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IMPROVING ACCURACY AND REDUCING COSTS OF ENVIRONMENTAL BENEFIT ASSESSMENTS

Value of Symptoms of Ozone Exposure: An Application of the Averting Behavior Method

by

Mark Dickie
Shelby Gerking
William Schulze
Anne Coulson
Donald Tashkin

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Project Officer

Dr. Alan Carlin
Office of Policy, Planning and Evaluation
U.S. Environmental Protection Agency
Washington, D.C. 20460

Report prepared for:

Office of Policy, Planning and Evaluation
U.S. Environmental Protection Agency
Washington D.C. 20460

by

The Institute for Policy Research, University of Wyoming
Laramie, Wyoming 82070

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CHAPTER 1

INTRODUCTION AND SUMMARY

This report presents estimates of the dollar benefits of reducing symptoms of exposure to ozone. These estimates are submitted as part of a larger, ongoing study of morbidity ozone relationships. Gerking et al. (1984) contains an estimate of the geographic distribution of benefits of ozone reduction as well as an epidemiological discussion of symptoms and health effects of ozone exposure. Future reports will estimate benefits of ozone control and explore methods used to value symptoms in greater depth. More specifically, benefits of ozone reduction will be based on medical demand equations presented in this report (see Chapter 6) and can be submitted within fifteen to thirty days. The further exploration of symptom valuation methods will be based on new data presently being collected in Los Angeles. These data will be analyzed during the remaining months of 1986.

Several previous research efforts aimed at estimating dollar health benefits of reducing ozone levels have focused mainly on measures of illness. For example, Gerking and Stanley (1986) examined the connection between the health of St. Louis residents, the ozone levels they face, and their consumption of medical care. Additionally, Portney and Mullahy (1983) analyzed the impact of ozone on health measures including restricted activity days, bed disability days, and work loss days among respondents in the 1979 national Health Interview Survey. Studies of this nature, however, do not explicitly consider health benefits arising from reductions in subclinical or minor symptomatic discomforts of ozone. Reducing these discomforts, which include headache, throat irritation, cough, and chest pain, is a potentially large source of benefits for three interrelated reasons. First, as discussed more fully in Gerking et al. (1984), minor symptomatic discomforts can occur even in healthy adults at ambient ozone levels below the present federal standard of 12 pphm. Second, even though these discomforts are less serious than diseases such as asthma, emphysema, and chronic bronchitis, they do cause individuals to limit activities. Third, these discomforts and activity limitations are experienced by a large share of the exposed population. As a consequence, willingness to pay to avoid them may be substantial and should be taken into account in the regulatory impact assessment process.

Two methods previously have been used to estimate benefits of reducing health symptoms associated with ozone exposure: (1) the cost of illness method (COI) and (2) the contingent valuation method (CVM). The COI has been applied both formally and informally by academicians and policymakers alike to estimate the direct and indirect expenditures required for symptom relief. As discussed in Chapter 2, examples of costs considered by this method include medical expenses and income foregone due to work loss. A fundamental criticism of the cost of illness approach, however, is that it does not correctly measure willingness to pay (WTP) to avoid symptoms. Barrington and Portney (1982) and Berger et al. (1985) argue that WTP generally exceeds COI estimates because the latter accounts neither for the disutility effects of symptoms (i.e., “pain and suffering”) nor for defensive expenditures for goods other than medical care. Consequently, the CVM, in which individuals are asked directly for their willingness to pay to avoid symptoms, has received attention.

CVM estimates of WTP to avoid ozone related symptoms were obtained by Green et al. (1978) and Berger et al. (1985). Table 1.1 presents example findings from the Berger study. In particular, symptoms are listed in the first column and mean CVM bids to avoid these symptoms for one day are presented in the second column. These estimates imply that if the average individual experienced each of these symptoms 10 days per year, he would be willing to pay $5335.50 annually to obtain complete relief.

TABLE 1.1. CVM BIDS TO AVOID OZONE RELATED SYMPTOMS FOR ONE DAY

Symptom	Mean Daily WTP
Coughing Spells	$105.34
Stuffed Up Sinuses	$ 38.84
Throat Congestion	$ 43.93
Headache	$173.21
Itching Eyes	$172.23

SOURCE: Berger et al. (1985)

This study estimates daily WTP to avoid ozone related symptoms using a new methodology, the averting behavior method (ABM). The ABM, which is based on an explicit model of consumer choice, yields estimates of WTP that are substantially lower than those obtained from the CVM. The model has two key features. First, good health is a direct source of satisfaction to the individual. Thus, the method can account for the disutility from experiencing symptoms. Second, individuals engage in averting activities in order to reduce the probability of symptom occurrence. Those adjustments, which include spending less time outdoors, driving an air conditioned automobile, using air conditioning and air purifying systems in the home, and cooking with electricity rather than gas, form the basis for the WTP calculations. In the simplest version of the model, where only one symptom is considered, marginal WTP for symptom avoidance is

$$WTP = \frac{q_i}{s_i} \qquad (1)$$

In equation (1), q_i denotes the full (time inclusive) price of the i^{th} averting activity and s_i denotes the marginal product of the i^{th} averting activity in reducing the symptom. In other words, marginal WTP equals the marginal cost of symptom avoidance. The derivation of this equation is presented in Chapter 2. Estimating WTP in more complex situations where multiple symptoms and multiple averting activities are present is considered in Chapter 3.

Data used to estimate WTP for symptom avoidance were collected from 229 residents of Glendora and Burbank. These individuals, who previously participated in the UCLA study Chronic Obstructive Respiratory Disease (CORD) (Detels et al. 1979, 1981) were contacted an average of just under four times apiece over the period July through December, 1985. Symptom experiences, health measures, and information on averting activities were obtained for the two days preceding the contact. The sample was stratified so that approximately 30 percent of the observations were obtained from individuals with physician diagnosed asthma, bronchitis, emphysema, or other respiratory disease. As a consequence, separate WTP estimates can be obtained for individuals with normal respiratory function and for those whose respiratory function is impaired. Daily air pollution measures on sulfur dioxide, oxides of nitrogen, and ozone, obtained from the South Coast Air Quality Management District, were merged with the information on symptoms and averting activities to complete the data set. Sampling and data collection are discussed more fully in Chapter 4.

To estimate the S_i terms in equation (l), production functions were estimated for nine symptoms, listed in the first columns of Tables 1.2 and 1.3, that have been linked to ozone exposure in prior epidemiological research (Tashkin et al., 1983). The econometric procedure combined a limited dependent variables approach in a simultaneous equations framework. A limited dependent variables model, logit, was applied because the variables measuring symptoms were binary dummies. A simultaneous equations framework was necessary because many averting activities are jointly determined with symptoms. For example, medical treatment may alleviate symptoms, but the onset of symptoms may prompt individuals to seek medical treatment. Chapter 5 discusses estimation procedures in greater detail.

Calculations of WTP to avoid one day's experience with particular symptoms, considered at length in Chapter 7, were obtained by combining estimates of S_i with direct data on the costs of averting activities. These calculations, shown in Tables 1.2 and 1.3, pertain to persons with normal respiratory function and those with impaired respiratory function. In these tables, the first column on the left hand side lists symptoms of ozone exposure and the second column lists the averting activity (or activities) used in the marginal product and price calculations. As shown,

TABLE 1.2. AVERTING BEHAVIOR AND WTP: NORMAL SUBSAMPLE SIMULTANEOUS EQUATION ESTIMATES

Symptom	Averting Good	Change in Probability of Symptom	Expected Symptom-Days Avoided	WTP per Symptom-Day Avoided
Could Not Breathe Deep	---[a]	---[a]	---[a]	---[a]
Pain on Deep Inhalation	GASCOOK*	.0079	2.88	$29.12
Out of Breath Easily	---[a]	---[a]	---[a]	---[a]
Wheezing/ Whistling Breath	---[a]	---[a]	---[a]	---[a]
Chest Tight	ACCAR***	.0116	4.25	$35.76
Cough	ACCAR*** GASCOOK***	.0287 .0866	10.47 31.63	$14.18 $2.66
Throat Irritation	ACCAR***	.0291	10.63	$14.30
Sinus Pain	ACCAR***	.0300	10.94	$13.89
Headache	ACCAR*	.0211	7.69	$19.77

[a]No coefficients of averting goods were correctly signed and statistically significant at 10 percent using a one-tail test in symptom production function.

*Denotes coefficient significant at .01 (one-tail) in symptom production function.

**Denotes coefficient significant at .05 (one-tail) in symptom production function.

***Denotes coefficient significant at .10 (one-tail) in symptom production function.

TABLE 1.3. AVERTING BEHAVIOR AND WTP: IMPAIRED SUBSAMPLE SIMULTANEOUS EQUATION ESTIMATES

Symptom	Averting Good	Change in Probability of Symptom	Expected Symptom-Days Avoided	WTP per Symptom-Day Avoided
Could Not Breathe Deep	GASCOOK**	.0908	33.14	$2.53
Pain on Deep Inhalation	ACCAR*	.0258	9.41	$16.15
Out of Breath Easily	GASCOOK***	.0954	34.82	$2.41
Wheezing/ Whistling Breath	GASCOOK**	.0781	28.51	$2.94
	ACHOME***	.0677	24.70	$16.80
Chest Tight	ACHOME*	.0476	17.38	$23.87
	ACCAR*	.0709	25.88	$5.87
	GASCOOK***	.2376	86.71	$0.97
Cough	ACCAR*	.0536	19.56	$7.77
Throat Irritation	ACCAR**	.0685	24.99	$6.08
Sinus Pain	ACHOME**	.0505	18.45	$22.49
Headache	ACHOME*	.0629	22.96	$18.07
	APHOME*	.0634	23.41	$5.21

*Denotes coefficient significant at .01 (one-tail) in symptom production function.

**Denotes coefficient significant at .05 (one-tail) in symptom production function.

***Denotes coefficient significant at .10 (one-tail) in symptom production function.

the four averting activities used are: (1) automobile air conditioning (ACCAR), (2) home air conditioning (ACHOME), (3) home air purifier (APHOME), and (4) switching from gas to electric cooking (GASCOOK). The third column from the left gives the change in daily probability of symptom occurrence as the averting good is employed; and in the fourth column, the daily probability change is multiplied by 365 to obtain the expected number of days per year the symptom would be avoided. Dividing the expected number of symptom days avoided into annualized full prices for the averting good yields the WTP per symptom-day avoided.

Before considering the WTP estimates in detail, four qualifications should be made explicit. These qualifications imply that the WTP figures are not precise and instead should be regarded as order-of-magnitude estimates. First, the estimates are based on estimated logistic regression coefficients. These coefficients have a probability distribution and, consequently, the true parameters which determine the productivity of the averting goods are measured subject to error. Second, construction of annualized full prices for the averting goods is arbitrary to some extent because particular values were chosen to approximate retail sales price, maintenance costs, interest rates, length of life and scrap values. Third, the four averting goods analyzed may provide direct utility; thus, calculations of WTP to avoid symptoms are upper bound estimates. Fourth, the estimates presented are based on frequency of symptoms. Symptom intensity, which may differ between the normal and impaired groups, is a difficult dimension to add to the analysis and may be a useful area for further research.

Table 1.2 shows that the WTP estimates for the normal subsample range from $2.66 to avoid one day of cough to $35.76 to avoid one day of chest tightness. Four of the WTP estimates cluster in the range from $13.89 to $19.77. Two WTP estimates, based on GASCOOK and ACCAR, were calculated for cough. These estimates are $2.66 and $14.18, respectively. The reason for this difference is that, GASCOOK is three times more productive than ACCAR in eliminating days of coughing (see column 4, Table 1.2) and the cost of switching from gas to electric cooking is lower than the cost of an automobile air conditioner. Also, WTP was not calculated for three symptoms, could not breathe deep, out of breath easily, and wheezing/whistling breath due to poor performance of all averting behavior variables in the estimated SPFs. As shown in Table 4.2 in Chapter 4, however, these symptoms were present in less than 3.5 percent of the observations in this subsample; consequently, there is little variation in the dependent variables for the averting behaviors to explain.

WTP estimates calculated for the impaired subsample for each of the nine symptoms range from $0.97 to $23.87. These two estimates both pertain to chest tightness and are based on GASCOOK and ACHOME, respectively. Two or more averting behaviors also were used to calculate WTP for the symptoms wheezing/whistling breath and headache. In Table 1.3, WTP estimates tend to be lowest when based on GASCOOK and highest when based on ACHOME. This outcome reflects both the productivity of each good in eliminating symptom days as well as their full prices.

The WTP estimates can be better understood by comparing the results for the normal subsample with those for the impaired subsample. Notice that normal individuals tend to be willing to pay more than impaired individuals to avoid a day's experience of a particular symptom. This result is most striking in cases where the same averting good is used to calculate WTP for avoiding a particular symptom in both the normal and impaired subsamples (i.e., compare the WTP estimates based on ACCAR for chest tight, cough, and throat irritation). The explanation for this outcome lies in the relationship between the logistic functional form chosen for the SPFs, the implied marginal cost schedule for symptom day reduction, and the difference in symptom frequency in the normal and impaired subsamples. These concepts are illustrated in Figures 1.1 and 1.2.

Figure 1.1 shows logistic cumulative distribution functions for symptom avoidance in normal and impaired individuals. In particular, the vertical axis shows the daily probability of avoiding a symptom and the horizontal axis measures the quantity of inputs employed in symptom reduction. The curve for the normal individuals lies above the curve for the impaired individuals. Thus, for given quantities of inputs devoted to symptom reduction, impaired individuals have a greater probability of symptom occurrence. Also, each cumulative distribution function takes the ogive shape often assumed to hold for biological dose response functions. Mathematically, this ogive shape is quasi-concave and is the curvature required for economic production functions.

Assuming that all individuals face the same prices, logistic SPFs imply marginal cost schedules of the form shown in Figure 1.2. Because the impaired group has inferior SPFs, its marginal cost schedule lies above those for the normal group. Additionally, Figure 1.2 illustrates a typical situation in which the normal group experiences symptoms less frequently

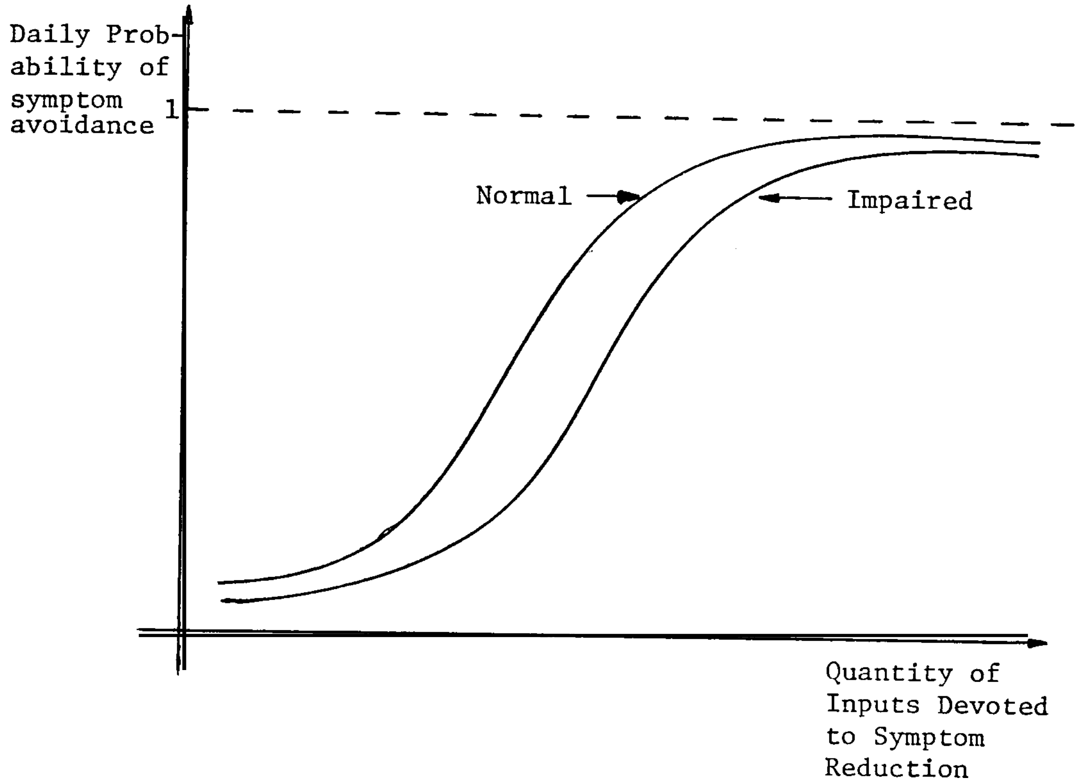

Figure 1.1. Logistic Cumulative Distribution Functions for Avoiding Symptoms

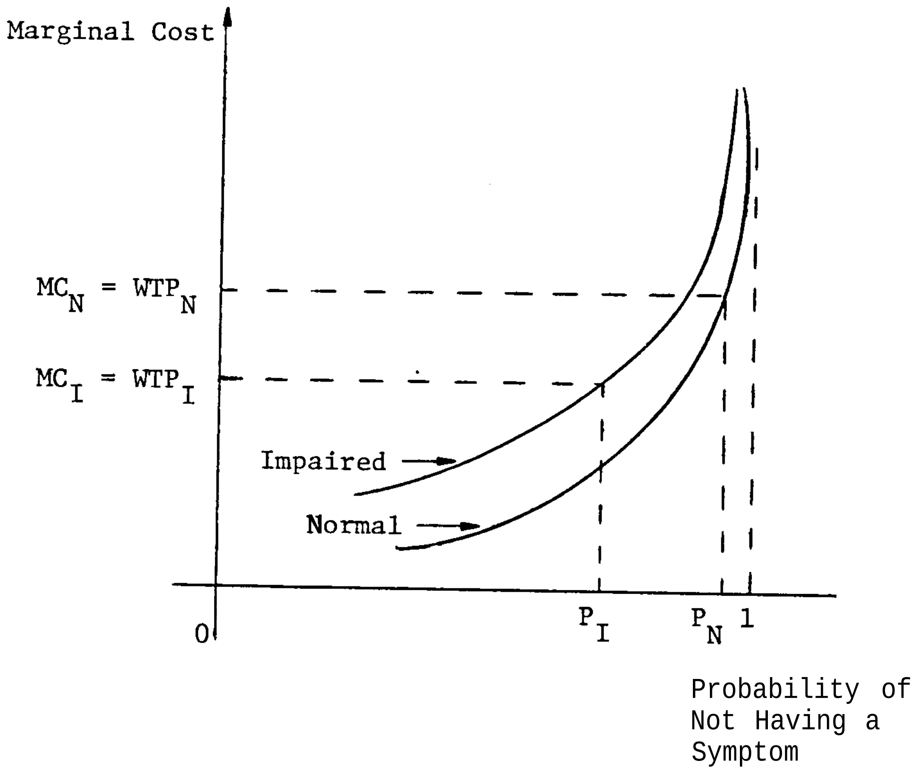

Figure 1.2. Marginal Cost Schedules for Avoiding Symptoms

than the impaired group. (Table 4.2 in Chapter 4 shows that this relationship holds for all nine symptoms analyzed.) Letting P_I and P_N denote the probabilities of not experiencing a symptom on a given day among impaired and normal group members, then $P_N > P_I$. If $P_N > P_I$, then normal group members are operating on more steeply sloped portions of their marginal cost schedules than are impaired group members. Alternatively stated, averting goods are more productive in reducing symptom days for impaired group members than for normal group members. In the empirical analysis this outcome is easily seen by comparing the fourth columns of Tables 1.2 and 1.3. Expected symptom days avoided are uniformly higher for the impaired group than the normal group. Thus, willingness to pay to avoid one symptom day is generally higher for the normal group members than for impaired group members (i.e., $MC_N = WTP_N > MC_I = WTP_I$).

To this point, the discussion has focused on marginal willingness to pay to avoid one day of symptom experience. $WTP_I < WTP_N$ because impaired group members experience symptoms more frequently and therefore have more symptom days that can be eliminated by taking averting action. This result, however, does not imply that the total willingness to pay to avoid symptoms is larger for normal group members than for impaired group members. To appreciate this distinction, first notice that the total willingness to pay to eliminate a symptom entirely would be infinite for both groups. The logistic SPFs imply that the probability of not experiencing a symptom is driven to unity only asymptotically. Consequently, the area under both marginal cost schedules between an arbitrary lower limit ($0 < P < 1$) and the upper limit $P = 1$ would be infinite. Next, consider a hypothetical symptom experienced by the two groups with equal frequency; for example, $P_I = P_N = .95$. The total WTP for increasing P_I and p_N to, say, .98 would be unambiguously larger for the impaired group than for the normal group. This total WTP calculation would measure the area under the two marginal cost schedules between P = ,95 and P = .98. Because the marginal cost schedule for the impaired group lies above the corresponding schedule for the normal group, the area under the former marginal cost schedule exceeds that for the latter.

Calculations of total WTP for the two groups could be made for each symptom using the SPF estimates presented in this chapter. Using the same upper and lower limits, the areas under impaired and normal marginal cost schedules could be evaluated. This comparison, however, could be highly misleading if the limits lie outside the range of observations for either group. A check of the SPFs reveals that this situation would arise for all nine symptoms. As a consequence, total WTP estimates were not calculated.

A further perspective on the WTP estimates presented in Tables 1.2 and 1.3 can be obtained by examining the contingent valuation bids in Table 1.4. In addition to the information needed to implement the ABM, the data collection instruments used in this study also asked directly for respondent's WTP to avoid one day's experience with ozone related and other symptoms. Bids were obtained only from respondents who reported having experienced the symptom with the previous 48 hours. Consequently, bids are linked to specific, recent events that are fresh in respondent's minds.

As shown by comparing the figures in Table 1.4 with those in Tables 1.2 and 1.3, the CVM bids for avoiding symptoms always are larger than those obtained with the ABM. Certain CVM bids exceed their ABM counterparts by a factor 10 or more. Also, in contrast to the ABM

TABLE 1.4. CVM ESTIMATES OF WTP FOR AVOIDING SYMPTOMS FOR ONE DAY

Symptom	Normal Mean Bid	Impaired Mean Bid
Could not Breath Deep	$ 32	$271
Pain on Deep Inhalation	$ 42	$194
Out of Breath Easily	$256	$374
Wheezing/Whistling Breath	$ 12	$334
Chest Tight	$204	$198
Cough	$140	$205
Throat Irritation	$ 45	$213
Sinus Pain	$ 97	$239
Headache	$126	$154

estimates, the CVM bids from impaired individuals exceed those elicited from normal individuals. A complete explanation of the large discrepancies between the CVM and ABM results will require further research. Nevertheless, speculation a to reasons underlying this outcome still is possible. One factor that may have contributed to the order of magnitude differences between ABM and CVM WTP estimates is that the former is based on revealed preferences whereas the latter is based on expressed preferences. Preferences can be expressed at zero cost; consequently, they may be a less reliable guide in estimating WTP for avoiding symptoms. A second factor is that the CVM bids are biased upward. As explained in Chapter 2, use of Heckman's (1979) technique to correct for sample selection bias may reduce estimates of the mean CVM bids. Additionally, since this technique adjusts for the probability that the symptom occurs, it could reverse the ordering of the CVM estimates of WTP between the normal and impaired groups. Third, in answering the contingent valuation question, respondents may have been bidding to avoid more than one day's experience with a symptom. The data collection instruments asked explicitly for bids to avoid a symptom for one day. Yet some respondents still may have bid to avoid symptoms for longer periods of time. Fourth, the comparatively large mean values in CVM responses often are due to very large bids given by a few respondents. Trimming the CVM bids by eliminating 2.5 percent of the bids in each tail of the bid distribution often produce very large reductions in the mean bid.

Fifth, large CVM bids may have been given by respondents who have been troubled by a symptom, but have not found a remedy or averting action that is effective in relieving it. Consider, for example, a business executive who experiences a particularly nagging headache and cannot obtain much relief using known pain medications. As indicated in equation (l), WTP would be large in this case because of the low marginal product of averting actions. Alternatively stated, this individual’s only remedy may be to stay home and rest; a costly option if important business is to be conducted. In any event, the relationship between possible averting activities and the size of CVM bids will be explored in ongoing research that already is underway. Until this research is completed, however, use of the lower ABM symptom value estimates is recommended for policy purposes.

CHAPTER 2

AIR POLLUTION, EPIDEMIOLOGY, AND ECONOMICS: A SURVEY

2.1 INTRODUCTION

Estimating human health benefits from reduced air pollution is important both to policymakers and academics. From a policy perspective, the Clean Air Act and its subsequent amendments direct the USEPA to establish primary standards to protect human health, with special emphasis on the health of particularly sensitive population groups. Additionally, Executive Order #12291 requires Regulatory Impact Assessments of major federal rules and regulations, making benefit-cost analysis of health oriented standards an important practical issue. From an academic viewpoint, valuation of improved health and other nonmarket commodities is a key aspect of applied welfare and environmental economics. Yet, until recently, methods used to compute benefits of reduced morbidity and mortality often have not been based on a measure of willingness to pay. As a consequence, there now is considerable interest in developing theoretically defensible and empirically feasible methods for valuing these benefits.

These two sources of interest in estimating the benefits of improved health have motivated a considerable volume of research. Relatively more research has been devoted to the mortality effects of air pollution and, more generally, to estimating the "value of life." One reason for this emphasis is that death is more easily measured than illness or injury.

Death is a one dimensional event, while there are varying degrees of illness and injury. However, benefits of reduced morbidity are equally important to obtain in light of the need to evaluate the removal of nonfatal hazards.

This chapter critically reviews methods for estimating benefits of reduced morbidity. A corresponding recent survey of methods for estimating the marginal value of safety or "value of life" may be found in Fisher, Chestnut, and Violette (1986). Additionally, a somewhat older but still highly useful survey of morbidity benefit estimation has been prepared by Chestnut and Violette (1984). This review of morbidity benefit estimation focuses on three methods. Section 2.2 surveys the cost of illness method and Section 2.3 surveys the contingent valuation method. The averting behavior method is discussed in Section 2.4. As indicated in chapter 1, developing the averting behavior method is the major focus of this research; consequently, averting behavior is treated more comprehensively than the other two methods. Conclusions are presented in Section 2.5.

2.2 THE COST OF ILLNESS METHOD

The cost of illness (COI) method measures the total economic cost which morbidity imposes on society and does not estimate willingness to pay (WTP). This total cost Is defined as the sum of direct and indirect costs. Direct costs measure the value of resources devoted to the treatment of illness including (1) hospital care, (2) nursing home care, (3) home health care, (4) services of physicians, dentists, and other health specialists, (5) drugs, and (6) eye glasses. Indirect costs measure the value of lost productivity due to illness. Indirect costs usually are estimated by the wage multiplied by the time lost from work, often with some adjustment for the value of homemaker services. Losses associated with disutility of illness, such as for pain and suffering, are not included in cost of illness estimates.

Total costs may be estimated on either a prevalence or an incidence basis. The prevalence of a disease is the number of existing cases of the disease in a given time period. Prevalence based costs, then, are all costs associated with all cases of the disease in that time period. The incidence of a disease is the number of new cases of the disease that occur in a given time period. Incidence based costs are all discounted costs associated with new cases of the disease, from the onset of illness until recovery or death occurs. Prevalence and incidence are nearly identical for short term illnesses, such as the minor symptoms which are the focus of this research.

Hartunian et al. (1980) argue that prevalence based costs are more relevant for analyzing programs that would reduce the severity of existing cases of disease, while incidence based costs should be used for programs that involved prevention of additional cases of disease. As Chestnut and Violette (1984) point out, air pollution may be associated both with increased severity of existing diseases and increased incidence of illness. Thus, both prevalence and incidence based costs are relevant to pollution control questions. Prevalence-based costs are more available, however, and hence are used more often in COI studies.

To use the COI to value the impact of air pollution on morbidity, a two-step procedure often is employed. In the first step, the marginal effect of air pollution on health is derived from a physical damage function which relates a particular health effect to measures of air quality and a set of sociodemographic, medical, and perhaps lifestyle variables. In the second step, total direct and indirect costs attributable to air pollution are computed by applying COI estimates of the medical expenses and the value of time lost from work associated with the health response to air pollution. There are at least two important variations to this two step procedure which have been used by economists studying air pollution and morbidity. One variation is to define the dependent variable in the damage function in dollar terms; for example, medical expenses could be regressed on air pollution and other variables to estimate the impact of air pollution on direct costs. The second variation is to estimate only the damage function and provide no benefit estimates.

The paper by Seskin (1979) is an example of the two-step damage function procedure and is particularly relevant because it focuses on oxidant pollution. The work of Jaksch and Stoevener (1974) and Bhagia and Stoevener (1978) illustrate the method of defining the damage function in value terms. Ostro (1983) and Portney and Mullahy (1983) estimate damage functions but do not provide benefit estimates. Like Seskin, Portney and Mullahy concentrated on oxidant pollution. In addition to these five studies, this section will review the widely cited paper by Cooper and Rice (1976) because it is used as a basis for many COI estimates. For a comprehensive review of the COI method generally, see Hu and Sandifer (1981).

2.2.1 Cooper and Rice (1976)

Cooper and Rice updated the prevalence based illness cost estimates of Rice (1966) to the year 1972. Costs were allocated among 16 disease categories on the basis of primary diagnosis. For each disease, direct costs were allocated among seven medical expenditure categories, such as hospital care, physicians services, drugs and drug sundries. Total direct costs of illness in 1972 were approximately $90 billion. Of this total, approximately $75 billion were allocated to the primary medical expenditure categories described above. Costs for research, construction, program administration, government public health activities, and insurance net revenue, representing about $15 billion, were not allocated to particular diseases. Data on lost work days by primary diagnosis, age, and sex were multiplied by mean wages to estimate indirect costs for the employed population. Indirect costs for housekeeping services were computed on the basis of market prices for comparable services. Indirect costs for those unable to work due to illness or disability and for the institutional population were computed by estimating the percentage of the disabled or institutionalized individuals who could be expected to be employed or keeping house were they not disabled or institutionalized.

The Cooper and Rice estimates of total direct and indirect costs of illness are presented in Table 2.1. Two aspects of the Cooper and Rice estimates are relevant to the research reported later in this volume. First, colds, flu, and other respiratory diseases account for 30 percent of all morbidity losses. Second, 25 percent of expenditures for physician services, the second largest expenditure category, were for "special conditions without sickness" and "symptoms and ill-defined conditions." These two results suggest that direct and indirect costs may be significant for the minor symptomatic discomforts considered in this research, particularly for the respiratory symptoms.

TABLE 2.1. TOTAL COSTS OF ILLNESS, 1972

Type of Cost	Dollar Amount (in billions)	Percent of Total
Direct Costs[a]	$ 75.2	39.8%
Indirect Costs		
Morbidity	42.3	22.5
Mortality	71.3	37.8
Total Costs	188.8	100.0

[a]Direct costs in 1972 actually were estimated at $90 billion, but $15 billion were left unallocated.

Source: Cooper and Rice (1976)

2.2.2 Seskin (1979)

Seskin applied the Cooper and Rice cost estimates to a damage function relating oxidant pollution to short-term health effects. Data for unscheduled visits for outpatient care were obtained from a prepaid group practice medical care plan of about 100,000 members in the Washington, D.C. area. These visits were chosen because they best reflect acute, or short-term, health responses to air pollution. Unscheduled visits in 1973 and 1974 to the following four departments were considered: urgent visit clinic, internal medicine, pediatrics, and ophthalmology. The only consistently significant pollution-unscheduled visit relationship was between oxidants and unscheduled visits to ophthalmology in both 1973 and 1974.

