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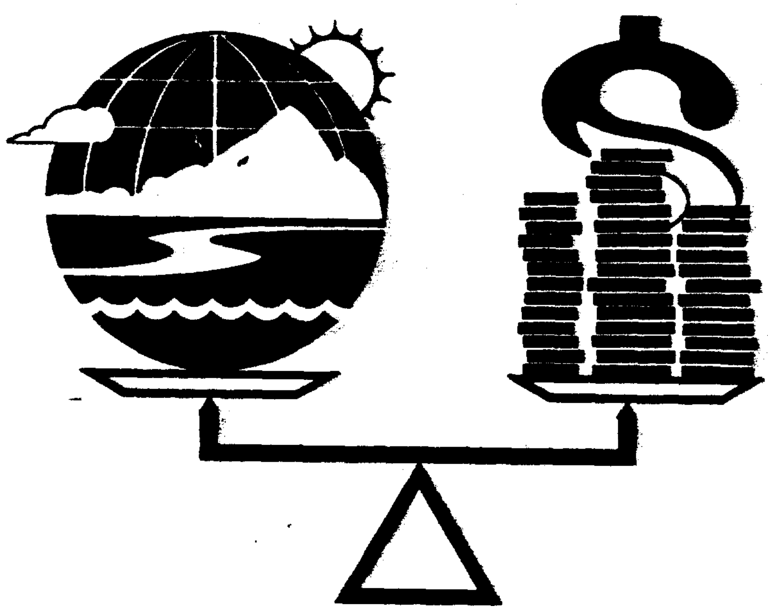
Addendum to Oxidants and Asthmatics in Los Angeles:

A Benefits Analysis



Alan

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

June 25, 1986

MEMORANDUM

SUBJECT: Valuing Reductions in, Morbidity

FROM: Ann Fisher Ann Fisher

To: Addressees

Sometime ago, you received a copy of the Rowe and Chestnut report, Oxidants and Asthmatics in Los Angeles: A Benefits Analysis. Bob Rowe and Laurie Chestnut did some additional work with the unique data set they had collected. The extra work was mostly in response to comments on the above report.

Attached are the findings from this new effort. I hope you will find them to be useful. Currently, the approach for asthmatics is being modified to examine the benefits to heart disease patients of reducing their symptoms, possibly caused by carbon monoxide exposure. If you have any questions or comments, please call me at 202/382-5500.

Attachments

EPA-230-09-86-017

ADDENDUM TO:

OXIDANTS AND ASTHMATICS IN LOS ANGELES: A BENEFITS ANALYSIS

Robert D. Rowe
Lauraine G. Chestnut

Energy and Resource Consultants, Inc.
P.O. Drawer O
Boulder, CO 80306
(303) 449-5515

Prepared for:

Ann Fisher
Economic Analysis Division
U.S. Environmental Protection Agency

and

Sylvia Champonier
Research Division
California Air Resources Board

March, 1986

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ACKNOWLEDGEMENTS

We thank the EPA technical contract manager, Ann Fisher, for technical suggestions, support and patience. We also thank Don Valdman of the Department of Economics at the Univeristy of Colorado, Doug Shaw and Doug Orr, all of whom assisted on the design and /or implementation of the additional econometric analyses.

Work on the original phase of this research was co-funded by the U.S. EPA and by the California Air Resources Board Economics Studies Section. The research effort was conducted in cooperation with the UCLA School of Medicine; Dr. Henry Gong, Principal Investigator. The draft of this Addendum was completed in October of 1985 and finalized in March of 1986.

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1.0 INTRODUCTION

1.1 OBJECTIVES

This report serves as an addendum to the U.S. EPA report Oxidants And Asthmatics In Los Angeles: A Benafits Analysis (EPA-230-07-85-010) by R. D. Rowe and L. G. Chestnut (1985). The paper reports on additional statistical analyses, corrections and other work completed after the above report was printed.

This research effort examines changes in behavior, expenditures and willingness to pay as related to changes in asthma severity and air pollution. It is based upon information obtained from a panel of 82 asthmatics in Glendora, California, in the fall of 1983. The panel of asthmatics represents individuals in a population expected to be sensitive to ambient oxidant levels. Additional summary information on the methods used and the initial statistical findings are found in the Executive Summary covering both the earlier report and this addendum. The Executive Summary is available through the U. S. EPA. A summary of variable names used throughout this analysis is found in Table 1.

The specific analyses covered in this addendum include nine tasks identified below. Section 2.0 reports the detailed approach and findings for each task.

Task 1. Alternative asthma severity measures were obtained and used to re-examine selected analyses.

Task 2. A logit analysis was used to estimate the relationship between the perception that air pollution might adversely affect asthma on a given day and actual oxidant levels for that day. In the initial analysis, this relationship was estimated with ordinary least squares.

Task 3. Refinements of the daily diary behavior model were made to account for possible simultaneity between the hours spent in an activity and expectations of a bad asthma day with air pollution as a possible cause.

Task 4. The specification of the tax bid regression model was linked to alternative utility functions and the variable GDAY was converted from a continuous variable to a categorical variable. Errors in the original calculations are reported and corrected.

Task 5. The medical cost and tax bid analyses and consistency checks were empirically reexamined by using consistent measures of asthma severity in each analysis and through examination of additional data. The consistency check is important due to its use in assessing the credibility of the tax bids and in estimating the WTP/COI ratio.

Task 6. The average willingness to pay for a reduction in bad asthma days was estimated separately for those individuals who changed activities in response to concern about asthma symptoms and for those who did not.

Task 7. Additional theoretical discussion is provided on the validity of the consistency check procedure, especially as it vas used to bound the WTP/COI ratio.

Task 8. The plausibility of a value-of-information study is considered based upon available scientific and economic information on asthma-related behaviors and changes in asthma due to changes in behavior.

Task 9. A data set and complete documentation have been provided and are available from the U.S. EPA. This task is not discussed in this report.

1.2 SUMMARY OF PINDINGS

Task 1. Revised severity measures obtained from the UCLA School of Medicine included pulmonary function measures, an alternative severity index, and a medicine use index. These measures generally performed less well in the statistical analyses than the original severity measure. Possible explanations for this result are discussed. No findings from the initial report are modified as a result of this effort.

Task 2. The logit analysis confirmed the statistical significance of the relationship between concerns that air pollution might affect asthma on a given day and actual air quality levels as measured by ambient levels of ozone. The predicted percentage of respondents expecting air pollution to adversely affect their asthma did not change significantly from the ordinary least squares results presented in the original report.

Task 3. The results of the estimation of the simultaneous model did not particularly support the hypothesis of simultaneity between hours in a given activity and expectations of a bad asthma day with concern about air pollution. The analysis focused on hours in active outdoor activities, which were expected to be most sensitive to concern about air pollution affecting asthma. The coefficients estimated vith two stage least squares generally had the expected signs but their statistical significance was low. In addition to modeling the potential simultaneity, the specification of the activities equation was modified in several ways relative to the previous analysis. When estimated as a single independent equation, the new activities equation shoved somewhat stronger evidence of mitigating behavior than was previously found, but the percentage of day to day variation in activities explained by the model remained low.

Task 4. Additional tax bid specifications defined consistent with consumer utility theory and with alternative methods for incorporating asthma severity generally performed less well than the original specification. However, some problems in these revised specifications could be attributed to potential multicollinearity and to potential limitations in the nonlinear estimation package used. A refined version of the tax bid specification from the original report was defined that could be related to utility theory and was found to yield similiar results to those presented in the original report.

A significant error vas detected in the earlier analysis. The per person and sample average number of bad asthma days per year were previously understated by nearly one-half. Correcting this error reduced the estimated average and marginal value of reducing bad asthma days by about one-half. Revised table are provided.

Task 5. Additional empirical evidence was found to substantiate the WTP/COI ratio calculations and consistency check procedure. In one analysis, the use of a comparable severity measure and functional form specification for the variable medical cost and tax bid equations found the elasticity of the tax bid with respect to bad asthma days to be 1.83 times the elasticity of MEDVHH with respect to change in bad asthma days.

Task 6. The average willingness to pay (tax bid) by the individuals who expressed some concern about air pollution affecting asthma and appeared to take some mitigating action was compared to that of those who expressed concern about air pollution but did not appear to take mitigating action. The two means were not statistically different.

Task 7. In the analysis using the ranking results, it was assumed that willingness to pay for each of the individual benefits would follow the same order as the rankings. This interpretation of the rankings presumes that the pain and suffering being considered, for example, is that which remains after medical treatment is undertaken. Since medical treatment seldom alleviates all discomfort and need for activity changes, a reduction in asthma symptoms could mean a reduction in discomfort, reduced medical expenditures, and reduced need for lifestyle adjustments. The analysis presumes that the respondents were considering the net effects of asthma that occur after optimal readjustment of medical treatment has been undertaken.

Task 8. A value of information study was found to be impossible with the available data. The data on how asthmatics adjust their behavior in response to perceptions and expectations of air pollution and its effects on their asthma are, at best, weak (see Task 3). Even more important, no information is currently available to relate changes in characteristics of behavior, such as type and location of activity and the resulting change in air pollution exposure, to changes in asthma symptoms.

