reporting of symptoms related to pesticide application and the intensity of pesticide use. Income includes wealth of land, agricultural and off-farm income and access to finance. Personal characteristics of the respondent like age and education as well as household size and location can also influence WTP for pesticide-related health and were used in the regression models.

The survey was implemented in face-to-face interviews with 433 small-scale farmers in the four main vegetable growing regions in Nicaragua. The survey instrument familiarized the farmers gradually with the problem of pesticide-related health. Respondents were asked to recall their pesticide use in the previous growing period and their experiences with poisoning and poisoning symptoms. After this, information was given about possible health effects of pesticides, presenting a list classifying the most commonly applied pesticides into high, medium and low risk following WHO classification (WHO 2002). The distinction between acute and chronic health risks was explained. Chronic illnesses were defined as long-term effects of pesticide exposure, without necessarily having experienced acute poisoning. As an example served the case of the victims of Nemagon use in the 1970ies, (Associated Press 2005) which was much discussed at the time of the survey. Then the interviewer selected the respondent's most frequently used high-risk pesticides from the input list obtained before. The farmer was asked the pesticide price and then was offered a hypothetical reduced risk formulation of the same product in the two scenarios explained above. The elicitation of the WTP was designed as an open ended bidding game, starting with a 100% price premium, then lowering or increasing the price depending on the farmer's response. After two bidding rounds, the farmer was asked to rethink his decision and the WTP question was repeated. WTP was calculated as the product of price premium and the purchased amount of the pesticide.

4. Results

The results of the valuation for the two scenarios "chronic" and "chronic and acute" are presented in table 4.1. The average price increments are 69 and 157% for the scenario "chronic" and "chronic and acute" respectively. 13.8% of the sample were excluded because they did not use any high-risk pesticides or did not plan to use in the next cropping cycle, another 42 refused to answer the WTP questions. In total, 330 valid WTP answers were obtained, of which 293 had a positive WTP for the scenario "chronic and acute" and 206 for both scenarios. The reasons given for zero bids included budget constraints and no importance given to the issue of pesticide health risks.

A first indicator for the validity of WTP responses is the difference of WTP between the scenarios. The benefits from the scenario “chronic and acute” are higher than “chronic”, thus WTP is expected to be higher as well. This is confirmed as shown in table 4.1. The difference between the scenarios is highly significant.

Table 4.1: Median and mean WTP in two valuation scenarios

Indicator	Unit	Mean (s.e.)	Median	25 Quartile	75 Quartile	Skew.
Total WTP "chronic"	US$	25.8 (3.7)	6.00	0	20.3	6.2
Total WTP "chronic and acute"	US$	61.6 (9.6)	20.75	6.0	50.0	7.8

Source: own calculations

Taking into account that the most respondents are resource poor small-scale farmers, the stated contingent values seem relatively high. However, variation is very high and the distribution is skewed, so for a first assessment of plausibility of the values, WTP is compared to family expenditure for general health care and individual household income and pesticide expenditure (table 4.2). With respect to the total pesticide expenditure the WTP may appear high with an increase of about 25%, considering that most farmers (63%) need external finance for buying pesticides and fertilizer. However, expressed as share of household income WTP is much lower, with a median of 1.2% and a mean of 3.1%. Also, actual expenditure on family health care per year is higher than the mean WTP for avoiding health risks from pesticides. In conclusion, the contingent values for the two scenarios are reasonable by these plausibility indicators.