An effort was made to uncover lagged effects of air pollution by including the three previous days' air pollution measures in the regression as well as by using an Almon distributed lag procedure. To test for episodic effects, the current day's air pollution was multiplied by air pollution on the previous two days. Synergistic effects were investigated by entering in the regression the products of oxidant pollution and the following three pollutants: nitrogen dioxide (NO_2), sulfur dioxide (SO_2), and carbon monoxide (CO). No significant lag, episodic, or synergistic effects were found.

Benefits were estimated by calculating the effects of the roughly 50 percent reduction in oxidant pollution necessary to comply with national standards. The regression equation predicted that a six percent decrease in unscheduled ophthalmology visits, amounting to 135 fewer visits, would have resulted from a 50 percent reduction in oxidant pollution in 1973.

Linear regressions normally are regarded as local linear approximations to a true damage function of unknown functional form. Assuming that linearity holds in the face of a 50 percent reduction in ozone levels may not be warranted. In any case, at $20 per visit, this six percent reduction in visits yields a direct cost savings (or benefit) to group members of $2,700. Cooper and Rice estimates indicate that for diseases of the nervous system and sense organs, indirect costs are about 66 percent of direct costs, implying an indirect cost figure of $1,790 for 1973. Total costs for group members then were $4,490. For illustrative purposes, results for this group were extended to the entire Washington population by multiplying by 20, yielding an area-wide benefit estimate of about $89,800 annually or about $.04 per resident per year.

2.2.3 Jaksch and Stoevener (1974) and Bhagia and Stoevener (1978)

Jaksch and Stoevener also attempted to quantify a relationship between outpatient medical services and air pollution. Medical services were defined both in dollar terms and in terms of number of visits. Data from the Kaiser Foundation Health Plan were combined with meteorological and particulate data for the Portland, Oregon SMSA. Deteriorating air quality was found to be associated with an increased consumption of outpatient services per outpatient contact, but not with an increased number of outpatient contacts. In contrast to Seskin (1979), Jaksch and Stoevener found a time delay between exposure to relatively high levels of particulate and contact with the medical system. Bhagia and Stoevener conducted a parallel study of the dollar value of the consumption of inpatient medical services as related to total suspended particulate

(TSP). No significant relationship was found between TSP and the consumption of inpatient medical services.

2.2.4 Ostro (1983)

Ostro (1983) estimated damage functions relating health, socioeconomic, weather, and pollution variables to work loss days (WLDs) and restricted activity days (RADs). Using data from the 1976 Health Interview Survey (HIS) conducted by the National Center for Health Statistics allowed Ostro to control for a wide range of health and socioeconomic variables. These health and demographic data were merged with weather data from the National Oceanic and Atmospheric Administration (NOAA) and with pollution data from EPA's Storage and Retrieval of Aerometric Data (SAROAD). The pollution variables chosen were the annual arithmetic means of TSP and sulfates.

Ostro restricted the sample to 84 SMSAs of medium population (100,000 to 600,000 people) in order to reduce the degree of intracity variation in pollution. Thus, his results are not necessarily representative of all cities in the U.S. Three subsamples were employed in the analysis. The first sample included all people aged 18 to 65 in the RAD regression and all workers aged 18 to 65 in the WLD regression. The second sample was identical to the first except that all smokers were excluded to control for possible synergistic effects between pollution and cigarettes as well as for the possible simultaneous determination of smoking and health status variables. The third sample consisted of male nonsmokers aged 18 to 65. For this third sample, no analysis of RADs was presented.

For each of the three samples, Ostro used ordinary least squares to regress the number of WLDS (and the number of RADs for the first two samples) on the following independent variables: the annual arithmetic means of total suspended particulate (TSP) and sulfates, annual mean temperature, annual precipitation, population density, the number of chronic conditions the respondent reported, age, income, the number of cigarettes smoked (for the first sample only) and dummy variables for race, gender, marital status, and whether respondent was a blue collar worker. The WLD regressions explained about one percent of the variation in WLDs, while the RAD regressions explained about 10 percent of the variation in RADs. For the first two samples, the coefficient on annual mean TSP was positive and significant at the five percent level in the WLD regressions and at the one percent level in the RAD regressions in one-tailed tests. The estimated elasticities of WLD and RAD with respect to TSP ranged from 0.31 to 0.52. Sulfates often entered the equation with a negative coefficient, but the sulfate coefficient never was significant. The number of chronic conditions was positively and significantly related to the number of WLDs and RADs at the one percent level, as were age and annual average temperature.

As Ostro points out, OLS is not the appropriate statistical model to analyze WLDs or RADs since both these variables are truncated at zero (for example, 70 to 95 percent of the respondents in Ostro’s sample reported zero days lost from work). As a consequence, Ostro experimented with two other statistical approaches in his analysis of WLDs for male nonsmokers (the third sample). The first of these alternatives was the Tobit model, which accounts for the truncation of the dependent variable. The results from the Tobit regression were similar to those from the OLS regressions.

In particular, TSP was positively and significantly (at five percent) related to WLD.

Ostro argues that the Tobit technique has the disadvantage of assuming that the same factors which cause the existence of a work loss day also explain the number of work loss days experienced. Thus, he proposes a two-step logit-linear model as being most consistent with the data. In the first step, a logit regression is used to explain the probability of an individual having at least one WLD during the survey period. In the second step, a conditional linear regression is used to explain the number of WLDs, given that one has occurred. The results from these regressions suggest that TSP is positively and significantly associated with the probability of at least one WLD occurring, but not with the number of WLDs which occur.

Unfortunately, the estimated coefficients in Ostro’s second stage linear regression are biased and inconsistent estimates owing to sample selection bias. The second step of Ostro’s logit-linear model may be written

$$WLD_t = \begin{cases} X_t'\beta + e_t & \text{if } WLD_t > 0 \\ 0 & \text{otherwise,} \end{cases} \qquad (1)$$

where X_t is a vector of explanatory variables for individual t, ß is the parameter vector to be estimated, and e_t is a random disturbance, t = 1, ..., T. Following Judge et al. (1985), assume that the last

zero, but the first (T - s) are nonzero. Then Ostro's second stage regression function can be written

$$E(WLD_t | X_t, WLD_t > 0) = X_t'\beta + E(e_t | WLD_t > 0) \qquad (2)$$

$$t = 1, \ldots, T - s$$

where E is the expectation operator. The problem is that the conditional expectation of the error term is not zero, which violates the assumptions underlying ordinary least squares:

$$E(e_t | WLD_t > 0) = E(e_t | e_t > -X_t'\beta) = \sigma\lambda_t, \tag{3}$$

where

$$\lambda_t = \frac{f(-X_t'\beta/\sigma)}{1 - F(-X_t'\beta/\sigma)}, \tag{4}$$

where $f(\check{Z})$ and $F(\check{Z})$ are, respectively, the density and cumulative distribution of a standard normal random variable and where it has been assumed that the e_t are independent normal random variables, with mean zero and variance σ^2. Thus Ostro's regression function can be written

$$E(WLD_t | X_t, WLD_t > 0) = X_t'\beta + \sigma\lambda_t, \qquad t = 1, \ldots, T - s. \tag{5}$$

Least squares omits the "sample selection" term on the right hand side of equation (5), and as a consequence produces biased and inconsistent estimates of the parameter vector β/σ whether applied to the whole sample or the subsample of nonzero observations (see Judge, et al., 1985).

In addition to the use of inappropriate statistical models, Ostro's analysis suffers from some data limitations. First of all, the exclusive use of average annual pollution measures to explain the acute morbidity measures WLD and RAD is questionable, given the evidence linking acute morbidity to peak pollution readings. Second, as Ostro points out, the degree of illness endured before missing work is a subjective decision, and it may be a decision involving many factors which are not controlled in Ostro's equations such as the hourly wage and the availability of paid sick leave. While sick leave data are relatively unavailable, dummy variables for industry might proxy for this factor, as might Ostro's blue-collar dummy. Finally, there is no control at all for preventive or ameliorative health care.

2.2.5 Portney and Mullahy (1983)

Portney and Mullahy (1983) conducted a damage function analysis of chronic and acute morbidity with special emphasis placed on ozone (O_3) as a contributing cause of morbidity. These authors merged 1979 HIS data, including special supplements on residential mobility and lifetime cigarette consumption, with weather and pollution data obtained from, respectively, NOAA and SAROAD. In addition, Portney and Mullahy used data on paid sick leave from a 1974 HIS supplement. The data set they constructed also included aggregate measures of the availability of doctors, the probability of cooking with natural gas, and pollen. No data on diet, exercise, or alcohol consumption were used.

Since the basic damage function technique has been illustrated earlier in this section of the literature review, a comprehensive survey of the work of Portney and Mullahy will be foregone. Rather, this subsection will focus on results pertaining to ozone and measures of acute morbidity.

Ozone was almost always positively, but often insignificantly, related to acute health effects. Positive and significant associations were found between ozone and both minor restricted activity days and total restricted activity days. A restricted activity day (RAD) is a day on which a respondent cuts down on his usual activities for the entire day because of illness or injury. A minor restricted activity day is an RAD that does not involve work loss or bed disability. No significant association between ozone and work loss or bed disability were found.

Portney and Mullahy estimated that a 1 pphm reduction in the average daily maximum one-hour ozone concentration would result in 0.64 fewer minor RADS due to all causes per person-year. Extrapolating this result to a U.S. SMSA population of about 110 million adults gives a 70.4 million day decrease in minor RA.Ls due to all causes for a 1 pphm decrease in ozone.

Additionally, Portney and Mullahy estimated that a 1 pphm decrease in average daily one-hour maximum ozone concentrations would reduce total RADs due to acute respiratory disease by 0.39 days. Again extrapolating the number of person-days to an SMSA population of 110 million, an estimate of 42.9 million fewer RADs due to acute respiratory disease is obtained.

Portney and Mullahy also found some evidence that ozone increases the incidence of chronic disease. If this is true, then the effect of ozone on acute morbidity equals the sum of the direct effect and an indirect effect operating through the change in chronic morbidity. Those authors estimated that the indirect effect was 23 percent of the direct effect.

2.3 THE CONTINGENT VALUATION METHOD

A fundamental criticism of the cost of illness approach is that it does not correspond to a theoretically correct measure of the benefits of reduced morbidity such as willingness to pay (WTP). Harrington and Portney (1982) argue that the WTP exceeds COI because the latter accounts neither for the disutility effects of disease nor defensive expenditures for goods other than medical care. Additionally, in a recent theoretical analysis, Berger et al. (1986) rigorously show that COI underestimates WTP in all but a special case. As a consequence, alternative benefit estimation methods, including the contingent valuation method (CVM) have received considerable attention.

In applying the CVM, survey respondents are presented with a hypothetical situation describing how a change in morbidity will be accomplished and how payment would be made. Payment mechanisms include the use of iterative bidding, payment cards, and “referendum” questions. Regardless of which mechanism is adopted, however, the respondents are asked for their maximum willingness to pay for a specific reduction in morbidity or for the minimum compensation they would accept for a specific increase in morbidity. Thus, the CVM, in contrast to the COI, attempts to measure the appropriate theoretical quantity. However, data to implement the CVM must be obtained from primary rather than secondary sources.

CVM benefit estimates are subject to a number of possible biases which are discussed at length by Cummings, Brookshire, and Schulze (1986). One source of bias in data drawn from hypothetical situations, which is most relevant when dealing with public goods, is the strategic misrepresentation of preferences. For instance, a respondent who has a strong desire for a good may overreport his true willingness to pay if he feels that his bid will influence the good’s provision, but that he will never actually have to pay this amount. This potential problem suggests that CVM studies in the morbidity area should focus on valuing changes in private health attributes, such as symptoms, rather than on valuing changes in environmental hazards. If symptoms are valued, then the benefits stemming from environmental changes can be obtained by linking the CVM bids to dose-response or damage functions. Additional biases in the CVM benefit estimates may result if the individual is unfamiliar with the commodity or if the commodity is intangible or complex. As a consequence, more accurate bids may result when the respondent is asked to focus on symptoms experienced in the very recent past (i. e., the last two or three days), rather than on symptoms experienced in the past year, or worse yet, on diseases which are a complex bundle of symptoms. Still other sources of bias include vehicle bias, where the method of payment may influence the results, and starting point bias, where an initial price suggested by the interviewer may influence the final value reported by the respondent.

Even in situations where these potential biases either can be avoided or minimized, the CVM bids obtained across all respondents frequently display an uncomfortably large dispersion. The mean bid sometimes is exceeded by its standard error. Moreover, the bids often display a marked skewness with the mean bid as much as five to ten times higher than the median bid (see Green et al., 1978 for examples of this phenomenon). In specific cases, this skewness may be at least partially accounted for by a few very large bids from respondents who either did not understand the question or were protesting the fact that it was asked. Detecting these bids, however, is difficult because very large bids also may be obtained from individuals in poor health who have been unable to find treatments which effectively relieve their symptoms.

This section surveys six representative studies in which the CVM is applied to air pollution-morbidity relationships. The first three studies (Loehman et al., 1979 and Loehman and De, 1982; Berger, Blomquist, Kenkel and Tolley, 1986; and Rowe and Chestnut, 1984) assess willingness to pay for improvements in health. Using this approach, the resulting morbidity valuation can be related to air pollution with a separately estimated dose-response or damage function. The second set of three studies (Brookshire, d'Arge, Schulze, and Thayer, 1979; Loehman, Boldt, and

Chaikin, 1984; and Schulze et al., 1983) illustrate the alternative method of valuing reductions in air pollution directly. In these studies, respondents are given information on the health effects of air pollution prior to being asked the valuation question. This approach assumes that respondents can implicitly estimate their own dose-response functions.

2.3.1 Loehman et al. (1979) and Loehman and De (1982)

The Loehman et al. (1979) study involved a comprehensive simulation of the effects of changing regulations regarding the sulfur content of coal. Computer models were developed to trace the effects of this policy change on emissions and ambient air quality. A dose response model then was developed to relate ambient air quality, defined in terms of SO_2, NO_2, CO, O_3, and TSP, to the incidence of five diseases: asthma, chronic bronchitis, lower respiratory illness in children, chest pain, and eye irritation. The five disease effects were converted into three classes of symptoms: (1) shortness of breath/chest pain, (2) coughing/sneezing, and (3) head congestion/eye, ear, or throat irritation. The three symptoms were defined in terms of severity and duration as follows. A minor symptom would allow continuation of normal daily activities, while a severe symptom would require restriction of daily activities. Duration was defined as one seven, or 90 days.

Approximately 1800 questionnaires were mailed to residents of the Tampa Bay area of Florida; about 400 of these were returned. Following an explanation that sometimes there exists a tradeoff between discomfort and money, respondents were asked to value the symptoms listed above by marking a payment card which listed 10 values ranging from $0 to $1000.

As can be seen from Table 2.2, the mean CVM bids exceed the medians, reflecting a distribution skewed to the right. The authors suggest that this skewness reflects extremely high bids from some respondents who may have objected to the WTP question. As Chestnut and Violette (1984) point out, however, the skewness may be partly attributable to the increasing size of the increments between dollar amounts listed on the payment card as the dollar amounts increased in size.

Chestnut and Violette also note an ambiguity in the WTP question itself. It seems unclear whether the question relates to a reduction in currently occurring symptoms, or the prevention of additional symptoms. For example, if a respondent did not experience three months of a symptom and interpreted the question as reducing currently occurring symptoms, he naturally would not be willing to pay much.

In any event, Loehman and De (1982) aggregated the sample into income and health groups in order to conduct a logit analysis of the sample odds ratio (P/(1-P)), where P denotes the proportion of the sample who would prefer to pay an amount m rather than suffer an illness of duration d. The log of this odds ratio was regressed on the natural logarithms of: m, d, mean household income (M) and mean days ill in the past year (D) in the income-health group. A number of sociodemographic variables also were included in the regression, including the proportion of respondents in the income-health status group covered by medical insurance. The coefficients on m, d, M, and D all were correctly signed (negative for m and positive for the others) and significant. An interesting feature of the logit regressions is that insurance was negatively and significantly related to the odds of paying a given amount; moreover, the insurance effect was

TABLE 2.2. MEAN AND MEDIAN WTP TO AVOID SYMPTOMS

	Days of Health Effect					
	1		7		90	
Symptom	Mean	Median	Mean	Median	Mean	Median
Mild Shortness Breath	$48.61	$ 4.90	$ 73.87	$13.64	$145.93	$35.96
Severe Shortness Breath	79.15	10.92	136.12	35.93	251.84	97.80
Mild Cough/Sneeze	26.40	2.31	44.67	7.84	86.03	22.85
Severe Cough/Sneeze	45.77	6.95	72.29	19.90	147.48	50.56
Mild Head Congestion/ Eye, Ear, Throat Irritation	32.50	3.80	41.51	9.58	90.37	25.14
Severe Head Congestion/ Eye, Ear, Throat Irritation	53.42	8.17	80.32	20.34	179.94	61.68

Source: Green et al. (1978)

greater for the severe symptoms, those for which it is more likely that medical attention would be sought.

This study represents an early attempt to value symptoms using the CVM. Unlike many applications of the CVM, income had a significant, positive relationship to the bid. In addition, the research suggests a positive association between poor health and WTP, as well as a negative association between insurance and WTP. Several problems with the Loehman et al. research include the low response rate (approximately 22 percent) and the change in the size of the WTP increments as WTP values increased on the payment card. A more serious drawback is the possibility that respondents were not familiar with the symptoms which they were asked to value. Many respondents may never have experienced the more severe symptoms, especially those of a longer duration.

2.3.2 Berger, Blomquist, Kenkel and Tolley (1986)

The Berger et al. research involved several elements, including a theoretical analysis of averting behavior and health under uncertainty, a contingent valuation of seven light symptoms, and an empirical comparison of WTP and COI. The theoretical portion of the Berger et al. paper will be reviewed in Section 2.4; here the focus is on the CVM and its comparison to COI.

The seven symptoms considered by Berger et al. were: (1) coughing spells, (2) stuffed up sinuses, (3) throat congestion, (4) itching eyes, (5) drowsiness, (6) headache, and (7) nausea. Door-to-door and mall intercept methods were used to sample 131 individuals in Denver and Chicago; nine incomplete surveys reduced the number of observations to 122. Respondents were asked the number of symptom days experienced in the previous year and the costs associated with each symptom. Respondents then were asked to rank the symptoms according to their relative undesirability and to state their WTP for additional symptom-free days. Mean daily WTP, mean daily private COI, and a t-statistic for testing the hypothesis that WTP = COI are presented for each of the seven symptoms in Table 2.3. The null hypothesis WTP = COI is rejected five of seven times at the five percent significance level in favor of the alternative WTP > COI.

In their comprehensive review of the CVM, Cummings et al. (1986) specify four "reference operating conditions" (ROCs) under which the use of the CVM is most defensible. The first of these four ROCs states that subjects must be familiar with the commodity to be valued. This first ROC casts some doubt on the Loehman et al. (1979) procedure of allowing randomly chosen respondents to value a severe symptom of long duration, a commodity with which healthier subjects may have no familiarity. Instead, this ROC suggests that the Berger et al. procedure of restricting the CVM analysis to those subjects who actually experienced the symptom may be preferable because those subjects would have at least some familiarity with the commodity they were asked to value. From an econometric viewpoint, however, the Berger et al. analysis of mean WTP may be inappropriate owing to the sample selection bias problem discussed in connection with the Ostro study.

In computing their mean WTP bids, Berger et al. take n. account of the fact that WTP is observed only if a symptom day was experienced. It was mentioned in relation to the Ostro paper that ordinary least squares estimates of the parameters of a model where the dependent variable is observed only if it exceeds some critical value are biased and inconsistent. Recalling that the mean is a population parameter that may be estimated by an OLS regression of the dependent variable on a constant term, it follows that the mean WTP values presented by Berger et al. are biased and inconsistent estimates of population mean WTP. The term to correct for sample selection in the Berger et al. estimate of the mean is $\sigma\lambda_t$, where σ is the square root of the variance of the error and where

$$\lambda_t = \frac{f(-a/\sigma)}{1 - F(-a/\sigma)}, \qquad (6)$$

where a is mean WTP. The term $\sigma\lambda_t$ is positive, implying that mean WTP for the subsample who experienced symptoms (i.e., the OLS estimate of a) is an overestimate of the true mean WTP.

As indicated in connection with the Loehman et al. and Loehman and De studies, another reason that the mean daily WTP values in Table 2.3 appear large, is that cognitive errors on the part of respondents may be responsible for a few very large bids. In other words, some respondents may have given a bid to avoid suffering from a particular symptom ever again, rather than a bid for additional symptom free days at the margin. Yet another possible complication is that respondents may have difficulty recalling the number of days in the previous year on which they suffered from a symptom.

2.3.3 Rowe and Chestnut (1984)

The Rowe and Chestnut study was designed to investigate the effects of air pollution perceptions and averting behavior for a sample of 82 asthmatics in Glendora, a suburb of Los Angeles. Benefits were estimated using the CVM. Respondents were asked to pick the worst rating on a seven-point asthma severity scale which they would consider a “good asthma day." A "bad asthma day" was defined as anything worse than the chosen rating. WTP questions were framed in terms of increased taxes to finance a public program which would decrease the number of bad asthma days by 50 percent. Of the 82 respondents, 69 reported a WTP > 0, 12 reported WTP = 0, and one respondent refused to answer the question. On the basis of an extensive check of the consistency of WTP responses with other data collected in the survey, Rowe and Chestnut selected a sample containing 65 bids, six of which were zero.

The 65 WTP responses selected by the researchers were regressed on the number of bad days reduced, the worst severity rating considered a good day, income, age, sex, and a dummy reflecting whether or not the respondent was an adult. The regression was specified in double-log form, with values of zero for the tax bid or the number of bad days reduced arbitrarily recoded to 0.5 before taking logs. The only variables significant at 10 percent in this regression were the number of bad days reduced and the worst good day rating, both of which were positively related to the tax bid. Total WTP increased less than proportionately with the number of bad asthma days reduced, thus WTP per bad day reduced declined as the number of bad days reduced rose. For example, predicted WTP per bad day reduced for an asthmatic whose worst good day rating involved "mild symptoms" fell from $41 for one bad day reduced to $7 per day for 50 bad days reduced.

In both the Rowe and Chestnut and Berger et al. studies, respondents were asked to rank, in order of importance, the benefits they might receive from better health. In the Berger et al. survey, respondents ranked the benefits of relief from the seven symptoms, while the respondents in the Rowe and Chestnut survey ranked the benefits of reduced asthma. Despite the difference in the health effect considered and the radical difference

TABLE 2.3. DAILY WTP AND COI

Symptom	Number Experiencing Symptom[a]	Mean Daily WTP	Mean Daily Private COI	t-statistic
Coughing Spells	27	$105.34	$11.29	2.12
Stuffed Up Sinuses	43	38.84	6.79	2.22
Throat Congestion	24	43.93	14.27	1.59
Itching Eyes	16	172.23	14.56	1.24
Heavy Drowsiness	6	173.89	21.50	2.57
Headache	48	173.21	3.33	2.07
Nausea	18	91.24	2.36	2.03

[a]Only those experiencing the symptom are included in calculating the sample statistics.

Source: Berger et al. (1986)

in the composition of the two samples, the rankings are remarkably similar across the two studies. In both studies, reduced discomfort was most often ranked as the most important benefit category. In the Rowe and Chestnut study, activity effects were the next most important category, followed by medical costs and work loss. In Berger et al., medical costs and work loss were ranked as most important more frequently than work loss at home and recreation loss (see Table 2.4). It is noteworthy that discomfort and activity effects, both of which are entirely ignored by the COI method, appear to be the most important sources of benefits.

The next three studies reviewed used the CVM to value changes in air pollution as related to health. Respondents were asked to value air quality directly, rather than some measure of health. The Brookshire et al. (1979) and Loehman et al. (1984) studies are reviewed because their results suggest some issues that could be analyzed with the averting behavior model; the Schulze et al. (1983) study is reviewed because it focuses on ozone.

2.3.4 Brookshire, d'Arge, Schulze and Thayer (1979)

The Brookshire et al. research was designed to test for many potential sources of bias in the CVM as well as to compare CVM values with those obtained from a hedonic property value study. Respondents were asked their WTP in terms of a higher utility bill or a lump sum monthly payment for improved air quality. One objective of the CVM analysis was to disaggregate the bids for air quality into aesthetic, and chronic and acute health components. Brookshire et al. assumed that total WTP for an air quality change would equal the sum of the acute, chronic, and aesthetic bids. Under this assumption, the authors concluded that the total WTP was insensitive to the sequence in which the health and aesthetic bids were obtained from the respondents, but that the relative value of the components may be sensitive to the sequence of information. Health effects were about 65 percent of the bid, with the acute component larger than the chronic. Thus, bids to avoid minor symptomatic discomforts may be a significant portion of the benefits stemming from improved pollution control.

2.3.5 Loehman, Boldt, and Chaikin (1984)

The Loehman et al. (1984) research sheds more light on the relationship between the health component of a WTP bid and the total bid. Six areas of San Francisco were defined in terms of annual days with different levels of visibility and health. Respondents were asked their maximum WTP to prevent or to obtain a change in air quality in their area of residence from its current level to each of the other levels. Some of these changes in air quality involved changes in health only, others involved changes in visibility only, while others involved both. Loehman et al. (1984) found that the sum of the health and visibility bids was not equal to the total bid. For an improvement in air quality, the health bid plus the visibility bid exceeded the total bid, while for a decrease in air quality, the summed bids were less than the total. This result suggests that individuals may have some difficulty separating health and other damages of air pollution. An analysis of the theoretical relationship between WTP for health and total WTP in the context of an averting behavior model can be found in Coulson et al. (1985).

Two other aspects of the Loehman et al. (1984) research are worth mentioning. First, the health bid comprised, on average, about one half

TABLE 2.4. RANKINGS OF BENEFIT CATEGORIES PERCENTAGE OF RESPONDENTS RANKING AS MOST IMPORTANT

	Rowe and Chestnut	Berger et al.
Discomfort	49%	67%
Activity Effects	27	a
Medical Costs	15	11
Work Loss at Job	8	12
Residential Location	1	a
Work Loss at Home	a	6
Recreation Loss	a	2
Other	a	2

[a] Not listed as a category for respondents to rank.

the total bid. Second, smokers, and those in worse health tended to have higher health bids.

2.3.6 Schulze et al. (1983)

The Schulze et al. survey was conducted in Los Angeles in December 1982. Respondents were asked to recall a highly publicized ozone episode over the previous Labor Day weekend and were shown a chart relating varying levels of ozone concentrations to health effects. The ozone concentrations were classified as very poor, poor, fair, or good. Respondents were asked their WTP to reduce the daily high ozone reading on the peak ozone day of the Labor Day weekend in their community to a lower ozone reading. For example, respondents in a community where the peak ozone reading was in the "poor" category were asked their WTP to reduce the ozone reading from "poor" to "fair" and from "poor" to "good." The payment vehicle was a generalized price increase with special attention drawn to motor vehicle operating costs. The Schulze et al. study found that respondents were WTP about $7.75/day to reduce hourly average ozone concentrations from a level of 20 pphm to 12 pphm.

2.4 THE AVERTING BEHAVIOR METHOD

The averting behavior method provides estimates of willingness to pay for health improvements based on individuals' revealed preferences for health and health related goods. Unlike the cost of illness and contingent valuation approaches, the averting behavior method is based on an explicit model of consumer choice. This model has three key features. First, good health is assumed to be a direct source of satisfaction to the individual. Thus the method can, in principle, account for the disutility, or "pain and suffering" associated with ill health. Second, health is considered a determinant not only of time available for work, but also of time available for leisure activities. As a result, the model provides a basis for valuing time lost from both employment and nonemployment activities. Third, health is endogenous in the averting behavior model; that is, the individual can choose his state of health subject to certain biological and economic constraints. Health is produced by a number of exogenous inputs, such as air pollution, as well as some endogenous inputs, such as medical care. The model predicts that, in response to a change in some exogenous input, the individual will adjust his consumption of the endogenous inputs in order to maximize the benefit (minimize the loss) he obtains from the exogenous change. Thus the model directly accounts for behavioral responses to air pollution changes.

2.4.1 Averting Behavior Models Not Providing Health Benefit Estimates

An important strand of the averting behavior approach focuses exclusively on theoretical considerations. Barrington and Portney (1982) and Berger, Blomquist, Kenkel, and Tolley (1986) give theoretical analyses of averting behavior health benefit estimates and their relation to the cost of illness, but neither of those papers estimates the WTP expression derived from the model. Courant and Porter (1981) and Harford (1984) provide theoretical comparisons of WTP and averting expenditure in the context of household cleanliness and pollution, while Watson and Jaksch (1982, 1985) estimate WTP, also in a cleanliness-pollution framework. Bartik (1986) has extended averting behavior theory to nonmarginal welfare analysis, and the previously cited Berger et al. paper extends the theory to account for health risks.

This subsection summarizes the main implications ‘of these papers for environmental benefit estimation measurement. Related theoretical work has focused on the relationship between averting behavior and optimal policy design for pollution control (see Zeckhauser and Fisher, 1976, and Shibata and Wenrich, 1983). Given the emphasis of the present research on using averting behavior to estimate WTP, the part of the literature relating to policy design is omitted from this survey.

The averting behavior model represents an application of the household production framework which was first used to analyze health by Grossman (1972). Thus, the welfare measurement issues that have arisen in the home production framework are relevant to the ABM. Pollack and Wachter (1975) showed that jointness or nonconstant returns to scale in the household technology would complicate interpretation of the model. In particular, the “implicit prices” of the home-produced commodities are given by the marginal costs of producing them. In the presence of jointness or the absence of constant returns to scale, these marginal costs are not independent of the consumption bundle chosen by the household.

Bockstael and McConnell (1983) extended Pollak and Wachter’s analysis to show that the endogeneity of implicit prices prevents the identification of a unique Marshallian demand curve relating the quantity of a final commodity consumed to its marginal cost, unless the entire cost function or technology is known. Although a compensated demand curve for each household commodity exits, and WTP is equal to the area between this marginal value curve and the corresponding marginal cost curve, the nonuniqueness of the Marshallian demand curves for the household outputs precludes the use of consumer surplus to approximate willingness to pay.

The Bockstael-McConnell solution is to use the input market to derive nonmarginal welfare measures. The value of a change in an exogenous environmental improvement can be approximated by the area under a single Marshallian input demand curve provided that input is essential to all final commodities to which the exogenous factor is complementary. This approach to welfare measurement in the home production model does not require estimation of the entire technology, but, as Bartik (1986) points out, does require using input demand estimates near the price which drives demand to zero. This price normally will lie outside the range of the data.

The theoretically correct measure of WTP is the area behind the Hicksian or compensated demand curve. This demand curve is derived by holding utility constant, however, and thus is unobservable. The solution to this problem in applied welfare economics is to use the area behind the observable Marshallian demand curve to approximate the area behind the Hicksian demand curve. Willig (1976) has shown that for goods with small income effects or small ratios of income equivalents of price changes to total income, the percentage error in using consumers' surplus (the area behind the Marshallian demand curve) as an approximation of WTP (the area behind the Hicksian demand curve) is small.

While Bockstael and McConnell consider nonmarginal welfare measurement when the technology is unknown, Hori (1975) considers the case of marginal welfare measurement when technology is known, but the amounts of final goods consumed are unknown. In an analysis which bears similarity to the theory to be presented in Chapter 3, Hori determines the conditions under which a utility function could be deduced from knowledge of the home production technology and the demand for private goods.

Without exception, the averting behavior models named at the beginning of this subsection assume nonjointness in the production of the household outputs. Jointness would occur if an input were used in the production of more than one household output, or if an input were itself a direct source of utility. Despite the Pollak and Wachter argument that jointness is pervasive in the home production framework, all previous work in the averting behavior literature has assumed nonjointness. Constant returns to scale, on the other hand, is not a universal assumption in averting behavior models.