Table 1

Definition of Variables

Name	Definition	Source
AQ1	Maximum hourly ozone reading (pphm)	CARB
AQ2	Daily Average Ozone (pphm)	CARB
A2	Concerned that illness Might affect asthma today = 1, 0 othervise	Diary
A3	Concerned that tension, stress might affect asthma today = 1,0 otherwise	Diary
A4	Concerned that exercise might affect asthma today = 1, 0 otherwise	Diary
AS	Concerned that air pollution might affect asthma today = 1, 0 othervise	Diary
A6	Concerned that allergies might affect asthma today = 1, 0 otherwise	Diary
A7	Concerned that weather might affect asthma today . 1, 0 otherwise	Diary
A8	Concerned that a bad day yesterday might affect asthma today = 1, 0 othervise	Diary
EXP4	Expected a bad asthma day with exercise as a concern	Diary
EXP5	Expected a bad asthma day with air pollution as a concern	Diary
EXP6	Expected a bad asthma day with allergies as a concern	Diary
EXP7	Expected a bad asthma day with weather as a concern	Diary
TEMP	Daily temperature (F.) at 1 p.m. at El Monte airport	UCLA
HUMID	Daily relative humidity at 1 p.m. at El Monte airport	UCLA
PRECIP	Daily precipitation (inches) at Glendora West Fire Control	UCLA
AGN1 to AGN10	Ten daily allergen levels (trees, shrubs, molds, etc.)	UCLA
SYMPTOM	Summary of daily asthma symptoms reported by the respondent over the entire UCLA study period; used as an indicator of severity	UCLA
HOA	Daily hours in outdoor active activities	UCLA
WEEKEND	1 if a non-work day for the individual, 0 other-vise	UCLA
SEV	Severity of asthma based upon respondents reported monthly frequency times intensity (reported on UCLA instruments) summed over the calendar year	UCLA
INC	Income	General
AGE	Age	UCLA
SEX	Sex; 0 = male, 1 = female	UCLA

Table 1 (continued)

MEDVHH	Variable medical costs/year paid by the household for this asthmatic (doctors, hospitals, medicines, etc.)	General
RTFM	Respondent's share of total household asthma (0-100%)	General
GDAY	Highest day rating on UCLA scale still considered to be a good day	Diary and General
NBAD	Number of bad days/year - number of days where the day rating is greater than GDAY	UCLA
NBADR	1/2 NBAD = Number of days reduced in WTP scenarios	--
ADULT	Is the respondent an adult (16+ years) l = yes, 0 = no	General
TAXBID	WTP response to reduce bad asthma days in half through a tax vehicle	General
NOBS	Number of observatories used in the analysis	--

Note: The prefix D is used to denote deviations from the mean, P to denote percentage of the mean and LN to denote the natural log of the variable.

UCLA = UCLA Survey Instruments
Diary = ERC Daily Diary Survey Instrument
General = ERC General Questionnaire
CARB = California Air Resources Board

2.0 DETAILED METHODS AND FINDINGS FOR TASKS 1 THROUGH 8

2.1 TASK 1 - ALTERNATIVE SEVERITY MEASURES

The initial asthma severity measure used was defined as:

$$SEV = \sum_{i=1}^{12} I_i * F_i$$

where I_i and F_i are the respondents' perceived intensity and frequency of asthma symptoms in each month using the UCLA 1-to-7 scale. Because this measure was defined in a somewhat ad hoc manner by the researchers, and based upon the subjects' overall assessment data rather than daily data or other objective measures, it was felt that other measures may better represent severity for use in the economic analysis.

Two alternative severity measures were developed by the UCLA research team and examined in the economic analysis.

1. SYMPTOM. This measure was an annual average of the respondent's daily severity rating using the l-to-7 scale. A nighttime severity rating was also available, but the simple correlation between the two measures was so high as to make the measures indistinguishable for our analysis.

2. PEAKFLOW. This measure was the annual average of daily (daytime) pulmonary peak flow readings for adults only. A nighttime measure was available, but was very highly correlated with the daytime measure.

A third alternative severity measure based upon medication use was also obtained, but was not used in the analysis as medication use and variable household medical expenditures for asthma are, by definition, highly correlated. In addition, this measure was only available for adults.

The original and revised versions of the variable medical cost regression model, which relate variable medical costs to the household for asthma to severity and socioeconomic characteristics, were reexamined with both of the alternative severity measures. In addition to using the, variables representing the measures as defined above, several alternative model specifications were considered including power functions, logs and exponential. In no case did the statistical significance of these alternative measures come close to that of the SEV measure and in many cases the revised severity measures were not significant at even a 10 percent (one-tailed) test level.

The failure of the alternative severity measures in the variable medical cost equations leads to the question: is SEV a better severity measure for the economic behavior analysis or were the previous results just fortuitous? It is possible that SEV is a better measure for this analysis, which can be shown by comparing SEV to PEAKFLOW and SYMPTOMS.

The principal difference between SEV and PEAKFLOW is that SEV is based upon the respondent's perceptions concerning overall severity and intensity of all of their asthma symptoms, not just pulmonary function. Because the respondents will take actions in terms of medical expenditures and will base their displeasure with (and willingness to pay to reduce) asthma symptoms upon their perceptions of severity for all symptoms, it is not surprising that the one dimensional PEAKFLOW measure performed less well in the analyses.

The principal differences between SEV and SYMPTOMS is that SEV better accounts for the possible nonlinearity in the progression of symptom severity in the UCLA 7 point severity scale, particularly at the upper end of the scale, and SEV relies even more heavily upon respondents' perceptions of their asthma severity.

Table 2 gives values for SEV and SYMPTOMS calculated for several alternative hypothetical cases of asthma symptom intensity and frequency to illustrate the differences between these two measures. SEV has been normalized by dividing by 12 so the two measures have the same base level of 1 for the no symptoms

TABLE 2

Comparison of the SEV and SYMPTOMS Severity Measures for Hypothetical Examples

CASE	Likely Value for Severity Measures: SYMPTOMS*	SEV**
1. No symptoms at and time (rating of 1 on each day)	1 [(1*366)/366]	1 [(1*1*12)/12]
2. Very mild symptoms (2) half of the time. No symptoms otherwise.	1.5 [(2*183+1*183)/366]	4 [(2*2*12)/12]
3. One month of very severe symptoms (7) every day. No symptoms (1) all other days.	1.5 [(7*30.5+335.5*1)/366]	5 [7*7*1+1*1*11)/12]
4 Two months of very severe symptoms (7) every day. No symptoms (1) all other days.	2 [(7*61+1*305)/366]	9 [7*7*2+1*1*10)/12]
5. Very Severe Symptoms (7) infrequently (1-2/month) every month, otherwise no symptoms.	1.3 [(7*20+1*346)/366]	14 [7*2*12)/12]
6. Very Severe Symptoms (7) occasionally (4/month) every month, otherwise no symptoms.	1.8 [(7*48+1*318)/366]	24.5 [(7*3.5*12)/12]

* Defined as the annual average of daily readings

** Defined as the average over 12 months of the perceived monthly severity (l-7) times frequency (l-7). Perceived frequency is often confounded by perceived intensity. The SEV measure used in the statistical analysis is not divided by 12 as in this table.

case. The measures differ most dramatically when the individual has highly variable asthma symptoms. The cases are ordered to result in increasing values using the SEV measure. It is readily apparent that the values for SYMPTOMS do not increase as one proceeds through the hypothetical cases. Comparing cases 2 and 3 with 5 highlight the important differences. If the individual is more dramatically affected by, and responds to, infrequent but very severe symptoms than by continued periodic very mild symptoms, the SEV measure is more appropriate. Because major medical expenses such as non-routine doctor visits and hospital visits are more likely related to very severe symptoms than to continued mild symptoms, the relative performance of SEV versus SYMPTOMS in the medical cost equations seem appropriate.

To capture the possible nonlinearity of the 7 point severity scale, the SYMPTOMS measure could be recalculated as the average of the daily severity measure taken to a power, such as squared, with alternative power transformations examined and then averaged across the year.

Alternative tax bid models, relating the willingness to pay (WTP) through a tax vehicle to reduce bad asthma days, were examined with the revised severity measures defined above as well as with the SEV measure rather than NBADR measure originally used. The revised severity measures were consistently insignificant in these tax bid WTP models.

The failure of the alternative severity measures in the tax bid regressions is, we feel, for the same reason that SEV was statistically weaker than NBADR in these models, as indicated in the original report. The tax bid questions were framed in terms of willingness to pay to reduce bad asthma days, as defined by the respondent, not to reduce average symptoms or pulmonary function. The analytical results support the contention that respondents bid to reduce bad asthma days. Due to the 10V correlation between the other severity measures and NBAD (number of bad asthma days), the other severity measures were veak proxies for NBADR in the tax bid regression model.

2.2 TAKS 2 - PERCEPTIONS OF AMBIENT AIR POLLUTION

The perception equation originally reported in Table 4.3 was rerun as a logit specification to correctly treat the dichotomous dependent variable. This estimation examines the factors that influence whether the individual indicated concern about air pollution affecting his or her asthma that day. The statistical package being used was unable to provide results for the entire sample (1779 observations), but the results obtained with the reduced sample (866 observations) are very similar to the results obtained using ordinary least squares estimation. The reduced sample includes all the days for those individuals who indicated concern about air pollution on at least one day during the study period.

The results of the logit estimation with the reduced sample are reported in' Table 3. The same variables were statistically significant as in the OLS estimation: maximum daily ozone levels (AQ1) and SEX. The coefficients in the logit estimation are not directly comparable to OLS coefficients. In order to compare the magnitudes of the ozone coefficients, elasticities were calculated. These are reported in Table 4 and show that the estimated effect of daily ozone levels on concern about air pollution affecting asthma is almost identical across the OLS and logit specifications.

2.3 TASK3 - ANALYSIS OF MITIGATING BEHAVIOR

2.3.1 Background

In the previous analysis, hours in each category were regressed separately on whether the individual expected a bad asthma day and was concerned that air pollution might affect his or her asthma (EXPECT) and on other characteristics of the individual. The hypothesis was that physically active outdoor activities would be especially sensitive to concern about air pollution (since exposure is higher outdoors and the individual is more likely to be affected by pollution when physically active), but the results only partially supported this hypothesis. The estimated coefficients on EXPECT were generally negative as expected for the outdoor or "active" activities, but were statistically

Table 3

Results of the Logit Estimation of the Perceptions Equation for the Reduced Sanple*

Dependent Variable = A5 (Respondent felt air pollution might affect asthma 'hat day, mean = "318)

Explanatory Variable	Variable Mean	Logit coefficients	Previous OLS Coefficients
Constant		-.572 (1.17)	.358 (3.7)
AQ1	8.3	.88E-1 (5.61)	.18E-1 (5.8)
SEV	172.4	-.11 E-2 (.83)	-.18 E-3 (.69)
INC	32125	-.34 E-5 (.74)	-.82 E-6 (.77)
AGE	38.5	-.49 E-2 (.83)	-.89 E-3 (.78)
SEX	.52	-.93 (5.48)	-*191 (5.65)
R^2			.086**
F			16.2
Likelihood Ratio Test		76.38	
NOBS	866	866	866

* t - statistics given in parentheses

** The R^2's previously reported vere in error. The multiple R was incorrectly reported. The correct R^2's for previous Table 4.3 are:

Equation:	1	2	3	4
R^2:	.040	.043	.086	.088

Table 4

Comparison of Logit and OLS Results from
Perceptions Equation for the Reduced Sample

	Logit	OLS
Elasticity Formula*	B[A5(1=A5)*Q1/A5]	B*AQ1/A5
Elasticity at the Variable Means	.50%	.47%
Elasticity at AQ1=12pphm (NAAQS Standard)	.72%	.68%
Approximate Percentage Change in A5 when AQ1 increased from mean to 12 pphm**	28%	27%
Predicted Percent of Sample Concerned About Air Pollution at AQ1+12	41%	40%

* Elasticity is the percentage change in the dependent variable (A5 in this case) that is associated with a 1% change in an independent variable (AQ1 in this case).

