Valuing Morbidity: Acute Respiratory Illnesses in Bogotá, Colombia

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I. Introduction

Human health is increasingly viewed as central in economic development, both as a measure of development and as an input. Early mortality and excessive morbidity are serious constraints to economic growth. The impact of pollution on human health has recently become a focus of research in developing countries. The effect can be substantial. Pollution levels in developing countries increase with industrialization, population growth, and urbanization. The enforcement of pollution laws is hampered by poverty, corruption and the limited means of environmental agencies. Further, industries in developing countries' cities are often scattered throughout cities, even in residential neighborhoods, because of limited city planning. Hence, exposure to pollution may be higher than in developed countries, even when emissions are similar. Contraction of respiratory illnesses is common, and may be attributed to air pollution, and welfare losses from health effects may be large. Empirical evidence on economic losses from pollution is therefore crucial to demonstrate more forcefully the importance of devising policies and implementing programs to abate pollution.

In this paper we study the economic costs of morbidity from acute respiratory illnesses in Bogotá, Colombia. Our purpose is to estimate the willingness to pay for a reduction in respiratory morbidity; the unit valued is a day's illness. Our research is based on a household survey of residents of Bogotá, conducted in the person's home. Our approach is based on the research of Alberini *et al*. (1997) that analyses how familiarity with the commodity valued affects WTP for reductions in sick days, and on the study of Cropper et al. (2000) that estimates the demand for a malaria vaccine based on contingent valuation surveys conducted in Ethiopia.

Contingent valuation surveys that estimate willingness to pay for reduced illnesses can take two approaches in describing the type of illness to be valued. The first approach is to allow the respondent to describe the illness to be valued. In the second approach, the interviewer, through the questionnaire, describes the illness the respondent must value. The advantage of the former approach is that respondents are familiar with the illness they are describing, and thus valuing. One drawback is that responses to the survey can be endogenous to the illness described by the respondent because individuals will base their responses on the behavior they adopted in the last episode. Although the second approach circumvents this problem, little room for averting behavior is left, and respondents might not be familiar with the illness described (Alberini et al, 1997). Finally, both approaches fail to describe how the illness will be reduced, and how they will pay for the reductions, adding more abstractness to the already abstract service of a reduction in a day of illness.

We present empirical results based on a survey of 1,200 residents of Bogotá, conducted during the first months of 2000. The purpose of the survey is to investigate willingness to pay for reducing days of acute respiratory illness (ARI). The survey is designed carefully to reduce endogeneity bias, increase familiarity of the good being valued and introduce concreteness in the mechanism to reduce the illness and the payment vehicle. We estimate the demand for reduced illness days assuming that the demand for reduction in days is distributed randomly as a Poisson distribution. Based on this model we estimate willingness to pay (WTP) for reduction in days. Results show losses from contraction of ARI in Bogotá are significant, but that WTP is lower when concreteness is included to the WTP question.

We believe the paper contributes in three important issues. First, the paper provides additional evidence on economic losses from morbidity in a developing country. Second, when coupled with evidence on the effects of air pollution on morbidity, as study we are now engaged in, the paper can provide empirical evidence about the demand for environmental quality in developing countries. Empirical research on preferences for environmental quality from micro-level in developed countries, while extensive, is not applicable to developing countries. Although these studies have consistently found a systematic relation between income and environmental quality, the results can not be extrapolated to developing countries where the level of income, education and awareness of pollution are typically less than in developed countries. Third, the study carefully designs a survey to address the problems described above.

II. Literature Review

When using a stated preference approach, a contingent market for a hypothetical commodity must be created. Description of the commodity offered, in our case reductions in symptoms days, is crucial for the credibility of the values estimated. The complexity of describing symptoms days poses several challenges. First, respondents should be familiar with the commodity offered; otherwise, the researcher may not elicit true values. Second, description of the commodity should be precise enough to allow researchers and policy makers to identify the commodity valued in terms of symptoms, duration of episode, activity restrictions and costs, and link it with air pollution levels. Third, the WTP question, although abstract, should be sufficiently credible to avoid eliciting hypothetical answers to hypothetical questions.