All averting behavior models have a common underlying structure, subject to a few variations. This structure is

$$U = U(X, H) \tag{7}$$

$$H = H(V, a) \tag{8}$$

$$I = r_X X + r_V V. \tag{9}$$

where U denotes utility, X represents a composite good (or composite expenditures if $r_x = 1$), and H denotes the household output of interest, such as health or the cleanliness of the home. This output is produced in equation (8) by an averting behavior, V (which might be medical care in the case of health or the frequency of cleaning in the case of home cleanliness), and an exogenous variable or vector of exogenous variables *a*, which might be measures of air pollution. Equation (9) is a budget constraint where I is income and the r_i is the price of good i, i = X, V. Often. V is defined as averting expenditure with $r_V = 1$.

A few variations to this structure have been made. To analyze home cleanliness, Harford (1984) and Watson and Jaksch (1985) write r_v as a function of V and α, thus incorporating a tradeoff between the frequency of cleaning, V, and its intensity, measured by its unit price r_v. To analyze health issues, the budget constraint may be generalized to incorporate the value of time, as in Gerking and Stanley (1986). Another extension in the health area, made by Barrington and Portney (1982) and Berger et al. (1986), is to define a function M(H) giving medical and possibly other costs of illness as a function the health stock. As mentioned previously, Berger et al. further generalize the model to an uncertainty framework which accounts for health risks. Finally, Bartik (1986) focuses on the function $V(H, \alpha)$ giving the amount of averting expenditure necessary to achieve output H given pollution a, rather than the primal production function $H(V, \alpha)$.

In this model, the individual is assumed to maximize utility in equation (7) subject to the production function (8) and some variant of the budget constraint, (9). By totally differentiating the utility function with respect to pollution while holding utility constant at the constrained maximum, the following marginal WTP expression can be derived:

$$WTP = - \frac{r_V}{H_V} H_\alpha. \qquad (10)$$

This expression states that the marginal benefits of a reduction in pollution are equal to the marginal cost of achieving the same improvement in health through the use of V. More specifically, seven aspects of this benefit expression are worth noting. First, WTP is higher, the higher the full price and the lower the marginal productivity of the averting input V.

This may explain why some contingent valuation surveys have found a negative association between health insurance and WTP: insurance lowers the full price of medical care. Second, if the marginal damage of air pollution (H_α) is higher (more negative) for those in poor health, then WTP would be higher as well. This would explain the finding in CVM studies that poor health is associated with higher WTP. Third, despite the fact that health enters the utility function, no utility terms appear in the WTP expression, making estimation of equation (10) a relatively straightforward matter. Further, partial, rather than the total, derivatives of the health production function are relevant to calculating WTP. Thus the structural form of the health production function, rather than its reduced form, should be used in the benefit calculations. Fifth, the WTP for health improvements can be obtained from equation (10) simply by dividing both sides by H_α. This operation results in $WTP/H_\alpha = (\partial I/\partial \alpha)(1/H_\alpha) = \partial I/\partial H$.

The seventh point to note about the benefit expression in equation (10) concerns its interpretation in terms of standard macroeconomic theory. To simplify the exposition, interpret a as a measure of air quality rather than of air pollution, so that a is a good. WTP is simply the price the individual would be willing to pay, at the margin, per unit of air quality. Let r_α denote this price. Now suppose that a market existed for air quality, with units of air quality traded at price r_α. The individual is assumed to choose X, V, and a to maximize utility in equation (7) subject to the budget constraint $I = Xr_X + Vr_V + \alpha r_\alpha$.

It is clear that whatever level of health is chosen in the utility maximization process must be produced at minimum cost. If the chosen level of health could be produced at lower cost, then more of the good X could be purchased while maintaining the same consumption of health, which would increase utility and violate the hypothesized utility maximization. The cost-minimizing producer of health facing given prices r_α and r_V, would choose the levels of a and V so that the marginal rate of technical substitution between these two inputs was equated to their price ratio:

$$\frac{H_\alpha}{H_V} = -\frac{r_\alpha}{r_V}. \tag{11}$$

This familiar tangency between an isoquant and an isocost line is illustrated in Figure 2.1.

In reality, no market exists for air quality, and the individual faces a given quantity of a rather than a given price r_α. Given some quantity $\alpha°$, though, the individual's chosen level of V, v°, determines a point on an isoquant. Knowledge of the production function then allows determination of the slope of the isoquant at that point. Finally, observing the price r_V allows the willingness to pay for air quality r_α, to be inferred. Algebraically, the WTP expression in equation (10) can be obtained by multiplying both sides of the cost-minimizing tangency condition in equation (11) by $-r_V$. Thus, the ABM allows inference of WTP through knowledge of the production function and prices.

Two additional issues that have arisen in analyzing the WTP expression in equation (10) are: (1) the relationship between WTP and expenditures on averting activities, and (2) the relationship between COI and WTP. Courant and Porter (1981) and Berger et al. (1986) have demonstrated that under plausible conditions, averting expenditure will be lower bound on marginal WTP. The Berger et al. comparison was made in the context of uncertainty and hence is not directly relevant here. The Courant and Porter comparison

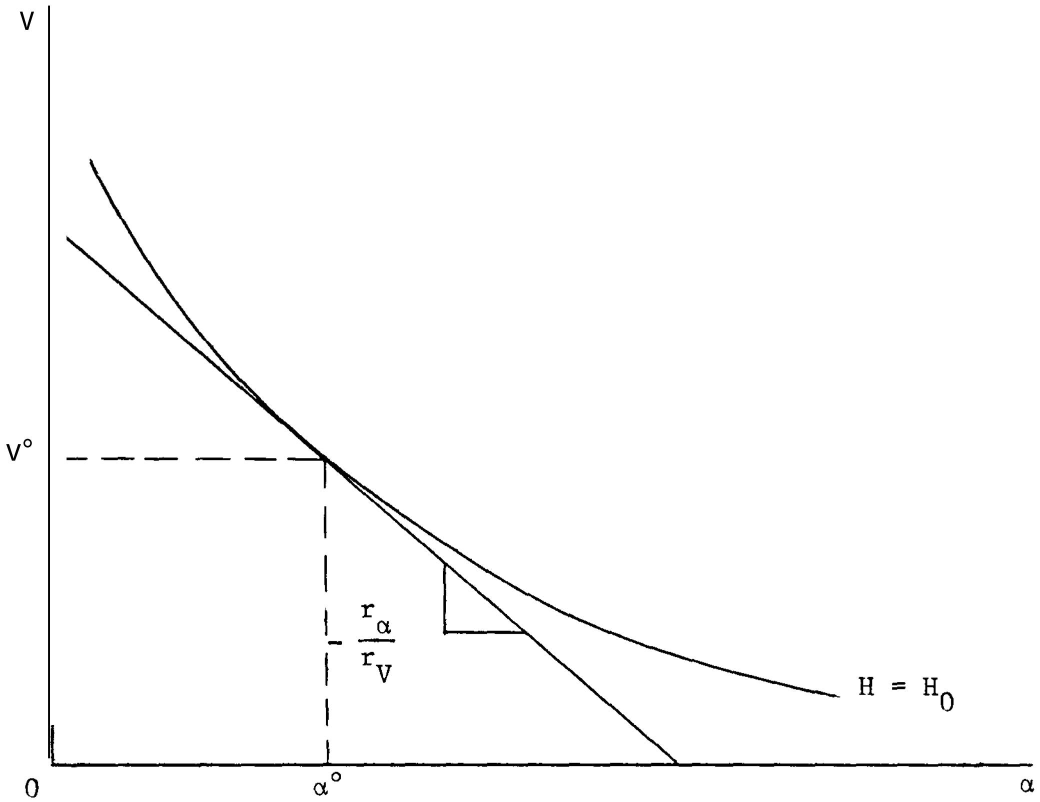

Figure 2.1. Cost-Minimizing Production of Health

The cost minimizing health producer who faced a market for air quality would equate the slope of an isoquant to the slope of an isocost line. When no market for air quality exists, cost minimizing production can be used to infer r_α.

involved calculating averting expenditure while holding utility constant and hence is of limited empirical relevance. Thus the relationship between marginal WTP and averting expenditure is not entirely settled. Bartik (1986) has shown, though, that the change in averting expenditure will always be a lower bound to WTP, but the bound is not necessarily tight.

Barrington and Portney (1982) and Berger et al. developed theoretical comparisons of WTP and COI to the individual. Barrington and Portney demonstrated that for the model above, WTP would exceed COI provided $dH/d\alpha < 0$ and $\partial V/\partial\alpha > 0$, that is, provided the total effect of pollution on health is negative and averting behavior increases with pollution. Both these conditions seem plausible, but neither is a theoretical requirement of the model. Berger et al. concur that under plausible conditions, COI is lower bound on WTP.

The work of Bockstael and McConnell (1983) and Bartik (1986) can be used to extend the marginal welfare analysis presented above to the case of nonmarginal welfare changes. Bockstael and McConnell show that changes in the area behind the Hicksian demand curve for a necessary input can be used to value environmental quality. Both Bartik and Bockstael and McConnell show that, if a single household output is affected by air pollution, then changes in the area behind the Hicksian demand curve for that output can be used to measure WTP. The difficulties inherent in estimating such a demand curve, or in approximating it with a Marshallian demand curve under conditions of joint production, are noted by Bockstael and McConnell.

A final point to make about the averting behavior method is its close connection to hedonic price models. Bartik points out that in the averting behavior model, the household's opportunity locus is determined by pollution levels and the averting technology. In hedonic price models, this locus is determined by demand and supply equilibrium.

The theoretical implications of previous averting behavior models for health benefit estimation then are as follows. (1) Marginal WTP can be estimated with knowledge of the production function and prices alone; no knowledge of preferences is required. (2) It is likely, although not certain, that the change in averting expenditure in response to pollution change is a lower bound on WTP. (3) Under plausible conditions, an individual's COI will be less than his WTP. Note that all of these conclusions are derived from simple, essentially identical, models which do not allow for joint products. A natural theoretical extension to the ABM, then, would be to analyze these three issues in a joint production Framework.

2.4.2 Empirical Evidence Regarding Averting Behavior

Several researchers have examined the existence and nature of averting responses to pollution. Smith and Desvousges (1986) conducted a probit analysis to explain the likelihood of engaging in three possible averting responses to water pollution. Berger et al. and Rowe and Chestnut provide some evidence linking averting behavior to health states. These latter two papers also empirically test the relationship between WTP and COI.

Smith and Desvousges found that of a sample of Boston area residents, 30 percent had purchased bottled water in the past five years and 7 percent had installed water filters, for the sole purpose of reducing the risk of exposure to hazardous waste. Key variables that explained these actions included indexes of the respondent's attitudes toward (1) the degree of harm associated with hazardous waste and (2) the effectiveness of the local public water supplier. Smith and Desvousges conclude that “private responses do appear to arise to mitigate the potential effects of environmental externalities” (p. 295). One shortcoming in the data used by Smith and Desvousges was that no information was available on the full prices or marginal productivities of the averting behaviors considered. As a result, no benefit estimates could be made based on these data.

Berger et al. collected data on some relatively long-run preventive expenditures: air conditioners, air purifiers, humidifiers, and other preventive expenditures. For each of these defensive expenditure categories except humidifiers, those respondents who had experienced at least one symptom were more likely to have made preventive expenditures for health reasons than those who reported no symptoms.

Rowe and Chestnut tested for short-run averting responses to air pollution involving changes in daily activities to avoid worsening asthma. Those respondents who expected air pollution to aggravate their asthma on a given day were about twice as likely to change their leisure or sleep activities to avoid worsening their asthma that day. Rowe and Chestnut present an eight-way classification of sample proportions based on the following three two-way classifications: (1) Did respondent expect bad asthma day? (2) Did he engage in any mitigating behavior? (3) Did he have a bad asthma day? These sample proportions reveal that, whether or not a bad asthma day is expected, mitigating behavior is positively associated with the probability of having a bad day. These proportions suggest that averting behaviors may be jointly determined with health. Rowe and Chestnut report that their data reveal a tendency for mitigating behavior to involve substitutions away from active leisure, both outdoor and indoor, away from outdoor chores, and into more indoor chores. On the basis of these three studies, it appears that individuals attempt to mitigate the effects of pollution in at least three ways: (1) by making expenditures on durable goods such as air purifiers and water filters, (2) by making expenditures on nondurable such as bottled water, and (3) by changing their daily schedule to avoid pollution exposure. None of the three studies incorporated both durable and nondurable expenditures and scheduling changes in the analysis, nor did they examine the price/effectiveness ratio of these averting activities.

2.4.3 Averting Behavior and Health Benefit Estimates

There have been relatively few attempts to use the averting behavior model to obtain benefit estimates. One reason for this outcome is that the simplicity and intuitive appeal of equation (12) is not achieved without cost. Chestnut and Violette (1984), for example, correctly argue that this equation implicitly: (1) values the individual's time at his wage rate, (2) considers only private, as opposed to total, social costs of medical care, (3) allows for no interdependence of utility among friends and family members, and (4) considers only small (marginal) changes in pollution and health. Additionally, as noted by Gerking and Stanley (1986), the ultimate averting behavior, moving from an area to avoid exposure to environmental toxins, is not adequately captured in existing ABM approaches. Finally, from an implementation viewpoint, the ABM requires special primary data collection. This subsection surveys two recent attempts to use the ABM to estimate equation (12); the work of Cropper (1981) and Gerking and Stanley (1986). In Cropper's model, each person is endowed with a stock of health capital measuring his resistance to illness. This health stock can be augmented by investing in health care; it depreciates at a rate dependent upon air pollution and other stress. Health is a pure investment good which is desired only to reduce the time spent ill and hence to increase income. Thus the individual chooses a time path of investment in health to maximize the present value of full income net of investment; he then maximizes utility subject to full income. In order to maximize full income net of investment, the individual equates the marginal product of health capital to its supply price.

Using Cobb-Douglas functional forms for the investment function, the marginal cost of investment, and for time spent ill as a function of the health stock, Cropper derives a benefit measure equal to twice the value of time lost from work. Assuming medical costs are negligible for the acute illnesses Cropper considers, this benefit measure is twice as large as the cost of illness.

Cropper's empirical work used data from the Michigan Panel Study in Income Dynamics for the years 1970, 1974, and 1976. The sample consisted of men age 18 to 45. Separate equations were estimated for each interview year, the dependent variable being the natural logarithm of [work loss days/(work loss days + days worked)] x 365. Since 50 percent of the sample reported zero work loss days, the equations were estimated in a tobit framework, but it is unclear how the natural logarithm was computed if WLD = 0. Pollution was measured as the annual geometric mean of sulfur dioxide, which Cropper regards as a pollution index owing to collinearity between pollutants.

The estimated coefficient on mean SO_2 was positive and significant at the 10 percent level in a one-tail test. Another interesting feature of

Cropper's equations is that the existence of a chronic condition was positively and significantly related to work loss days. However, the wage was positively and significantly related to work loss; this is contrary to expectation since a higher wage implies a higher value to healthy time. Cropper suggested that the wage may act as a proxy for deleterious consumption habits. Another possible explanation is that higher wage workers may have more liberal sick leave coverage, thus reducing the personal loss associated with sick time. Another possibility is that high wages are correlated with high non-wage income; if time away from work is a normal good, then the time spent working should decrease with non-wage income. Using the 1976 sample Cropper presents an annual WTP estimate for a 10 percent reduction in mean SO_2. The average worker in that sample, who earned $6.00 per hour, would pay $7.20 annually for that reduction in pollution.

Cropper's paper is noteworthy in representing an early attempt to incorporate behavioral adjustments to pollution and to compare the magnitude of WTP and COI. The model provides a theoretical justification for using work loss days as a basis for health benefit estimation. Cropper's model suffers from a serious deficiency, however, in that health is not allowed to affect utility directly. Additionally, as Chestnut and Violette (1984) point out, the empirical results presented are based on specific untested functional forms.

The Gerking and Stanley model, which is similar to the one presented in Section 2.4.1, generalizes Cropper's approach by allowing health to affect utility directly and by considering the time lost from work and leisure activities. Estimates of WTP were obtained using health, economic, and demographic data taken from a survey of 2594 households in St. Louis, Missouri over the period 1977-1980. Only 824 observations were included in the analysis presented in the paper, however; the remainder of the sample either were not fully employed or did not report their wage. Three health measures were contained in the St. Louis data: (1) subjectively reported health status (excellent, good, fair, or poor), (2) the existence of chronic illnesses, and (3) years of suffering from those chronic conditions. Gerking and Stanley used the latter two variables, CHRO and LENGTH, respectively, in the estimation. Consumption of medical services are proxied by MED, which took the value unity if the respondent usually saw a doctor at least once per year. Air quality data were taken from the Regional Air Pollution Study over the period 1974-1977. Averages over this period were computed for ozone, sulfur dioxide, TSP, and oxides of nitrogen (NO_x). Respondents were matched to the monitoring station closest to their residence.

To incorporate both CHRO and LENGTH in the estimation, Gerking and Stanley used the implicit function theorem to rewrite the health production function as

$$M = M(H; \alpha, \delta) \tag{12}$$

As a result, two measures of H could be included on the right hand side of equation (12). To account for the simultaneity between medical care and health, Gerking and Stanley used a procedure analogous to two stage least squares. First, reduced form equations for CHRO and LENGTH were estimated using logit and tobit, respectively. Then the fitted values $\dot{\text{CHRO}}$ and $\dot{\text{LENGTH}}$ were used to estimate equation (12) in a logit framework. The expected signs of these two health measures were negative, while their coefficients were positive but generally insignificant at 10 percent. Of the pollution variables, only ozone was positive and significant (at one percent) in all the reported equations. As a consequence, ozone was chosen to make the willingness to pay calculations. For a 30 percent reduction in ambient mean ozone concentrations, the annual willingness to pay estimates range from $18.24 to $24.48.

The work by Gerking and Stanley is important for at least two reasons. First, their model illustrates the derivation of a simple, estimable willingness to pay expression when health is a direct source of utility. Second, their empirical work accounts for the simultaneity of medical care and health. The key problem with this paper is the data. The health and pollution data do not pertain to the same years. Moreover, the use of recent pollution levels in explaining long-term illnesses assumes that recent levels are typical of lifetime exposure patterns, which may bias results, particularly if ill health induces migration to less polluted environments. The dependent variable MED is not a good measure of medical care consumption since it only reflects whether the respondent normally sees a doctor at least once a year.

2.5 COMPARISON OF THE THREE METHODS

This chapter has reviewed three methods for estimating the monetary damages associated with the adverse effects of air pollution on health: the cost of illness method, the contingent valuation method, and the averting behavior method. The three methods differ greatly with respect to the theoretical assumptions which underlie them, the interpretation of the values they produce, and the costs of implementing them. This section will briefly summarize these issues. First, however, it should be noted that there is at least one major difficulty shared by all three methods, namely, the estimation physical damage or health production function.

The estimation of such a function, whether for morbidity or mortality, involves a great deal of specification and measurement uncertainty. Specification uncertainty enters because the functional form of the relationship between air pollution and health and the proper set of explanatory variables are unknown. Additionally, some variables which might explain the relationship between air pollution and health are subject to the control of individuals, introducing the possibility of simultaneous equation bias. A key example of measurement error is in the measurement of pollution exposure. Individuals normally are matched to a pollution monitoring station somewhere in the vicinity of their residence, but the pollution levels measured at this station may be a poor indicator of actual exposure. For a more complete discussion of specification and measurement difficulties in estimating the health effects of air pollution, see Crocker et al. (1979) and Gerking and Schulze (1981).

Returning to the comparison of the three damage function estimation techniques, consider first the theoretical differences among them. The COI approach effectively assumes that individuals are ignorant of the health damages of air pollution and/or are unable to adjust their behavior to mitigate these damages. As Lave (1972) indicates, it is this assumption of individual ignorance that justifies the two-step approach of (1) estimating a physical damage function, and (2) simple multiplication of this damage function by some price schedule. In contrast, the ABM assumes that individuals rationally adjust their behavior to minimize the value of air pollution losses. Cropper (1981) argues that this process of rational adjustment does not require that individuals be fully aware of the effects of air pollution on health; rather, it need only be assumed that individuals adjust their behavior when they perceive some change in their health. The marginal conditions of the model, which require optimal adjustment to infinitesimal changes in pollution, however, seem more consistent with an assumption of complete knowledge on the part of individuals. As a practical matter, people must have at least some knowledge of an association between air pollution and ill health if averting behaviors such as spending less time outdoors and reducing indoor air pollution are to be used to produce benefit estimates. The CVM, when applied to measures of morbidity, does not require any knowledge at all on the part of respondents of the link between air pollution and health. Subjects value the health effect, and the association to air pollution is made by the analyst. If the CVM is applied to air pollution directly, however, it is assumed that respondents know their own damage function.

In addition to the degree of knowledge assumed, the three techniques differ in their treatment of behavioral responses to air pollution. The COI method and the CVM tend to ignore averting behavior; only the ABM directly accounts for behavioral adjustments to mitigate pollution effects.

Perhaps the most important distinction between these techniques is the interpretation of the values they produce. The COI estimates the monetary costs which illness imposes on society. It does not estimate WTP, nor does it include values for the disutility of illness. Both the CVM and the ABM, on the other hand, estimate individuals' WTP, and the WTP value includes the monetary value of the disutility of illness. The CVM estimates WTP on the basis of expressed preferences, while the ABM estimates WTP on the basis of revealed preferences. A comparison of WTP and COI is complicated by the fact that COI values tend to be for society as a whole, while WTP values are for individuals. This is significant because 68 percent of all health-related expenditures are made by third parties such as insurance companies (Chestnut and Violette, 1984). Thus, the costs faced by individuals do not reflect social costs.

A final, and perhaps the most practical, distinction between these three methods is the cost of implementing each. The COI approach seems the least costly to implement, since no primary data collection effort is required. Damage functions can be estimated from existing data sets, such as the HIS, and the Cooper and Rice cost estimates can be applied. The CVM is more costly to apply in that primary data collection on WTP and other economic variables is required. The ABM is the most costly, since the primary data collection effort must extend to the prices and quantities of averting behaviors.

A tradeoff emerges, them, between the costs of obtaining estimates of the value of air pollution damages and the type of estimates obtained. The COI is the least costly, but does not cover the disutility of illness and does not measure WTP. The CVM and the ABM are more costly because of the primary data collection efforts they require, but they do estimate WTP. The incremental cost of the ABM over the CVM is the price paid for revealed values, which some economists and policymakers would prefer to the expressed values produced by the CVM.

CHAPTER 3

AVERTING BEHAVIOR, JOINT HOUSEHOLD PRODUCTION, AND WELFARE MEASUREMENT

3.1 INTRODUCTION

The empirical implementation of the averting behavior model appears to be a straightforward matter because, as several authors have noted, the marginal willingness to pay expression implied by the model depends only on observable variables. Chapter 2 indicated that this marginal WTP function, which may be calculated using prices and parameters of the production function, is derived from models having a single underlying structure. The essential features of this structure are (1) there is only one averting behavior and one household output of interest, and more importantly, (2) the averting behavior is not a direct source of utility. The primary effect of these two features is to preclude the possibility of joint household production. In this nonjoint averting behavior model, the marginal WTP for the household output is equal to the marginal cost of producing it, and the marginal WTP for some publicly-provided factor of production, like air quality, is equal to the marginal effect of that factor on the total cost of producing the household output. The nonjoint averting behavior model and its WTP expressions are special cases of Hori's (1975) analysis, which demonstrated that the marginal value of a public good can be inferred from the demand for private goods, provided that (1) the household technology is known, and (2) the number of private good inputs is at least as great as the number of household outputs.

While the simplicity of the marginal WTP expressions described above is appealing, the averting behavior model used to generate these expressions may not be sufficiently general to apply to some problems. For example, there are a number of symptomatic effects associated with air pollution exposure, and a number of averting behaviors which may be used to reduce exposure or to relieve the symptoms. Moreover, a single averting behavior may be effective in reducing more than one symptom, and some averting behaviors may be direct sources of utility. Air conditioning in the home or car, or changes in the amount of time spent outdoors, could be used not only to reduce exposure and hence relieve a number of symptoms, but could have direct impacts on utility as well. In other words, jointness may be pervasive in the context of averting behavior, but the averting behavior model precludes jointness by construction.

This chapter derives the conditions under which the averting behavior model can be generalized to allow for joint production yet still yield an empirically measurable expression for WTP. Bockstael and McConnell (1983), building on the results of Pollak and Wachter (1975), showed that joint production complicates welfare measurement in the household production framework. The Bockstael-McConnell solution, which can be used without knowledge of the entire home technology, is to derive welfare measures using the Hicks-compensated demand for a single necessary input. Empirical implementation of the Bockstael-McConnell technique might require approximation of the utility-constant Hicksian demand curve with its money-income-constant Marshallian counterpart. In contrast, the nonjoint averting behavior model provides an exact welfare measure which is observable and hence need not be approximated.

The next section of this chapter extends the non joint averting behavior model and the work of Hori to allow the inputs in the household technology to be direct sources of utility. The purposes are to derive exact measures of marginal and nonmarginal welfare change and to determine, in Section 3.3, the conditions under which these exact measures will be functions only of observable parameters. In Section 3.4, welfare measures for the household outputs will be considered. An input market analysis which follows Bockstael and McConnell is described in Section 3.5. A method of recovering an estimate of the disutility of illness is discussed in Section 3.6, and conclusions follow in Section 3.7.

3.2 AN IMPURE AVERTING GOODS MODEL

In this section, welfare measures are derived from a model which generalizes the nonjoint averting behavior model presented in Chapter 2 by (1) allowing for multiple outputs and averting inputs, and (2) allowing some averting inputs to be direct sources of utility.

Define a pure averting input as a good which is used solely to reduce pollution exposure or to mitigate the effects of exposure; pure averting inputs are not direct sources of utility. An impure averting input, on the other hand, not only enters the home production technology but is a direct source of utility as well. Suppose there are a total of I averting goods $V_1, V_2, \ldots, V_I$, the first K of which are impure, and the remaining (I - K) of which are pure.

Suppose there are J home-produced commodities $S_1, S_2, \ldots, S_J$, which for purposes of this research are symptoms of pollution exposure. Utility is a function of the J commodities. the K impure averting goods, and a composite commodity X:

$$U = U(X, S_1, \ldots, S_J, V_1, \ldots, V_K) \tag{1}$$

where $U_X = \partial U/\partial X > 0,$

$U_j = \partial U/\partial S_j < 0 \qquad j = 1, \ldots, J$

$U_k = \partial U/\partial V_k > 0 \qquad k = 1, \ldots, K.$

The symptoms are produced according to the J production functions

$$S_j = S_j(V_1, \ldots, V_K, V_{K+1}), \ldots, V_I; \alpha, \delta, H) \tag{2}$$

where $S_{ji} = \partial S_j/\partial V_i < 0, \forall i, j$

$S_{j\alpha} = \partial S_j/\partial \alpha > 0,$

$S_{j\delta} = \partial S_j/\partial \delta \gtrless 0,$

$S_{jH} = \partial S_j/\partial H < 0, \forall j,$

$j = 1, \ldots, J.$

In these symptom production functions (SPFs), the pure and impure averting goods reduce the symptoms. The variable α denotes air pollution, which increases the symptoms; H denotes the individual's health stock, increases in which reduce the symptoms; δ denotes other personal factors which may influence the efficiency of production. In the empirical work presented in later chapters, α, δ, and H are specified as vectors.

In addition to the biomedical constraints embodied in the SPFs, the individual is faced with a series of economic constraints:

$$Wt_W + A = XP_X + \sum_{i=1}^{I} V_iP_i \tag{3a}$$

$$T = Xt_X + \sum_{i=1}^{I} V_it_i + T_L \tag{3b}$$

$$T_L = G(S_1, \ldots, S_J). \tag{3c}$$

In equation (3a), W denotes the individual's wage rate, T_w denotes the time spent working, A denotes the amount of income the individual receives which is unaffected by labor/leisure decisions. This “asset income” is taken to be exogenous during the time period encompassed by the model. The variable P_X represents the money price of the composite good X, while P_i represents the money price of good V_i, $i = 1, \ldots, I$. Thus equation (3a) constrains expenditures to income.

Equation (3b) simply requires that total time available (T) is allocated among all possible uses of time. In this equation, t_X represents the amount of time required to consume a unit of X, and t_i similarly represents the amount of time required to use a unit of V_i, $i = 1, \ldots, I$. T_L denotes time lost from market and nonmarket activities, which is a nondecreasing function of each of the symptoms in equation (3c), $G_j = \partial G/\partial S_j \geq 0 \;\forall\; j$.

Equations (3a), (3b), and (3c) can be combined into the following “full income” budget constraint:

$$WT + A = Xr_X + \sum_{i=1}^{I} V_i r_i + WG(S_1, \ldots, S_J) \qquad (4)$$

where

$$r_X = P_X + WT_X$$

$$r_i = P_i + WT_i, \;\forall_i .$$

The r variables denote the “full price” of the associated good, including both the money price and the time price where all time is valued at the wage rate.

The individual is assumed to maximize utility in equation (1) subject to the symptom production functions in equations (2) and the full income budget constraint in equation (4). Measures of the change in economic well being associated with air pollution changes can be derived from that maximization problem, but those measures of welfare change involve holding utility constant. Therefore a more direct approach to deriving welfare measures is to use the dual expenditure minimization problem in which utility already is held constant. Following Just, Hueth and Schmitz (1982) define the pseudo expenditure function $A(r_X, r_1, \ldots, r_I, W, \alpha, \delta, H, U^\circ)$ as the function giving the minimum amount of exogenous income necessary to achieve utility level U° given values for the parameters $r_X, r_1, \ldots, r_I$, W, α, δ, and H. The pseudo-expenditure function is defined as

$$A(r_X, r_1, \ldots, r_I, W, \alpha, \delta, H, U^\circ)$$

$$= \min_{X,V}\{Xr_X + \sum_{i=1}^{I} V_i r_i + WG(S_1, \ldots, S_J) | \tag{5}$$

$$U^\circ = U(X, S_1, \ldots, S_J, V_1, \ldots, V_K)\},$$

where $S_j = S_j(V_1, \ldots, V_I; \alpha, \delta, H) \; \forall \, j$. The pseudo-expenditure function is used in place of the traditional expenditure function when consumers are also labor suppliers. The properties of the pseudo-expenditure function are analogous to the properties of the expenditure function; see Just et al. for the details.

The first order conditions for the expenditure minimization problem are

$$r_X - \mu U_X = 0 \tag{6}$$

$$r_k + W \sum_{j=1}^{J} G_j S_{jk} - \mu[U_k + \sum_{j=1}^{J} U_j S_{jk}] = 0 \quad k = 1, \ldots, K \tag{7}$$

$$r_i + W \sum_{j=1}^{J} G_j S_{ji} - \mu \sum_{j=1}^{J} U_j S_{ji} = 0 \quad i = K + 1, \ldots, I \tag{8}$$

plus the utility constraint $U^\circ - U(\cdot) = 0$, where μ is the Lagrangian multiplier associated with the utility constraint and is interpreted as the marginal cost of achieving utility level U°. Equation (6) requires the monetary value of the marginal utility of good X be equal to the full price of consuming one unit of X. Equations (7) and (8) require the monetary value of the utility change associated with a small change in an averting good be equal to the full price of that good plus the monetary value of any associated change in time lost from market and nonmarket activities. The K equations in (7) relate to the impure averting goods, while the (I - K) equations in (8) relate to the pure averting goods. The only difference between the first order conditions for the pure and impure averting goods is that the impure averting good equations contain an additional marginal utility term U_k reflecting the direct effect on utility of a small change in an impure averting good. In contrast, the only effect the pure averting goods have on utility is via the symptom production functions.