** Using the mid point of the elasticities at mean and 12 pphm.

significant at the 10 percent (two-tailed) level only for chores, both indoor and outdoor.

This analysis extends the previous work by considering the possibility of simultaneity between hours spent in a given activity category and expectations about asthma symptoms. For example, while concerns about air pollution may lead to mitigation in terms of fewer hours spent outdoors, it is also possible that when more hours outdoors are planned an asthmatic might be more concerned about air pollution affecting his or her asthma and might be more likely to expect a bad asthma day. It was therefore hypothesized that the individual would spend less time in active outdoor activities on days when he or she expected a bad asthma day and was concerned about air pollution. It was also hypothesized that on days when more active outdoor activities were planned, the individual might be more likely to expect a bad asthma day related to air pollution. To the extent that this simultaneity exists, it could have biased the coefficients on EXPECT toward zero in the previous analysis.

All physically active outdoor activities were grouped together to simplify the analysis and to focus on substitution from active outdoor activities to indoor or "inactive" activities. This active outdoor hours variable was defined as the sum of hours in outdoor chores, active outdoor leisure, and work hours if the individual had an active outdoor job.

2.3.2 The Model

The following general model was hypothesized. A person with asthma can be expected to chose the amount of time spent in outdoor active activities for the day as a function of:

1. Expectations about asthma severity including concern about specific factors that might affect asthma and that could be related to outdoor active activities, such as air pollution, exercise, weather, and pollens.
2. Weather that day.
3. Opportunities and previous commitments, e.g. weekends may differ from weekdays.

4. How the person feels that day, e.g. illness and tension.

A person's expectations about having a bad asthma day related to air pollution can be expected to be a function of:

1. Hours planned in outdoor active activities that day.
2. Expectations of a bad asthma day as it relates to weather, exercise or pollens.
3. Air pollution levels.
4. Individual characteristics such as sex, age, income, and asthma severity.
5. Asthma symptoms the previous day.
6. Other possible aggravating factors such as illness and tension.

2.3.3 Estimation of the Model

The nature of the data obtained from the ERC daily diary have to be considered in the estimation of this model. There are 1779 daily observations, 64 individuals on about 28 days each, over the period October 12, 1983, to November 29, 1983. Differences between individuals are taken into account by defining outdoor active hours as the deviation of that day's hours from the individual's mean over the four week diary period, or as the percentage of the individual's mean hours. This should help to isolate changes in schedules that might be considered mitigating behavior.

One limitation of the data is that individuals might make adjustments in their schedules throughout the day. The diary asked how many hours they actually spent in each activity category and about their expectations concerning asthma at the beginning of the day. We are therefore assuming that something can be said about how the day was spent as a function of expectations at the beginning of the day. The data cannot be used to determine if schedules are being adjusted throughout the day in response to changing expectations. A finding of no relationship between expectations and schedules in these data cannot, therefore, be interpreted as indicating that no mitigating behavior occurs.

Data on daily weather and allergens in Glendora were added to the data previously compiled. Variable names are as defined in Table 1. New variables are:

A2 = Concerned that illness might affect asthma today = 1, 0 otherwise
A3 = Concerned that tension or stress might affect asthma today = 1, 0 otherwise
A4 = Concerned that exercise might affect asthma today = 1, 0 otherwise
A5 = Concerned that air pollution might affect asthma today = 1, 0 otherwise
A6 = Concerned that allergies might affect asthma today = 1, 0 otherwise
A7 = Concerned that weather might affect asthma today = 1, 0 otherwise
A8 = Concerned that a bad day yesterday might affect asthma today = 1, 0 otherwise
EXP4 = Expected a bad asthma day with exercise as a concern
EXP5 = Expected a bad asthma day with ‘air pollution as a concern
EXP6 = Expected a bad asthma day with allergies as a concern
EXP7 = Expected a bad asthma day with weather as a concern
TEMP = Daily temperature (F.) at 1 p.m. at El Monte airport
HUMID = Daily relative humidity at 1 p.m. at El Monte airport
PRECIP = Daily precipitation (inches) at Glendora West Fire Control
AGN1 to AGN10 = Ten daily allergen levels (trees, shrubs, molds, etc.)
SYMPTOM = Summary of daily asthma symptoms reported by the respondent over the entire UCLA study period; used as an indicator of severity
ACTJOB = 1 if individual has an active job (either indoor or outdoor), 0 otherwise
HOA = Daily hours in outdoor-active activities
WEEKEND = 1 if a non-work day for the individual, 0 otherwise

The prefix D is used to denote deviations from the mean, P will be used to denote percentage of the mean, and LN will be used to denote the natural log of the variable.

The following endogenous and exogenous variables were included in the estimation:

endogenous: HOA, EXP4, EXP5, EXP6, EXP7

exogenous: AQ1, A2, A3, A8, TEMP, HUMID, PRECIP, AGN1, AGN2, AGN3, AGN4, AGN5, AGN6, AGN7, AGN8, AGN9, AGN10, WEEKEND, SYMPTOM, INC, AGE, SEX, ACTJOB

Any of the endogenous expectations variables could affect the amount of time spent in outdoor active activities and could in turn be affected by the amount of time planned in outdoor active activities. Since respondents seldom checked only air pollution as a factor that they were concerned might affect their asthma that day, it was important to include other factors in the model to determine the independent importance of concerns about air pollution, if possible. In general, the correlations among these expectations variables were between .2 and .4. Concern about illness, stress, and a bad asthma day yesterday were treated as exogenous since these concerns were believed to be less likely to be a function of the amount of time planned in outdoor active activities.

The following system of five equations was hypothesized based on the model and the available data:

Eq.	Dep. Var.	Independent Variables
1	HOA	EXP4, EXP5, EXP6, EXP7, WEEKEND, A2, A3, A8, PRECIP, TEMP
2	EXP5	HOA, EXP4, EXP6, EXP7, INC, SEX, AGE, SEV, A2, A3, A8, AQ1
3	EXP4	HOA, EXP5, EXP6, EXP7, INC, SEX, AGE, SEV, A2, A3, A8, WEEKEND, ACTJOB, PRECIP
4	EXP6	HOA, EXP4, EXP5, EXP7, INC, SEX, AGE, SEV, A2, A3, A8, AGN1, AGN2, AGN3, AGN4, AGN5, AGN6, AGN7, AGN8, AGN9, AGN10
5	EXP7	HOA, EXP4, EXP5, EXP6, INC, SEX, AGE, SEV, A2, A3, A8, HUMID, TMEP

Equations (1) and (2) were the ones of primary interest and were therefore the only ones estimated for this analysis.

An effort was made to add particulate pollution levels to the data set because, in addition to ozone, particulate have been found to be related to asthma symptoms. However, daily particulate levels were available for a station near Glendora only through October 31. The error in the analysis from omitting particulate and using changes in ozone as a measure of changes in both pollutants was, however, likely to be small as the correlation between ozone (AQ1) and particulate for the period for which data were available was .8.

Two different functional forms were used to estimate equation (1). Both of these forms control for differences between people by adjusting their daily activities by the mean for that individual. One form was deviations from the means for the activities variable:

$$DHOA = (HOA_{ti} - \overline{HOA}_i) = a + b_1 EXP4_{ti} + b_2 EXP5_{ti} + b_3 EXP6_{ti} + b_4 EXP7_{ti} + b_5 WEEKEND_{ti} + b_6 A2_{ti} + b_7 A3_{ti} + b_8 A8_{ti} + b_9 PRECIP_t + b_{10} TEMP_t$$

where t = days and i = individuals

The other functional form used the natural logs of the percentage of the mean value for each day for the activities variable. This is comparable to the one that was used in the previous analysis.

$$LN(PHOA) = LN(HOA_{ti}/\overline{HOA}_i) = a + b_1 EXP4_{ti} + b_2 EXP5_{ti} + b_3 EXP6_{ti} + b_4 EXP7_{ti} + b_5 \cdot WEEKEND_{ti} + b_6 A2_{ti} + b_7 A3_{ti} + b_8 A8_{ti} + b_9 PRECIP_t + b_{10} \cdot TEMP_t$$

The log form assumes a multiplicative relationship among the variables, implying, for example, that a change in hours as a function of a change in concern about air pollution will be a function of the other variables as well, while the deviations form assumes an additive relationship.

In addition to the incorporation of simultaneity, the specification of Equation (1) differs from that used previously in the following ways:

1. The activities variable is the sum of outdoor chores, active outdoor leisure, and active outdoor employment. These were the categories expected to be most sensitive to concern about air pollution. Summing them simplifies the analysis and implies that the day can be meaningfully split into time in outdoor active activities and time in all other types of activities. Previously, each activity category was considered separately.

2. Other expectations variables and concerns variables are included in addition to air pollution. Since air pollution was seldom marked as a concern without also marking other concerns, it seemed preferable to include all of the concerns in the estimation in order to avoid falsely attributing an effect to concern about air pollution. Multicollinearity may, however, make it difficult to confidently separate the effect of the different concerns.

3. Characteristics of individuals were excluded from the activities equation (Equation 1) on the assumption that using deviations from the mean was already adjusting for differences between individuals. Individual characteristics were included in the expectations equation (Equation 2).