Table 4.2: WTP as share of pesticide expenditure and income

	Unit	Mean (s.e.)	Median	25 Quart.	75 Quart.
Pesticide expenditure	[US$]	865.6 (71.8)	418.9	214.7	933.2
WTP “chronic and acute” / pesticide expenditure [a)]	[%]	24.7 (2.7)	8.6	2.1	21.7
Agricultural income / year	[US$]	1846.5 (228.4)	666.7	143.3	1851.7
Household income / year	[US$]	2096.0 (235.6)	904.7	265.0	2257.3
WTP “chronic and acute” / household income [a)]	[%]	3.1 (1.6)	1.2	0.07	3.8
Family expenditure for health care	[US$]	97.8 (14.3)	30	0	66.7

a) Values are the means of the ratios over the total sample

Source: own calculations

The results for the logistic regression on positive WTP in the scenario “chronic” are shown in table 4.3. For the farmers, chronic effects are more difficult to understand, so that the share of zero bids is much higher than for the scenario that includes acute health effects. Of the personal and household characteristics, respondents’ age and the number of household members are significant, with a negative coefficient. This is straightforward: the older the farmers, the less he will be concerned about future chronic effects of pesticides, particularly, if he doesn't suffer from illnesses so far. Also, for bigger households, a zero WTP is more probable, since family labour is less scarce and health risks are shared among the family members.

There are differences in WTP among the survey regions: In the Northern highlands, Jinotega and Matagalpa, fewer respondents have a positive WTP as compared to the region of Pacifico Sur. Of the income characteristics, sharecropping is associated with a lower probability of WTP. Sharecroppers usually are highly dependent on wealthier partners, who provide finance and external inputs like pesticides and fertilizer in exchange for 50% of the yield. Therefore they cannot decide freely on higher quality pesticides for higher prices. Of the health and exposure-related variables, the number of poisoning symptoms reported by the farmers is positively related to paying attention to health aspects and therefore to a positive WTP.

Table 4.3: Logit model for positive willingness to pay in the scenario "avoiding chronic effects"

		Coeffic.	Odds ratio	Sig.
	Intercept	2,548	12,787	***
Household characteristics	Age	-0,019	0,981	**
	School	0,006	1,006	
	HH members	-0,117	0,890	**
	IPM Index	-0,032	0,968	
	Trained	0,395	1,484	
	pac_sur	0,341	1,406	
	Matag	-0,919	0,399	***
	Jinotega	-0,843	0,430	***
Income and wealth	Credito	0,211	1,235	
	Sharing	-0,484	0,616	*
	Net return	0,000	1,000	
	Off-farm	0,000	1,000	
	Farm worker	0,109	1,115	
	Farmsize	0,001	1,001	
	Crop area	-0,021	0,979	
	Subsistence	-0,193	0,825	
Exposure to pesticides and health experiences	Severity	0,032	1,033	
	Symptoms	0,127	1,135	*
	WHO I &II / mz	0,004	1,004	
	WHO III & IV / mz	-0,003	0,997	
	Sales agent	-0,262	0,769	
	Extension	-0,449	0,638	
	Reference price	0,002	1,002	
	Constant	0,137	1,146	
Model Summary	-2 Log likelihood	446,502		
	Nagelkerke R Square	0,168		

Percentage Correct	65,565		
Chi-square	48,357		***

*****: significant at 0.01 level; ** significant at 0.05 level; * significant at 0.1 level;** source: own calculation

Table 4.4 shows the results of the log-linear regression model for the WTP in the scenario "acute and chronic". For detection of possible multicollinearity in the model, the variance inflation factors (VIFs) were calculated. These are smaller than 2 for all variables, indicating that correlation between explaining variables may not affect the estimation of coefficients. The intensity of pesticide use, an indicator for health risks through exposure is a significantly explanatory variable. Also, previous experiences with poisoning, expressed in the severity of poisoning and the number of reported symptoms are significant factors.