The compensating variation (CV) measure of the change in individual welfare associated with a decrease in air pollution is defined as the amount of income which, when taken away from the individual after the air pollution change, would leave him just as well off as before the change. In other words, CV is the change in the value of the pseudo-expenditure function when air pollution changes. Using the envelope theorem, the CV of a marginal decrease in air pollution can be expressed as

$$\frac{\partial A}{\partial \alpha} = W \sum_{j=1}^{J} G_j S_{j\alpha} - \mu \sum_{j=1}^{J} U_j S_{j\alpha}. \tag{9}$$

The first term on the right hand side of the marginal WTP expression is the monetary value of the change in time lost from market and nonmarket activities when air pollution changes, while the second term measures the monetary value of the utility change associated with the pollution change. For a nonmarginal change in air pollution of $\Delta\alpha = \alpha^1 - \alpha^0$, the compensating variation is

$$CV = A(r_X, r_1, \ldots, r_I, W, \delta, H, \alpha^0, U°)$$
$$- A(r_X, r_1, \ldots, r_I, W, \delta, H, \alpha^1, U°). \quad (10)$$

Equations (9) and (10) give exact measures of the WTP for, respectively, a marginal and nonmarginal, air pollution decrease. The empirical worth of these equations is limited, however, because of the presence of unobservable marginal utility terms in equation (9) and because the value of the expenditure function at $(\alpha^1, U°)$ is not observed. The next two sections demonstrate that under certain conditions, these exact welfare measures can be reduced to functions of observable market and technological parameters.

3.3 EXACT WELFARE MEASUREMENT USING THE AVERTING TECHNOLOGY

The marginal WTP expression in equation (9) is unobservable since it contains a total of J marginal utility terms $-\mu U_j$, j = 1, . . ., J. These same J marginal utility terms, however, appear in each of the (I - K) first order conditions in equations (8). Thus if (I - K) > J, the first order conditions of the model provide enough information to reduce the marginal WTP expression to a function of market and technological parameters. In other words, if the number of pure averting goods is at least as great as the number of symptoms, then marginal WTP is observable.

Note that the K first order conditions in equations (7) are by themselves useless in solving for WTP since each of these equations contains a unique marginal utility term U_k in addition to the J unknowns μU_j. Equations (7) then are K equations in (J + K) unknowns. That is, the first order conditions for the impure averting goods do not provide enough information to solve for WTP because of the direct impacts these goods have on utility.

To illustrate the method of solving for WTP in terms of observable parameters, it is helpful to rewrite the marginal WTP expression and the first order conditions for the pure averting goods in matrix terms. Define the vectors $[r] = [r_{K+1} \ldots r_I]^T$; $[WG'] = [WG_1 \ldots WG_J]^T$; $[\mu U'] = [\mu U_1 \ldots \mu U_J]^T$; $[S'_\alpha] = [S_{1\alpha} \ldots S_{j\alpha}]^T$, where the superscript T indicates transposition. Let $[S']$ be the (I - K x J) matrix whose typical element is $S_{ji} = \partial S_j/\partial V_i$, $i = K + 1, \ldots, I$, $j = 1, \ldots, J$. Marginal WTP then can be expressed as

$$\frac{\partial A}{\partial \alpha} = (-[\mu U'] + [WG'])^T[S'_\alpha]. \qquad (9')$$

The first order conditions for the pure averting goods can be rewritten as

$$[S'] [\mu U'] = [r] + [S'][WG']. \qquad (8')$$

Solving for the benefit expression in terms of market and observable parameters then involves solving equation (9′) for the vector $[\mu U']$ and substituting the result into equation (8′). There are three cases to consider.

Case 1: I-K=J. If the number of pure averting goods is equal to the number of symptoms, then assuming the rows of [S'] are linearly independent,

$$[\mu U'] = [S']^{-1}[r] + [WG'] \qquad (11)$$

and

$$\frac{\partial A}{\partial \alpha} = -([S']^{-1}[r])^T[S'_\alpha]. \qquad (12)$$

Case 2: I - K> J. If the number of pure averting goods exceeds the number of symptoms, then any subset of J rows of the matrix [S′] can be used to obtain equations (11) and (12). Since all of the first order conditions must hold, any subset of them can be used to solve for WTP. In this case the model provides more information than the minimum necessary to compute WTP; the additional information can be used to test the model since WTP must be the same regardless of which of the (I - K)!/(J![I - K - J]!) methods of calculating WTP are used.

Case 3: I - K < J. If the number of pure averting goods is less than the number of symptoms, then marginal WTP cannot be expressed as a function of market and technological parameters. The model does not contain enough information to solve for WTP as a function of observable variables.

The condition for expressing marginal WTP in terms of observable parameters, then, is that the number of pure averting goods be at least as great as the number of household outputs affected by pollution. The present analysis is a generalization both of Hori's work and of the averting behavior literature. The model presented above reduces to Hori's model if there are no impure averting goods (K = O). In that case the condition for observability of WTP is I > J, which is Hori's result. The existing averting behavior models represent the even more special case of K =0, I = J = 1. In that case, the one pure averting good provides just enough information to value pollution.

Although the marginal WTP expression in equation (12) is simply a generalization of equation (12) in Chapter 2, the interpretation of the WTP expression in the more general model is not immediately apparent. The next section provides an interpretation of the WTP expression and illustrates a method for valuing the symptoms as well.

3.4 AVERTING EXPENDITURE AND THE VALUE OF SYMPTOMS

To maximize utility subject to a budget constraint, the individual must produce the household outputs at minimum cost. Another way of looking at the consumer's problem, then, is in two stages. In the first stage the individual minimizes the cost of producing any level of symptoms; in the second stage utility is maximized subject to a budget constraint that includes the symptom cost function from stage one. This two-stage approach often is used in the household production literature.

Define the joint symptom cost function or averting expenditure function as the optimal value of the objective function for the first-stage problem:

$$C(S_1, \ldots, S_J, V_1, \ldots, V_K; H, \alpha, \delta)$$

$$= \min\{\sum_{i=K+1}^{I} V_i r_i \mid S_j^\circ = S_j(V_1^\circ, \ldots, V_K^\circ, V_{K+1}, \ldots, V_I; H, \alpha, \delta),$$

$$j = 1, \ldots, J\}.$$

The first order conditions are

$$r_i - \sum_{j=1}^{J} \Pi_j S_{ji} = 0 \qquad i = K + 1, \ldots, I \tag{14}$$

$$S_j^\circ - S_j(\cdot) = 0 \qquad j = 1, \ldots, J, \tag{15}$$

where Π_j is the Lagrangian multiplier associated with the j^{th} constraint. Using the envelope theorem,

$$C_j = \Pi_j \qquad j = 1, \ldots, J \tag{16}$$

$$C_\alpha = -\sum_{j=1}^{J} \Pi_j S_{j\alpha} = -\Sigma C_j S_{j\alpha}. \tag{17}$$

The Lagrangian multipliers Π_j are the marginal costs of the symptoms, and the marginal effect of air pollution on the total cost of producing a given level of symptoms is given by equation (17).

The dual to the second stage problem is to

$$\min\{Xr_X + \sum_{k=1}^{k} V_k r_k + C(\cdot) + WG(S_1, \ldots, S_J) |$$

$$U^\circ = U(X, S_1, \ldots, S_J, V_1, \ldots, V_K)\}. \quad (18)$$

The optimal value of the objective function of this problem is of course the pseudo expenditure function.

The envelope theorem can be used to show that

$$\frac{\partial A}{\partial \alpha} = \frac{\partial C}{\partial \alpha}. \quad (22)$$

Equation (22) provides the interpretation of marginal WTP in the averting behavior model: because of the individual's optimization process, the marginal benefits of a reduction in pollution are equal to the marginal costs of that reduction. This result is due to the fact that air pollution is playing a role for the household producer that is analogous to the role of a fixed factor of production in the theory of the firm; the imputed value of pollution in production then is given by its effect on costs. Because pollution affects the individual in this model only through its impact on health production, then the entire benefit of pollution reduction is captured by the reduction in the costs of achieving a given level of health.

To compute $\partial C/\partial \alpha$, however, the values of the J Lagrangian multipliers Π_j must be determined. These J unknowns appear in (I - K) first order conditions and can be determined provided (I - K) > J. Thus the condition that the number of pure averting goods be at least as great as the number of symptoms is necessary in order to compute the marginal costs of the symptoms C_j; by the first order conditions in equations (21), these marginal costs are equal to the marginal values of the symptoms.

The symptom cost function or averting expenditure function illustrates two results for marginal welfare measurement. First, the marginal WTP for a pollution reduction is equal to the marginal impact of that pollution reduction on the total cost of producing a given level of symptoms. Second, the marginal value of a symptom is equal to the marginal cost of producing that symptom.

The cost function also is useful in solving for nonmarginal welfare measures. The compensating variation for a reduction in pollution given by equation (1) can be expressed as

$$\int_{\alpha^0}^{\alpha^1} \frac{\partial A}{\partial \alpha} d\alpha. \tag{23}$$

By equation (22), this is equivalence to

$$\int_{\alpha^0}^{\alpha^1} \frac{\partial C}{\partial \alpha} d\alpha. \tag{24}$$

If $(I \quad K) \geq J$, then $\partial C/\partial \alpha$ can be expressed entirely in terms of market and technological parameters, in which case knowledge of the cost function would provide an exact measure of nonmarginal welfare change.

3.5 WELFARE MEASURES IN THE INPUT MARKET

This section will explain briefly the Bockstael-McConnell results in the context of the impure averting goods model. The compensated demand curve for a pure or impure averting good can be found by differentiating the pseudo-expenditure function with respect to that input's price:

$$\frac{\partial A}{\partial r_i} = V_i(r_X, r_1, \ldots, r_I, W, H, \alpha, \delta, U^\circ). \tag{25}$$

The change in the area behind this demand curve when pollution changes by $\Delta\alpha = \alpha^1 - \alpha^0$ is

$$\int_{r_i^\circ}^{\bar{r}_i(\alpha^1)} V_i(\cdot, \alpha^1, U^\circ)dr_i - \int_{r_i^\circ}^{\bar{r}_i(\alpha^0)} V_i(\cdot, \alpha^0, U^\circ)dr_i$$

where r_i° is the prevailing price and $\bar{r}_i(\alpha)$ is the choke price. Bockstael and McConnell showed that the change in the area behind the compensated demand curve will equal the compensating variation if V_i is a necessary input, provided that α does not enter the preference function directly. Since this approach does not require solving for marginal utility terms, no restrictions on the number of inputs or outputs are required.

Utility constant demand curves are not readily observable, but in the averting behavior model, the utility constant demand for a pure averting good is equal to the output constant cost-minimizing demand for that good. Because the cost-minimizing demands are observable, an exact measure of welfare change can be derived in the market for a pure averting good. Alternatively, the area behind the Marshallian demand curve (consumer surplus) for a pure or impure averting good can be used to approximate the true WTP measure. Just et al. (1982) have extended Willig’s (1976) analysis to show that no more than a five percent error would be made in using consumer surplus as a measure of compensating variation provided that one-half of the product of exogenous income elasticity and the ratio of surplus change to total exogenous income is less than 0.05 in absolute value.

3.6 ESTIMATING THE DISUTILITY OF ILLNESS

As mentioned in the literature review, one of the key differences between the cost of illness method and the averting behavior method is that the WTP expression derived from the latter includes the monetary value of the disutility of illness, while the cost of illness does not attempt to measure this quantity. The magnitude of this utility term then would be indicative of the divergence between WTP and COI.

The averting behavior method provides a means of estimating the monetary value of the marginal disutility of air pollution-induced illness. Using equation (9),

$$\frac{\partial A}{\partial \alpha} - W\sum_j G_j S_{j\alpha} = -\mu \sum_j U_j S_{j\alpha}. \tag{27}$$

The WTP for an air pollution reduction can be estimated using the SPFs as described in Sections 3.2 and 3.3, or using the demand for a necessary input as in Section 3.4. The time lost from market and nonmarket activities can be estimated using observable variables and then valued at the wage rate. Subtracting the value of time lost from WTP then allows recovery of the monetary value of the marginal disutility of air pollution-induced illness.

3.7 TOWARD IMPLEMENTATION: ESTIMATING WTP

The analysis of this chapter has suggested a number of methods of estimating WTP based on averting behavior. One method is to estimate the symptom production functions and invert the matrix of marginal products [S′] as in equation (12). If the number of symptoms is greater than two or three, however, this would be a tedious process. An alternative is to estimate the symptom cost function or averting expenditure function and to obtain WTP for symptoms or for pollution by simple differentiation of that function. Both the SPF and cost function methods require that the number of pure averting goods be at least as great as the number of symptoms, but as a practical matter, there is no guarantee that this condition will hold. Consider, for example, some averting behaviors for air pollution: medical care, air purifying, air conditioning in the home or car, spending less time outdoors or other changes in leisure activities, taking a recreational trip outside the area. It might be argued that the first two averting behaviors in this list are not direct sources of utility, but the others almost certainly are. While the above list may not exhaust all possible averting behaviors, it provides only two pure averting goods. Prior biomedical evidence, on the other hand, suggests that there are nine symptoms which definitely can be associated with ozone exposure (see Chapter 4). It seems doubtful that seven more pure averting goods could be found, making estimation of WTP a more complicated matter.

There are several ways to get around the numbering restriction on the pure averting goods and symptoms. One way is to respecify the model; two respecifications will be considered below.

First, suppose that the averting behaviors can be divided into two groups: (1) avoidance behaviors, which reduce personal exposure given the ambient concentration of air pollution, and (2) mitigating behaviors, which reduce symptoms given the level of personal exposure.

The avoidance goods would include such items as air purifiers and conditioners, while the mitigating goods might include medical care and medications. In such a model, WTP for air pollution can be expressed in terms of market and technological parameters provided only that there is one avoidance good which is not a direct source of utility. The WTP for symptoms, however, can be reduced to a function of observable variables only if the number of mitigating goods is at least as great as the number of symptoms.

To illustrate this model, suppose there are three symptoms and two averting behaviors, one of which, M, is a mitigating good, the other, V, being an avoidance good used to reduce exposure, E. The pseudo expenditure function is

$$A(\cdot) = \min\{Xr_X + Mr_M + Vr_V + WG(S_1, S_2, S_3)\,|\,U° = U(X, S_1, S_2, S_3)\} \qquad (28)$$

where $S_j = S_j[M, E(V, \alpha)]$, j = 1, 2, 3. The first order conditions are, in addition to the constraint,

$$r_X - \mu U_X = 0 \qquad (29)$$

$$r_M + W\sum_j G_j S_{jm} - \mu\sum_j U_j S_{jm} \qquad (30)$$

$$r_V + W\sum_j G_j S_{jE}E_V - \mu\sum_j U_j S_{jE}E_V = 0. \qquad (31)$$

WTP for a reduction in pollution is

$$\frac{\partial A}{\partial \alpha} = W\sum_j G_j S_{jE}E_\alpha - \mu\sum_j U_j S_{jE}E_\alpha$$

$$= -\frac{r_V}{E_V} E_\alpha. \qquad (32)$$

Most data sets do not contain data on E, however. But using the composite function rule, $S_{jV} = S_{jE}E_V$ and $S_{j\alpha} = S_{jE}E_\alpha$, j = 1, 2, 3. Thus

$$\frac{\partial A}{\partial \alpha} = -\frac{r_V}{S_{jV}}S_{j\alpha} \qquad j = 1, 2, 3. \qquad (33)$$

Despite the fact that there are three symptoms and only two pure averting goods, WTP for pollution can be expressed entirely in terms of observable variables. Clearly, all that is required is one pure avoidance good.

Moreover, in contrast to Bartik's (1986) approach, the level of personal environmental quality E need not be observed.

Valuation of the individual symptoms, however, still requires enough information to recover the marginal utility terms $-\mu U_j$. The simple respecification presented above will not automatically provide this information. To value the symptoms, consider a second respecification of the model. Suppose that there is a single "macro" averting good which is unique to each symptom. These macro averting goods are composed of some or all of the averting activities $V_1, \ldots, V_I$, but the weight attached to any V_i may vary according to which macro good is being constructed. In this case, any one of the pure averting activities which make up the macro good can be used to value a given symptom, and valuation can proceed one symptom at a time.

A third way around the problem posed by a larger number of symptoms than pure averting goods is to use the Bockstael-McConnell input market analysis. Assuming a necessary averting good can be found, the welfare effects of a change in air pollution can be evaluated using the area behind the demand curve for that good.

The empirical work presented in later chapters will use the following valuation procedure. Ozone will be valued using the Marshallian demand curve for medical care. The value of time lost due to ozone will be approximated by estimating the value of the time lost from work. Subtracting the latter from the former will allow recovery of the disutility of ozone-induced symptoms. Symptoms will be valued by estimating the SPFs and using one averting activity to value each symptom.

CHAPTER 4

SAMPLING STRATEGY AND DATA DESCRIPTION

4.1 INTRODUCTION

The data necessary to implement contingent valuation and averting behavior approaches and to compare them to the cost of illness were collected from a sample of 229 residents of two Los Angeles communities over the period of July to December, 1985. Two survey instruments were designed to collect detailed information on measures of respiratory health, symptoms, potential averting behaviors, and other personal characteristics. Collecting detailed information from the subjects necessitated keeping the recall period short; thus respondents were asked to provide data for the two days immediately preceding the day of the survey. Respondents were contacted an average of just under four times during the six month sampling period. Considering the two days' worth of data collected at each contact as two individual observations then makes for a panel of just over 1800 observations.

The sample was stratified so that almost 30 percent of the observations were on individuals with physician-diagnosed asthma, bronchitis, emphysema, or other lung disease. As a result, enough data are available on impaired individuals to allow separate benefit estimation for the impaired and normal groups. About two-thirds of the respondents are residents of Glendora, a community with high levels of oxidant pollution; the remaining one-third of the respondents live in Burbank, which has lower levels of oxidant pollution. All respondents were matched to a monitoring station within one mile of their homes.

This chapter explains the sampling methods and describes the data. The next four sections describe the selection and recruitment of the subjects and the choice of the two communities. Sections 4.6 and 4.7 describe the two survey instruments, while Section 4.8 covers the collection of pollution data. Finally, the last two sections of this chapter present the construction of the panel of observations and present descriptive statistics.

4.2 SOURCE OF SUBJECTS

Subjects for this research were drawn from the population studied by Detels et al. (1979, 1981) in the Chronic Obstructive Respiratory Disease (CORD) study (see also, Rokaw et al., 1980; and Tashkin et al., 1979). The CORD study includes approximately 15,000 persons, who were aged 7 and above, at the time of the first mobile lung function laboratory determinations in the early 1970s. These individuals were residents of a specific census tract in one of four communities in the Los Angeles area which were selected because of historical exposure to different levels and types of air pollution, because of their demographic similarity to each other (median income, proportion home owners, median age, percent white, etc.) and because of proximity to an air monitoring station of the South Coast Air Quality Management District (SCAQMD). All residents of households in the selected area, exclusive of children under 7 years of age and individuals physically unable to climb the 10 steps to the laboratory, were invited to participate in the study. About eighty percent of the invited residents actually participated in the study.

Measurements, including a battery of lung function tests and a detailed questionnaire on symptoms, smoking, residence and occupational histories and demographic information, were made in a mobile lung function laboratory which was located convenient to the population to be studied.

Approximately five years after the first set of measurements in each community, a second round of measurements was performed. Measurements made were the same, and the questionnaire was modified to update information already collected. A third visit was made to all communities except Glendora. In this visit, limited measurements were made on study participants who were available and willing to come to the mobile laboratory for the measurements during the few weeks of the study. The four communities and information about the CORD studies in each are given below.

Burbank (East San Fernando Valley); moderate oxidant pollution; 3,226 persons studies in 1973; 2,733 of these in 1978, 1,084 in 1983.

Lancaster (Antelope Valley, edge of Mohave Desert, higher altitude than the rest) selected for the study because of “clean air,” Lancaster experienced a rise in oxidant air pollution that is only slightly lower than that of Burbank; 4,584 persons studied in 1973, 2,544 of these in 1979, 1,103 in 1982.

Long Beach (coastal community south of Los Angeles, oil drilling and refineries) ; particulate and sulfur oxide pollution; 3,797 persons studies i 1974, 1,828 of these in 1980 and 1,024 in 1983.

Glendora (East San Gabriel Valley); high levels of oxidant pollution with some sulfates; 3,858 persons studies in 1977, 2,117 of these in 1982.

4.3 SELECTION OF COMMUNITY

Of the four CORD communities, two were selected for inclusion in the current study: Burbank and Glendora. Glendora has much the higher oxidant pollution levels, though this may be somewhat confounded by the higher sulfate levels. The Glendora CORD population had its second round of measurements more recently, in 1982. In addition, two other studies of sensitive individuals (persons with CORD and self-identified pollution "responders") have been performed in Glendora in the last two years.

Burbank has more moderate levels of ozone pollution with less contamination with sulfates. The second round of measurements was earlier, in 1978, though the later restudy of available participants was done in 1983. Because the Burbank studies were started five years earlier, the population is five years older.

A panel of scientists (see Appendix D of Gerking et al., 1984) with investigative experience in health effects of oxidant air pollution recommended that Glendora be selected, primarily on the basis of the higher levels of air pollution. The panel suggested that the Glendora pollution levels offered more "criteria days" and more opportunity to observe more noticeable health effects.

The selection of a community with ozone levels high relative to the rest of the U.S., however, makes it difficult to extrapolate any results obtained to other areas of the nation which have a less severe ozone problem. Relative representativeness would be sacrificed to obtain more clearly observable differences. The frequency of poor air quality in Glendora also may lead to permanent accommodation on the part of residents, including indoor areas for physical activity and recreation, thus minimizing the changes in behavior one might expect in response to high levels of ozone. The levels of ozone found in Burbank, on the other hand, are more representative of other parts of the U.S. with an ozone problem.

Therefore, with attention to the panel's recommendation, both the Glendora and the Burbank CORD population were used in this study. The Glendora subsample included 147 individuals, while 76 individuals from Burbank were included in the study.

4.4 SAMPLING

Using the Burbank and Glendora CORD populations, individuals were selected for recruitment. Selection was restricted to those still living in the same census tract in the area, or, if they have moved, in the same proximity to the air quality monitoring station.

Because of the confounding associated with smoking, only those individuals who are non-smokers, or who are former smokers who have not smoked for at least two years, were eligible to participate. It would be interesting to determine the combined, perhaps synergistic, effects of ozone exposure and cigarette smoking and perhaps the effect of ozone level on cigarette smoking. However, the sample size used for this study is not sufficiently large for this objective, given the number of important variables associated with smoking such as number of years smoked, daily amount of consumption, characteristics of cigarettes used, and the number of other smokers in the household.

Subjects were identified as potentially eligible for recruitment if they were between 25 and 59 years of age. Children were excluded as primary respondents because of the problems of interviewing them on the phone. Age 25 was selected as the lowest level because lung development is completed by that age, and individuals at that age are more likely to be settled than younger adults. Age 59 was selected as the upper limit to restrict the sample to those drawn from the prime working population.

Given of the economic nature of this study, one additional eligibility criterion was imposed. All subjects are household heads working at least 1600 hours per year at a regular job. A wage rate can be calculated for such workers from which a value of time can be computed. That value of time is needed in order to implement the ABM approach discussed in Chapter 3. The definition of a head of household was that used in the CORD study: if an adult male was present, he was considered the head of the household. An adult female was considered to be the head of the household if an adult male was not present. The term "adult" did not include grown children of the female head of household.

Sampling was stratified by measures of sensitivity or vulnerability. Approximately 20 percent of the sample were selected from the sensitive and vulnerable category, while the remainder of the sample is randomly selected from individuals having normal respiratory function. The sensitive and vulnerable category was defined to include individuals who have obstructive respiratory disease (asthma, bronchitis, emphysema) or who have impaired lung function.

4.5 RECRUITMENT

The initial step in recruiting consisted of a letter from Dean Detels as principal investigator of the CORD study, explaining the new study, encouraging their participation and explaining that the individual would be called in the next week regarding the new study.

The second step was a phone call. During this call, the study was more fully explained, questions were answered, required eligibility criteria were ascertained (non-smoking, still live in the area, working full time) and agreement to participate was obtained. Upon agreement, an in-person baseline interview was scheduled.

Following recruitment, a letter was sent acknowledging the participant’s agreement, and describing the study and the terms of payment. A copy of this letter, with a return envelope, was included for the subject to sign, record his or her social security number for payment, and return. If the copy was not returned by the time of the baseline interview, the data collector obtained the signature at that time.

To reduce waiting time, recruitment proceeded simultaneously on enough individuals to fill both the normal and impaired groups. To avoid bias involved in recruiting the “easier” subjects, however, no one on a randomized list, beyond the number needed for the group, was recruited until a refusal, ineligibility or transfer occurs among those within the number needed. That is, if 30 persons were needed for a given group, recruitment proceeded simultaneously on the first 30 persons on the randomized list. Person number 31 would not be recruited until it was known that one of the first 30 was not a participant. Individuals definitely declining to participate on the first phone call were not contacted further, Their identity was retained only to preclude further contact in recruitment.

The number of contacts with this panel of subjects necessitated paying them if continued participation was to be assured. Each individual was paid the sum of $5.00 per contact. Subjects in Glendora were contacted at most five times (the baseline and four follow up interviews), while Burbank subjects were contacted at most three times (the baseline and two follow-ups). Some subjects missed one or more contacts in both Burbank and Glendora.

4.6 SURVEY INSTRUMENTS

Two survey instruments, a background and a follow-up survey, were designed to collect the data necessary to implement the cost of illness, contingent valuation, and averting behavior methods. The surveys were designed in a joint effort involving economists at the Universities of Wyoming and Colorado, and epidemiologists and medical doctors at UCLA. The background survey was pretested by professional interviewers before the surveying began. The follow-up survey consists primarily of a subset of questions found on the background survey and hence was not separately pretested. The background and follow-up surveys are included as Appendix A and B, respectively. Data were collected by a staff specially trained by a professional interviewer to administer the surveys.

The follow up survey, designed to be administered by telephone, collects data for a two-day recall period on respondent's symptoms, perceptions regarding air quality, work and leisure activities, and medical visits and medication. The background survey, administered in the participant's home following recruitment, obtained baseline health, demographic, and activity data. Additionally, the background survey was designed to collect the same type of data as the follow-up for the two days preceding the day of the interview.

A more complete description of the variables measured by the two instruments, as well as means and standard deviations of these variables, is presented below.

4.7 VARIABLES MEASURED

To implement the cost of illness approach, data are required on time lost from work, medical expenses, and air pollution. The contingent valuation method requires data on symptoms and respondent-reported willingness to pay to avoid those symptoms. The data necessary to implement the averting behavior method are dictated by the theoretical model presented in Chapter 3.

Beginning with the budget constraint in the averting behavior model, the background survey collects hourly wage or annual salary data, depending on how the respondent is paid, as well as the hours usually spent working each day of the week, and the weeks worked per year. Both the background and follow up surveys collect data on hours spent at work for each of the two days preceding the interview, and these data are compared to the hours usually spent at work on the corresponding day of the week to construct measures of work loss. Work loss measures are important to implementing both the COI and the ABM. The background and follow-up surveys also collect data on the money prices of leisure activities, medical care, as well as the time spent in these activities.

Turning next to the estimation of the symptom production functions, the background survey collects data on the inputs which are fixed in the short run. These fixed inputs include measures of the respondent's health status, standard demographic information, and some averting behaviors which cannot be varied in the short run. Health status data are collected by repeating the National Heart, Lung, and Blood Institute symptom and respiratory disease questions. A medical history is obtained of diseases and medications which may imply a special sensitivity to air pollution.

Information is collected regarding typical usage of health care facilities along with the associated money and time costs. In addition, any recent contacts with the health care system are recorded. Detailed occupational and demographic information are collected, including education, occupation, industry and characteristics of the work environment which may affect respiratory health and symptoms, such as air conditioning at work and exposure to substances at work that may affect breathing. The respondent's age, sex, race, and the number of dependents in the household also are obtained on the background survey. Averting behaviors which are fixed in the short run include characteristics of the home environment such as presence and use of air conditioning, purifying, and filtering, fuel used for cooking and heating, character and extent of insulation, and use of air conditioned cars.

Both the baseline and follow-up survey collect data on variable averting behaviors for the two days preceding the interview. Leisure activities and changes in those activities are covered in detail in an attempt to measure the extent of averting behavior in response to ozone levels. The amount of time spent outdoors and the number of trips outside the area are included since changes in these variables also are possible averting behaviors. Additionally, respondents are asked on the background survey what, if anything, they do to avoid exposure to air pollution. This question is included in case some important averting responses were overlooked in the design of the survey.

Outputs of the symptom production functions are measured on both the background and follow up surveys. Prior biomedical evidence suggests that there are nine definite and nine probable symptoms of ozone exposure (for example, see Tashkin et al., 1983). A list of 26 symptoms, including the 18 definite and probable ozone symptoms as well as eight nonozone symptoms, is checked to discover whether the respondent experienced any of the symptoms during the preceding two days. For each symptom experienced, information is obtained on the duration and intensity of the symptom and the respondent's level of exertion at the onset of the symptom. Additionally, for each symptom experienced in the past two days, a contingent valuation question asks the maximum amount of money the respondent would have been willing to pay to have avoided that symptom for one day.

4.8 AIR QUALITY MEASURES

Air pollution data were obtained from the monthly listing of daily maximum hourly and average hourly values of ozone and other pollutants from the South Coast Air Quality Measurement District. Subjects living in Glendora were assigned pollution readings from the Azusa station (number 60), while Burbank subjects were matched to the Burbank station (number 69). The pollution measures used are the daily maximum one hour reading for ozone (OZ), sulfur dioxide (S02), and oxides of nitrogen (NOX). Future research will incorporate additional pollution measures, such as total suspended particulate (TSP).

The data contain a few missing values for each of the three pollution measures used in the study. Sampling with the background survey instrument began in early July, 1985, and some follow up surveys were conducted in early December, 1985. Ozone readings were obtained only for the period July-November; the missing December observations were set equal to the mean of the November daily maximum hourly ozone readings. The entire sample mean of the ozone measure was not used to replace missing observations because of the seasonal nature of ozone pollution. Ozone is lower in the late autumn and winter months, which is the period with the missing ozone data. For both SO2 and NOX, data were missing for November and December, and sample means were used to substitute missing values for these variables. Preliminary regressions using NOX produced unsatisfactory results; together with the missing data, this forced the exclusion of NOX from further empirical work.

4.9 CONSTRUCTION OF THE PANEL

As mentioned previously, data were collected for a two-day period each time the subjects were contacted. Observations then were defined in terms of the "person-day"; that is, there are two observations, one for each day, for every contact with a given subject. Constructing the sample in this manner results in a panel of 1820 observations. The panel used in this research is unusual in one important respect: observations on different cross sectional units are not drawn from the same time periods. In other words, the two-day period covered in, say, the second contact with one subject need not be the same two-day period covered in the second contact with another subject. Designing the research to create a more typical panel, where the observations on different cross sectional units are drawn from the same time period, would have resulted in much less variation in air pollution measures across the sample, and hence made it more difficult to identify a relationship between air pollution and either health or averting behavior.

4.10 DESCRIPTION OF THE DATA

Variable definitions, means, and standard deviations are presented in Tables 4.1 through 4.3. In each of these tables, the left hand column lists variable names, and the three right hand columns present means and standard deviations for the normal subsample, the impaired subsample and the whole sample. The whole sample includes all 1820 observations. The impaired subsample consists of all observations on respondents who reported physician-diagnosed asthma, bronchitis, emphysema, or other lung disease, while the normal subsample consists of all observations on respondents who did not report any of these respiratory disorders. There are 490 observations (27 percent of the total) in the impaired group and 1330 (73 percent of the total) in the normal group.

The means reported in Table 4.1 indicate that asthma is the most common respiratory ailment among the impaired group. Over 16 percent of the whole sample are asthmatics, while only two percent have emphysema. Note that in the impaired group, indicators of ill health are more than twice as prevalent than for the normal group. Despite the greater frequency of respiratory health problems among the impaired group, only two percent of the observations classified as impaired correspond to individuals who feel that their health is poor. Less than one percent of the normal observations fall in the category POOR.