The model was estimated for the full sample as well as for the reduced sample of individuals who on at least one day marked air pollution as a factor they were concerned might affect their asthma that day. Half of the individuals did not ever mark air pollution as a concern to them during the diary period. These people cannot be expected to consciously change their behavior in order to reduce their exposure to air pollution. Including them in the sample might obscure any mitigating behavior the other half of the individuals might be undertaking. Also, there is some medical evidence to suggest that some asthmatics may be sensitive to air pollution while others are not. Results found for the reduced sample are therefore not necessarily applicable to all asthmatics. It is also possible that pollution levels during the diary period were not high enough to cause concern for some people (see original report).

It should be noted that this approach tests for evidence of conscious mitigating behavior. It is also possible that individuals adjust the amount of time they spend in outdoor active activities without thinking air pollution is bothering them. They may simply feel worse and then change their behavior. Evidence of a conscious link between concern about air pollution and behavior would be stronger support of the hypothesis that mitigating and/or responsive behavior occurs, so this is the focus of the analysis.

2.3.4 Results of the Analysis

The estimation results for the mitigation model Equations (1) and (2) using the deviations from the mean approach and the full sample are reported in Table 5. The only variable with a statistically significant coefficient at the 95 percent level (two-tailed) in Equation 1 is WEEKEND. The WEEKEND coefficient indicates that individuals spend more time in outdoor active activities on non-work days, as would be expected. The coefficient for EXP5 has the expected sign, but is statistically insignificant. The overall explanatory power of the equation is weak. It should be noted that the t-ratios and the R-squared estimates are not entirely reliable in a two stage least squares estimation, but they are asymptotically unbiased and, considering the fairly large sample size for these estimations, are probably reasonably indicative of the actual significance. of the estimates.

The signs of the other expectations and concerns variables (EXP4, EXP6, EXP7, A2, A3, and A8) are mixed, although the statistical significance is quite low. The only coefficients vith t-ratios greater than 1 are for A2, which reflects concern about illness affecting asthma, and for A3, which reflects concern about tension and stress affecting asthma. The negative coefficient for A2 makes sense in that people who are ill will probably spend less time in outdoor active activities. The positive coefficient for A3 suggests that people who are concerned about stress affecting their asthma are likely to spend more time in outdoor-active activities.

The results for Equation (2) suggest the simultaneity between hours in outdoor active activities and expectations about air pollution effects is not significant, although the coefficient for DHOA is positive as hypothesized. Two variables have coefficients statistically significant at the 95 percent level (two-tailed): EXP6 (concern about allergens) and SEX. The coefficient for the ozone variable (AQ1) is positive, but not significant in this equation. This is somewhat inconsistent with the previous findings that the subjects are more likely to be concerned about pollution affecting their asthma when pollution levels are higher, although the variable EXP5 indicates being concerned about air pollution and expecting a bad asthma day, whereas

Table 5

Two Stage Least Squares Mitigation Model Vith Deviations — Full Sample*

Equation 1 — Dependent Variable = DEOA (mean = -.0279)

Variable	Coefficient	t-Ratio	Mean of Variable
Constant	-.629	-*97	
$\widehat{EXP4}$	.218	.12	.0488
$\widehat{EXP5}$	-.577	-.39	.0789
$\widehat{EXP6}$	-.134	-.07	.0715
$\widehat{EXP7}$	.233	.23	.1244
WEEKEND	1.603	9.67	.1260
A2	-.315	-1.57	.1374
A3	.257	1.29	.2122
A8	-.201	-.47	.1228
PRECIP	.136	.35	.0404
TEMP	.006	.67	70.69

R^2 = .09, N = 1230

Equation 2 — Dependent Variable = EXP5

Variable	Coefficient	t-Ratio
Constant	.028	.42
$\widehat{DEOA}$	.0083	.47
$\widehat{EXP4}$	.629	1.40
$\widehat{EXP6}$	.696	2.11
$\widehat{EXP7}$	-.104	-.56
A2	-.0017	-.05
A3	.022	.52
A8	-.102	-1.32
AQ1	.00094	.49
INC	-.00000056	-.53
AGE	.0012	1.53
SEV	-.000097	0.61
SEX	-.052	-2.29

R^2 = .09, N = 1230

* A "^" means the variable is endogenous.

Table 6

Correlation Coefficients for the Expectations Variables

	EXP4	EXP5	EXP6	EXP7
EXP4	1.000	.165	.146	.169
EXP5		1.000	.390	.232
EXP6			1.000	.243

the variable A5 used in Section 2.2 reflects simply concern about air pollution.

It is possible that multicollinearity among the expectations variables may make it difficult to sort out their individual effects. The simple correlations among the four expectations variables are shown in Table 6. The correlations are quite high, reative to the poor explanatory power of the estimated model.

Table 7 reports the estimation results using the deviations approach with the reduced sample of individuals who indicated concern about air pollution on at least one day during the study period. It was expected that mitigative behavior would be more pronounced for this subsample. The coefficient for EXP5 is indeed larger, but is still not statistically significant. The signs of the other expectations coefficients are all positive, contrary to the hypotheses of the model, but they are not significant. The coefficients for DHOA and AQ1 in Equation (2) are also larger, but their statistical significance remains very weak.

The results of the estimations using the logs of the percentages of the means were similar to those reported for the deviations except that the explanatory power of the model was even weaker. Therefore, these results are not reported.

The implications of the results reported in Tables 5 and 7are not entirely clear. The low statistical significance of the DHOA coefficients in Equation (2) suggests that simultaneity between expectations and hours spent in active outdoor activities may not be important.

Because several aspects of the specification were changed in addition to adding the simultaneity, the comparison to the previous results is somewhat problematic. To allow for a more straightfoward assessment of the effects of incorporating simultaneity in the model, Equation (1) was estimated as an independent equation using ordinary least squares. This estimation assumes that expectations related to air pollution effects are independent of the activities schedule and further assumes that the errors in Equations (1) and (2) are independent.

Table 7

Two Stage Least Squares Mitigation Model

With Deviations -- Reduced Sample*

Equation 1 Variable	Dependent Variable = DHOA (Mean = .0171) Coefficient	t-Ratio	Mean of Variable
CONSTANT	-.133	[redacted] -.14	
$\widehat{\text{EXP4}}$	1.328		.0788
$\widehat{\text{EXP5}}$	-1.779	-1.02	.1461
$\widehat{\text{EXP6}}$	1.736	.90	.1018
$\widehat{\text{EXP7}}$	.335	.35	.1659
WEEKEND	1.610	5.53	.1297
A2	-.476	-1.52	.1232
A3	.162	.75	.2726
A8	-.737	-1.31	.1264
PRECIP	.0016	.003	.0463
TEMP	-.00040	-.03	70.32

R^2 = .02, N = 609

Equation 2 Variable	Dependent Variable = EXP5 Coefficient	t-Ratio
CONSTANT	.0212	.15
$\widehat{\text{DHOA}}$	.0112	.34
$\widehat{\text{EXP4}}$	.618	1.44
$\widehat{\text{EXP6}}$	.860	2.67
$\widehat{\text{EXP7}}$	-.159	-.71
A2	.0356	.51
A3	-.00335	-.05
A8	-.111	-.96
AQ1	.0024	.67
INC	-.00000095	-.38
AGE	.00084	.47
SEV	.00024	
SEX	-.0769	-1.89

R^2 = .05, N = 609

* A "$\wedge$" means the variable is endogenous

The results of the independent estimations of Equation (1) for the full and reduced samples are presented in Table 8. The EXP5 coefficients have the expected sign and are statistically significant at the 95 percent level (two-tailed). The statistical significance of the coefficients for several of the other variables is also higher than in the two stage least squares estimations. It is interesting that the size of the EXP5 coefficients is, however, smaller than that obtained in the two stage least squares estimation. The OLS results imply that expecting a bad asthma day and being concerned about air pollution results in about a 17 percent reduction in time spent in outdoor active activities for the full sample and about a 20 percent reduction for the reduced sample. This is consistent with the magnitude of effects reported previously in Rowe and Chestnut (1985). This stability, when the other expectations variables are added, supports the conclusion that the subjects are changing their activities, at least in part, in response to concern about air pollution.

The ozone coefficient in the two stage least squares estimation was not statistically significant. Equation (2) was reestimated as an independent equation for the reduced sample to see if the results remained the same. Equation (2) in the model is similar to the perceptions equation previously reported by Rowe and Chestnut (1985) and reestimated as a logit regression in Task 2, except that EXP5 is used as the dependent variable instead of AS. Another important difference between Equation (2) and the perceptions equation estimated in Task 2, in addition to the different dependent variable, is that other expectations and concerns variables are also included since they are likely to be related to expecting a bad day and possibly to concern about air pollution.

The results of this estimation for Equation (2) are reported in Table 9. EXP6 (allergens), EXP7 (weather), A2 (illness), and A3 (stress) are all positively and significantly related to EXP5. The ozone (AQ1) coefficient is about one-half the size of the ozone coefficient in the AS equation (Table 3), but is still significant at the 10 percent (two-tailed) level. The results, when combined with the results reported in Table 3, suggest that when air pollution levels are higher, the subjects are more likely to be concerned that air

Table 8

OLS Estimation of Equation 1

a. Full Sample

Dependent Variable = DHOA

Variable	Coefficient	t-Ratio
CONSTANT	-.416	-.77
EXP4	.279	1.20
EXP5	-.401	-2.00
EXP6	.159	.74
EXP7	-.285	-1.78
WEEKEND	1.591	10.84
A2	-.255	-1.69
A3	.271	2.22
A8	-.182	-1.12
PRECIP	.230	.67
TEMP	.003	.42

R^2 = .10, N = 1230
F = 13.56

b. Reduced Sample

Dependent Variable = DHOA N = 609

Variable	Coefficient	t-Ratio
CONSTANT	.222	.27
EXP4	.147	.50
EXP5	-.627	-2.52
EXP6	.579	1.92
EXP7	-.317	-1.41
WEEKEND	1.647	7.15
A2	-.315	-1.31
A3	.303	1.70
A8	-.373	-1.48
PRECIP	.199	.45
TEMP	-.0050	-.44

R^2 = .10, N = 609
F = 6.53

Table 9

Logit Estimation of Equation 2 for the Reduced Sample

Dependent Variable = EXP5

Variable	coefficient	t-Ratio
CONSTANT	-3.864	-5.53
EXP4	.192	.51
EXP6	2.808	9.57
EXP7	1.348	4.88
A2	.881	2.77
A3	1.171	4.26
A8	-.701	-1.98
AQ1	.0422	1.74
INC	.0000212	2.53
AGE	.0349	4.20
SYMPTOM	-.461	-2.95
SEX	-1.308	-4.81

Likelihood Ratio Test 234.89, N = 837

pollution will affect their asthma symptoms, but they do not necessarily also expect a bad asthma day. It is unknown whether this is because they expect the effect on their asthma to be small or because they expect to be able to mitigate the effect. It is interesting that A8 (bad day yesterday) is significantly negatively related to EXP5. This suggests the possibility of multicollinearity problems since it seems unlikely that having a bad day yesterday would lower a person's expectations about having a bad day today due to air pollution. Potentially related, however, is the significant negative coefficient for SYMPTOM. This suggests that those individuals vith less severe asthma symptoms are more likely to expect a bad day and be concerned about air pollution. This is an unexpected result, but it may have some validity.