Table 4.4: Log linear regression on stated WTP for scenario "chronic and acute"

		Unstand. Coeff.	Std. Error	Stand. Coeff.	T	Sig.
	Intercept	5,283	0,515		10,248	***
Household characteristics	Age	0,000	0,007	0,004	0,061	
	School	-0,061	0,030	-0,141	-2,010	**
	HH members	-0,044	0,042	-0,066	-1,062	
	IPM Index	0,029	0,015	0,141	1,995	**
	Trained	-0,290	0,196	-0,110	-1,474	
	pac_sur	0,696	0,281	0,193	2,474	**
	Matag	-0,134	0,234	-0,041	-0,571	
	Jinotega	0,197	0,217	0,068	0,909	
Income and wealth	Credit	0,632	0,198	0,221	3,195	***
	Sharing	0,177	0,209	0,062	0,848	
	Net return	0,000	0,000	-0,029	-0,414	
	Off-farm	0,000	0,000	0,033	0,460	
	Farm worker	-0,352	0,230	-0,095	-1,530	
	Farmsize	-0,008	0,004	-0,123	-1,914	*
	Crop area	0,120	0,031	0,302	3,905	***
	Subsistence	-0,237	0,175	-0,088	-1,357	
Exposure to pesticides and health experiences	Severety	0,165	0,081	0,135	2,049	**
	Symptoms	0,079	0,048	0,107	1,669	*
	WHO I &II / mz	0,011	0,005	0,144	2,127	**
	WHO III & IV / mz	0,006	0,003	0,135	2,105	**
	Sales agent	-0,082	0,191	-0,029	-0,431	
	Extension	-0,158	0,217	-0,053	-0,727	
	Reference price	0,000	0,001	0,008	0,137	
Model	R Square	0,401345				
	Adjusted R Square	0,326104				
	Regression F-value	5,334137				***
	Number of observations	208				

*****: significant at 0.01 level; ** significant at 0.05 level; * significant at 0.1 level**

source: own calculation

Budget constraints are important: The access to credit, an indicator for a better income situation as compared to share croppers is positively related with stated WTP. That pesticide related health is probably an ambiguous good with respect to income sensitivity is illustrated by the variables farm size and cropped area. While the former has a negative sign, the latter is positively related to WTP. Land ownership can be interpreted as an indicator of wealth, however, since farmland can comprise larger areas of fallow/forest or only extensively used land, the area used for annual crops like vegetable may be much smaller. The reported area planted with vegetable or food grain crops therefore is more directly related to full-time farming with a high input of family labour, leading to a higher concern for pesticide-related health. The net returns from agricultural activities and the off-farm income are not significant in this model. Especially in vegetable production net returns are extremely variable, so that the one year's revenues are probably not decisive for the valuation of health effects. Of the personal characteristics, the age of the respondent has no impact on WTP, but schooling surprisingly has a negative effect. Adoption of practices of Integrated Pest Management can be interpreted as awareness of negative effects of pesticides and increases also WTP for health.

With respect to the different vegetable growing regions, WTP is again higher in the south pacific region, near to the capital Managua than in the northern plains and highlands of Matagalpa, Jinotega and Estelí.

5. Conclusions

The results of this contingent valuation study show that Nicaraguan vegetable farmers are aware of pesticide health risks and have a positive willingness to pay for avoiding these risks. The mean estimated willingness to pay seems to be in a plausible range, as compared to expenditure on family health and in relation to income. Comparing the ratio of WTP to the costs of pesticides, the results of this study with 25% are within the range of the results from the Philippines of (CUYNO 1999), where 22% of pesticide costs for human health category were found, but considerably lower than values from the US where WTP values of 60-70% (HIGHLEY and WINTERSTEEN 1992) and above 100% of pesticide costs (OWENS et al. 1998) were found. Theoretical validity tests show that relevant indicators of pesticide risk, previous experience with poisoning symptoms and income related variables are significant predictors for the individual WTP.

Development programmes that effectively reduce the use of highly toxic pesticides would earn considerable benefits. Also, health benefits can be assumed an important incentive for farmers to adopt technologies that reduce pesticide use, like IPM. This is underlined by the positive impact of the IPM adoption index on the WTP. In vegetable production, where productivity effects of IPM have not yet been demonstrated to be significant, health effects could provide the motivation to continue research on IPM and its implementation.

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