Turning to the demographic variables reported in Table 4.1, there appears to be little difference in the socioeconomic characteristics of the normal and impaired groups. In particular, the means of hourly wages and total household annual income are nearly identical across the two subsamples. The whole sample is predominantly male, white, and married.

The characteristics of the work environment reveal a surprising feature of these data. A greater percentage of the impaired group are exposed to a substance at work which affects their breathing and lack air conditioning in the workplace. Additionally, the impaired group spends more time on average outdoors while at work. Each of these factors would be expected to increase adverse reactions to air pollution.

The characteristics of the home environment measured on the background survey consist primarily of appliances which are expected to affect the air quality inside the home. Since individuals can control the purchase and use of these appliances, they are potential averting behaviors, at least in the long run. Gas stoves, for example, are believed to be a significant source of NO_2; note that a smaller percentage of the impaired group cook with gas. As expected, the impaired subsample contains relatively more observations with air purifiers in the home and air conditioners in the car. That pattern is reversed for home air conditioning, where a greater percentage of the normal observations have air conditioning at home.

Somewhat surprisingly, the impaired group tends to spend more leisure, as well as working, time outdoors than the normal group. About ten percent more of the impaired subsample have a regular doctor than the normal subsample; the prices paid for medical care appear to be similar for both groups.

In contrast to installing new appliances in the home or car, there are some short run adjustments in behavior which may be used to reduce air pollution exposure or its effects. For example, one could go to a doctor, spend more time indoors, or take a trip outside the area. Surprisingly, the normal group reported a greater frequency of seeing a doctor than the impaired group during the days covered by the survey, despite the fact that the average member of the impaired subsample typically visits the doctor more frequently than the average member of the normal group.

For the few cases which contained missing values of the variables listed in Table 4.1, the general procedure was to replace missing values for continuous or discrete variables with sample means or sample modes, respectively. Missing values were rare for the variables reported in Table 4.1. For example, none of the health status measures were missing, and very few of the demographic variables had any missing values. Total family income was unavailable for one respondent, while the hourly wage figure was missing for six respondents. Sample means were used to replace these missing values.

Apart from missing values for the air pollution measures, which were discussed in Section 4.8, the only variable in Table 4.1 with more than two or three missing values is FPMED. The reason FPMED has a large number of missing values is that it is undefined for those respondents without a regular doctor, meaning that it is undefined for about 16 percent of the sample. The overall sample mean of FPMED was used to substitute for missing values. An alternate procedure would have been to use the means of DOCPRICE, DOCGET, and DOCWAIT in conjunction with the observed value of WAGE for the missing cases.

Descriptive statistics for the 26 symptoms are reported in Tables 4.2 and 4.3. The nine definite ozone symptoms are listed in Table 4.2, along with some associated information on duration, intensity, and contingent valuation estimates of willingness to pay to avoid the symptoms. The empirical results presented in the following chapters pertain to these definite ozone symptoms; as a consequence, less information is presented for the 17 symptoms listed in Table 4.3. In both Tables 4.2 and 4.3, the symptoms take the value unity if the respondent reports experiencing that symptom on a given day, and the value zero otherwise. Thus the mean reported for a symptom represents the proportion of person-days on which the symptom was observed. In Table 4.2, the means for the variables "Duration," "Constant," and "CVM bid," are means of these variables, given that the associated symptom was reported. Recall from Chapter 2 that these conditional means are biased estimates of the true population means of these variables owing to sample selection bias.

The "Duration" variables in Table 4.2 were constructed as a measure of the number of hours the associated symptom was experienced. A question on the survey asked whether or not the symptom was experienced in the morning, the afternoon, the evening, and the night. In constructing the duration variables, it was assumed that experiencing the symptom for any of these time periods amounted to six hours of suffering from the symptom. The variable "Constant" takes the value unity if the respondent experienced the symptom constantly and zero if the symptom was off-and-on. The CVM bids, which are considered at greater length in Chapter 7, are the respondents self-reported WTP to avoid one day of the symptom. The CVM bids reported in Table 4.2 are somewhat larger, but of an order of magnitude similar to the bids reported in Green et al. (1978) and Berger et al. (1986). On the basis of CVM evidence alone, it would appear that avoiding symptoms is worth more than $100 per day per symptom.

Missing values were more prevalent for the duration, constancy, and CVM bid variables than for the other variables measured by the survey instrument. For example, even when a symptom was experienced, there often was no information on its duration. If no information was available for duration, it was assigned the value zero. Thus the means presented in Table 4.2 for duration underestimate the actual length of time the symptoms were experienced. Additionally, for the whole sample, when a definite ozone symptom was experienced, between two and ten values of the CVM bid were missing. Missing values for the CVM bid may represent rejection of the contingent valuation question and hence were excluded in calculating the mean bids reported in Table 4.2.

Data on the existence of the symptoms are complete. No missing values were found for any of the 26 symptoms.

The mean values of the symptoms reported in Table 4.2 and 4.3 reveal that, as expected, individuals in the impaired group tend to experience each of the symptoms more frequently than those in the normal group. The difference in frequency of symptoms is especially striking for the definite ozone symptom “wheezing/whistling breath,” which is experienced seven times more frequently in the impaired subsample. This symptom often is associated with asthma. Other definite ozone symptoms are experienced three to four times as frequently in the impaired subsample. Table 4.2 also reveals that mean expressed WTP to avoid one symptom day is higher for the impaired subsample than for the normal subsample, replicating a result of Loehman et al. (1979) and Loehman et al. (1981).

TABLE 4.1. SAMPLE MEANS AND STANDARD DEVIATIONS FOR ALL VARIABLES EXCEPT SYMPTOMS[a]

	Normal Subsample	Impaired Subsample	Whole Sample
A. Health Status Measures			
ASTHMA = 1 if respondent has physician-diagnosed asthma, 0 otherwise.	0 ---	.600 (.490)	.162 (.368)
BRONCH = 1 if respondent has physician-diagnosed bronchitis, 0 otherwise.	0 ---	.290 (.454)	.078 (.268)
EMPH = 1 if respondent has physician-diagnosed emphysema, 0 otherwise.	0 ---	.078 (.268)	.021 (.143)
OTHOIS = 1 if respondent has physician-diagnosed other respiratory disease, 0 otherwise.	0 ---	.314 (.465)	.085 (.278)
FLEMCO = 1 if respondent reports chronic cough or phlegm, 0 otherwise.	.171 (.376)	.457 (.499)	.248 (.432)
SHRTWHZ = 1 if respondent reports chronic wheezing or shortness of breath	.051 (.220)	.424 (.495)	.152 (.359)
HAYFEV = 1 if respondent has physician-diagnosed hay fever, 0 otherwise.	.170 (.376)	.339 (.474)	.215 (.411)
RESPINF = 1 if respondent reports a lot of trouble with respiratory infections in the past three years, 0 otherwise.	.008 (.086)	.073 (.261)	.025 (.157)
POOR = 1 if respondent's subjective evaluation of own health status is "poor," 0 if "excellent," "good," or "fair."	.008 (.091)	.020 (.142)	.012 (.107)
B. Demographic Variables			
AGE = years since birth.	47.246 (7.558)	48.465 (8.171)	47.574 (7.745)
SEX = 1 if male, O if female.	.925 (.264)	.935 (.247)	.927 (.259)
MARRIED = 1 if married and living with spouse, 0 otherwise.	.880 (.325)	.927 (.261)	.892 (.310)
NDEPEN = number of dependents.	3.528 (2.024)	3.412 (1.252)	3.497 (1.849)
EDGRADE = years of formal education.	14.781 (2.691)	14.514 (2.365)	14.709 (2.609)
BLUE = 1 if blue collar worker, O otherwise.	.271 (.445)	.376 (.485)	.299 (.458)
CONS = 1 if work in construction industry, 0 otherwise.	.114 (.318)	.118 (.323)	.115 (.320)
MFG = 1 if work in manufacturing, O otherwise.	.284 (.453)	.253 (.435)	.276 (.448)
TRASERV = 1 if work in wholesale/retail trade or in services, 0 otherwise.	.408 (.492)	.408 (.492)	.408 (.492)
INDOTHR = 1 if CONS, MFG, TRASERV all equal 0, 0 otherwise.	.195 (.396)	.220 (.415)	.202 (.401)
WAGE = hourly wage in dollars.	17.795 (9.178)	17.762 (17.678)	17.786 (12.067)
INCFAM = total household annual income in hundreds of dollars.	527.183 (185.954)	555.010 (262.500)	534.675 (188.385)
C. Characteristics of Work Environment			
EXPWRK = 1 if exposed to some substance at work which affects breathing, 0 otherwise.	.354 (.478)	.498 (.501)	.393 (.489)
ACWRK = 1 if workplace is air conditioned, 0 otherwise.	.768 (.422)	.747 (.435)	.763 (.426)
OUTWRK = hours usually outside during working day.	2.389 (2.821)	2.700 (3.200)	2.473 (2.930)
WRKESGV = 1 if work in the East San Gabriel Valley, 0 otherwise.	.422 (.494)	.494 (.500)	.441 (.497)

(continued)

Table 4.1, continued

	Normal Subsample	Impaired Subsample	Whole Sample
c. Characteristics of Work Environment, continued			
WRKMON = hours usually worked Monday.	8.753 (1.645)	8.714 (1.706)	8.742 (1.661)
WRKTUES = hours usually worked Tuesday.	8.689 (1.763)	8.849 (1.471)	8.732 (1.691)
WRKWED = hours usually worked Wednesday.	8.797 (1.538)	8.694 (1.733)	8.769 (1.593)
WRKTHUR = hours usually worked Thursday.	8.811 (1.557)	8.829 (1.448)	8.816 (1.528)
WRKFRI = hours usually worked Friday.	8.671 (1.800)	8.859 (1.930)	8.649 (1.836)
WRKSAT = hours usually worked Saturday.	1.146 (2.555)	1.331 (3.044)	1.196 (2.696)
WRKSUN = hours usually worked Sunday.	.365 (1.663)	.469 (1.760)	.393 (1.690)
WRKDAY = 1 if day is usually a work day, 0 otherwise.	.823 (.382)	.759 (.428)	.805 (.396)
WRKHRS = hours worked that day.	5.893 (6.330)	6.418 (6.126)	6.035 (6.278)
WLH = work loss hours = hours usually worked that day less WRKHRS.	-1.646 (0.986)	-2.725 (0.972)	-1.852 (0.985)
WLHO1 = 1 if WLH > 0, 0 otherwise.	.059 (.237)	.091 (.289)	.068 (.251)
WRKLOSS = hours missed from work if WLH > 0, undefined otherwise.	1.646 (1.899)	2.824 (3.176)	2.051 (2.464)
D. Characteristics of Home Environment and Long Run Averting Behaviors			
CASCOOK = 1 if cook with natural gas, 0 otherwise.	.902 (.298)	.873 (.333)	.894 (.308)
GASHEAT = 1 if heat with natural gas, 0 otherwise.	.958 (.162)	1.000 ---	.976 (.152)
ACHOME = 1 if home is air conditioned, 0 otherwise.	.796 (.403)	.767 (.423)	.788 (.409)
APHOME = 1 if have some type of air purifying/ filtering system at home, 0 otherwise.	.087 (.282)	.127 (.333)	.098 (.297)
INSUL = 1 if house is insulated, 0 otherwise.	.942 (.234)	.951 (.216)	.945 (.229)
TRAFFIC = 1 if live with 2 blocks of major street, 0 otherwise.	.789 (.408)	.800 (.400)	.792 (.406)
ACCAR = 1 if car is air conditioned, 0 otherwise.	.686 (.464)	.780 (.415)	.711 (.453)
MPG = miles per gallon of the car usually driven.	20.992 (7.816)	20.449 (8.007)	20.846 (7.870)
UOUT = total hours usually outdoors on that day of the week.	3.840 (3.212)	4.918 (3.547)	4.130 (3.339)
ULOUT = leisure hours usually outdoors on that day of the week.	1.933 (2.452)	2.778 (3.173)	2.160 (2.691)
DOCREG = 1 if have a regular doctor, 0 otherwise.	.812 (.391)	.910 (.286)	.838 (.368)
DOCPRICE = out of pocket expense at regular doctor.	21.305 (39.920)	19.420 (17.620)	20.798 35.334)
DOCCET = minutes commuting time to regular" doctor.	10.544 (9.937)	14.633 (13.615)	11.645 11.192)
DOCWAIT = minutes waiting time at regular doctor.	18.974 (16.560)	17.469 (17.218)	18.569 16.748)
FPMED = full price of medical care at regular doctor = (WAGE/60)(DOCGET + DOCWAIT) + DOCPRICE.	30.128 (41.570)	29.307 (26.717)	29.907 (38.139)

(continued)

Table 4.1, continued

	Normal Subsample	Impaired Subsample	Whole Sample
E. Short Run Averting Behaviors			
MED = 1 if respondent saw doctor on that day, 0 otherwise.	.062 (.241)	.037 (.188)	.055 (.228)
OUTHRS = hours spent outdoors on that day.	1.378 (2.380)	1.606 (2.687)	1.439 (2.467)
RECTRIP = 1 if respondent took a recreational trip outside the area during the two day survey recall period, 0 otherwise.	.104 (.305)	.094 (.292)	.101 (.302)
MEDIC = 1 if respondent took more medication than usual that day, 0 otherwise.	.045 (.472)	.052 (.531)	.048 (.489)
BEDMORE = 1 if respondent spent more time than spent more time than usual in bed, 0 otherwise.	.050 (.217)	.084 (.277)	.059 (.235)
BEDLESS = 1 if respondent spent less time than usual in bed	.030 (.171)	.027 (.161)	.029 (.168)
F. Air pollution measures			
OZO = daily maximum of hourly ozone concentrations for that day, in pphm	10.378 (5.887)	9.798 (5.215)	10.222 (5.727)
S02 = daily maximum of hourly sulfur dioxide concentrations for that day, in pphm.	.934 (.380)	.918 (.374)	.930 (.378)
NOX = daily maximum of hourly oxides of nitrogen concentrations for that day, in pphm.	15.117 (6.779)	15.266 (6.815)	15.157 (6.787)
G. Description of Survey			
GLENO = 1 if observation came from Glendora baseline, 0 otherwise.	.168 (.374)	.159 (.366)	.165 (.371)
GLEN1 = 1 if observation came from Clendora follow up 1, 0 otherwise.	.167 (.373)	.155 (.362)	.165 (.371)
CLEN2 = 1 if observation came from Clendora follow up 2, 0 otherwise.	.167 (.373)	.155 (.362)	.164 (.370)
GLEN3 = 1 if observation came from Glendora follow up 3, 0 otherwise.	.159 (.366)	.139 (.346)	.154 (.361)
GLEN4 = 1 if observation came from Glendora follow up 4, 0 otherwise.	.120 (.325)	.106 (.308)	.116 (.273)
BURBO =1 if observation came from Burbank baseline, 0 otherwise.	.075 (.264)	.098 (.298)	.082 (.273)
BURB1 = 1 if observation came from Burbank follow up 1, 0 otherwise.	.077 (2.66)	.098 (.298)	.081 (.273)
BURB2 = 1 if observation came from Burbank follow up 2, 0 otherwise.	.066 (.249)	.090 (.286)	.074 (.259)
MON = 1 if observation on Monday, 0 otherwise.	.191 (.393)	.147 (.354)	.179 (.384)
TUES = 1 if observation on Tuesday, 0 otherwise.	.359 (.480)	.367 (.483)	.361 (.480)
WED = 1 if observation on Wednesday, 0 otherwise.	.089 (.284)	.086 (.280)	.088 (.283)
THURS = 1 if observation on Thursday, 0 otherwise.	.129 (.336)	.110 (.313)	.124 (.330)
FRI = 1 if observation on Friday, 0 otherwise.	.041 (.197)	.033 (.178)	.038 (.192)
SAT = 1 if observation on Saturday, 0 otherwise.	.059 (.236)	.098 (.298)	.070 (.255)
SUN = 1 if observation on Sunday, 0 otherwise.	.054 (.226)	.086 (.280)	.063 (.242)
WEEKEND = 1 if SAT = 1 or if SUN = 1, 0 otherwise.	.114 (.317)	.184 (.388)	.132 (.339)

[a]Standard deviations in parentheses.

TABLE 4.2. SAMPLE MEANS AND STANDARD DEVIATIONS FOR DEFINITE OZONE SYMPTOMS AND ASSOCIATED Variables

	Normal Subsample	Impaired Subsample	Whole Sample
Pain on Deep Inhalation	.038 (.192)	.088 (.283)	.052 (.221)
Duration	1.059 (3.379)	4.186 (7.694)	2.489 (6.058)
Constant	.020 (.140)	.256 (.441)	.128 (.335)
CVM Bid	41.500 (197.897)	193.600 (378.298)	109.100 (300. 082)
Could not Breathe Deep	.034 (.181)	.084 (. 277)	.047 (.212)
Duration	1.733 (4.892)	2.049 (6.519)	1.884 (5.693)
Constant	.022 (.149)	.073 (.264)	.047 (.212)
CVM Bid	32.045 (150.998)	271.855 (422.511)	143.177 (328.823)
Out of Breath Easily	.024 (.153)	.090 (.286)	.042 (.200)
Duration	.188 (1.061)	.204 (.421)	.079 (.688)
Constant	0 ---	0 ---	0 ---
CVM Bid	255.844 (410.174)	374.440 (456.776)	323.155 (438.325)
Wheezing/Whistling Breath	.020 (.138)	.149 (.356)	.054 (.227)
Duration	4.154 (7.918)	6.411 (8.963)	5.818 (8. 718)
Constant	.115 (.326)	.260 (.442)	.222 (.418)
CVM Bid	11.542 (24.060)	333.746 (436.135)	252.347 (401.995)
Chest Tight	.031 (.173)	.135 (.342)	.059 (.235)
Duration	.439 (2.074)	.091 (. 739)	.224 (1.410)
Constant	.024 (.156)	0 ---	.009 (.097)
CVM Bid	203.825 (403.618)	197.547 (349.374)	199.962 (369.259)

(continued)

Table 4.2, continued

	Normal Subsample	Impaired Subsample	Whole Sample
Cough	.064	.192	.098
	(.245)	(.394)	(.298)
Duration	.565	.319	.436
	(2.195)	(1.615)	(1.911)
Constant	0	0	0
	---	---	---
CVM Bid	140.272	205.272	175.243
	(331.559)	(336.249)	(334.690)
Throat Irritation	.056	.124	.074
	(.229)	(.330)	(.262)
Duration	9.892	14.951	12.178
	(9.017)	(8.529)	(9. 124)
Constant	.514	.672	.585
	(.503)	(.473)	(.495)
CVM Bid	45.456	213.737	122.192
	(171.774)	(370.018)	(291.301)
Sinus Pain	.062	.167	.090
	(.241)	(.374)	(.286)
Duration	8.561	9.000	8.780
	(8. 795)	(9. 153)	(8.951)
Constant	.402	.402	.402
	(.493)	(.493)	(.492)
CVM Bid	97.316	238.750	168.478
	(267.293)	(393. 701)	(343.225)
Headache	.092	.190	.118
	(.289)	(.393)	(.323)
Duration	10.279	8.065	9.321
	(8.537)	(8. 600)	(8.614)
Constant	.615	.505	.567
	(.489)	(.503)	(.497)
CVM Bid	126.165	154.055	138.137
	(302.008)	(348.890)	(322.466)

[a]Standard deviations in parentheses.

TABLE 4.3. SAMPLE MEANS AND STANDARD DEVIATIONS OF PROBABLE AND NONOZONE SYMPTOMS[a]

	Normal Subsample	Impaired Subsample	Whole Sample
A. Probable Ozone Symptoms			
Eye irritation	.090	.149	.106
	(.287)	(.356)	(.308)
Nose bleed	.028	.043	.032
	(.165)	(.203)	(.176)
Dry nose	.045	.108	.062
	(.208)	(.311)	(.241)
Runny nose	.076	.176	.103
	(.265)	(.383)	(.304)
Phlegm	.054	.210	.096
	(.226)	(.408)	(.295)
Dizziness/faintness	.035	.047	.038
	(.183)	(.212)	(.191)
Spaced out/disoriented	.007	.033	.014
	(.082)	(.178)	(.116)
Fast hear when resting	.017	.082	.035
	(.130)	(.274)	(.183)
Swollen glands	.012	.035	.018
	(.109)	(.183)	(.133)
B. Not Ozone Symptoms			
Not see as well	.034	.078	.046
	(.181)	(.268)	(.209)
Sensitive to bright light	.038	.071	.047
	(.192)	(.258)	(.212)
Voice husky	.056	.127	.075
	(.231)	(.333)	(.264)
Tiredness	.065	.171	.094
	(.247)	(.377)	(.292)
Nausea	.009	.020	.012
	(.095)	(.142)	(.109)
Chills/fever	.006	.014	.008
	(.077)	(.119)	(.090)
Pain in ears	.011	.022	.014
	(.106)	(.148)	(.119)
Ringing in ears	.048	.037	.045
	(.214)	(.188)	(.207)

[a]Standard deviations in parentheses.

CHAPTER 5

ECONOMETRIC MODEL AND METHODOLOGY

5.1 INTRODUCTION

This chapter outlines the econometric procedures used to apply the averting behavior theory discussed in Chapter 3 to the data described in Chapter 4. Results from the analysis of averting behavior theory indicate that estimation of the symptom production functions is a key element of the implementation of the ABM. Three econometric difficulties arose in the symptom production function (SPF) estimation. First, the dependent variables in these estimating equations indicate only the presence or absence of a given symptom and hence are limited to the values zero and unity. There are well known econometric techniques designed to handle limited dependent variables; these are reviewed briefly in Section 5.2. The second problem in estimating the SPFS is the joint determination of symptoms and averting behaviors which may lead to simultaneous equations bias. Section 5.3 discusses the technique used to overcome simultaneous equations bias. Third, the data used in the empirical analysis make up a panel of multiple observations on individuals over time; a complication considered in Section 5.4. The econometric specification of the averting behavior model, incorporating both limited dependent variables and simultaneous equations, is presented in Section 5.5 and the chapter concludes with an outline of the procedures used to estimate ozone and symptom benefits.

5.2 LOGISTIC ESTIMATION OF SYMPTOM PRODUCTION FUNCTIONS

The dependent variables in the SPFs take the value unity if the respondent reports experiencing the symptom, zero otherwise. Several problems can arise when ordinary least squares is applied to data containing discrete dependent variables. Two of the most important problems are (1) a linear regression may predict values for the dependent variable outside the unit interval, and (2) the variance of the random error is not constant across observations.

The two statistical models most frequently used to handle discrete dependent variables are the probit and logit models, based on the normal and logistic cumulative distribution functions, respectively. The normal and logistic distributions are difficult to distinguish from one another unless there are a large number of observations or the data are concentrated in the tails of the distribution (Amemiya, 1981). As a result, probit and logit tend to produce similar parameter estimates, and in fact the estimated coefficients of one of these models can be estimated by a constant multiple of the coefficients of the other model. It is not always clear, then, which model should be chosen; logit is used in this research because it is computationally simpler than probit.

In the logit model, it is assumed that there exists, for each observation i, a continuous index $I_i = X_i'\beta + e_i$ where X_i' is a vector of values of explanatory variables for the i^{th} observation, β is a parameter vector common to the entire sample, and e_i is a random error. It is then assumed that an individual chooses the occurrence of an event, such as a symptom, if the value of the index I_i rises above some threshold level such as zero. The probability that symptom S occurs then is given by

$$\Pr(S|I_i) = \Pr(e_i > -X_i'\beta) = 1 - F(-X_i'\beta), \quad (1)$$

where F(•) is the value of the logistic cumulative distribution function evaluated at $-X_i'\beta$:

$$F(-X_i'\beta) = \frac{1}{1 + \exp(X_i'\beta)}, \quad (2)$$

where exp is the base of the natural logarithm.

The estimated coefficients of the logit model do not indicate the change in the probability of a symptom occurring for a small change in the corresponding variable. The marginal effect of regressor X_{ij} on the probability of a symptom is

$$\frac{\partial}{\partial X_{ij}}\left(\frac{1}{1 + \exp(-X'\beta)}\right) + \frac{\exp(-X_i'\beta)}{[1 + \exp(-X_i'\beta)]^2} \cdot \beta_j \quad (3)$$

where β_j is the coefficient associated with X_j.

5.3 SIMULTANEOUS EQUATION ESTIMATION OF SYMPTOM PRODUCTION FUNCTIONS

If symptoms and averting behaviors are jointly determined, then single equation estimation of the SPFs will produce biased and inconsistent estimates of the parameters of the SPFs. In other words, the expected value of the estimated parameters of the SPFs will not equal the true parameter values, and this bias will not disappear as the sample grows larger.

The data used in this research contain a classic example of joint determination. Medical care would be expected to reduce sickness. Medical attention is sought, however, when sickness occurs. Thus the data may reveal a positive association between medical care consumption and sickness. Similar arguments extend to all of the averting behaviors which can be varied in the short run (Crocker et al., 1979).

In linear regression, one solution to simultaneous equations bias is two stage least squares. The first stage of this technique involves estimating a set of reduced form equations in which a set of jointly determined variables are specified as functions of all the exogenous variables of the model. In some cases, results from the reduced form equations can be used in the second stage to identify the parameters of the structural equations, which are the original equations of the model. In this second stage, the observed values of the jointly determined variables are replaced in a structural equation by the values of these variables predicted by their reduced form equations. The structural parameters can be identified only if the number of exogenous variables excluded from the structural equation is at least as great as the number of included jointly dependent variables. If the structural equation is identified, then two stage least squares provides biased but consistent estimates of the true structural parameters. An analogous two stage procedure, illustrated by example below, is available for models with limited dependent variables. Nelson and Olson (1978) have shown that this procedure produces consistent estimated coefficients.

To illustrate the two step procedure, consider the following simple model.

$$U = U(X, S) \tag{4}$$

$$S = S(M; H, \alpha, \delta) \tag{5}$$

$$WT + A = Xr_X + Mr_M + WG(S) \tag{6}$$

where S = 1 if the symptom occurs, otherwise S = 0, and M = 1 if medical care is consumed, otherwise M = 0. The other notation was defined in Chapter 3.

Equation (5) is the structural form of the SPF. Single equation estimation of this expression would produce biased and inconsistent estimates. An alternative is to estimate the reduced form medical demand equation in equation (7)

$$M = M(r_M, r_X, W, A, H, \alpha, \delta). \quad (7)$$

The predicted values from the reduced form demand equation for medical care, denoted by $\hat{M}$, then may be used in place of M in the estimation of the SPF, as in equation (8):

$$S = S(\hat{M}; H, \alpha, (\quad (8)$$

Note that the SPF is over identified by exclusion restrictions since four exogenous variables are excluded (r_M, r_X, W, A), while only one jointly determined variable is included. The econometric model presented in the Section 5.5 is a generalization of the simple model in this example.

5.4 PANEL DATA

A third econometric problem encountered involves the nature of the data. As discussed in Chapter 4, the data are made up of a panel of multiple observations over time. Unlike panel data usually encountered in the social sciences, however, measurements on respondents in a given baseline or follow-up occur on different days. In the typical situation, the j^{th} measurement on the i^{th} respondent would occur at the same time. One way to use the added information contained in the panel structure is to specify each regression estimated in an error components framework. (See Judge et al., Chapter 13.) Yet this framework may be complex and difficult to implement in light of the special characteristics of the panel. Consequently, a simpler approach was adopted in which dummy variables indicating: (1) city of residence for the respondent (Glendora or Burbank) and (2) the source of the data (baseline interview or one of four follow-up questionnaires) were included in each regression. These dummy variables, defined in Chapter 4 as $GLEN_i$ (i = O, 1, 2, 3. 4) and $BURB_i$ (i = O, 1, 2), account for time, but not individual effects. Tests of hypotheses based on both reduced and structural form estimates, therefore, are conservative since potentially relevant information is not used.

5.5 THE ECONOMETRIC MODEL

The estimated structural forms of the SPFs are

$$S_j = S_j \text{(ASTHMA, BRONCH, EMPH, OTHDIS, FLEMCO, SHRTWHZ, HAYFEV, RESPINF, POOR, EDGRADE, AGE, SEX, MARRIED, GLEN1, GLEN2, GLEN3, BURBO, BURB1, BURB2, WRKESGV, EXPWRK, ACWRK, ACCAR, ACHOME, APHOME, GASCOOK, MED, OUTHRS, RECTRIP, S020, OZO)}, \quad (9)$$

where the index j runs over the nine definite ozone symptoms: (1) could not breath deep, (2) pain on deep inhalation, (3) out of breath, (4) wheezinglwhistling breath, (5) chest tight, (6) cough, (7) throat irritation, (8) sinus pain, and (9) headache.

Since this’ research is designed to estimate benefits of daily occurrences of symptoms, the following averting behaviors are considered fixed in the short run: ACCAR, ACHOME, APHOME, GASCOOK. The three remaining averting behaviors are variable in the short run and hence are considered jointly determined variables: MED, OUTHRS, RECTRIP. The reduced form equations for these three averting behaviors are

$$V_i = V_i \text{(ASTHMA, BRONCH, EMPH, OTHDIS, FLEMCO, SHRTWHZ, HAYFEV, RESPINF, POOR, EDGRADE, AGE, SEX, MARRIED, GLEN1, GLEN2, GLEN3, GLEN4, BURBO, BURB1, BURB2, WRKESGV, EXPWRK, ACWORK, OUTWRK, BLUE, CONS, TRASERV, INDOTHR, WAGE, INCFAM, NDEPEN, ACCAR, MPG, ACHOME, APHOME, GASCOOK, ULOUT, FPMED, DOCREG, WRKDAY, WEEKEND, S020, OZO)}, \ i = 1, 2, 3, \quad (l0)$$

where V_1 = MED, V_2 = OUTHRS, V_3 = RECTRIP. Additionally, a reduced form work loss equation, specified identically to equation (10), was estimated.

The reduced forms include a number of exogenous variables not found in the SPFs. The variables OUTWRK and ULOUT enter the model via the structural outdoor hours equation, FPMED and DOCREG enter the structural medical care equation, and the variable MPG is from the structural recreation trip equation. The occupation and industry dummies in equation (10) enter the model via the structural forms for medical care and work loss, since these variables may proxy for health insurance and sick leave policies. Finally, WAGE, INCFAM, and NDEPEN could conceivably enter the structural forms for all three short run averting behaviors. However, exact specifications of the structural forms of MED, OUTHRS, and RECTRIP are not required since for estimation of the reduced forms it is sufficient to know only the list of exogenous variables in the model.

The reduced form equations for MED and RECTRIP were estimated in a logit framework. The OUTHRS equation was estimated using ordinary least squares despite the truncation of this variable at zero. Tobit may be a more appropriate regression procedure for the OUTHRS equation, and might also be useful in estimating work loss hours. Instead of using tobit on the number of hours missed from work, a logit equation was specified using WLH01 as the dependent variable. WLH01 takes the value unity if any time was missed from work, zero otherwise.

The predicted values from the reduced form equations, denoted by the suffix “HAT,” were substituted into the structural form equations for the SPFs. These second stage SPFs are specified identically to equations (9) except that MEDHAT replaces MED, OUTHAT replaces OUTHRS, and RECHAT replaces RECTRIP.

Each reduced form equation is estimated three times: for the whole sample, for the normal subsample, and for the impaired subsample. Each of the nine SPFs are estimated in both a single equation and a simultaneous equation framework for the whole sample and for the normal and impaired groups separately. When estimating separate equations for the two subsamples, the variables ASTHMA, BRONCH, EMPH, and OTHDIS are dropped from the equations since these variables were used to define the subsamples.