2.3.5 Conclusions

The primary conclusion from this analysis is that simultaneity between hours in activities and asthma symptom expectations is probably of limited importance for this group of subjects during the sample period. This hypothesis provided one possible explanation for the statistically veak relationship observed between expecting a bad day and being concerned about air pollution, and hours spent in active outdoor leisure. Although the estimated magnitude of the change in schedules associated with expecting a bad asthma day and being concerned about air pollution was reasonably consistent with the previous findings, the statistical significance of the estimates was not robust across different model specifications. It appears that changes in schedules are associated with expecting a bad asthma day, but it is difficult to say with confidence how much of the change is due to mitigating efforts to reduce exposure to air pollution.

2.4 TASK 4 -REVISED TAX BID ANALYSES

2.4.1 Corrections to the Original Results and Interpretations

The estimated number of bad asthma days for each respondent in the original report was discovered to have been calculated based upon UCLA data covering only four to seven months of the year, depending upon the respondent. On average, the data covered almost exactly one-half of the year. Data for the entire year were still unavailable from the UCLA researchers for the revised analysis, so the existing data were scaled up to a year, with the appropriate scaling factor calculated separately for each respondent. Unfortunately, there may still be biases for each individual or for the sample as a whole if the period of time for which data were available is in some manner systematically unrepresentative of total annual asthma severity. The revision resulted in a change in the estimate of the average number of bad asthma days in the sample from 38 to 74.

Due to this revision, the original tax bid regression model and the predicted total, marginal, and average willingness to pay figures were reestimated and are reported here as Tables 10 and 11. Two other changes were made: (1) the tax bid equation was estimated without the medical cost variable, which was insignificant in the original specifications and is determined by asthma severity and characteristics of the individual represented by other variables in the equation; and (2) in version 2, Table 10, income was deleted as it was insignificant in the original specification and this deletion allows the specification to be tied to a utility functional form under a very specific assumption (see below).

The results for the reestimated original tax bid specification show little significant difference from those in the original report. The constant term changes to reflect the difference in the total number of bad asthma days, and the statistical significance of GDAY increases to the 10 percent (one-tailed) level. However, the predicted total, marginal, and average willingness to pay estimates decrease by half or more for each of the original levels reported.

This error may also explain very large tax bids made by several individuals with zero or very few estimated bad asthma days, especially since for some of these individuals the bid, ranking and medical cost data are consistent, These bids may be accurate for yearly asthma levels if their asthma severity is lower in the 4 to 6 month sample period than in the remainder of the year. However, if this type of seasonal measurement error is occuring for these individuals, the true NBAD must exceed the estimated NBAD and-including these

Table 10

Tax Bid Regression and Predicted WTP Values for a

50 Percent Reduction in Bad Asthma Days

(Revised Table 4.15)*

a. Regression Model

Dependent Variable Log (Tax Bid)

Explanatory Variable	Coefficient (t-ratio) Version 1	Version 2
Cons tsnt	1.48 (.37)	4.28 (2.78)
in (NBADR)	.535 (4.07)	.552 (4.26)
in (GDAY)	1.15 (1.70)	1.08 (1.61)
in (INC)	.263 (.77)	
in AGE	-.663 (-1.17)	-.683 (-1.21)
SEX	-.43, (-.99)	-.47 (-1.09)
ADULT	.78 (.99)	.77 (.98)
NOBS	65	65
F Statistic	4.45	5.26
R^2	.315	.308
$\bar{R}^2$	.245	.250

b. Predicted WTP Values ($'s, Version l)**

GDAY	No. of Bad Days Reduced 1	5	15	50
1 (no symptoms)	$ 9	$22	$ 40	$ 79
2 (very mild symptoms)	19	47	86	166
3 (mild symptoms)	30	72	133	258
4 (moderate symptoms)	41	99	181	353

* Revision of Table 4.15 in Rowe and Chestnut (1985) to correct for errors in earlier estimates of NBADR. Other minor revisions were also made, see accompanying text. Variable names defined in Table 1. Logs in base e.

** Predicted WTP values calculated for adult males at the sample means for other variables.

Table 11
WTP Values for a Reduction in a Bad Asthma Day

(REVISED Table 4.16)*

a. Marginal Tax Bid for the Next Bad Astma Day Reduced**

BDAY Level *	No. Bed Days Already Reduced (NBADR) 1	5	15	50
1 (no symptoms)	$ 4	$ 2	$ 2	$ 1
2 (very mild symptoms)	9	5	3	2
3 (mild symptoms)	14	8	4	3
4 (moderate symptoms)	19	10	7	4

b. Average Tax Bid Per Bad Day Reduced***

GDAY*	No. Bad Days Reduced (NBADR) 1	5	15	50
1 (no symptoms)	$ 9	$4.4	$ 2.7	$1.6
2 (very mild symptoms)	19	9.4	5.7	3.3
3 (mild symptoms)	30	14.4	8.9	5.2
4 (moderate symptoms)	41	19.8	12.1	7.1

* Revisions to Table 4.16 of original report. Bad Asthma Days are days with symptoms rated as exceeding the GDAY level. Results for Table 10, model Version 1.

** Marginal values calculated as the first derivative of the regression model.

*** Average values are predicted tax bids (Table 4.15b) divided by number of bad days reduced.

observations in the tax bid regression analysis would introduce a systematic bias in the estimates. While seasonal measurement error may occur for all the observations, it is not known for any other individuals whether the measurement error is positive or negative so that no systematic bias is introduced. However; it is known that random measurement error in explanatory variables of a regression model biases the corresponding estimated regression coefficients toward zero.

2.4.2 Revised Tax Bid Specifications

Two issues were addressed in the revised tax bid analysis. First, the GDAY variable was a categorical variable representing the highest level of asthma symptom severity (using the UCLA 1-7 scale) that the respondent still considered to be a good asthma day. The initial analysis incorporated the effect of individuals bidding to reduce bad asthma days of different severity by incorporating GDAY as a continuous, rather than categorical, variable. As such, a GDAY cutoff of 4 is implicitly assumed to be twice as severe as a GDAY cutoff of 2 and so forth. This was an assumption of convenience, but for which there was no supportive evidence.

The second issue was that the tax bid specification was not derived from a utility function specification, and as such the implicit utility function assumptions could not be ascertained. These two issues are first addressed separately, then joined together in the analysis.

Accounting for the Severity of Bad Asthma Days

Two methods were identified to address the differences across individuals in terms of the severity of bad asthma days being reduced. The first approach is to simply replace N, the total number of bad asthma days, with a function of the number of bad asthma days at each severity level: $f(N_i)$, $i=2,3,\ldots,7$. If i is less than or equal to GDAY then N_i equals 0 (i starts at 2 as level 1 equaled no symptoms). In this case a term such as $a_0N^{a_1}$ in a utility function would be replaced by:

$$a_0 * N2^{a2} * N3^{a3} \ldots N7^{a7} \quad (1)$$

where a_0, $a_2, a_3, \ldots a_7$ are coefficients to be estimated.

A problem with this approach is that for many individuals Ni will equal zero for many i levels as the i level is not considered a bad asthma day, or simply because no bad days occurred at that level. As a result, the simple multiplicative specifications and log transformations used in the analysis need to be modified. Equation (2) provides such a modification.

$$e^{(a2*N2 \; + \; . \; . \; . \; + \; a_7*N7)} \quad (2)$$

A second problem with this approach is one variable, N, is replaced with six variables: N2,N3, . . . N7; creating multicollinearity problems. Therefore, in" the analysis three new variables were defined as N23=N2+N3, N45=N4+N5, and N67=N6+N7.

A second approach is to incorporate the effect of different severity levels into the coefficients on N. For example, a term: $a_0 N^{a1}$ in a utility function would be replaced by:

$$(a. + a_2*D_2 + a_3*D_3 + a_4*D_4)*N**(b_0 + b_2*D_2 + b_3*D_3 + b_4*D_4) \quad (3)$$

where Di . 0 if GDAY > i
= 1 if GDAY $\leq$ i
ai, bi = coefficients to be estimated

The disadvantage of this approach is that two coefficients are replaced by eight.

Alternative Tax Bid Functional Form Specifications

Numerous alternative utility function specifications were considered in attempting to derive a consumer's surplus equation. The specifications are presented using N for bad asthma days, with N replaced by measures accounting for severity of bad asthma days in the analysis section. In general, the definition of the compensating surplus measure of consumer's surplus is given by:

$$u = u(Y,X,N) = u(Y-CS,X,N-NR) \quad (4)$$

where:

u	=	Utility
u	=	An unspecified utility functional form
x	=	A socioeconomic or other characteristic
Y	=	Income
CS	=	Compensating surplus measure of consumer's surplus, measured by the tax bid
N	=	Number of bad asthma days
NR	=	Number of bad asthma days reduced (=.5*N = N-NR due to the specific nature of the WTP question asked)

Utility function specifications are desired such that the first partial derivative of utility with respect to N Is negative and the second partial with respect to N is greater than or equal to zero.