The economic literature takes two approaches to overcome these challenges. In the first approach, the WTP question describes the illness the respondent must value. Berger *et al*. (1987) measures the consumer surplus of avoiding days of light symptoms in Denver and Chicago. The survey instrument asks respondents to describe the number of symptom days experienced the previous year and the associated costs of each symptom. Respondents were then asked to rank seven light symptoms previously chosen and state the value for reductions in symptom days for each symptom. Chestnut *et al*. (1997) estimated WTP for preventing a future day with respiratory symptoms in Bangkok, Thailand. After filling a three-month daily symptom dairy, a survey describing a future day with respiratory symptoms with three different levels of severity was administered. The description of severity was based on activity restriction. Johnson *et al*. (1998) use stated preferences and health-state classifications to estimate the value of reducing pollution in Canada. The study characterizes the illness based on four attributes - symptoms, duration, daily activity level, and cost – that are combined into health bundles. Health bundles are then use in graded-pair format or discrete choice questions. Although this approach describes precisely the commodity valued, respondents might not be familiar with the illness described and little room for averting behavior is left.

The second approach allows the respondent to describe the illness being valued. Alberini *et al*. (1996) estimate WTP to avoid a recurrence of the last episode of ARI experienced in Taiwan. The sample was divided in two subsamples to test the effect of familiarity with the commodity valued on WTP. One subsample answers the survey after filling daily health diaries. The other describes the last episode of illness being valued and proceeds to answer the survey. Before answering the WTP question, respondents were asked to describe the duration, symptoms and severity of the last episode of ARI experienced. Then, respondents were asked to value avoidance of the recurrence of the same episode. Description of the last bout of ARI increases familiarity with the commodity valued. But recalling the last episode of ARI might induce respondents to base their answers on the behavior they adopted, and, thus, endogeneity may arise.

III. A Model of the Demand for Reductions in Morbidity

Models to estimate willingness to pay for health improvements for reductions in pollution abound in the literature. The model we develop is based on Cropper and Freeman (1991), Alberini *et al*. (1996) and Cropper *et al*. (2000). The utility function of an individual is determined by a numeraire good (x), leisure time (l) and the number of days spent ill during a year (s),

(1) $U = U(x, s, l)$.

The number of days spent ill is determined by environmental pollution (q), activities that mitigate the exposure to pollution (m) and averting activities (a). Mitigating activities include doctor visits, taking medicines or using folk remedies, among others. Some averting activities include installing an air conditioning to the car or moving to less polluted neighborhoods. The number of illness day also depends on the severity (v) and number of symptoms (n). The health production function is then defined as

(2) $s = s(q, m, a, v, n)$.

The expenditure function is represented by

$$e(p_x, w, p_a, p_m, q, v, n, \overline{U}) = \begin{Bmatrix} \min p_x x + p_a a + p_m m - (Y + w(T - l - s(q,m,a,v,n))); \\ \text{subject to } U(x,l,s) \geq \overline{U} \end{Bmatrix}$$

where Y is non-wage income, w is the wage rate, T is total time available, p_x is the price of the numberaire good, p_m is the price of one unit of mitigating activities and p_a is the price of one unit of averting activities. For convenience, the arguments Y and T are omitted from the expenditure function.

Improvements in environmental quality increase utility indirectly by reducing the numbers of illness days, and increasing leisure time. Willingness to pay for a pollution reduction from q^0 to q^1 is defined as

(3) $$WTP = e(p_x, w, p_a, p_m, q^0, v, n, \overline{U}) - e(p_x, w, p_a, p_m, q^1, v, n, \overline{U}).$$

An alternative measure of WTP for reductions in pollution is to estimate directly WTP for reductions in illness days, and relate reductions in illness to decreases in pollution through a dose-response function. This approach, although indirect, avoids the biases that arise in a CV study in which the respondent values changes in pollution. The CV literature has demonstrated that linking pollution to reductions in illness days biases upward WTP estimates because respondents are valuing other benefits from reducing pollution (e.g. increases in visibility). However, in the case of morbidity, if one values morbidity directly and then uses epidemiological research to infer the effects of air pollution on morbidity, then the CV study will not incorporate other effects of air pollution, and to the extent that the CV results are an accurate reflection of preferences, this approach will not have systematic biases. We will follow this approach to measure WTP.