The large number of explanatory variables in the reduced forms created computational difficulties for the iterative maximum likelihood program used to estimate the logit equations. To allow estimation of these equations, the six dummy variables reflecting location and survey period were reduced to a single dummy variable, BURB, which indicates simply whether an observation came from Burbank. Additionally, certain variables caused convergence problems in one or another of the estimated equations. For example, the low frequency of observations on RESPINF and POOR, particularly for the normal group, often was a source of nonconvergence. In such a situation the variable simply was dropped from the equation to allow the empirical work to proceed.

The next two chapters present the results from estimating the model described in this section. Chapter 6 presents the reduced form estimates. The reduced forms can be used not only to correct for simultaneity in the estimation of the SPFs, but the MED equation itself can be used as a basis for benefit estimation. By assuming that medical care is an essential input in the prevention of symptoms, the change in the area behind the

Marshallian demand curve for medical care when ozone changes can be used as a approximation of the WTP to avoid ozone, following Bockstael and McConnell (1983).

Chapter 7 presents single- and simultaneous-equation estimates of the symptom production functions. The WTP to avoid these symptoms is calculated using the ABM procedure described in Chapter 3.

CHAPTER 6

REDUCED FORM ESTIMATES, DISUTILITY OF ILLNESS, AND BENEFITS OF OZONE CONTROL

6.1 INTRODUCTION

The main purpose of this chapter is to present estimates of reduced form demand equations for the short term averting activities MED, RECTRIP, and OUTHRS. In the empirical model discussed in Chapter 5, these variables are jointly determined with symptoms. Predicted values from reduced form equations, therefore, are needed in order to appropriately estimate the symptom production functions. Reduced form estimates to explain each of the short-run averting behavior variables are obtained from the whole sample and separately for the normal and impaired subsamples.

This chapter also uses the reduced form estimates to measure: (1) the benefits of oxidant control and (2) the disutility of illness. The benefit estimate of reduced ambient oxidant concentrations is based on the reduced form demand equation for MED. Under the assumption that medical care is a necessary input in ameliorating the health consequences of oxidant exposure, this demand equation is used to estimate willingness to pay for oxidant control. Once the WTP value has been obtained, methods developed in Chapter 3 are used to estimate the monetary value of the disutility of oxidant induced symptoms and illness. In particular, the willingness to pay expression derived from the averting behavior model is

$$\frac{\partial A}{\partial \alpha} = - \mu_j \sum_j U_j S_{j\alpha} + W \sum_j G_j S_{j\alpha}, \qquad (1)$$

where the first term on the right hand side measures the monetary value of disutility of illness, and the second measures the value of time lost from market and nonmarket activities. The disutility term is estimated by subtracting the value of time lost from the willingness to pay for oxidant control based on the MED reduced form. Value of time lost from market and nonmarket activities is approximated in these calculations from a fourth reduced form equation to explain work loss.

Section 6.2 presents reduced form estimates of the demand for medical care and compares the income, full price, and implied money and time price elasticities to other estimates of medical demand. The reduced form equations for work loss hours are presented in Section 6.3. Section 6.4 contains estimates of reduced form equations for OUTHRS and RECTRIP. Estimates of WTP for ozone reductions are found in Section 6.5. Estimates of the value of work loss due to ozone, and of the monetary value of the disutility of ozone-induced illness are presented in Section 6.6 Conclusions follow in Section 6.7.

6.2 ESTIMATING THE DEMAND FOR MEDICAL CARE

A well known comprehensive model of demand for health services was developed by Andersen (1968). The reduced form demand equation specified in Chapter 5 contains most of the features of this model. Andersen's model, discussed in more detail in Sorkin (1984) focuses on a sequence of three determinants of demand: predisposing, enabling, and illness level. The predisposing component of individual demand for health services consists of demographic and health factors such as chronic and past acute illness, marital status, age, sex, race, education, occupation, and family size, as well as attitudes toward disease and health services. The medical .

care demand estimates presented in this chapter control for all of these predisposing factors except attitudes. Andersen's enabling component includes income, prices of health services, health insurance, and access to a regular source of health care, all of which are controlled in the regressions presented in this chapter. The enabling component also includes community factors, such as the manpower devoted to health services, which affect the supply of health care services. Community factors are controlled here by the dummy variable which differentiates between the two communities used in this research. In addition to predisposing and enabling conditions, an individual's demand for health care in Andersen's model will depend on "medical need" or his level of illness. In the averting behavior model, illness is determined jointly with medical care demand. The structural medical demand equation includes symptoms as explanatory variables, but the solution for the reduced form expresses medical demand as a function only of the predetermined variables in the model (see Section 5.5). As a result, the symptoms do not appear among the list of independent variables in the regressions presented in this chapter.

In specifying a medical demand equation, there is some uncertainty as to the choice of dependent variable. It is difficult to measure both the quantity and quality of medical services consumed, and the traditional units of measurement, such as physician visits, hospital admissions, tests and drugs prescribed may not be the goods which enter the consumer's health production or utility function. Feldstein (1983) argues that the consumer demands "treatment of illness"; the consumer then consults a physician who prescribes a treatment consisting of some combination of drugs and therapy and the like. Thus, the appropriate measure of the demand for medical care may be a 0-1 variable which simply measures whether or not a physician was consulted, indicating that “treatment for illness” was demanded. The dependent variable MED used in the medical demand equations reported in this section is just such a variable.

Logistic regression estimates of reduced form demand equations for MED are presented in Table 6.1. The first column of the table lists explanatory variables. Coefficient estimates and t-statistics (in parentheses) are presented for the whole sample, normal subsample, and impaired subsample in columns two to four. Three variables of particular interest in these equations are the price of medical care (FPMED), family income (INCFAM), and ozone (OZO).

In all three equations, the coefficients of FPMED are negative as expected, but not significantly different from zero at conventional significance levels. Thus, the demand for medical care appears to be quite price inelastic. Ignoring the outcome of these significance tests, full price elasticities of medical demand evaluated at the means of all explanatory variables are: (1) -0.10 for the whole sample, (2) -0.062 in the normal subsample, and (3) -0.27 for the impaired subsample. These price elasticities compare favorably with those reported elsewhere in the literature. For example, Holtmann and Olsen found price elasticities of demand ranging from -.01 to -.15,; Newhouse, Phelps, and Marquis (1980) report price elasticities of -.09 to -.13; Phelps reported a value of -.18, and Newhouse and Phelps (1976) found a price elasticity of physician visits of -.16.

TABLE 6.1. MEDICAL CARE DEMAND EQUATION[a,b]

Explanatory Variable	Whole Sample	Normal Subsample	Impaired Subsample
ASTHMA	-.0618	---	---
	(-.276)		
BRONCH	-.7781	---	---
	(-2.032)		
OTHDIS	.1990	---	---
	(.857)		
HAYFEV	.3387	.1686	1.3235
	(2.365)	(.892)	(1.882)
FLEMCO	.1782	-.1694	1.6788
	(1.216)	(-.863)	(1.679)
SHRTWHZ	-.4689	---	.5552
	(-1.779)		(.468)
POOR	1.0353	2.0674	---
	(2.516)	(3.518)	
WRKESCV	.3028	.2002	-.3693
	(2.499)	(1.465)	(-.662)
EXPWRK	.0804	.0990	-1.0740
	(.643)	(.708)	(-1.132)
ACWRK	.1264	.4492	-1.5007
	(.778)	(2.252)	(-1.263)
OUTWRK	-.0092	-.0210	-.3341
	(-.419)	(-.786)	(-1.692)
BLUE	-.2040	.0446	-.0895
	(-1.326)	(.261)	(-.194)
CONS	.1659	.2888	3.0954
	(.703)	(1.072)	(1.659)
TRASERV	.1207	.0765	1.7503
	(.785)	(.458)	(1.690)
INDOTHR	.1303	.0098	2.5965
	(.714)	(.044)	(1.803)
WAGE	-.0108	-.0080	-.0624
	-1.249)	(-.777)	(-1.072)
INCFAM	-.0011	-.0020	.0046
	-2.460)	-3.588)	(1.918)
NDEPEN	.0405	.0410	-.3017
	(1.496)	(1.463)	(-1.058)
APHOME	-.3825	-.4804	-.7483
	(-1.355)	(-1.240)	(-.632)
ACHOME	.0832	.1127	2.5289
	(.568)	(.702)	(1.698)
ACCAR	.0134	-.0071	-.0765
	(.097)	(-.046)	(-.105)
MPG	-.0154	-.0064	-.0665
	(-1.917)	(-.738)	(-1.375)
GASCOOK	-.2139	-.3005	.0250
	(-1.245)	(-1.467)	(.039)
ULOUT	.0288	.0550	-.2203
	(.977)	(1.581)	(-1.213)
FPMED	-.0016	-.0010	-.0046
	(-.664)	(-.339)	(-.329)
DOCREG	.0260	.0329	---[c]
	(.156)	(.177)	
WRKDAY	-.0572	.1754	-1.9891
	(-.256)	(.659)	(-1.716)
WEEKEND	-.4020	-.2981	-1.0375
	(-1.714)	(-1.110)	(-1.636)
BURB	.1649	.3389	.4316
	(1.158)	(2.140)	(.548)
EDGRADE	-.0026	-.0008	.0454
	(-.108)	(-.030)	(.350)

(continued)

Table 6.1, continued

Explanatory Variable	Whole Sample	Normal Subsample	Impaired Subsample
ACE	-.0040	-.0053	.0338
	(-.481)	(-.544)	(.765)
SEX	.2853	.2090	---
	(1.199)	(.777)	
MARRIED	-,2048	.0020	-3.5245
	(-1.004)	(.008)	(-1.848)
S02	.0620	.0911	.4087
	(.402)	(.526)	(.844)
OZO	.0362	.0308	.0885
	(3.807)	(2.924)	(2.702)

[a]The dependent variable in the regression is a transformation, T(p) of the dependent variable p in the model: $T(p) = 5 + 0.5[\ln(p/(1-p))]$. To obtain estimates of the true parameters of the logistic regression, multiply slope coefficients by 2; subtract 5 from the intercept and multiply by 2.

[b] t-statistics in parentheses.

[c]Variable excluded due to convergence problems.

Recall from Chapter 4 that the full price of medical care is the sum of the money cost (after insurance) of medical care and the value of commuting and waiting time:

$$FPMED = DOCPRICE + (WAGE/60)\,(D0CGET + DOCWAIT).$$

Thus, the medical demand equations imply an elasticity for each of the components of the full price of medical care as well. These implied money and time price elasticities are presented in Table 6.2. A better method to estimate the elasticities in Table 6.2 might be to enter the money and time prices separately in the logistic regression; inferring these elasticities from the full price elasticities is an approximation which is used because it does not require estimation of additional equations. In any case, Acton (1976) reported the following time price elasticities of visits to physicians: -.05 for waiting time and -.25 to -.37 for travel time. Holtmann and Olsen found a waiting time elasticity of -.015 to -.039, while Phelps reported a waiting time elasticity of -.07. Thus, the implied elasticities of waiting time reported in Table 6.2 are similar to those reported by other researchers; the commuting time elasticities are an order of magnitude lower than those reported by Acton.

INCFAM, contrary to expectation, enters the whole sample and normal subsample equations with negative and significant coefficients; however, this variable positively and significantly (at the five percent level) affects the probability of seeing a doctor for the impaired individuals. The behavior of the coefficient of INCFAM in the equation for normal respondents supports the idea that higher income individuals have better knowledge of how to treat themselves for minor afflictions and therefore tend to contact the health care system less frequently. Nevertheless,

TABLE 6.2. IMPLIED MONEY AND TIME PRICE ELASTICITIES OF DEMAND FOR MEDICAL CARE

Explanatory Variable	Whole Sample	Normal Subsample	Impaired Subsample
DOCPRICE	-0.070	-0.044	-0.177
DOCGET	-0.012	-0.064	-0.039
DOCWAIT	-0.018	-0.012	-0.047

these results contrast with medical demand-income relationships found in other studies. Holtmann and Olsen (1978), for example, found an income elasticity range of .057 to .293, and Phelps (1975) reported an income elasticity of .11. In a probit equation of the probability of making nonzero medical expenditures, Manning et al. (1981) found an income elasticity of .04. For pediatric visits, Goldman and Grossman (1978) report an income elasticity of 1.32.

Part of the divergence between the income elasticities reported in Table 6.2 and those reported elsewhere in the literature can be attributed to differences in the definition of the dependent variable, in the specification of the equation, and in the type of data collected. Those factors, however, would not be expected to explain a sign difference. A partial explanation for the poor results obtained for income in this research is that income is correlated with the value of time, and the variable FPMED does not fully capture the time costs of a doctor visit. Additionally, a theoretical argument can be made that INCFAM is not the appropriate income variable to include in a demand equation. Total family income includes a component for the labor earnings of the respondent, but the model assumes that the time spent working is a choice variable and hence should not be included in a reduced form equation. Rather, the theoretically correct income measure is exogenous income, i.e., that part of INCFAM not earned by the respondent’s labor. (See Just et al., 1982, for further discussion of the roles of endogenous and exogenous income in demand specification and welfare measurement.) In any case, further investigation of the income elasticity of medical demand would be useful.

Next, the coefficient of OZO is positive and highly significant in each of the three equations. In fact, many alternative specifications of the reduced form medical demand were estimated to check the robustness of this result. Positive and highly significant coefficients of OZO occurred in virtually all cases. Since relatively few air quality measures could be included in this analysis due to data availability, OZO is perhaps best interpreted as a proxy for the oxidant mix. This mix of pollutants appears strongly and positively related to doctor visits.

Finally, in the whole sample regression, the health status measures ASTHMA, BRONCH, and OTHDIS are not positively and significantly related to the probability of obtaining medical care. This result can be explained by the sample proportions presented in Table 4.1: the normal subsample had a greater frequency of visits to doctors and hospitals than the impaired group during the sampling period. Among the other health status measures, the coefficients of HAYFEV and FLEMCO are positive and significant at the five percent level using a one-tail test in the impaired equation, but not in the normal equation. It appears that these health problems would be more likely to send a person to the doctor if he already had some more serious impairment. The variable POOR is positively and significantly (at one percent) related to the probability of seeing a doctor for the normal group; however, this variable was excluded in the estimation of the impaired equation because of convergence problems.

In general, the signs, magnitudes, and significance levels of the estimated coefficients vary substantially across the three medical care demand equations presented in Table 6.1 Although no formal test was conducted of the hypothesis that health technologies are identical as between the normal and impaired groups, inspection of the equations in Table 6.1, as well as the SPF estimates in the next chapter, suggests that hypothesis would be rejected.

With the exception of the anomalous results obtained for family income, then, the reduced form demand equations presented in Table 6.1 appear to be roughly consistent with prior research and to provide an adequate basis for benefit estimation. These equations will be used to calculate benefits of oxidant control in Section 6.5 after results for the other reduced form equations are presented.

6.3 WORK LOSS HOURS ESTIMATION

Three work loss hours reduced form equations are presented in Table 6.3. The dependent variable in these equations takes the value unity if any hours were missed from work, and zero otherwise. The work loss equation is estimated in a logit framework. The work loss equation is similar to a labor supply curve, and the key variables are own price (WAGE), income, and ozone.

The coefficient of the hourly wage variable WAGE is negative and significant at the one percent level in all three work loss equations, indicating that less working time is missed when the opportunity cost of missing work is higher. The coefficient of INCFAM is positively and significantly (at five percent) related to the probability of work loss. This positive income effect indicates that time away from work is a normal good. Silver (1970) found a similar pattern of negative correlation between work loss rates and labor earnings, and positive correlation between work loss rates and income. Silver concluded that work loss was a poor measure of health status since it was strongly influenced by economic

TABLE 6.3. WORK LOSS HOURS EQUATION[a, b]

Explanatory Variable	Whole Sample	Normal Subsample	Impaired Subsample
ASTHMA	-.1850	---	---
	(-.851)		
BRONCH	.3687	---	---
	(1:281)		
OTHDIS	.4329	---	---
	(1.942)		
HAYFEV	.3858	-.6584	3.6737
	(1.804)	(-1.721)	(2.667)
FLEMCO	.3054	.9196	-.2630
	(1:593)	(3.268)	(-.208)
SHRTWHZ	-.2215	-.7972	.3862
	(-.972)	(-1.445)	(.339)
WRKESGV	-.2326	-.3722	.1747
	(-1.447)	(-1.788)	(.183)
EXPWRK	.0478	.1167	2.0080
	(.284)	(.536)	(1.703)
ACWRK	.0891	.2044	-.9648
	(.495)	(.900)	(-.660)
OUTWORK	-.0235	-.0168	-,2696
	(-.959)	(-.500)	(-1.441)
BLUE	.1633	.0224	2.2604
	(.898)	(.080)	(2.978)
CONS	.8186	1.1262	.9630
	(2.796)	(3.180)	(.560)
TRASERV	.9822	1.3271	1.6911
	(4.109)	(3.941)	(1.527)
INDOTHR	1.4133	1.5597	4.2583
	(5.379)	(4.611)	(2.249)
WAGE	-.0833	-.1027	-.2806
	(-6.582)	(-5.579)	(-2.896)
INCFAM	.0017	.0021	.0105
	(3.283)	(3.043)	(2.529)
NDEPEN	.1335	.1516	.1284
	(3.284)	(3.037)	(.375)
APHOME	.3860	.6343	.8882
	(1.916)	(2.296)	(1.117)
ACHOME	1.1424	1.6626	-.7271
	(3.885)	(3.634)	(-.746)
ACCAR	-.3872	-.3546	-.9515
	(-2.170)	(-1.612)	(-.802)
MPG	.0126	.0108	-.0890
	(1.439)	(.796)	(-2.043)
GASCOOK	1.5554	1.5762	---[c]
	(2.952)	(2.626)	
ULOUT	.0123	.0512	-.1664
	(.238)	(.785)	(-.503)
FPMED	.0069	.0104	-.0149
	(3.581)	(2.750)	(-.790)
DOCREG	-.8854	-.5945	---[c]
	(-4.635)	(-2.561)	
WEEKEND	.6772	.6535	-.0285
	(3.418)	(2.543)	(-.074)
BURB	-.3816	-.1530	-.4432
	(-1.917)	(-.609)	(-.419)
EDGRADE	.0245	.0310	.4404
	(.743)	(.734)	(1.813)
AGE	.0635	.0750	.1464
	(5.027)	(4.466)	(2.298)
SEX	-.4659	-.7940	---[c]
	(-1.204)	(-1.558)	

(continued)

Table 6.3, continued

Explanatory Variable	Whole Sample	Normal Subsample	Impaired Subsample
MARRIED	-.5911	-.7825	---[c]
	(-2.054)	(-2.103)	
S02	.1551	.1530	-.0732
	(.935)	(.780)	(-.196)
OZO	.0202	.0258	-.0139
	(1.924)	(2.104)	(-.537)

[a]The dependent variable in the regression is a transformation, T(p) of the dependent variable p in the model : $T(p) = 5 + [\ell n(p/(1-p))]$. To obtain estimates of the true parameters of the logistic regression, multiply slope coefficients by 2; subtract 5 from the intercept and multiply by 2.

[b] t-statistics in parentheses.

[c]Variable excluded due to convergence problems.

variables. Ostro (1983), in contrast, reported negative income coefficients in his work loss regressions, but did not control for the wage. The coefficient of ozone is positive and significant at five percent for the normal group, but negative and insignificant for the impaired subsample. Thus ozone is positively related to work loss for the normal group, but appears to be unrelated to work loss for the impaired group.

The positive and significant coefficient on FPMED in the normal group's equation reflects a cross-price effect: a higher full price of medical care raises the cost of investing in health and hence increases work loss. The negative and significant coefficient on DOCREG in the same equation reflects a similar type of substitution effect. Having a regular doctor increases the availability of medical care and results in less time lost from work.

The variables APHOME, ACHOME, and GASCOOK, which are related to the quality of the home environment, all enter the normal work loss regression with the expected sign and are significant at the one percent level. The variable EXPWORK, a measure of the quality of the work environment, enters each equation with the correct sign and is significant at five percent in the impaired equation.

All three equations indicate that the probability of work loss increases significantly with age. Additionally, in the whole sample regression, all of the chronic health disorders except ASTHMA and SHRTWHZ are positively and significantly related to work loss. As expected, the impaired individuals are more likely to miss work. A similar result was obtained in both the Cropper and Ostro papers, where the existence of chronic conditions and the number of chronic conditions, respectively, were positive and significant factors in explaining work loss.

6.4 OUTDOOR HOURS AND RECREATIONAL TRIP ESTIMATION

The two remaining reduced form equations, for outdoor hours and recreational trips, did not perform as well as the medical care and work loss equations. The relatively poorer results from the OUTHRS and RECTRIP equations, reported in Tables 6.4 and 6.5, respectively, are not surprising in that the data collection effort was not directed specifically toward explaining these variables.

The outdoor hours equations reveal that measures of poor health are more often than not negatively associated with the time spent outdoors, but these effects rarely are significant at the ten percent level. Spending more time outside habitually, measured by OUTWORK and ULOUT, is associated with spending more time out on the days of the survey. More time is spent outdoors on weekends, and respondents in Burbank spend more time outdoors than those in Glendora. The residential location dummy is significant at one percent in all three equations.

The pollution variable S02 is negatively and significantly (at one percent) related to the time spent outdoors in the equation for the normal subsample, suggesting that normally healthy adults choose to stay inside when sulfur dioxide levels are high. No sulfur dioxide effect is perceptible in the impaired equation. The coefficient on ozone, in contrast, is positive and significant at the one percent level in all three equations.

The positive and significant ozone coefficient seems to suggest that, contrary to expectation, people like to be outside when ozone levels are

TABLE 6.4. OUTDOOR HOURS EQUATION[a,b]

Explanatory Variable	Whole Sample	Normal Subsample	Impaired Subsample
WEEKEND	.3897	.2957	.7446
	(1.918)	(1.218)	(1.887)
OTHDIS	.2834	---	---
	(1.271)		
INDOTHR	-.2030	-.2964	-.1235
	(-1.147)	(-1.380)	(-.253)
EDCRADE	.0100	.0032	.0588
	(.377)	(.111)	(.863)
GASCOOK	.0645	.2676	-.3443
	(.343)	(1.199)	(-.793)
ACHOME	.0473	.0390	.3228
	(.311)	(.219)	(.807)
S02	-.6293	-.9154	-.1037
	(-4.056)	(-5.231)	(-.296)
HAYFEV	-.0149	-.0408	.0625
	(-.097)	(-.202)	(.201)
BRONCH	-.1280	---	---
	(-.529)		
POOR	.0037	-.6636	.9097
	(.007)	(-.832)	(.933)
DOCREG	.2962	.3308	-.5024
	(1.740)	(1.797)	-.872)
MARRIED	.0226	.0160	-.3017
	(.094)	(.061)	-.389)
OUTWRK	.1485	.1246	.1888
	(6.410)	(4.344)	3.604)
APHOME	.0316	.1787	-.3795
	(.151)	(.723)	-.871)
Ozo	.1154	.0994	.1758
	10.790)	(8.443)	6.853)
MPG	-.0080	-.0022	-.0084
	-1.061)	(-.256)	-.434)
WAGE	.0029	.0007	.0033
	(.521)	(.081)	(.324)
AGE	-.0014	.0047	-.0099
	(-.160)	(.474)	-.473)
EXPWRK	.2056	.3008	.0536
	(1.583)	(2.000)	(.144)
EMPH	-.2304	---	---
	(-.527)		
ASTHMA	.0902	---	---
	(.479)		
ACCAR	-.0446	-.1277	.4240
	(-.321)	(-.812)	(1.183)
WRKESGV	-.0556	-.0620	.0889
	(-.434)	(-.429)	(.280)
CONS	-.1026	-.2117	-.2303
	(-.452)	(-.820)	(-.377)
BURB	.6908	.7616	.8943
	(4.495)	(4.307)	(2.411)
ULOUT	.0949	.0801	.1483
	(2.981)	(2.057)	(2.226)
ACWRK	.0679	.0343	-.4719
	(.420)	(.179)	(-1.230)
NDEPEN	-.0232	-.0127	-.1280
	(-.659)	(-.344)	(-.941)
FLEMCO	-.1783	-.1129	-.1842
	(-1.144)	(-.576)	(-.506)
FPMED	-.0012	-.0002	-.0035
	(-.657)	(-.108)	(-.497)
INCFAM	-.0000	.0005	-.0007
	(-.035)	(.940)	(-.721)

(continued)

Table 6.4, continued

Explanatory Variable	Whole Sample	Normal Subsample	Impaired Subsample
SHRTWHZ	.0681	-.0517	-.0536
	(.342)	(-.152)	(-.129)
BLUE	-.0849	-.0873	-.0824
	(-.530)	(-.459)	(-.223)
SEX	.1105	.0403	.4722
	(.381)	(.126)	(.498)
TRASERV	-.0672	-.1012	.0042
	(-.438)	(-.575)	(.011)
WRKDAY	.6188	.5650	.9865
	(2.608)	(2.075)	(1.911)
CONSTANT	-.7095	-.7892	-.9380
	(-.918)	(-.879)	(-.537)

[a] The dependent variable in the regression is a transformation, T(p) of the dependent variable p in the model : $T(p) = 5 + 0.5[\ell n(p/(1-p))]$. To obtain estimates of the true parameters of the logistic regression, multiply slope coefficients by 2; subtract 5 from the intercept and multiply by 2.

[b] t-statistics in parentheses.

TABLE 6.5. RECREATIONAL TRIP EQUATION[a, b]

Explanatory Variable	Whole Sample	Normal Subsample	Impaired Subsample
ASTHMA	.1002	---	---
	(.725)		
BRONCH	.1602	---	---
	(.960)		
OTHDIS	-,1598	---	---
	(-.913)		
HAYFEV	.1079	.1779	.1562
	(1.001)	(1.216)	(.535)
FLEMCO	-.2190	-.3058	.2025
	(-1.830)	(-1.926)	(.777)
SHRTWHZ	-.1191	.3950	-1.2676
	(-.800)	(1.732)	(-2.837)
WRKESGV	.0790	.0185	-.2064
	(.886)	(.174)	(-.615)
EXPWRK	.0048	.2476	-1.5606
	(.051)	(2.176)	(-3.892)
ACWRK	-.0230	.0514	.3643
	(-.194)	(.363)	(.836)
OUTWRK	.0157	.0198	-.1752
	(.918)	(.932)	(-2.702)
BLUE	.0106	.0363	.7700
	(.090)	(.260)	(1.815)
CONS	-.3418	-.1830	---[c]
	(-1.850)	(-.865)	
TRASERV	.0266	.0958	-1.1758
	(.246)	(.720)	(-2.812)
INOOTHR	-.0561	-.0954	-1.4653
	(-.437)	(-.574)	(-2.761)
WAGE	.0046	.0016	.0220
	(1.388)	(.227)	(2.208)
INCFAM	-.0002	1.0002	-.0019
	(-.587)	(-.426)	(-1.793)
NDEPEN	.0303	.0482	-.3263
	(1.308)	(1.994)	(-2.265)
APHOME	-.0095	-.2649	1.0162
	(-.062)	(-1.254)	(2.259)
ACHOME	.0244	.1762	-.2863
	(.227)	(1.310)	(-1.053)
ACCAR	-.1418	-.2518	1.0449
	(-1.438)	(-2.184)	(2.109)
MPG	-.0022	-.0054	-.0259
	(-.382)	(-.752)	(-.987)
GASCOOK	.2538	.6106	.5727
	(1.566)	(2.287)	(1.723)
ULOUT	.0023	.0197	-.0259
	(.103)	(.723)	(-.356)
FPMEO	.0007	.0021	-.0251
	(.660)	(1.720)	(-2.819)
OOCREG	.2134	.2020	.8157
	(1.559)	(1.290)	(1.476)
WRKOAY	-.0117	-.0453	.2341
	(-.070)	(-.228)	(.498)
WEEKEND	.2274	.1651	.7125
	(1.680)	(1.011)	(2.516)
BURB	-.2091	-.3261	-.3567
	(-1.806)	(-2.219)	(-1.127)
EDGRADE	.0051	-.0055	.0468
	(.275)	(-.245)	(.715)
AGE	.0020	.0008	.0299
	(.317)	(.112)	(1.435)
SEX	-.3456	-.1422	---[c]
	(-1.719)	(-.648)	

(continued)

Table 6.5. continued

Explanatory Variable	Whole Sample	Normal Subsample	Impaired Subsample
MARRIED	.1863	-.1648	---
	(1.011)	(-.858)	
S02	.1219	-.0060	.6407
	(1.112)	(-.047)	(2.152)
OZO	-.0101	-.0070	-.0103
	(-1.301)	(-.784)	(-.496)

[a]The dependent variable in the regression is a transformation, T(p) of the dependent variable p in the model: $T(p) = 5 + 0.5[\ell n(p/(1-p))]$. To obtain estimates of the true parameters of the logistic regression, multiply slope coefficients by 2; subtract 5 from the intercept and multiply by 2.

[b]t-statistics in parentheses.

[c]Variable excluded due to convergence problems.

high. This result could be explained if ozone were correlated with other factors which caused people to spend more time outdoors. In fact, photochemical oxidants are produced by sunlight irradiation of atmospheric mixtures of hydrocarbons and nitrogen oxides (Purdom, 1980). As a consequence of the photochemical process by which ozone is created, then, one would expect ozone levels to be high on warm, sunny days when people tend to be outdoors.

The "true" structural equation for time spent outdoors almost surely contains one or more variables which reflect how pleasant the weather is. If one of these variables, such as the amount of sunshine, were highly correlated with ozone, then the exclusion of the correlated meteorological variable from all of the reduced form equations would bias the ozone coefficient in those equations.

To avoid bias in the ozone coefficients, some effort was devoted to constructing an appropriate set of meteorological measures, but the exact set of weather variables which influence time spent outdoors is not immediately apparent. People are expected to spend more time outdoors when they perceive the ambient conditions to be pleasant. Some factors which might contribute to pleasant conditions or a “nice day” are sunshine, visibility, temperature, humidity, windspeed, and precipitation. The most readily available variables from this list are temperature and humidity. Daily high and low temperature and humidity readings, measured at the Burbank and Ontario weather stations and reported in the Los Angeles Times were matched to Burbank and Glendora subjects, respectively.

Previous researchers on the benefits of ozone control have reported high correlations between ozone and measure of temperature. For example, Portney and Mullahy (1983) reported a Pearson correlation coefficient between ozone and temperature of 0.53, while Mjelde et al. (1984) reported a correlation coefficient of 0.58. The Pearson correlation coefficients between ozone and the daily high temperature, the daily low temperature, and the daily average of high and low temperature for the present sample are 0.81, 0.50, and 0.73, respectively.

The high degree of correlation between ozone and measures of heat makes it virtually impossible to use sample information to separate the effects of these two variables in a regression. When the specification of the reduced form equations is expanded to include measures of heat and humidity, a pattern typical of multicollinearity emerges between the coefficients of ozone and temperature: one of these coefficients will be correctly signed and possibly significant, while the other takes the wrong sign.

While the poor results produced by the temperature variable are disappointing, it is not clear that a linear combination of temperature and humidity is the appropriate measure of how pleasant a day is. Meteorologists have created an index which combines temperature and humidity nonlinearly and is supposed to measure “how it feels” outside, expressed in degrees Fahrenheit. Unfortunately, temperature dominates humidity in the formula defining this index, and the index is just as correlated with ozone as the high temperature. In a final effort to merge temperature measures with the survey and pollution data, a dummy variable was created to measure whether the temperature was pleasant. This variable would take the value unity if the daily high temperature fell within some range (the ranges 70-90°F, 65-85°F, and 60-90°F were each tried independently) , but regression results using these variables were unsatisfactory as well.