A simple linear additive form as in Equation (5), where lower case letters represent coefficients, plugged into Equation 4 results in a CS function as in Equation (6).

$$u = aN + bY + cX + dXY + eNY + fNX \quad (5)$$

$$CS = \frac{-NR(a + fX + eY)}{b + eNR + dX} \quad (6)$$

The CS function is intrinsically nonlinear unless the coefficients d, and b or e, are zero. If d and e are zero, the CS function is independent of income.

A Cobb-Douglas form, as in Equation (7) has the unlikely result that CS, Equation (8), is not a function of the number of bad asthma days. The Weber-Fechner utility function results in an identical CS function. [Note also that N/(N-NR) = 2 in this case study.]

$$U \cdot X^{b1}Y^{b2}N^{b3} \quad (7)$$

$$CS = Y\left[1-\left(\frac{N}{N-NR}\right)^{b3/b2}\right] \quad (8)$$

Furthermore, the resulting utility function (7) is undefined when N is zero. In a practical sense this may be of little empirical concern when nearly all observations of N are substantially larger than 1 and deleting a few observations at N=0 (or replacing by N=1/2) would have minimal impact on the analysis. This problem is, however, aggravated when the total bad asthma days, N, is replaced with the number of bad days at each severity level, which therefore requires a modification such as Equation (2).

Other standard utility function specifications, including the CES, translog and the Stone-Geary, were examined but found to result in highly complicated, intrinsically nonlinear CS functions.

Other forms were also considered. One alternative was to consider variations on a Cobb-Douglas type of specification, as given in Equation (9), where $f_1(X)$ is an unspecified function of X and YP is the potential income without bad asthma days. With bad asthma days, actual income, Y, is reduced in relationship to YP as in Equation (10), by the term exp(-cN), and the ability of the person to enjoy income is further reduced by the term exp(dN), resulting in utility function (11) and CS function (12).

$$u = f_1(X)YP^a \quad (9)$$

$$Y = YP \cdot e^{-cN} \quad (10)$$

$$U = f_1(X)Y^a e^{cN} \cdot e^{dN} = f_1(X)Y^a e^{bN} \quad (11)$$

$$CS = Y(1-e^{(b/a)NR}) \quad (12)$$

Equation (12) is an intrinsically nonlinear, yet uncomplicated, function, but is not a function of socioeconomic or other characteristics of the individual. Equation (11) has the nice property that if the individual were to have zero bad asthma days, the function reverts to Equation (9). The introduction of bad asthma days in Equation (11) reduces one's ability to produce and enjoy income, although these effects cannot be separated.

If asthma requires preventative or responsive treatment, this reduces disposable income and reduces utility. This treatment effect could be entered into the analysis, as was the reduction in earning ability above, by multiplying the utility function by a term exp(-fN), which would result in a consumer's surplus function given by Equation (13) and for which the independent effects of treatment costs, income reduction, and enjoyment could not be statistically separated.

$$Cs = Y(1-e^{((b+f)/a)NR}) \qquad (13)$$

Alternatively, treatment costs could be incorporated as a linear reduction in gross income resulting in a net income for consumption of other goods and services entering into the utility function as Equation (14) and resulting in CS Equation (15), which is intrinsically nonlinear.

$$u = f_1(X)(Y-f_2(X)e^{gN})^a e^{bN} \qquad (14)$$

$$CS = Y(1-e^{(b/a)NR})+f_2(X)(e^{(2g+b/a)NR}-e^{gNR}) \qquad (15)$$

Variations on each of the above specifications were estimated with both of the GDAY replacements.

A Digression on the Original Tax Bid Specification.

The tax bid regression functional form in the original report as reestimated, with a slight modification in the explanatory variable set, in Table 10, version 2, is related to CS function (15). Specifically, assume utility function (16), which results in CS Equation (17), utilizing the condition that

N-NR-NR-(1/2)N in this study, and where the term $[f_2(X)*N^{b1}*GDAY^{b2}]$, is the effect of asthma on medical costs.

$$U = f_1(X)[(Y-f_2(X)N^{b1}GDAY^{b2})]N^{a1}GDAY^{a2} \qquad (16)$$

$$Cs = Y(1-2^{a1}) + (2^{a1+b1}-1)f_2(X)\ NR^{b1}GDAY^{b2} \qquad (17)$$

Equation (17), which is intrinsically nonlinear, simplifies to the linear equation reported in Table 10 version 2 if a1=0. Moreover, if income is uncorrelated with the other terms in the regression, as supported by data analysis, the omission of income, even if al is nonzero, would reduce the explanatory power of the regression, but not bias the other estimated coefficients. Therefore, to the degree that the GDAY specification of asthma severity is appropriate, the original taxbid specification, as revised and reported in Table 10, version 2, provides information that can be related to underlying utility theory. To examine the importance of the income term omission in the original specification, as reported in Table 10, Equation (17) was also estimated.

<u>Other Non-Utility Based Specifications</u>

The consistency check hypothesized that the tax bid should, at a minimum, be a function of the medical costs and the ranking of medical costs. In the final tax bid sample, bids were retained in the sample if:

TAXBID $\geq$ R1*.10*HEDVEH (18)
where: $\bar{R}1$ = rank of reduced MEDVHH
MEDVHH = Variable medical costs paid by the household

unless the bid was rejected or accepted for some other cause. The original report indicates using a threshold of 25 percent of MEDVHH. This however, resulted in the same sample as if a threshold of 10 percent of MEDVHH was used. The strength of this assumption was tested by estimating Equation (19).

$$TAXBID = a_0 R1^{a1} * MEDVHH^{a2} \qquad (19)$$

2.4.3 Results

All estimation was done with the SHAZAM package at the University of Colorado using the same sample as in the original report. Due to the volume of results, and the limited additional insights provided, only a few regressions will be presented and the results will be discussed in general. Reference will be made to the models outlined in Equations (5) through (19) above. The socioeconomic variables included in the models include transformations on AGE, ADULT, SEX, and RTFM. (Variables are defined in Table 1). All runs involving nonlinear estimation procedures were reestimated with alternative starting values to test the sensitivity of the results, resulting in several estimates for each specification.

The GDAY Modification

Replacing GDAY with other variables consistently decreased the ability of the models to explain the tax bids in a meaningful manner. The first approach of using the number of bad asthma days reduced at each severity level did not increase explanatory power of any model, as measured by the adjusted R-squared. Generally, the multicollinearity between these variables caused instability in the coefficient estimates, especially for those specifications that required the use of nonlinear estimation procedures.

Ultimately the six bad day variables were reduced to three, N23, N45, and N67 as defined above. This still reduced the explanatory power of the models, but with somewhat less instability of the coefficient estimates. Nevertheless, it was usually the case that the coefficients for these three variables alternated in sign. Generally, the coefficients on either N45 or N67 were of the expected sign, statistically significant, and substantially larger than the coefficients for the other variables. However, it was not always consistent which of these two variables would be the significant variable, perhaps reflecting continuing multicollinearity problems.

Replacing GDAY by dummy variables generally resulted in much poorer results, in terms of explanatory power of the regressions, than with the previous approach. Referring to Equation 3, the a0 and b0 coefficients were generally statistically significant and larger than the other coefficients. The a2 through a4 and b2 through b4 coefficients generally decreased in size, but often alternated sign and were almost always insignificant. Specifications using this approach are not discussed further.

<u>Alternative Models</u>

Nonlinear models of Equation (6) vere estimated assuming the coefficients e and d were equal to zero. In these models the coefficients on N23 and N45 were generally small and statistically insignificant (t-ratios always less than 1.0), while the coefficient on N67 was consistently large and statistically significantly with the expected negative sign. The estimated coefficient on N67 consistently equaled -11.9 with a t-ratio of around 12.

The model specified in Equation (8) resulted in an estimate of b3/b2 not being statistically different from zero (with a t-ratio in the vicinity of .2). The explanatory power of the model vas also extremely weak.

The model specified in Equation (15) vas estimated assuming the term Y*(1-exp((b/a)*NR) equaled zero so that linear transformations could more easily be made. Further, the terms involving NR vere replaced in the Equation (2) using N23, N45, N67. Overall, the results vere statistically significant at a 10V level with only the coefficient on N45 being significant. The full model Equation (15) was not estimated due to the complexity of the model when replacing NR by N23, etc. Specifically, the number of coefficients and the cross coefficient restrictions combined vith the sensitivity of the nonlinear estimates to starting values, which increased vith model complexity, led us to omit this estimation.

The model specified in Equation (17) vas estimated several vays. First, assuming a1=0, or by omitting the first term, the model is intrinsically linear and can be estimated vith ordinary least squares (OLS). These results are the same as those presented in Table 10, column 2. Next, the same abbreviated model (called the "linear model 17") and the "full model 17," with all the terms in Equation (17), were estimated with the nonlinear estimation procedure to test for consistency of results. The coefficient starting values for the nonlinear estimation were the coefficient estimates from OLS. The results are summarized in Table 12. An interesting result is the difference between the size and significance of the NBADR coefficient (b1) in the same "linear model 17" when estimated with OLS and with the nonlinear procedure. The nonlinear estimates of the coefficient and t-ratio are considerably smaller than the OLS estimate. In the nonlinear estimation of the "full model 17", the b1 coefficient and t-ratio increase, but not to the magnitude of the OLS model estimates. However, the al term is insignificant, suggesting that the OLS model may be sufficient to estimate the CS function in Equation (17). The log likelihood function value is lowest for this model as compared to all other nonlinear models estimated (including all other nonlinear CS functions estimated based upon Equations (6), (8) and (15)). However, limited credence is placed in all nonlinear estimates due to the substantial divergence between the OLS and nonlinear estimates for the same model and the occasional sensitivity of the nonlinear results to starting values.