IV. Results

a. Survey Questionnaire

Bogotá, the capital city of Colombia, has approximately 7,000,000 inhabitants. Extensive growth in cities, both in population size and economic activity, combined with larger fleets of automobiles without emission control devices have led to significant increases in pollution. Studies conducted by the Health Secretary in Bogotá show among the ten first causes of morbidity for 1996, 14% can be attributed to factors causing respiratory illness. Since 1995, environmental authorities have created regulation to control industrial pollution and to oblige new automobiles to install emission control devices. Also, circulation restrictions for vehicles have been imposed during the last years. The benefits and costs of these policies are yet unknown.

The purpose of this study is to value reductions in acute respiratory illnesses. The survey, representative of Bogota's population, was conducted to 1,200 individuals during the first months of the year 2000. Before administering the survey, four focus groups and two pilot surveys were carried out to refine the questionnaire. In-person interviews were undertaken in the respondents' house, which were carefully selected to create a representative sample of Bogotá. The instrument included questions eliciting the characteristics of the last episode of ARI experienced by the respondents and describing the households' profile. In addition, the survey elicited the WTP for reductions in symptoms days.

Similar to Alberini *et al*. (1997), we asked respondents to describe their last bout of ARI by enumerating the symptoms experienced and illustrating its severity and duration with the objective of increasing the respondent's familiarity with the good being valued. To help respondents understand the economic losses from contracting an acute respiratory illness, we elicited the costs they incurred when they experienced the last ARI such as doctor visits, medical expenses, time spent on doctor visits, lost income, disutility from the illness and reduction in leisure activities.

After carefully describing the last episode of ARI experienced, the WTP question was asked. To avoid inducing respondents to base their answers on the last episode of ARI, the question is based on the symptoms and severity of the last episode but the length of the disease was randomly determined. By defining the length of the disease, we reduce endogeneity and we account for variations in WTP due to length of the disease. The detailed valuation question is the following:

> Suppose in the following days you will contract an illness for X days and will experience the following symptoms [ENUMERATE SYMPTOMS OF LAST ARI]. How much will you be willing to pay to eliminate Y symptom days of this illness episode? Please remember that you will be paying for eliminating Y symptom days, which includes medical expenses, doctor visits, lost income and lost leisure time. Would you be willing to pay $Z to eliminate Y symptom days? ? Before you give your answer please remember that if you decide to pay then your usual budget would be reduced in that amount.

To test the effect of defining a concrete way of reducing the illness and a payment vehicle the survey is splitted in two parts: (i) respondents could buy directly reductions in Y symptoms days at price $Z; and (ii) respondents could buy a pill of price $Z to reduce Y symptoms days. Before asking the WTP question in the second option, we asked whether they used pills to reduce ARI symptoms. When respondents did not use pills to reduce symptoms, we used the WTP translated above. Otherwise we asked the following question:

> Recently, a plant in the Colombian jungle was discovered which eliminates the symptoms described above. This new medicine can be taken in pills. One pill reduces one symptom day, two pills reduce two symptoms days, and accordingly. Research has demonstrated frequent use of this pill does not produce secondary effects or addiction. Would you be willing to pay for this pill if it was available in drugstores? Please remember this survey is conducted only for academic purposes. We are not trying to sell you the medicine, and we do not represent any pharmaceutical company. Now, imagine in the following days you will contract an illness for X days and will experience the following symptoms [ENUMERATE SYMPTOMS OF LAST ARI]. If the price is $Z per pill, how many pills would you be willing to buy to eliminate the symptoms described above? Remember that if you want to eliminate X days you must buy X pills. You will be paying for eliminating the symptoms described, which include medical expenses, doctor visits, lost income and lost leisure time. How many pills of price $Z per pill would you be willing to buy? Before you give your answer please remember that if you decide to pay then your usual budget would be reduced in that amount.

Then the survey asked detailed questions about averting behavior, health status and household characteristics.

b. Survey responses

Respondents described the length, severity, symptoms and losses from the last episode of ARI. Table 1 shows that length of the disease was equally distributed across "more than one day" (33.8%), "more than one week" (35%) and "more than two weeks" (31.3%). Sixty five percent reported the last episode of the ARI was not severe or lightly severe (Table 2), and ten percent noted the episode was very severe. Percentages of symptoms reported are high (Table 3), which may occur because respondents have problems recalling their last episode of ARI, or respiratory diseases in Bogotá are more severe than expected due to high pollution levels. The symptoms experienced in a higher percentage were runny nose (82%) followed by headache (73%) and sore throat (68%).