Given that the sample does not provide the information necessary to separate the effects of ozone and heat, nonsample information must be combined with sample information to make a distinction between these two variables. Prior biomedical evidence suggests an association between ozone concentrations and the symptoms defined in Chapter 4. It is not clear that heat would play a major role in aggravating any of these symptoms. Thus it would seem that ozone would be a more important variable in explaining medical demand and work loss as well. Heat enters the model, then, only via the outdoor hours structural equation, but the temperature variables perform poorly in the outdoor hours reduced form. It seems safe to assume that the effects of ozone on the jointly dependent variables dominate the effects of heat, which justifies excluding the meteorological variables from the model. Further research using an expanded set of weather data may be warranted.

Turning now to the estimate of the recreational trip equation (Table 6.5), very few variables measured in these data are found to be significantly related to the probability of taking a recreation trip. Recreational trips are more likely to occur on weekends. Higher wages are positively associated with recreational trips, but surprisingly, higher family income is not. Residents of Burbank are less likely to take a recreational trip than residents of Glendora.

Averting behavior theory suggests that individuals may temporarily leave town to avoid pollution episodes. The only correctly signed and significant pollution variable in the recreational trip equation is S02 for the impaired subsample. Taking a trip would require some planning, and the relevant pollution variables might be lagged values of the variables used here. It seems more likely, however, that the direct utility effects of such a trip would overwhelm the averting behavior effects, making recreational trips an inadequate basis for averting behavior benefit calculations.

The weak results obtained from the outdoor hours and recreational trip equations make both of these equations poor choices for calculating benefits. Additionally, the prices of these variables are not measured in the data; thus their reduced form equations are not supply or demand equations. It is unclear how shifting these reduced form equations would provide a measure of welfare change.

In contrast, the medical care and work loss equations are closely related to demand and supply equations; the dependent variables in these equations have prices which are measured in the data; and the fits of these equations appear reasonably good. The reduced form medical care and work loss equations are used to measure the changes in welfare associated with changes in ozone concentrations in the next section.

6.5 ESTIMATING WTP USING MEDICAL DEMAND

The medical care demand equation estimates presented in Table 6.1 provide a basis for estimating WTP for an ozone reduction if medical care is a necessary input in the reduction of symptoms. Just et al. (1982) point out that if the input used for measuring welfare is not necessary, then that portion of surplus which could be realized in the absence of the input will not be reflected in the area behind the input demand curve.

Hence, if medical care is not a necessary input, total WTP will be understated, but changes in WTP may still be accurate.

The first step in using the medical care demand equations to estimate welfare change is to reduce demand to a function of price alone, holding all other variables constant. The resulting demand schedule is

$$Pr(M) = \frac{k \exp(OZ \cdot \beta_{OZ}) \exp(FPMED \cdot \beta_{FPMED})}{1 + k \exp(OZ \cdot \beta_{OZ}) \exp(FPMED \cdot \beta_{FPMED})} \qquad (2)$$

where β_{OZ} = the coefficient of ozone

β_{FPMED} = the coefficient of the full price of medical care

k = the exponent of the sum of the products of all other explanatory variables times their coefficients.

The area behind the medical care demand schedule between two prices $FPMED^0$ and $FPMED^1$ is

$$k \exp(OZ \cdot \beta_{OZ}) \cdot \int_{FPMED^0}^{FPMED^1} \frac{\exp(FPMED \cdot \beta_{FPMED})}{1 + k \exp(OZ \cdot \beta_{OZ}) \exp(FPMED \cdot \beta_{FPMED})} d(FPMED) \qquad (3)$$

$$= \frac{1}{\beta_{FPMED}} \ell n \left[\frac{1 + k \exp(OZ \cdot \beta_{OZ}) \exp(FPMED^1 \cdot \beta_{FPMED})}{1 + k \exp(OZ \cdot \beta_{OZ}) \exp(FPMED^0 \cdot \beta_{FPMED})} \right],$$

which can be evaluated at varying ozone levels.

In the Bockstael-McConnell analysis, the prices used in equation (3) would be the prevailing market price for $FPMED^0$ and the price which drives medical care demand to zero for $FPMED^1$. The price which drives medical demand to zero would vary with ozone levels, $FPMED^1 = f(OZ)$. The logistic equation, however, never predicts a zero probability of obtaining medical care, for finite values of all explanatory variables and coefficients. One solution to this problem would be to choose some small positive number ε, and solve for the lowest value of FPMED which resulted in a probability of medical care no greater than ε. A simpler solution, employed below, is to use the largest value of FPMED found in the sample. Additionally, $FPMED^0$ is set equal to zero.

In calculating the constant k which appears in the WTP formula, all explanatory variables (except FPMED and OZ) are set equal to their sample or subsample means. The example change in ozone considered is from a daily one-hour maximum of 12 pphm to 10 pphm.

Daily WTP figures for the above ozone reduction based on the reduced form demand equation estimates are presented in the first row of Table 6.6. These figures indicate the average individual in the sample, or the average individual in the normal subsample, would be willing to pay a little over one dollar per day for a 2 pphm decrease in daily maximum ozone concentrations on a day when the peak ozone reading is 12 pphm.

A disturbing feature of the first row of figures in Table 6.6 is that the average impaired individual's WTP is substantially less than the average normal individual for the same reduction in ozone, which is contrary to expectation. The reason for this unexpected result is that the reduced form demand equations predict a greater frequency of doctor visits for the normal group than for the impaired group. As mentioned previously, during the six month sampling period the normal group did report a higher frequency of doctor visits than the impaired group. It would seem, then, that the sampling period is atypical with respect to the medical care consumption of the subjects, and in fact the responses to two questions on the background survey confirm this suspicion. Respondents were asked the number of visits they made to a health care facility in the previous year and in a typical year. In a typical year, the average normal individual in

TABLE 6.6. DAILY WTP FOR A 2 PPHM OZONE REDUCTION

	Whole Sample	Normal Subsample	Impaired Subsample
Based on Sample Frequency of Medical Care	$1.26	1.29	0.09
Based on Typical Frequency of Medical Care	0.38	0.36	0.77

the sample would visit the doctor 1.8 times per year, while the average impaired person would visit the doctor 3.5 times per year, or almost twice as frequently.

The problem with the first row of WTP figures in Table 6.6, then, is that they are computed from demand equations which predict a greater than typical frequency of doctor visits for the normal group and a less than typical frequency for the impaired group. A solution to this problem is to adjust the intercepts of each medical care demand equation so that they predict a frequency of doctor visits which matches the frequency reported as typical. None of the slope coefficients in the demand equations need to be altered; only the intercepts are adjusted. In terms of the integral in equation (4), the adjustment produces a new value for the constant k.

Daily WTP figures based on the medical care demand equations with adjusted intercepts are presented in the bottom row of Table 6.6. As expected, average daily WTP for the normal group falls, while average daily WTP for the impaired group rises. These figures indicate that the average normal individual would be willing to pay about $.35 per day for a reduction of daily maximum ozone concentrations from 12 pphm to 10 pphm. The average impaired individual would be willing to pay about $.75 per day for that same reduction. These benefits may appear somewhat low, but the contemplated ozone reductions are small and begin at the current federal standard. Thus, there would appear to be positive benefits to reducing ozone concentrations below the current federal standard.

6.6 ESTIMATING THE DISUTILITY OF ILLNESS

To estimate the value of the disutility of ozone-induced illness, an estimate of the value of time lost from work must be obtained and subtracted from the WTP values presented in the previous section. The reduced form work loss hours equation provides an estimate of the probability of work loss given levels of the explanatory variables.

The probability of work loss was estimated at the mean values of all explanatory variables except ozone, and at ozone levels of 12 and 10 pphm. By subtracting the probability of work loss at OZO = 10 from that for OZO = 12, an estimate of the change in the probability of work loss is obtained. This change in the probability of work loss due to the change in ozone was multiplied by the mean hours of work loss, given that work loss had occurred, to obtain an estimate of the number of hours of work loss avoided due to the ozone reduction. Recall from the discussion in the literature review that this estimate of time lost is biased by sample selection. Nevertheless, it provides a simple estimate of the change in time lost from work.

Daily WTP based on typical frequency of medical care (see Table 6.6), the value of the change in time lost, and the annual monetary value of the disutility of ozone-induced illness are presented in Table 6.7. For the impaired subsample, only WTP is presented since the coefficient of ozone in the work loss equation for the impaired group was negative and insignificant. Although the values reported in Table 6.7 are illustrative because of the nature of the proposed ozone reduction, they do reveal that the disutility of illness dominates the value of work loss in WTP. Thus one would expect that morbidity values based in large part on work loss, such as Cropper's (1981) or Seskin's (1979), would seriously understate WTP.

TABLE 6.7. DAILY WTP, WORK LOSS, AND UTILITY CHANGE FOR OZONE REDUCTION

	Whole Sample	Normal Subsample	Impaired Subsample
WTP	$0.38	$0.36	$0.77
Value of Time Lost	$0.04	$0.07	---[a]
Monetary Value of Change in Utility	$0.34	$0.29	---[a]

[a]No value of time lost was computed for the impaired group since the coefficient of ozone was negative and insignificant in that regression.

6.7 CONCLUSIONS

This chapter has presented estimates of reduced form equations for medical care demand, work loss, outdoor hours, and recreational trips. The medical care demand equations formed the basis for making WTP calculations for a hypothetical reduction in ozone. The work loss equations provided estimates of the change in the value of time lost due to the same ozone reduction. Finally, the value of work loss was subtracted from WTP to estimate the monetary value of the disutility of ozone-induced illness.

Daily WTP for a reduction in ozone from 12 pphm per day to 10 pphm per day was estimated at about $0.36 per normal individual, and $0.77, or more than twice as much, per impaired individual. The value of work loss made up only about one-fifth of WTP for the normal group, with the remaining four-fifths attributed to the disutility of illness. The result that WTP is five times the value of time lost from work casts serious doubt on morbidity valuation techniques based largely on income foregone due to illness.

Several limitations and generalizations to the work of this chapter should be noted. First, medical care may not be an essential input into the production of health, which would render the WTP estimates more inexact. Second, the work loss equation could be estimated in a more general framework, such as tobit, to provide estimates of hours lost from work due to ozone. A solution to both these problems would be to assume that time was a necessary good, and to estimate a labor supply or leisure demand curve. Changes in the area behind a labor supply (leisure demand) curve also can be used as measures of WTP, and hence would provide a check on the values obtained from the medical demand equation. Additionally, the labor supply schedule would provide direct estimates of the change in hours worked when ozone changed.

A final limitation noted here is that the theory presented in Chapter 3 indicates that the value of time lost from market and nonmarket activities should be used to recover the disutility of illness. The procedure in this chapter estimated only the value of work loss. Hence, the estimates of the disutility of illness include the value of the time lost from nonmarket activities. The conclusion that WTP is five times as large as the value of work loss, however, is unaltered.

CHAPTER 7

ESTIMATING THE VALUE OF AVOIDING OZONE SYMPTOMS

7.1 INTRODUCTION

Since Grossman's (1972) analysis of the demand for health, numerous estimates of health production functions have appeared, yet virtually no studies have estimated production functions for minor symptoms. From the perspective of evaluating the health effects of air pollution, symptom production function estimation can complement results obtained from estimating the more long-term health effects of air pollution. For example, estimation of chronic health responses to air pollution would require control for historical exposures, but information on long-term exposure to air pollution is not included in most data sets. As a consequence, researchers have assumed that current air pollution levels reflect long-term exposure patterns. Crocker et al. (1979) pointed out that omitting data on historical exposures could bias coefficients of air pollution variables since migration is a long-run averting behavior determined jointly with past and current exposure levels. In contrast to the chronic health effects of air pollution, acute symptomatic responses are less likely to depend on long-term exposure patterns and are more likely to result from daily variations in pollution levels. Thus, symptom production function estimation can proceed with fewer apologies for lack of long-term exposure data.

A second reason why symptom production function estimates are needed to complement information from estimation of chronic response to air pollution is that many health effects of air pollution do not involve chronic illness. Acute symptomatic responses to ozone, for example, may be experienced by a large share of the exposed population at ozone concentrations near the current federal standard of 12 pphm (Gerking et al., 1984). Given the large number of affected individuals, the aggregate willingness to pay to avoid the symptoms of ozone exposure may be substantial, making measurement of WTP to avoid symptoms an important policy issue. Yet the only currently available measures of the value of symptom-days are based on the cost of illness or the contingent valuation methods. The COI is not a measure of WTP, and the CVM bids to avoid symptoms appear large (see Tables 2.2, 2.3, and 4.2). Thus another measure of WTP to avoid symptoms is needed as a check on the CVM estimates. The averting behavior model of Chapter 3 demonstrates that estimation of symptom production functions can serve as this alternative basis for valuing avoidance of symptoms.

Additionally, few studies have estimated separate health production functions according to the health status of the individuals in the sample. The efficiency of health production may vary with the individual's level of health capital. Separate estimation allows the effects of all explanatory variables to differ according to health status and hence provides more precise information. Aside from allowing symptom technologies to differ between individuals with different levels of health capital, separate production function estimation allows for separate benefit calculations for each health status group. Separate benefit estimation by health status group is important from a policy perspective since the Clean Air Act emphasizes the protection of health in impaired individuals.

This chapter presents estimates of symptom production functions (SPFs) for nine symptoms which prior epidemiological evidence suggests are definitely associated with ozone (Tashkin et al.. 1983). Each SPF is estimated for the whole sample and separately for normal and impaired subsamples, making a total of 27 SPFs. Moreover, each SPF is estimated in both a single equation and a simultaneous equation framework. As explained more fully in Chapter 5, the simultaneous equation SPF estimates are obtained by replacing the observed values of the jointly determined variables MED, OUTHRS, and RECTRIP with the values predicted for these variables from their respective reduced form equations. Thus there are 54 estimated equations. These estimates are discussed in Section 7.2.

The primary purpose of estimating the SPFs is to derive measures of WTP for symptom days avoided. While averting behavior theory demonstrates that SPF estimates also can be used to value ozone, WTP for ozone reductions already has been considered in Chapter 6. Additionally, the ozone coefficient is not consistently of the right sign and significant in the SPF equations, thus these equations may not provide an appropriate basis for valuing ozone reductions. Ozone levels during the study period were quite low by historical standards; a situation that may have contributed to the relatively poor performance of the ozone variable. In any case, benefits of reducing symptoms, as opposed to ozone, are important in a policy context particularly if symptom-ozone relationships are established by separate dose response analysis. Section 7.3 discusses the method used to value symptoms, the choice of averting goods used in the calculations, and the construction of prices for these averting goods.

Estimates of willingness to pay to avoid symptoms are derived in Section 7.4 as follows. The reduced probability of occurrence of a symptom is calculated for a change in an averting good. This change in probability then is converted into an expected number of days per year that the symptom would not occur, and WTP is calculated on the basis of symptom days avoided. The willingness to pay estimates per symptom day avoided generally are lower than comparable CVM values, often by a factor of ten or more. Conclusions are found in Section 7.5.

7.2 SYMPTOM PRODUCTION FUNCTION ESTIMATION

The 54 estimated symptom production functions are presented in Tables 7.1 through 7.27 at the end of the Chapter. Each table contains single equation and simultaneous equation logit estimates of the coefficients and t-statistics of one SPF either for the whole sample or the normal or impaired subsample. The tables are grouped in sets of three; for each symptom, the whole sample regressions appear first, followed by the normal and then the impaired subsample regressions. For example, Tables 7.1 through 7.3 present production function estimates for the symptom "could not breathe deep," with the whole sample estimates appearing in Table 7.1, the normal subsample estimates in Table 7.2, and the impaired subsample estimates in Table 7.3. As indicated in Chapter 6, convergence problems with the maximum likelihood logit algorithm occasionally forced the exclusion of a few explanatory variables from the SPFs. These instances are noted among the coefficient estimates presented in the tables.

Before proceeding to a symptom by symptom discussion of results, some general conclusions can be drawn from these 54 equations as a group. One general issue concerns the degree to which simultaneous equation estimates differ from single equation estimates. A second issue concerns the effectiveness of the averting behaviors in reducing symptoms. A third issue is the extent to which symptom technologies differ between the normal and the impaired groups. The whole sample results are treated briefly in the individual symptom discussion contained in Sections 7.2.1 through 7.2.9. The discussion to follow jointly treats these three issues. Also, it emphasizes the regressions for the normal and the impaired subsamples, rather than those for the whole sample, because of the apparently large differences in SPF structure between the two groups.

Because of simultaneous equations bias, the expected signs of coefficients of the jointly determined variables MED, OUTHRS, and RECTRIP are unclear in single equation estimation context. Estimated coefficients of MEDHAT, OUTHAT, and RECHAT are expected to be, respectively negative, positive, and negative. Both MED and MEDHAT performed poorly. At the 10 percent level using a one-tail test, the coefficient of MED was negative and significantly related to only one symptom (Cough) in the impaired regressions and was never negative and significant in the SPFs for the normal subsample. MEDHAT never was negative and significant in SPFs for either subsample. Thus, the two-stage estimation procedure was ineffective in unraveling the simultaneous determination of symptom occurrence and the consumption of medical services.

RECTRIP and RECHAT performed,better than the medical care variables. Both variables were negative and significant at the 10 percent level using a one-tail test in two of nine equations in both the normal and impaired subsamples. However, the normal subsample regressions exhibit three occasions where the coefficient of RECHAT is wrongly signed (positive) and significant.

Of the three jointly determined averting behavior variables, the variables measuring hours outdoors (OUTHRS and OUTHAT) perform best. In the normal subsample regressions, the coefficient of OUTHRS was positive and significant at the 10 percent level five times and the coefficient of OUTHAT was positive and significant in four equations. In the impaired subsample, the coefficient of OUTHAT was positive and significant in six equations, whereas the coefficient of OUTHRS only was positive and significant in two equations. For the impaired subsample, then, two-stage estimation results in more equations showing a positive and significant effect of hours outdoors on the occurrence of definite ozone symptoms. Finally, the coefficients of OUTHRS and OUTHAT seldom were wrongly signed and significant.

In contrast to the short run averting behaviors, the estimated coefficient signs, magnitudes and significance levels on the more long run averting behaviors are quite stable between the simultaneous and single equation estimates. Additionally, among these variables (ACCAR, ACHOME, APHOME, and GASCOOK), ACCAR performs best. In the two-stage estimates, for example, the coefficient of ACCAR correctly signed (negative) and significant at the 10 percent level using a one-tail test in five of the normal subsample equations and in four of the impaired subsample equations. The coefficient of ACCAR never is wrongly signed and significant. GASCOOK performs next best. In the two-stage estimates, the coefficient of this variable is correctly signed (positive) and significant at 10 percent in a one-tail test in two of the normal subsample SPFs, and in four of the impaired subsample SPFs. ACHOME and APHOME, on the other hand, perform less well. In the normal subsample regressions, neither variable was significant at 10 percent in a one-tail test and correctly signed. Significant and wrong signed coefficients occasionally occur for these variables. In the impaired subsample, performance of ACHOME improves as its coefficient in the two-stage estimates is negative and significant in four equations. The coefficient of APHOME is negative and significant only in the impaired subsample SPF for headache.

The results for both the short and long run averting behavior variables indicate that no single averting good or combination of averting goods significantly reduces the probability of all nine symptoms. As a result, there may be a unique package of averting goods for each symptom and the method of evaluating benefits using one symptom and one averting good at a time, as outlined in Chapter 3, appears to be justified. Additionally, an averting behavior which is significant in a given SPF in one of the subsamples often is not significant for that SPF in the other sample. It appears, then, that the normal and impaired groups have different technologies for reducing symptoms.

With respect to demographic and location indicators, years of education tends to be negatively and significantly associated with symptoms for the the impaired group, but is not significantly related to symptoms for those in the normal group. Age tends to be positively associated with symptoms. Marital status is negatively related to symptom occurrence, while the coefficient of SEX tends to be negative whenever it is significant, suggesting that males may have fewer symptoms than females. Time and location dummies, GLEN1 through GLEN4 and BURBO through BURB2, are significant in some SPFs, but overall performance of these variables is uneven.

As previously indicated, the pollution variables perform poorly in the SPFs. Also, no consistent pattern of coefficients emerges when comparing different symptoms for a given subsample, two subsamples for a given symptom, and single and simultaneous equation estimates for given symptom and subsample. Moreover, in contrast to the reduced forms, inclusion of NOX as an explanatory variable can result in large changes in the S02 and OZO coefficients possibly due to the roughly 0.80 Pearson correlation between NOX and OZO. Thus, the data do not reveal a consistent association between either S02 or OZO and the nine symptoms. More research on the association between these symptoms and various pollutants is warranted.

7.2.1 Could Not Breathe Deep

In the whole sample regression for the symptom "could not breathe deep," none of the variables used to define impaired status are significant at the ten percent level in a one-tail test, suggesting that there are no significant differences in the constant terms of the normal and impaired regressions for this symptom. Among the other health status measures, HAYFEV is positive and significant in both the normal and impaired regressions.

In the normal subsample SPF, the coefficient of medical care is negative but insignificant in both the single and simultaneous equation estimates. Just the opposite occurs in the impaired regressions: medical care is positive in both equations. Outdoor hours is positively and significantly (at five percent) associated with the probability of this symptom in the simultaneous equations for both the normal and impaired groups, and the coefficient is nearly five times as large in the simultaneous equation estimates as in the single equation estimates.

None of the long-run averting behaviors are significant and correctly signed in the normal regression for the symptom “could not breathe deep”; ACHOME is positive (wrong sign) and significant for the normals. For the impaired group, GASCOOK is correctly signed; its coefficient significant at the five percent level in the simultaneous SPF estimates.

The pollution variable S02 shows an interesting pattern in going from single equation to simultaneous equation estimation. In the normal SPF for “could not breathe deep,” the S02 coefficient is positive using both estimation methods, but the two-stage simultaneous equation procedure produces a coefficient 50 times larger, and significant. In the impaired regression, using simultaneous equation methods changes the sign of the s02 coefficient from negative to positive, but the coefficient is insignificant in both impaired equations. Ozone, on the other hand, enters the single equation impaired SPF positively and significantly, but becomes negative and insignificant in the simultaneous equation SPF.

7.2.2 Pain on Deep Inhalation

The “pain on deep inhalation” SPFs presented in Tables 7.4 to 7.6 are qualitatively similar in many respects to the “could not breathe deep” SPFs. The similarity in the estimated equations for these two symptoms may reflect a basic similarity in the two symptoms themselves and may provide a basis for aggregating the two symptoms in future research.

The “pain on deep inhalation” SPFs exhibit greater changes than the “could not breathe deep” SPFs in the magnitudes of the coefficients of the jointly determined variables. The coefficients of OUTHAT and OUTHRS in the normal subsample SPF Is correctly signed and significant. Coefficients of GASCOOK also are correctly signed and significant in the single and simultaneous equation estimates for the normal subsample. The coefficient of ACCAR is correctly signed and (almost) significant at the 10 percent level in a one-tail test in the impaired subsample. Additionally, neither ozone nor sulfur dioxide is a significant factor in the production of pain on deep inhalation.

7.2.3 Out of Breath Easily

The estimated “out of breath easily” SPFs appear in Tables 7.7 through 7.9. The whole sample SPF reveals a significant positive association between bronchitis and getting out of breath easily. In the separate subsample regressions, the health status indicators not used to define impaired status (FLEMCO, SHRTWHZ, HAYFEV, RESPINF, and POOR) are all positively and significantly associated with this symptom, with the exception of SHRTWHZ and FLEMCO in the normal group’s equations and POOR in the impaired group’s equations.

Simultaneous equation methods produce mixed results for the two subsamples. For the normal subsample, simultaneous equation estimation changes the single equation’s positive and significant medical care coefficient to a negative, insignificant coefficient. For the impaired subsample, the medical care coefficient’s sign changes the wrong way as simultaneous equation estimation replaces single equation estimation. The coefficient on outdoor hours is larger in the simultaneous equation estimates for both the subsamples, while the magnitude of the recreational trip variable’s coefficient changes in the wrong direction for the normal group and the right direction for the impaired group. In the normal subsample, none of the other averting behaviors take the expected signs with significant coefficients in the two-stage estimates, but the coefficient of GASCOOK is positive and significant at 10 percent using a one-tail test in the single equation estimates. Similarly, in the impaired "out of breath easily" SPFs, the coefficient of GASCOOK is correctly signed and significant at five percent using a one-tail test.

Age is positively and significantly related to this symptom for both the normal and impaired groups. EDGRADE takes a negative and significant coefficient in the impaired equations, while MARRIED enters the normal regressions negatively and significantly. The single equation SPF estimates for both subsamples suggest that ozone is a positive and significant factor in producing "out of breath easily," but in the simultaneous equation results, this outcome does not hold.

7.2.4 Wheezing/Whistling Breath

The symptom "wheezing/whistling breath" is unique among the definite ozone symptoms in that it is experienced almost exclusively by the impaired individuals, particularly the asthmatics. This symptom is reported in only 26 of the 1330 observations from the normal subsample, making any inferences based on that group's regression results of doubtful quality. The impaired group's SPFs for "wheezing/whistling breath," on the other hand, produce a number of interesting results. First, each of the jointly determined variables take the expected sign in the simultaneous SPF estimates for the impaired subsample, although only the recreational trip variable is significant. Second, the coefficients of two other averting goods, ACHOME and GASCOOK, are correctly signed and significant, at one percent and five percent, respectively. Third, the pollution variable coefficients are relatively stable between the single and simultaneous equation estimates, but neither S02 nor OZO appears significantly related to this symptom. Fourth, the health variables FLEMCO, SHRTWHZ HAYFEV, and RESPINF perform well in both the simultaneous and single equation estimates.

7.2.5 Chest Tight

Tables 7.13 through 7.15 present the SPF estimates for "chest tight." The whole sample regression reveals that ASTHMA and BRONCH are positively and significantly related to the probability of occurrence of this symptom. In the normal group's regressions, FLEMCO, SHRTWHZ, and HAYFEV all have positive coefficients, but only the coefficient of HAYFEV is significant in the simultaneous estimates. The impaired group's regressions, on the other hand, reveal a pattern among the health status measures that occurs for several symptoms: All of the health impairments except the subjective evaluation POOR are positively and significantly related to the probability of occurrence of the symptom. The coefficient of EDGRADE is negative and significant for the impaired group and positive and significant for the normal group. The coefficient of SEX is negative and significant for both groups. Simultaneous equation methods reveal less of an association between ozone and chest tightness than single equation methods.

Among the jointly determined averting behaviors, both OUTHAT and RECHAT are correctly signed and significant at the 1 percent level in the normal subsample equation. However, in the impaired subsample regressions, the coefficients of these variables are correctly signed but insignificant. Moreover, in the normal subsample, ACCAR performs well in both the simultaneous and single equation estimates. ACCAR, ACHOME, and GASCOOK perform well in the impaired subsample regressions. All three variables have coefficients that are correctly signed and significant at the 10 percent level (or lower) using a one-tail test.

7.2.6 Cough

The SPF estimates for "cough'! are found in Tables 7.16 to 7.18. In the whole sample regressions, the health variables ASTHMA, BRONCH, OTHDIS, HAYFEV, RESPINF, and POOR are strongly and positively associated with the occurrence of this symptom. In the normal subsample regressions, younger, male, married respondents, with more years of education cough less and workers exposed to breathing hazards on the job experience this symptom with greater frequency. In the impaired subsample regressions, the coefficients of EDGRADE, SEX, and MARRIED remain significant and positive, negative, and negative respectively; however, the coefficient of AGE is significantly positive and the coefficient of EXPWORK is curiously negative and significant. Turning to the averting behavior variables, the coefficients of OUTHAT and RECHAT both are correctly signed in each subsample; but these variables perform better in the normal subsample. ACCAR significantly reduces coughing in both subsamples and GASCOOK significantly increases the occurrence of this symptom in the normal subsample. The coefficients of ACHOME and APHOME are wrongly signed (positive) and significant in the impaired subsample.

7.2.7 Throat Irritation

The SPF estimates for "throat irritation" are found in Tables 7.19 to 7.21. The whole sample regression results show that among the health status variables only RESPINF and OTHDIS are positively and significantly associated with the occurrence of this symptom. In the normal subsample regressions, SHRTWHZ and HAYFEV perform well. Also, in this subsample, throat irritation is more frequently experienced by those with more years of education who are exposed to breathing hazards at work. In the impaired subsample, on the other hand, the coefficients of RESPINF and MARRIED are significant with signs of positive and negative, respectively. Among the averting behavior variables, ACCAR significantly reduces throat irritation for respondents in each subsample. The coefficient of APHOME is wrongly signed and significant in the impaired subsample. The coefficient of OZO is positive and significant in the single equation regression for the impaired subsample, but the significance vanishes in the simultaneous equation estimates.

7.2.8 Sinus Pain

SPF estimates for “sinus pain” are presented in Tables 7.22 to 7.24. The whole sample regression results indicate that respondents with ASTHMA, BRONCH, and HAYFEV experience sinus pain more frequently. Also, among respondents with normal respiratory function, the coefficients of FLEMCO, HAYFEV, AGE, SEX, and WRKESGV are significantly different from zero. Coefficients of these variables are positive except for SEX. Approximately the same pattern of coefficient estimates for these variables is displayed in the regressions for the impaired subsample. ACCAR is the only averting activity variable that performs well in the normal subsample regressions, whereas the coefficients of ACHOME, RECHAT, and OUTHAT are correctly signed and significant in the impaired subsample regressions. The air pollution variables perform poorly in the regressions for both subsamples.

7.2.9 Headache

SPFs for headache are presented in Tables 7.25 to 7.27. The whole sample regression results again show that selected health status variables (OTHDIS, FLEMCO, SHRTWHZ, HAYFEV, and RESPINF) are positively associated with the occurrence of this symptom. In the normal subsample, older females exposed to breathing hazards at work who reported certain indicators of reduced respiratory health (FLEMCO and HAYFEV) tend to have headaches with greater frequency. In the impaired subsample, FLEMCO, SHRTWHZ, HAYFEV and RESPINF are positively linked to headaches. Additionally among impaired respondents, unmarried males have this symptom with greater frequency. As a group, the averting behavior variables perform relatively poorly in the headache SPFs. For the normal group, only the coefficient of ACCAR is correctly signed and significant at the 10 percent level using a one-tail test. In the impaired subsample regressions, the same statement can be made for ACHOME and it almost holds for APHOME.

7.3 METHOD FOR ESTIMATING WTP

Chapter 3 concluded with the observation that each SPF may contain a unique package of averting inputs. The empirical results just presented appear to confirm this argument. No single averting input or combination of averting inputs is significant in all of the SPFs. Thus, it can be argued that each SPF contains a unique “macro” averting good which is a combination of individual averting activities and that a separate benefit calculation can be made for each symptom using one of the averting activities which compose the macro averting good.

At least one averting behavior, then, needs to be selected to value each symptom. The averting behaviors specified as inputs in the SPFs are MED, OUTHRS, RECTRIP (or MEDHAT, OUTHAT, RECHAT), ACCAR, ACHOME, APHOME, and GASCOOK. For each symptom, averting behaviors having coefficients that are correctly signed and significant at the 10 percent level using a one-tail test were chosen to make the WTP calculations. If no averting behavior variables met this criterion, no benefit estimates were made. For certain symptoms, then, WTP is computed using two or more averting behavior variables. However, for three symptoms experienced by the normal subsample, the averting behavior method fails to support benefit calculations.

Once an averting behavior was selected as a basis for valuing a symptom, two pieces of information are needed: (1) an estimate of the marginal productivity of the input in reducing the symptom, and (2) the full price of the input. Recall from the discussion of the averting behavior model in Chapters 2 and 3 (for example, see, equation (10) of Chapter 2) that the marginal benefit of reducing a symptom is equal to the marginal cost of achieving that reduction in the symptom. The marginal cost of production can be expressed as the ratio of the price of an input to its marginal product. Thus, using averting activity V_i to value symptom S_j in the benefit expression

$$WTP = \frac{q_i}{S_{ji}} \tag{1}$$

where q_i is the full price of averting input V_i and S_{ji} is the marginal product of averting input V_i in the production of symptom S_j.