Other Models

The results of model Equation (19) using the tax bid sample are (with t-ratios in parentheses under the estimated coefficients):

$$TAXBID = 3.1 * R1^{1.3} * MEDVHH^{.08} \qquad \text{R-Squared} = .1702$$
$$(3.6) \quad (3.5) \qquad (.52) \qquad F\ (2,62) = 6.35$$

The rank of medical costs does seem to be a highly significant determinant of the tax bid once the consistency criteria were met (that the tax bid equaled or exceeded the rank of medical costs times at least 10% of medical costs).

Finally, a revised "linear model 17" was estimated replacing NBADR and GDAY by SEV^{b1}, where SEV is the severity index measure. While SEV was not significant in earlier analyses, in this revised specification a b1 coefficient of 1.69 was estimated with a t-ratio of 2.45 (see Table 13). The R-squared is .1303,

Table 12

Comparison of Results for Equation 17*

"Full Model 17": $TAXBID = Y(1-2^{a1}) + (2^{a1+b1}-1) * NBADR^{b1}) * GDAy^{b2} e^{c1*SES+c2ADULT} * AGE^{c3}$

"Linear Model 17": Full Model 17 without the term $Y(1-2^{a1})$

Coefficient	OLS Estimates "Linear Model 17"	"Nonlinear Estimates** "Linear Model 17"	"Nonlinear Estimates** "Full Model 17"
'1	5.64 ***	8.6 (4.3)	-.089 (-.77)
b_1	.552 (4.3)	.111 (1.06)	.184 (2.5)
b_2	1.08 (1.61)	.665 (1.19)	1.02 (2.01)
c_1	-.47 (-1.09)	-.91 (-1.7)	-.57 (-1.25)
c_2	.77 (.98)	1.5 (1.9)	1.4 (1.5)
c_3	-.68 (-1.21)	-.58 (-.104)	-.46 (-1.2)
R^2	.308		
Log likelihood function value		-509.83	-510.8

* t-ratios in parentheses. If TAXBID = 0, TAXBID set = 1; If NBADR = 0, NBADR set . .5

** Starting values = OLS estimates

*** Statistical significance cannot be determined.

Table 13

TAXBID as a Function of SEV Using "Linear Model 17"*

Dependent Variable: in TAXBID

Sample: Tax Bid Sample

	Variable					
	Intercept	in (AGE)	in (RTFM)	ADULT	SEX	in (SEV)
Coefficient	- 3.0	-.126	-.0067	.218	- .72	1.69
t-ratio	.68	-.18	-.04	.247	-1.44	2.4S

R^2 = .1303
F (5.59) = 1.77

* in refers to log base e.

however, the F-statistic is significant at only the 10 percent significance level. These results are discussed further in Section 2.5.

In summary, the analysis still supports that the tax bids are functionally related to the number of bad asthma days reduced or some other measure of asthma severity. The OLS estimate of the "linear model 17" provides the best overall fit of the data, in terms of R-squared or value of the log likelihood function measures. The results for this model are quite similar to those presented in the original report. The inconsistencies of the nonlinear estimates suggest some potential problems with the nonlinear estimation procedure that make it difficult to evaluate the results.

2.5 TASK 5 - EMPIRICAL REEXAMINATION OF TEE CONSISTENCY CHECK AND WTP/COI CALCULATION PROCEDURES

The medical cost data, rankings, and tax bids were used to conduct a consistency check on the validity of the tax bids and as one means to estimate the WTP/COI ratio. Unfortunately, in the original analysis the medical cost and tax bid equations were not estimated for the same asthma severity measure. Further, the use of the rankings to infer the expected size of tax bids relative to medical costs has been questioned (see also Task 7 discussion). This section empirically reexamines the validity of the assumptions used in the consistency check and in the calculations of the WTP/COI ratio.

The consistency checks and calculations of WTP/COI ratios were based upon estimated changes in medical costs and tax bids for changes in asthma severity, but the tax bid and medical cost equations used different measures of asthma severity. SEV was used in the medical cost equations because preventative and responsive medical costs would be expected to be based upon all symptoms, not just bad asthma days. Bad asthma days was used in the tax bid analysis due to the framing of the question.

The tax bid 'Linear Model 17" was reestimated with SEV^{b1} in place of $(NR^{b1})*(GDAY^{b2})$ so that both the tax bid and variable medical cost equations use the same severity measure. The coefficient on SEV in the tax bid equation

(Table 13) is 1.83 times the SEV coefficient in the comparable specification of the variable medical costs paid by the household equation (See Table 4.10 in the original report). Using these two models (Tables 13 here and 4.10 of the original report) with the SEV measures of severity, a 50 percent reduction in asthma severity would increase willingness to pay, on average, by 1.83 times the expected decrease in medical costs. This provides additional evidence that tax bids should exceed reduced medical costs. This finding is also consistent with the use of the more lenient criterion that the tax bid equal or exceed tme medical cost ranking times a 25 percent decrease in medical costs. These results must be caveated by the fact that the statistical significance of the tax bid equation is very low when using the SEV measure in place of the number of bad asthma days. It is presumed this is the case because the tax bid question was in terms of bad asthma days, not severity, and because there is only a moderate correlation between the two measures. Therefore, it is encouraging for the consistency check that the SEV coefficient in the tax bid equation is substantially larger than in the medical cost equation.

The tax bid and medical cost equations were also reestimated for the model presented in Equation (15) in Section 2.4 using asthma severity measures equal to the number of asthma days at alternative severity levels. However, there is limited consistency between the results of the tax bid and variable medical cost models making the results difficult to compare in terms of consistency checks. Most importantly, in the tax bid model only bad asthma days at levels 4 and 5 had a significant affect (positive) on the WTP response, while in the medical cost equation bad asthma days at levels 6 and 7 dominate (See Table 14). Some of these differences could be attributed to multicollinearity problems and/or to inappropriate model specification using the linear model approximation.

A simple alternative method vas also devised to examine the validity of the assumption that tax bids for a 50 percent reduction in bad asthma days should equal or exceed the rank of medical costs times the predicted 46 percent reduction in variable medical costs associated vith a 50 percent reduction in asthma severity (using the model in Table 4.10 of the original report). For this approach we simply calculated the average TAXBID/ΔMEDVHH ratio for all

Table 14

MEDVHH as a Function of Total Asthma Days at Each Severity Level

Dependent Variable = in (MEDVHH)

Explanatory Variable	Coefficients/(t-ration) Tax Bid Sample		Coefficients/(t-ration) Full Sample
in (AGE)	-.53 (-1.2)		-.37 (-.87)
ADULT	1.53 (.63)		1.0 (1.8)
in (RTFM)	-.10 (-1.0)		-.09 (-1.0)
SEX	.88 (2.4)		.78 (2.4)
N23	-.88 E-5 (-.6 E-2)		.44 E-3 (-.32)
N45	-.004 (-2.0)		-.004 (-2.0)
N67	-.041 (2.57)		.037 (2.8)
Intercept	4.2 (3.4)		4.3 (3.8)
R^2	.3263	R^2	.2554
$\bar{R}^2$	.2436	$\bar{R}^2$	.1840
F (7,57)	3.94	F (7, 74)	3.58

in is log base e.

Nij = total number asthma days at severity levels i + j.

individuals who ranked medical costs first, then for all individuals who ranked medical costs second, and so forth. The results are presented in Table 15. The average rankings are calculated for those individuals in the tax bid sample as well as for the full sample except those with zero protest bids or bids exceeding income.

The results show a consistent pattern of increasing TAXBID/ΔMEDVHH as the rank of MEDVHH increases, and the average TAXBID/ΔMEDVHH ratio exceeding the rank of MEDVHH. The finding that when MEDVHH is ranked sixth, the TAXBID/ΔMEDVHH ratio is lower than the average ratio when MEDVHH is ranked fifth, is not contradictory. When MEDVHH is ranked sixth, often other categories are also ranked unimportant, or sixth. However, when MEDVHH is ranked fifth, all other categories were ranked as more important than MEDVHH. The findings of this analysis are supportive of the consistency checks and WTP/COI ratio calculation procedures, but due to small sample sizes and large interpersonal variation, the statistical significance of this analysis is limited.

Reexamination Of The MEDVHH Equation

Given the additional attention to the respecification of the tax bid model, it was decided to reexamine the sensitivity of the MEDVHH model to functional form specification. The model was respecified with several alternative functional forms, different samples (adults only, children only, all respondents, the tax bid sample), and with different severity measures including SEV, the number of asthma days at different severity levels, and the total number of bad asthma days weighted by severity.

Among the alternative severity measures, SEV consistently provided the best statistical relationship to MEDVHH. While at least one alternative functional form (the semi-log exponential) and several subsamples, each using the SEV measure, resulted in higher F statistics and R-squares than the model presented in the original report, the estimated elasticity between SEV and MEDVHH was not statistically different across any of the specifications. In fact, this elasticity seldom varied by more than a few percentage points. As a result, it appears the relationship between SEV and MEDVHH, as measured in the previous analysis, is quite robust to model specification.

Table 15

Average TAXBID/ΔMEDVHH Ratio

by Rank of Medical Costs

Rank of Medical Costs (MEDVHH)	1	2	3	4	5	6**
I. Tax Bid Sample						
$\bar{x}$ = TAXBID/ΔMEDVHH*	1.32	3.73	9.83	14.68	93.97	42.02
$SE\bar{x}$	.54	2.52	3.74	6.67	33.74	19.33
N (Total= 65)	11	9	17	5	4	20
II. Full Sample w/o Protest zero bids (includes some bids deleted in Tax Bid Sample)						
$\bar{x}$	9.09	3.39	9.54	14.68	75.41	39.13
$SE\bar{x}$	7.78	2.06	3.53	6.67	32.05	16.14
N (Total=75)	12	11	18	5	5	24

* Change in MEDVHH assumed to equal .46 variable medical costs. See original report consistency check.

** A rank of six was assigned if the category was listed as not important. Often many categories were listed as not important. However, when medical costs are ranked 5th, all other categories were ranked as more important. Therefore, it is reasonable that $\bar{x}$ is smaller when MEDVHH is ranked 6th than when MEDVHH is ranked 5th.