Table 4 reports losses experienced from the last episode of ARI, and characterizes the intensity of the loss as none, moderate, high and extremely high. Respondents experienced higher losses from disutility (25.7%), less leisure time (18.3%) and diminish capacity to engage in regular activities (13.2%). Monetary losses were moderate as twelve percent reported additional expenses as high or extremely high, eight percent reported expenses in doctors and medicines as high or extremely high and four percent stated income losses were high or extremely high.

The sample was divided in half to evaluate the effects on WTP of defining a concrete mechanism to reduce illness and a credible payment vehicle. Before asking the WTP question describing a new pill that eliminates symptoms without collateral effects, respondents were asked whether they used pills to reduce symptoms. Only 32.6% of respondents use pills to reduce symptoms. This result is low but not surprising since during the four focus groups we encountered a high propensity to use folk remedies to reduce symptoms as a substitute of over the counter medicines.

The average number of symptoms in both samples is 6.8 (Table 5), which far exceeds the number of symptoms reported, 2.2 days, in the Alberini et al. (1996) study for Taiwan. Half of the pill and non-pill sample avoid exposure to air pollution, and eighty percent boil or treat water to reduce the risk of contracting waterborne diseases. Willingness to pay is 49% for respondents answering the pill question, 66% for respondents answering the non-pill question but from the pill sample and 63% for the non-pill sample. Willingness to pay seems to decrease when confronted to a concrete way of reducing the illness and a credible payment vehicle.

c. Econometric Model and Results

The survey defined randomly the length of the disease and the number of days or pills the respondent could “buy”. Assume the demand for reduction in days of the illness episode is given by

(4) $$d = f(p, s, x \mid D)$$

where *p* is price per day of reduction, s is the set of symptoms and other characteristics of the illness, *x* is socioeconomic variables, and $f(p,s,x|D)$ is conditioned on *D* the length of the illness as described in the questionnaire. Let the vector $w = (p,s,x)$.

If respondent says yes, then he will buy at least *k* reduced symptoms at a price *p* per unit. The probability the respondent is willing to pay for *k* reduced days is defined by

(5) *Prob(demand ≥ k) =1-Prob(d<k) = 1 – [(Prob(d = 0)+Prob(d =1) + Prob(d = 2) + ... +Prob(d = k-1)]*

If we let the demand be distributed Poisson, ignoring for the moment the truncation at *D*, then the probability that demand equals d is given by:

(6) $$Prob(d) = \frac{exp(-\lambda)\lambda^d}{d!}$$

where $\lambda = \exp(w\beta)$. Then the probability that a respondent says yes to the question: will you buy *k* days at a price *p*? is given by

(7) $$Prob(respondent\ says\ yes) = 1 - \sum_{d=0}^{k-1} \frac{exp(-\lambda)\lambda^d}{d!}.$$

By the same reasoning as we used for the yes responses, we can write the probability of a no response as

(8) $$Prob(respondent\ says\ no) = 1 - \sum_{d=k}^{D} \frac{exp(-\lambda)\lambda^d}{d!}.$$

Each of the probabilities needs to be normalized by the probability that $d \leq D$, which is given by

(9) $$Prob(d \leq D) = \sum_{d=0}^{D} \frac{exp(-\lambda)\lambda^d}{d!}$$

Given these probabilities, we write the i^{th} contribution to the likelihood function as

(10) $$L(\beta \mid w)_i = \frac{\left(\sum_{d=0}^{k-1} \frac{\exp(-\lambda)\lambda^d}{d!}\right)^{1=Y_1} \left(\sum_{d=k}^{D} \frac{\exp(-\lambda)\lambda^d}{d!}\right)^{Y_i}}{\sum_{d=0}^{D_i} \frac{\exp(-\lambda)\lambda^d}{d!}}$$

Where $Y_i = 1$ when the respondent says yes and 0 when the respondent says no.

The parameter estimates for this model are given in Tables 6-9, where several different versions of the model are presented. Each model was estimated for the pill question but results are not reported. Models were unstable due to the small size of the sample, 196 observations. All the models were estimated in Gauss. The models we present are the Poisson as shown in the equation above. There is little difference in the parameter estimates and even significance between the negative binomial and Poisson. We present relatively simple models although we have estimated more complicated versions. The expected demand is given approximately by

$$Ed = exp(\,\beta_0 + \beta_1 Price + \beta_2 Inc + \beta_3 numsym) + \beta_4 Age + \beta_4 Bad\ Health\,(or\ Bad\ Episode)\,)$$

.

where *Price* is the price per day, *Inc* is the household income per month, and then the model includes several other variables relating to the episode. The variable *numsym* is the number of symptoms enumerated for the episode, *Age* is the age in years of the respondent, and then the other variable is either *Bad Health* or *Bad Episode*, each a dummy variable signifying that the individual believes s/he has bad health or that the ARI was especially bad, based on the description of the episode. We expect that if the ARI is more acute, the demand for healthy days will increase, but we have no hypothesis for *Bad Health.*

The parameter estimates are typically significant with the appropriate sign. Price has a significant negative impact, income a positive effect and age has a negative effect. The age effect can be attributed to expectations about health, or perhaps to the present discounted losses. Measures of the severity of the episode increase the demand for 'healthy days'. *Bad Episode*, a dummy variable created from respondents' assessments of a series of questions about the illness, represents dichotomous measures of how bad the episode was. The variable n*usym* is a count of the number of symptoms that the respondents recognized in their last illness. The measures used to describe the episode demonstrate that the demand for 'healthy' days increases when the episode is worse. However, this does not seem to be related to the health status of an individual. An index of health taking the value one when the individual has bad health (self-assessed), *Bad Health*, is not significantly different from zero, and does not change any of the other parameters in any significant way when included in the model.

The two-day model works significantly better than the five day model, at least for the variables measuring severity. Several different specifications failed to reveal a significant effect from any of the severity variables in the five-day model.

c. *Welfare measures*.

The welfare comes from the demand for healthy days, which is the demand function we have estimated. Suppose that an individual is faced with a five-day bout of ARI. The demand for days of reduced ARI goes from zero to five. The WTP for all give days is the total area under the demand curve, from zero to five:

(11) $$WTP = \int_0^5 p(days)ddays$$

where *p(days)* is the inverse demand curve for healthy days. When the expected demand is given by

(12) $$Ed = exp(\beta^* + \beta_1 Price).$$

where $\beta^* = \beta_0 + \beta_2 Inc + \beta_3(severity, numsym) + \beta_4 Days = 2$ or sometimes other exogenous variables. The essence is that β^* includes all of the exogenous variables besides the price. Given this expected demand, the marginal willingness to pay function or the inverse demand is

(13) $$p(Ed) = -\beta_1^{-1} ln(b^* / Ed)$$

where $b^* = exp(\beta^*) = exp(\beta^* + \beta_1 0) = Ed(0)$. That is, b* is the demand for healthy days when the price is zero.

Suppose that we want to find the willingness to pay for x days of reduced ARI. Integrating gives

(14) $$WTP = \int_0^x p(days)ddays = -\beta_1^{-1}\int_0^x \ln(b^*/Ed)dEd^e = -\beta^{-1}[x\ln(b^*/x) + x]$$

This welfare measure can be calculated with the coefficients and other information from the estimated Poisson model.

Willingness to pay for reductions in one symptom day is calculated for the two-day model and the bad episode version (Table 10). Willingness to pay is evaluated at 2.2 number of symptoms to compare results with Alberini et al. (1996). Willingness to pay when the individual experience a bad episode is $25.7, while when the episode is mild, willingness to pay is $21.8. Results are similar to Alberini et al, which are $20.5 for reductions per day of the episode in a one-day episode of a cold and $30.7 when the episode is not a cold. Willingness to pay does not seem to be higher in Taiwan where GDP is higher than in Colombia.

Conclusion

We have described a contingent valuation study of acute respiratory illness in Bogotá, Colombia. The study estimates the demand for 'healthy days', conditional on two illness episodes of two days or five days. The CV responses appear systematic, in the sense that demand increases with income, the severity of the illness, and the quantity demanded decreases with price.

The difficulty with the model is that the demand has to be carefully specified. In particular, we have not yet developed a model that fits the length of the episode precisely. The precise model would ensure that the marginal value of 'healthy days' equals zero when the marginal value schedule equals the length of the episode. We have not yet imposed the constraint that the demand be less than the length of the episode.