2.6 TASK 6 - WTP FOR THOSE WHO MITIGATE

The purpose of this task was to examine the differences in the WTP tax bid responses for those who did and did not change their behavior in association with expecting a bad asthma day and being concerned about air pollution. Which group would be expected to have a higher WTP is not entirely clear. On the one hand, those who mitigate might have a lower WTP for changes in environmental conditions that could improve their asthma because they perceive that they can effectively mitigate the effects on their asthma by changing their behavior, while others may not be able to mitigate due to schedule constraints or other reasons. On the other hand, those who exhibit mitigating behavior might have stronger preferences for reductions in asthma symptoms and might therefore have a higher WTP for improvements in environmental conditions.

Two groups of adults were defined as follows:

Group 1 reported some workloss, some change in leisure activity, or some change in sleep to avoid having or worsening asthma symptoms on at least one day on which they expected a bad asthma day and were concerned about air pollution.

Group 2 reported no workloss, no change in leisure activities, and no change in sleep to avoid having or worsening asthma symptoms on all days on which they expected a bad asthma day and were concerned about air pollution.

The mean tax bids for each group of individuals who passed the minimal consistency check were as follows:

Group	N	Mean	Min	Max	Variance	Std Error of the Mean
1	13	$462	10	1500	201386	124
2	9	$972	0	5000	2470694	524

The mean of group 2 is higher than the mean for group 1, but due to the small sample sizes these means are not statistically significantly different.

2.7 TASK 7 - INTERPRETATION OF RANKINGS

An important conclusion of the previous analysis was that the results of the study suggest that willingness to pay (WTP) estimates for reductions in asthma symptoms are probably about twice the magnitude of cost of illness (COI) estimates including medical costs and workloss. This conclusion was based in part on the results of the subjects' rankings of the benefits of improvements in asthma. The consistency check used to evaluate the tax bid responses was also based in part on the rankings.

Before being asked to estimated their willingness to pay for programs that would result in an improvement in their asthma symptoms, respondents were asked to rank, in order of importance to themselves, a list of five possible benefits that might result if their asthma were to improve. These benefits were related to different ways that changes in the severity of an individual's asthma might affect his or her utility and therefore reflect the different things that would determine the individual's willingness to pay to obtain an improvement in asthma.

In the analysis of the ranking results, it was assumed that willingness to pay for each of the individual benefits would follow the same order as the rankings. For example, if having less pain and suffering were ranked more important than having lower medical expenditures, it was assumed that willingness to pay for less pain and suffering would be greater than willingness to pay for lower medical expenditures. This assumption that there is some predictable relationship between the rankings and willingness to pay is important to the conclusion that WTP exceeds COI by about 2. Since some questions have been raised about this assumption, some discussion of its rationale seemed merited.

The primary question seems to be that medical expenditures are undertaken in order to reduce symptoms and therefore to obtain some of the other benefits. It seems potentially problematic to say that reducing pain and suffering or reducing workloss is worth more to the individual than reducing medical costs because they rank the former higher than the latter, since medical costs are incurred in order to reduce pain and suffering, prevent workloss, and obtain other benefits. Our interpretations of the rankings as they relate to willingness to pay for each benefit category presumes that the pain and suffering being considered, for example, is that which remains after medical treatment is undertaken. It is presumed that the individual has already chosen the amount of medical treatment and lifestyle adjustments that maximizes his or her well-being, but it is likely that some discomfort remains. A reduction in asthma symptoms would therefore mean both a reduction in discomfort and a reduction in medical expenditures and lifestyle adjustments that would be required to keep the person in a position of maximizing his or her well-being.

To illustrate this more concretely, consider the following simple utility model:

$$u = U(X,H) \qquad (1)$$

Where:

U = utility
X = consumption of goods and services with price per unit set equal to 1 to simplify the analysis, $\partial U/\partial X > 0$
H = health, $\partial U/\partial H > 0$

The individual's health affects utility by affecting physical comfort, ability to undertake desired activities, etc. Individuals influence their health in the following way:

$$H = H(M,P,Z) \qquad (2)$$

Where:

M = preventive and/or symptom-relieving medical treatment with price per unit set equal to 1 to simplify the analysis
P = external factors such as pollution exposure
Z = individual characteristics

There is a simultaneous relationship between H and M such that

$$M = M(H,I)$$

Where:

I = income

The individual's health will also affect the amount of income lost due to illness:

$$L = L(H) \tag{4}$$

Where:

L = lost income due to illness

M and L are presumed to have no direct effect on utility, but to affect utility only through H and the budget constrain! (affecting the amount of money available for X). The individual can be expected to maximize income subject to the budget constraint:

$$I \leq M + X + L \tag{5}$$

If the individual were fully able to trade off medical expenditures and health, he would choose the amount of medical expenditures such that the marginal cost equaled the value to him of the marginal improvement in health obtained. The tradeoff is, however, limited because there are seldom treatments available, at any price, that can relieve all symptoms. The individual can be expected to maximize utility subject to the feasible treatments available to him.

If an external factor that influences health, such as air pollution, changes for the worse, then H will decline if the individual does nothing, causing an increase in discomfort, activity restriction, and income lost due to illness. The individual, however, can be expected to increase M, if possible, to offset to some extent the adverse effect on H. The total change in utility that would result from a change in P once the individual has adjusted to a new utility maximization would be:

$$\frac{\partial U}{\partial X} * -\frac{dM}{dP} + \frac{\partial U}{\partial H} * \frac{\partial H}{\partial P} + \frac{dU}{dX} * \frac{\partial L}{\partial H} * \frac{dH}{dP} \qquad (6)$$

where dM and dH represent the total changes in M and H that occur once the individual has made the optimal adjustment.

Our interpretation of the rankings presumes that the questions regarding discomfort, activity restrictions, and workloss refer to the dH/dP rather than $\partial H/\partial P$, the latter having been possibly offset to some extent by a change in M. This interpretation is valid as long as the respondents were considering the net effects of asthma that occur after optimal readjustment of medical treatment has been undertaken. Although they probably do not think of it in those terms, they are quite familiar with the degree to which medical treatment can relieve their symptoms. It would be expected that an individual who is able to fully control his or her asthma symptoms with medication would rank reduction in medical expenditures as the most important benefit of an improvement in asthma and the other benefits as unimportant. This appears to be a reasonable interpretation, but cannot be empirically tested without more information from the subjects.

If this assumption is not correct, the use of the ranking results to develop an alternative estimate of the WTP/COI ratio and for the consistency check is not valid. This would not, however, affect the estimated WTP/COI ratio based on the tax bid responses and the predicted change in medical costs. In this case, the rankings were used only to support the assumption that the average change in work loss equals the average change in medical costs because these were ranked the same, on average. The WTP/COI ratio estimated this way was about 1.6, in the same range as the estimates using the rankings in other ways.

2.8 TASK 8 - VALUE OF INFORMATION STUDY

Information on ambient air pollution levels may be of value to asthmatics if they could use that information to optimally adjust their behavior to minimize exposure that may adversely affect their asthma and thereby reduce the expected level of asthma symptoms." Such a study, if possible, may be able to indicate what levels of information efforts, such as smog alerts, should be undertaken and whether it would be more efficient, in terms of social welfare, to increase information about occasional air pollution incidents rather than to try to prevent each incident from occurring.

Several pieces of information would be required to complete a value of air pollution information study for asthmatics:

1. Knowlege or assumptions concerning how asthmatics receive and process the information.

2. A relationship between information about potentially adverse conditions and the resulting actual behavior undertaken to mitigate adverse impacts. The optimal behavioral adjustments, in terms of reducing asthma symptoms, may not be the actual behavior adjustments undertaken because of other benefits, costs and constraints faced by the individual.

3. A function relating alternative behaviors (active, inactive, etc.) in alternative environments (indoors, outdoors, at work, at leisure, etc.) to changes in air pollution exposure and then to changes in expected asthma symptoms for that exposure level and activity type. From this function changes in behavior could be translated into changes in expected asthma symptoms severity.

4. A function relating alternative levels of asthma symptom severity to value.

It appears impossible to undertake a value of information study with the available data. Assumptions could be made to fulfill step 1 using the perceptions information discussed in Section 2.2. The tax bid analysis also provides sufficient information for step 4. However, information for steps 2 and 3 are incomplete, or completely absent. As discussed in Section 2.3 of this report, the evidence is weak concerning behavior adjustments as a result of perceptions and expectations about adverse air pollution (Step 2). At present, one could only estimate the value of information based upon an assumption of what changes in behavior could be, if all other information were available.

3.0 CORRECTED PAGE 4-37 OF ROWE AND CHESTNUT (1985)

Sample Selection for Tax Bid Analyses

For subsequent tax bid analyses a number of observations were deleted. The reasons for these deletions and the number of responses involved are summarized below. Bids were deleted if:

1. NBAD equaled 0, due to the respondent's selection of a maximum good day value that indicated that there were no bad days to reduce (perhaps their asthma is in remission), and the tax bid was greater than or equal to $100/year ($950 average). In this case the bid could not be to reduce NBAD, as we had measured it. (4 respondents)
2. NBAD was less than or equal to 3 (1/13 the sample average) and the 'tax bid was greater than or equal to $1000/year (more than twice the sample average). As with the respondents who fell in category #1, there were few bad days to reduce. It appears these respondents answered the tax bid question in terms of reducing overall severity rather than bad days. It may be the case that most respondents answered this way, but the difference between reducing overall severity and bad days becomes less significant as the number of bad days increase (see consistency checks below). (3 respondents)
3. The tax bid equaled zero, number of bad days exceeded 9, variable medical costs exceeded $75/year and generally were not ranked first (6 or 7), and a rejection response was given on the zero bid follow-up question (30b). It is likely many of these respondents simply rejected the tax bid question as unrealistic or in some way objectionable or less desirable than other approaches. (7 respondents)
4. Tax bids were less than or equal to $50, number of bad days was greater than 75 and the tax bid/medical cost/ranking consistency check would not work even using one-tenth of medical expenditures (see section on consistency checks). It appears these respondents were not willing to pay to reduce asthma through the vehicle provided. (2 respondents)
5. No tax bid response was provided. (1 respondent) In some analyses, this individual was included as a valid zero bid because the estimated number of bad asthma days was zero and yearly variable medical costs were estaimted as $22.

4.0 REFERENCES

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