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Table 1. Length Last Episode ARI

Length	Percent
More than one day	33.8
More than a week	35.0
More than two weeks	31.3
Total	100.0

Table 2. Severity Last Episode ARI

Severity	Percent
Not severe	29.1
Lightly severe	36.2
Severe	24.8
Very severe	9.9
Total	100.0

Table 3. Symptoms Last Episode ARI

Symptom	Percent
Runny nose	82.8
Sore throat	72.8
Headache	68.4
Dry throat	67.6
Dry cough	57.2
Aching muscles	55.4
Fever	49.4
Eye irritation	45.5
Wheezing days	37.2
Cough with phlegm	34.1
Chest discomfort	26.8
Tightness of chest	24.8
Shortness of breath	24.6
Other symptoms	7.8
Rash	5.8

Table 4. Losses Last Episode ARI

Losses	None	Moderate	High	Extremely High
Expenses doctors and medicines	52.8	38.8	6.9	1.4
Time spent doctors visits	67.2	24.5	7.0	1.3
Income loss	82.7	13.2	3.3	0.8
Utility losses	27.3	47.1	20.0	5.7
Losses leisure time	45.4	36.2	15.7	2.6
Diminish capacity regular activities	57.2	29.5	11.3	1.9
Losses for other familiy members	65.4	25.3	8.0	1.3
Additional expenses	28.0	59.6	11.4	1.0
Other losses	73.5	25.3	1.0	0.2

Table 5. Summary Statistics for the Pill and Non-Pill Survey

	Pill Question			Non-Pill Question		
Variable	Obs	Mean	Std. Dev.	Obs	Mean	Std. Dev.
Number of symptoms	601	6.81	3.40	599	6.88	3.36
Willingness to buy pill	196	0.49	-	-	-	-
WTP for reductions symptom days	405	0.66	-	599	0.63	-
Avoid exposure to pollution	600	0.54	-	599	0.51	-
Age	600	39.88	16.26	597	41.20	16.11
Male respondent	601	0.41	-	599	0.42	-
Boil water	601	0.88	-	599	0.84	-
Income in dollars [a]	587	402.62	301.79	586	404.09	300.72

[a] Currency rate $2,000 pesos for 1 dollar

Table 6: Poisson Model for Two Days' Illness: Demand for Reduction in Morbidity

Number of Symptoms and Bad Episode Version

Variable	Parameter Estimates	Standard Error	Estimate/St. Error
Constant	0.6350	0.1646	3.86
Price	-0.0678	0.0105	6.49
Income	0.0003	0.0001	2.68
Num Sym	0.0415	0.014	2.95
Age	-0.0092	0.0029	3.20
Bad Episode	0.2674	0.14	1.86

Table 7: Poisson Model for Five Days' Illness: Demand for Reduction in Morbidity

Number of Symptoms and Bad Episode Version

Variable	Parameter Estimates	Standard Error	Estimate/St. Error
Constant	1.0922	0.2525	4.33

Price	-0.0974	0.0139	7.03
Income	0.0007	0.0002	4.06
Num Sym	0.0131	0.0222	0.59
Age	-0.0124	0.0041	3.03
Bad Episode	0.0996	0.1972	0.505

Table 8: Poisson Model for Two Days' Illness: Demand for Reduction in Morbidity

Number of Symptoms and Bad Health Version

Variable	Parameter Estimates	Standard Error	Estimate/St. Error
Constant	0.5392	0.1624	3.65
Price	-0.0661	0.0104	6.38
Income	0.0003	0.0001	2.72
Num Sym	0.0511	0.0131	3.88
Age	-0.0092	0.0029	3.17
Bad Health	-0.0941	0.3598	0.79

Table 9: Poisson Model for Five Days' Illness: Demand for Reduction in Morbidity

Number of Symptoms and Bad Health Version

Variable	Parameter Estimates	Standard Error	Estimate/St. Error
Constant	1.0694	0.2540	4.21
Price	-0.0972	0.0138	7.02
Income	0.0007	0.0002	4.01
Num Sym	0.0181	0.0214	0.85
Age	-0.0122	0.0042	2.93
Bad Health	-0.2157	0.4881	0.442

Table 10: WTP for One Day

	WTP
	1 day
Bad Episode	$25.70
Mild Episode	21.80