All WTP estimates are based on one or more of the longer run averting behaviors ACCAR, ACHOME, APHOME, and GASCOOK. The medical care variables performed poorly in the estimated SPFs and therefore were not used. Also, difficulty in obtaining full price data for hours outdoors and for recreational trips precluded the use of these variables in making benefit calculations. Nevertheless, the relatively strong performance of particularly OUTHAT and to a lesser extent RECTRIP and RECHAT still lends support to the averting behavior approach.

A problem with the WTP calculations is that the averting behaviors analyzed are impure in that they may provide direct utility. ACCAR and ACHOME provide a cooler and more comfortable environment in addition to symptom relief. Symptom reduction associated with recreational trips may be a side benefit having little to do with the primary motivation for the activity. Natural gas may be preferred to alternative cooking fuels because of the difference in warm-up time. Air purifiers may keep homes cleaner by filtering out particulate. Pure averting goods, which enter symptom production functions but not utility functions, probably are few. In any case, WTP estimates based on impure averting goods are biased upward. Impure averting goods, as discussed in Chapter 3, provide utility directly and these utility effects would be included in the WTP estimates. As a consequence. calculations presented in this chapter are upper bound estimates of WTP for symptom avoidance.

Because the four variables used in the WTP calculations are specified as dummies, their incremental productivity in reducing symptoms is calculated in discrete form as shown in equation (2)

$$\frac{\Delta P_r(S_j)}{\Delta V_i} = F(-X'\beta|V_i = 1) - F(-X'\beta|V_i = 0) \qquad (2)$$

where F(•) is the cumulative logistic distribution function, V_i = ACCAR, AC'HOME, APHOME, GASCOOK, and S_j is one of the nine symptoms. Equation (2) gives the incremental product of an averting good, that is, the reduction in probability that a symptom occurs on a given day. This probability then can be multiplied by 365 in order to obtain the expected number of days per year the symptom is avoided through use of that averting good.

Given estimates of the incremental products of the averting behaviors from equation (3), the remaining information needed to estimate WTP for symptoms avoided are the full prices of the averting inputs. Annualized full prices for ACCAR, ACHOME, APHOME, and GASCOOK were constructed by contacting major retailers and utilities in the Burbank and Glendora areas to obtain estimates of the initial investment, operating and maintenance costs, useful life span, and scrap value for each of these goods. The exact methods used are discussed more fully in the four subsections below. These calculations assume that no time is spent in exclusive use of these goods. Thus, prices reported in the four subsections below involve only out-of-pocket expenditures.

7.3.1 Auto Air Conditioning

The increase in the sticker price of a new car when air conditioning is added as well as the cost to add air conditioning to an older car varies by manufacturer and model, but these prices tend to be in the $700 to $1000 range, and cluster around $800. When a car is sold or traded, the air conditioner has a scrap value. Comparing "blue book" used car values with and without air conditioning yields a differential of $350 to $725, with a mean of about $450. Assuming an ownership period of five years and an interest rate of eight percent implies a present scrap value of $306.26 making the present value of the net investment $800 - $306.26 = $493.74. Amortizing, at 8 percent, this investment over the assumed five year ownership period gives an equivalent annual payment of $123.66, In addition to the annual investment cost, there is a fuel expense associated with car air conditioning. An air conditioner lowers the gas mileage of a new midsize car by one or two miles per gallon. Given that the sample average number of miles driven per week of 258.70, an average gas mileage of 23.85 mpg, and an average price of unleaded regular gasoline of $1.15 per gallon in the last half of 1985, the estimated operating costs of a car air conditioner are $28.38 per year. The full price of car air conditioning then is $123.66 + $28.48, or about $152 per year.

7.3.2 Home Air Conditioning

A central air conditioning system for the home costs $1300 to $2000 per ton; three ton units are the most common. Assuming a price of $1500 x 3 = $4500 and a useful life of 20 years, and again amortizing at eight percent gives an annual investment cost of about $325 per year. The electricity expense of home air conditioning varies widely according to personal tastes for heat, construction of the home, insulation, and other factors. After consulting with air conditioner dealers and electric utilities in Southern California, it was determined that the average three-ton unit in the Los Angeles basin would consume 3000 kilowatt-hours of electricity. At $.03/kilowatt, this amounts to $90 per year fuel expense. The annual full price of ACHOME then is $325 + $90 = $415.

An electronic air purifier with a charcoal filter costs $700 to $1000 to install, lasts as long as the central air conditioning unit to which it is attached, and does not add appreciably to fuel costs. Filters must be replaced once or twice per year at $25 to $30. Amortizing the mean price, $850. over 20 years at eight percent and adding $41.25 filter replacement cost per year yields an annual full price of APHOME of about $122.

7.3.3 Gas vs. Electricity for Cooking

New electric ranges purchased from the appliance dealers surveyed in the Burbank and Glendora areas cost about $400. A three year old gas range has a trade-in value of roughly $50 to the same appliance dealers. Amortizing a net investment of $350 over an expected life of ten years gives $47.36 per year. Electric ranges are more costly to operate than gas ranges, however. Information obtained from utilities and several appliance dealers indicate the difference is about a $.10 a day, or $36.50 per year. Thus the annual full price of switching from gas to electric cooking is $83.86.

The next section combines the foregoing annual full prices of averting goods with estimates of their incremental productivities in reducing symptoms to derive measures of WTP to avoid symptoms.

7.4 ESTIMATES OF WTP TO AVOID SYMPTOMS

7.4.1 Averting Behavior Estimates

WTP estimates for avoidance of symptom days based on simultaneous equation estimation of SPFs are presented in Tables 7.28 through 7.30. Table 7.28 presents estimates for the normal subsample, and Tables 7.29 and 7.30 present corresponding estimates for the impaired subsample and whole sample, respectively. Because of the apparent differences in SPF structure between the two subsamples, WTP calculations for the whole subsample are presented only for illustrative purposes. Additionally, simultaneous equation, rather than single equation, estimates were selected to be the basis for WTP calculations because they are more defensible on econometric grounds. In the tables, the first column on the left hand side lists the symptoms, while the second column lists the averting good (or goods) used to make the WTP calculation. The third column from the left gives the change in the daily probability of occurrence of the symptom as the averting good is employed; and in the fourth column, the daily probability change is multiplied by 365 to obtain the expected number of days per year the symptom would be avoided. Dividing the expected number of symptom days avoided into the annualized full price of the averting good yields the WTP per symptom-day avoided. This figure is presented in the last column of Tables 7.28 through 7.30.

Before considering the WTP estimates in detail, four general caveats should be made explicit. These caveats imply that the WTP figures are not precise and instead should be regarded as order-of-magnitude estimates. First, the estimates are based on estimated logistic regression coefficients. These coefficients have a probability distribution and, consequently, the true parameters which determine the productivity of the averting goods are measured subject to error. Second, construction of annualized full prices for the averting goods is arbitrary to some extent because particular values were chosen to approximate retail sales price, maintenance costs, interest rates, length of life and scrap values. Third, as previously indicated, the four averting goods analyzed may provide direct utility; thus, calculations of WTP to avoid symptoms probably are upper bound estimates. Fourth, the estimates presented are based on frequency of symptoms. Symptom intensity, which may differ between the normal and impaired groups, is a difficult dimension to add to the analysis and may be a useful area for further research.

Table 7.28 shows that the WTP estimates for the normal subsample range from $2.66 to avoid one day of cough to $35.76 to avoid one day of chest tightness. Four of the WTP estimates cluster in the range from $13.89 to $19.77. Two WTP estimates, based on GASCOOK and ACCAR, were calculated for cough. These estimates are $2.66 and $14.18, respectively. The reason for this difference is that, GASCOOK is three times productive than ACCAR in eliminating days of coughing (see column 4, Table 7.28) and the cost of switching from gas to electric cooking is lower than the cost of an automobile air conditioner. Also, WTP was not calculated for three symptoms, could not breathe deep, out of breath easily, and wheezing/whistling breath due to poor performance of the averting behavior variables in the estimated SPFs. As shown in Table 4.2, however, these symptoms were present In less than 3.5 percent of the observations in this subsample; consequently, there is little variation in the dependent variables for the averting behaviors to explain.

WTP estimates, which could be calculated in the impaired subsample for each of the nine symptoms, range from $0.97 to $23.87. These two estimates both pertain to chest tightness and are based on GASCOOK and ACHOME, respectively. Two or more averting behaviors also were used to calculate WTP for the symptoms wheezing/whistling breath and headache, In Table 7.29, WTP estimates tend to be lowest when based on GASCOOK and highest when based on ACHOME. This outcome reflects both the productivity of each good in eliminating symptom days as well as their full prices.

The WTP estimates can be better understood by comparing the results for the normal subsample with those for the impaired subsample. Notice that normal individuals tend to be willing to pay more than impaired individuals to avoid a day's experience of a particular symptom. This result is most striking in cases where the same averting good is used to calculate WTP for avoiding a particular symptom in both the normal and impaired subsamples (i.e., compare the WTP estimates based on ACCAR for chest tight, cough, and throat irritation). The explanation for this outcome lies in the relationship between the logistic functional form chosen for the SPFs, the implied marginal cost schedule for symptom day reduction, and the difference in symptom frequency in the normal and impaired subsamples. These concepts are illustrated in Figures 7.1 and 7.2.

Figure 7.1 shows logistic cumulative distribution functions for symptom avoidance in normal and impaired individuals. In particular, the vertical axis shows the daily probability of avoiding a symptom and the horizontal axis measures the quantity of inputs employed in symptom reduction. The curve for the normal individuals lies above the curve for the impaired individuals. Thus, for given quantities of inputs devoted to symptom reduction, impaired individuals have a greater probability of symptom occurrence. Also, each cumulative distribution function takes the ogive shape often assumed to hold for biological dose response functions. Mathematically, this ogive shape is quasi-concave and is the curvature required for economic production functions.

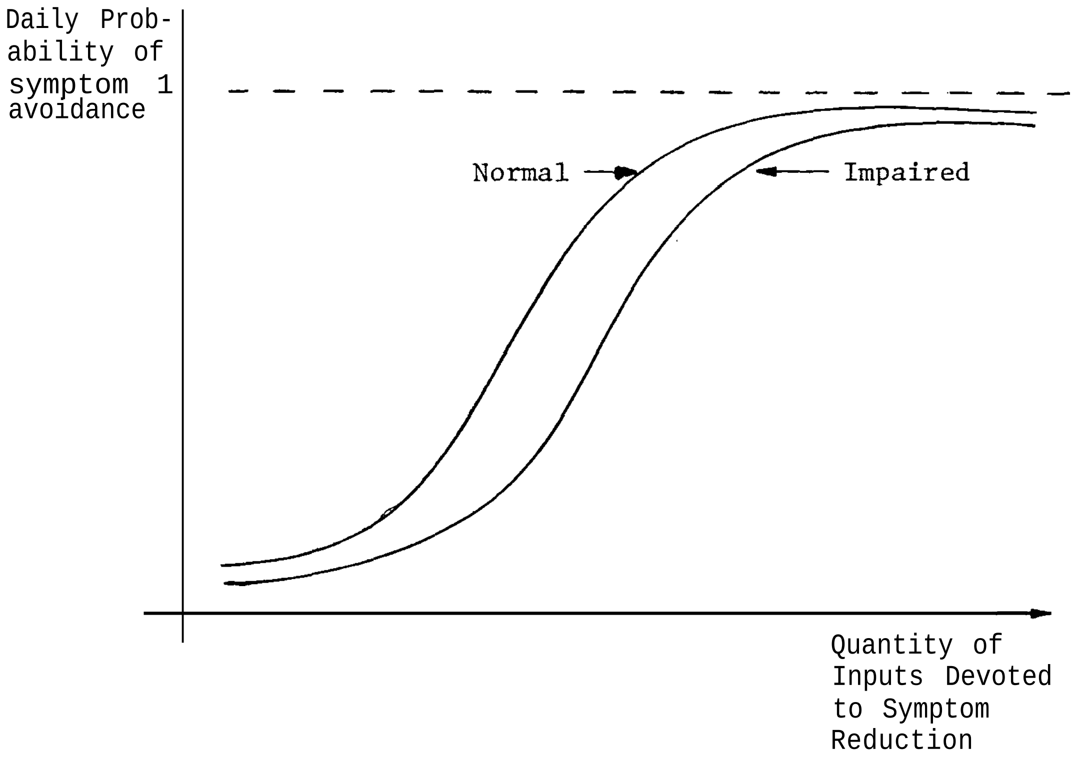

Figure 7.1. Logistic Cumulative Distribution Functions for Avoiding Symptoms

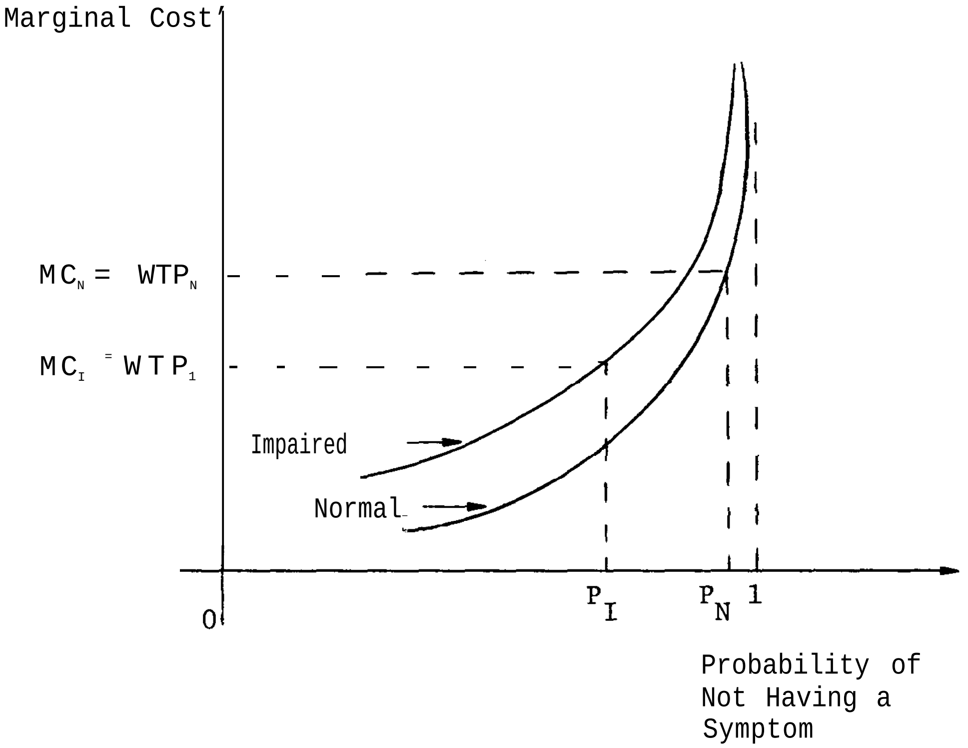

Figure 7.2. Marginal Cost Schedules for Avoiding Symptoms

Assuming that all individuals face the same prices, the logistic SPFs imply marginal cost schedules of the form shown in Figure 7.2. Because the impaired group has inferior SPFs, its marginal cost schedule lies above that for the normal group. Additionally, Figure 7.2 illustrates a typical situation in which the normal group experiences symptoms less frequently than the impaired group. (Table 4.2 shows that this relationship holds for all nine symptoms analyzed.) Letting P_I and P_N denote the probabilities of not experiencing a symptom among impaired and normal group members, then $P_N > P_I$. If $P_N > P_I$, then, normal group members are operating on more steeply sloped portions of their marginal cost schedules than are impaired group members. Alternatively stated, averting goods are more productive in reducing symptom days for impaired group members than for normal group members. In the empirical analysis this outcome is easily seen by comparing the fourth columns of Tables 7.29 and 7.30. Expected symptom days avoided are uniformly higher for the impaired group than the normal group. Thus, willingness to pay to avoid one symptom day is generally higher for the normal group members than for impaired group members (i.e., $MC_N = WTP_N > MC_I = WTP_I$).

It is worth emphasizing that the discussion to this point has focused on marginal willingness to pay to avoid one day of symptom experience. $WTP_1 < WTP_N$ because impaired group members experience symptoms more frequently and therefore have more symptom days that can be eliminated by taking averting action, This result, however, does not imply that the <u>total</u> willingness to pay to avoid symptoms is larger for normal group members than for impaired group members. To better appreciate this distinction, first notice that the total willingness to pay to eliminate a symptom entirely would be infinite for both groups. The logistic SPFs imply that the probability of not experiencing a symptom is driven to unity only asymptotically. Consequently, the area under both marginal cost schedules between an arbitrary lower limit of integration ($0 < P < 1$) and the upper limit $P = 1$ would be infinite. Next, consider a hypothetical symptom experienced by the two groups with equal frequency; for example, $P_I = P_N = .95$. The total WTP for increasing P_I and P_N to, say, .98 would be unambiguously larger for the impaired group than for the normal group. This total WTP calculation would measure the area under the two marginal cost schedules between $P = .95$ and $P = .98$. Because the marginal cost schedule for the impaired group lies above the corresponding schedule for the normal group, the area under the former marginal cost schedule exceeds that for the latter.

Calculations of total WTP for the two groups could be made for each symptom using the SPF estimates presented in this chapter. Using the same upper and lower limits of integration, the areas under impaired and normal marginal cost schedules could be evaluated. This comparison, however, could be highly misleading if the integration limits lie outside the range of observations for either group. A check of the SPFs reveals that this situation would arise for all nine symptoms. As a consequence, total WTP estimates were not calculated.

7.4.2 Contingent Valuation Estimates

A further perspective on the WTP estimates presented in Tables 7.28 to 7.30 can be obtained by reconsidering the contingent valuation (CVM) bids presented in Table 4.2. As indicated in Chapter 4, both the background and following survey instruments asked directly for respondents' willingness to pay to avoid one days' experience with particular symptoms, Bids were obtained only from respondents who reported having the symptoms within the 48 hours just preceding the interview. Consequently, bids are linked to specific, recent events which are fresh in respondents' minds. This approach contrasts with that of Loehman et al. where mail survey respondents were asked for bids to avoid symptoms they may never have experienced. Also, it contrasts with the approach taken by Tolley et al. in which respondents were asked to recall symptoms experienced over the year prior to the survey.

The CVM bids presented in Table 4.2 are reproduced in Table 7.31 along with ABM WTP values from Tables 7.28 to 7.30. Three aspects of these figures are of interest. First, as indicated in Chapter 4, these bids are larger but of a similar order of magnitude as those reported by Green et al. (1978) and Berger et al. (1985). For example, the bid obtained in this study to eliminate a day of coughing is $175 in the whole sample whereas the corresponding bids obtained by Berger et al. and Green et al. were $105 and $26 to $45, respectively. Further comparisons of this type can be made with reference to Tables 2.2 and 2.3 in Chapter 2. Second, in contrast to the ABM estimates, the CVM bids from impaired respondents exceed those from the normal respondents, often by a substantial margin. Third, the CVM bids for avoiding symptoms always are larger than those obtained with the ABM. Certain CVM bids exceed their ABM counterparts by a factor of 10 or more.

A complete explanation of the large discrepancies between the CVM and ABM results requires further research. Nevertheless, speculation a to reasons underlying this outcome still is possible. One factor that may have contributed to the order of magnitude differences between ABM and CVM

WTP estimates is that the former is based on revealed preferences whereas the latter is based on expressed preferences. Preferences can be expressed at zero cost; consequently, they may be a less reliable guide in estimating WTP for avoiding symptoms. A second factor is that the CVM bids are biased upward. As explained in Chapter 2, use of Heckman's (1979) technique to correct for sample selection bias may reduce estimates of the mean CVM bids. Additionally, since this technique adjusts for the probability that the symptom occurs, it could reverse the ordering of the CVM estimates of WTP between the normal and impaired groups. Third, in answering the contingent valuation question, respondents may have been bidding to avoid more than one day's experience with a symptom. As indicated in the background and follow-up questionnaires, respondents were asked explicitly for their bid to avoid a symptom for one day. Yet some respondents still may have bid to avoid symptoms for longer periods of time. Fourth, large CVM bids may have been given by respondents who have been troubled by a symptom, but have not found a remedy or averting action that is effective in relieving it. Thus, a key reference operating condition (prior experience) for using the CVM may not have been satisfied for all respondents. (For a more complete explanation of reference operating conditions and the consequences of violating them, see Cummings, Brookshire, and Schulze, 1986.)

A fifth, and final, factor of note in analyzing the CVM responses is that, particularly for the normal group, the comparatively large mean values are due to very large bids given by a few respondents. Table 7.32 shows the effect of trimming the CVM bids by 5 percent. More specifically, the mean bids for the normal and impaired groups are reproduced from Table

7.31. Also, the trimmed means which disregard 2.5 percent of the bids in each tail of the bid distribution are presented for comparison purposes. Outlier bids have come under increasing scrutiny in CVM calculations and Mendelssohn has surveyed alternative approaches to trimming. Even though the degree of trimming used here is arbitrary, it surely removes some protest and nonparticipatory bids at the low end as well as some ill-considered and implausibly large responses at the high end. Table 7.32 shows that after trimming, the CVM bids fall in all cases; a result that illustrates the tendency for the bid distribution to be skewed to the right. In fact, even a comparatively small amount of trimming produces precipitous reductions in WTP estimates for some symptoms in the normal group (see, for example, chest tightness and pain on deep inhalation). Reductions in WTP estimates for the impaired group tend to be smaller than those for the normal group.

TABLE 7.1. COULD NOT BREATHE DEEP PRODUCTION FUNCTION: WHOLE SAMPLE[a, b]

Explanatory Variable	Simultaneous Equation Estimates	Single Equation Estimates
ASTHMA	-.0196 (-.097)	.0612 (.312)
BRONCH	.0252 (.102)	.1198 (.565)
OTHDIS	.1076 (.506)	.1632 (.807)
FLEMCO	.2114 (1.183)	.1770 (1.149)
SHRTWHZ	.3232 (1.528)	.3555 (1.800)
HAYFEV	.4140 (2.644)	.4242 (3.054)
RESPINF	.4369 (1.428)	.3513 (1.192)
POOR	.5889 (1.253)	.3777 (.920)
EDCRADE	.0138 (.522)	.0122 (.459)
ACE	.0116 (1.335)	.0116 (1.309)
SEX	-.0605 (-.183)	-.0522 (-.188)
MARRIED	-.5916 (-2.361)	-.5253 (-2.280)
GLEN1	.3906 (2.093)	.7544 (2.832)
GLEN2	-.1449 (-.635)	.2511 (.854)
CLEN3	-.1362 (-.516)	.1310 (.408)
GLEN4	-.4287 (-1.385)	-.1346 (-.374)
BURBO	-.8811 (-2.027)	-.6168 (-1.504)
BURB1	.0965 (.332)	.6615 (2.076)
BURB2	-.5323 (-1.553)	.0487 (.133)
WRKESCV	.0906 (.574)	.0162 (.116)
EXPWRK	.2499 (1.719)	.3188 (2.384)
ACWRK	.3988 (2.114)	.2455 (1.356)
ACCAR	-.0057 (-.037)	.0140 (.094)
ACHOME	.3397 (1.798)	.3673 (2.018)
APHOME	-.1393 (-.653)	-.0186 (-.093)
GASCOOK	.1741 (.716)	.2211 (.994)
MEDHAT	-.6366 (-.388)	---
MED	---	-.2008 (-.611)
OUTHAT	.4587 (3.784)	---

(continued)

Table 7.1, continued

Explanatory Variable	Simultaneous Equation Estimates	Single Equation Estimates
OUTHRS	---	.0829 (2.633)
RECHAT	.9933 (.504)	---
RECTRIP	---	.0137 (.061)
SO2	.3942 (2.015)	.1462 (.871)
OZO	-.0347 (-1.647)	.0114 (.920)

[a]The dependent variable in the regression is a transformation, T(P), of the dependent variable p in the model: $T(p) = 5 + 0.5[\ell n(p/(1-p))]$. To obtain estimates of the true parameters of the logistic regression, multiply slope coefficients by 2; subtract 5 from the intercept and multiply by 2.

[b]t-statistics in parentheses.

TABLE 7.2. COULD NOT BREATHE DEEP PRODUCTION FUNCTION: NORMAL SUBSAMPLE[a,b]

Explanatory Variable	Simultaneous Equation Estimates	Single Equation Estimates
FLEMCO	.3320 (1.277)	.1597 (.711)
SHRTWHZ	-.5370 (-.907)	-.3441 (-.616)
HAYFEV	.3717 (1.662)	.4267 (2.124)
EDCRADE	.0167 (.542)	.0065 (.219)
ACE	.0134 (1.143)	.0173 (1.508)
SEX	-.0998 (-.252)	-.0029 (-.008)
MARRIEO	-.2638 (-.884)	-.1179 (-.402)
GLEN1	.4775 (1.864)	.9849 (2.522)
CLEN2	-.3168 (-.933)	.1355 (.304)
CLEN3	-.2571 (-.705)	.1356 (.295)
GLEN4	-.7936 (-1.429)	-.3787 (-.604)
BURBO	-.7268 (-1.329)	-.3370 (-.709)
BURB1	-.1386 (-.310)	.7928 (1.715)
BURB2	-.2799 (-.609)	.6323 (1.358)
WRKESGV	-.0719 (-.397)	-.1281 (-.722)
EXPWRK	.0715 (.347)	.3194 (1.875)
ACWRK	.3275 (1.411)	.1605 (.754)
ACCAR	-.1694 (-.887)	-.1794 (-.992)
ACHOME	.6407 (1.926)	.7764 (2.423)
APHOME	-.2192 (-.690)	.0695 (.263)
GASCOOK	-.1396 (-.446)	-.0086 (-.035)
MEDHAT	-.3732 (-.246)	---
MED	---	-.5526 (-1.038)
OUTHAT	.6376 (2.761)	---
OUTHRS	---	.1014 (2.275)
RECHAT	1.0025 (.501)	---
RECTRIP	---	.4200 (1.745)

(continued)

Table 7.2, continued

Explanatory Variable	Simultaneous Equation Estimates	Single Equation Estimates
S02	.5374	.0136
	(1.809)	(.062)
OZO	-.0608	-.0034
	(-1.992)	(-.211)

[a]The dependent variable in the regression is a transformation, T(P), of the dependent variable p in the model: $T(P) = 5 + 0.5[\ln(p/(1-p))]$. To obtain estimates of the true parameters of the logistic regression, multiply slope coefficients by 2; subtract 5 from the intercept and multiply by 2.

[b]t-statistics in parentheses.

TABLE 7.3. COULD NOT BREATHE DEE PRODUCTION FUNCTION: IMPAIRED SUBSAMPLE[a,b]

Explanatory Variable	Simultaneous Equation Estimates	Single Equation Estimates
FLEMCO	.2513	.3987
	(.889)	(1.521)
SHRTWHZ	.3853	.3220
	(1.321)	(1.105)
HAYFEV	.3697	.4843
	(1.338)	(1.852)
RESPINF	.2165	.2261
	(.489)	(.522)
POOR	1.0120	.9494
	(1.565)	(1.506)
EDCRADE	-.0117	-.0124
	(-.185)	(-.204)
AGE	.0269	.0171
	(1.460)	(.976)
SEX	-.1534	.4809
	(-.184)	(.639)
MARRIED	-.8601	-1.6022
	(-1.167)	(-2.358)
GLEN1	.8300	1.0522
	(2.671)	(2.628)
GLEN2	.5806	.8327
	(1.712)	(1.990)
CLEN3	.6259	.7389
	(l.482)	(1.580)
GLEN4	.4031	.5829
	(.939)	(1.222)
BURBO	---[c]	---[c]
BURB1	1.0624	1.3998
	(2.843)	(3.302)
BURB2	---[c]	---[c]
WRKESGV	.5696	.4653
	(1.802)	(1.591)
EXPWRK	-.2410	-.0909
	(-.718)	(-.297)
ACWRK	.9973	.5627
	(2.188)	(1.477)
ACCAR	.0596	.3096
	(.173)	(.989)
ACHOME	.2640	.5306
	(.605)	(1.234)
APHOME	.4752	.1792
	(1.291)	(.524)
GASCOOK	1.2343	.9396
	(1.994)	(1.593)
MEDHAT	1.8441	---
	(1.347)	
MED	---	.3378
		(.658)
OUTHAT	.3757	---
	(2.420)	
OUTHRS	---	.0749
		(1.531)
RECHAT	-.9814	---
	(-.851)	

(continued)

Table 7.3, continued

Explanatory Variable	Simultaneous Equation Estimates	Single Equation Estimates
RECTRIP	---	---
S02	.0845	-.0090
	(.266)	(-.029)
OZO	-.0068	.0603
	(-.188)	(2.576)

[a]The dependent variable in the regression is a transformation, T(P)S of the dependent variable p in the model: $T(p) = 5 + 0.5[\ell n(p/(1-p))]$. To obtain estimates of the true parameters of the logistic regression, multiply slope coefficients by 2; subtract 5 from the intercept and multiply by 2.

[b]t-statistics in parentheses.

[c]Variable excluded due to convergence problems.

TABLE 7.4. PAIN ON DEEP INHALATION PRODUCTION FUNCTION: WHOLE SAMPLE[a,b]

Explanatory Variable	Simultaneous Equation Estimates	Single Equation Estimates
ASTHMA	.2196	.2485
	(1.223)	(1.416)
BRONCH	-.0435	-.0046
	(-.176)	(-.022)
OTHDIS	-.1671	-.1400
	(-.720)	(-.615)
FLEMCO	.1757	.1828
	(1.042)	(1.207)
SHRTWHZ	.3065	.3547
	(1.563)	(1.931)
HAYFEV	.3022	.2803
	(1.978)	(2.035)
RESPINF	.3497	.3308
	(1.126)	(1.078)
POOR	.0955	-.1041
	(.182)	(-.228)
EDGRADE	-.0391	-.0386
	(-1.470)	(-1.454)
AGE	.0017	.0031
	(.213)	(.372)
SEX	-.2178	-.1509
	(-.694)	(-.571)
MARRIED	-.3650	-.3519
	(-1.484)	(-1.561)
GLEN1	1.4035	1.5902
	(6.868)	(6.228)
GLEN2	.4539	.6673
	(1.817)	(2.298)
GLEN3	---[c]	---[c]
GLEN4	.8349	.9911
	(3.358)	(3.435)
BURBO	.1822	.2751
	(.477)	(.757)
BURB1	1.0092	1.3087
	(3.558)	(4.442)
BURB2	-.0487	.3184
	(-.113)	(.730)
WRKESCV	.1833	.1103
	(1.265)	(.847)
EXPWRK	.2337	.2854
	(1.692)	(2.227)
ACWRK	.1927	.1028
	(1.153)	(.641)
ACCAR	-.0961	-.0642
	(-.696)	(-.476)
ACHOME	.2345	.2478
	(1.386)	(1.496)
APHOME	-.1523	-.1080
	(-.711)	(-.519)
GASCOOK	.2679	.3301
	(1.075)	(1.423)
MEDHAT	-.7447	---
	(-.449)	
MED	---	-.0456
		(-.117)
OUTHAT	.2826	---
	(2.302)	

(continued)

Table 7.4. continued

Explanatory Variable	Simultaneous Equation Estimates	Single Equation Estimates
OUTHRS	---	.0635 (1.797)
RECHAT	-.2835 (-.147)	---
RECTRIP	---	-.2069 (-.747)
S02	-.1167 (-.646)	-.2653 (-1.712)
OZO	-.0135 (-.675)	.0120 (1.046)

[a]The dependent variable in the regression is a transformation, T(p), of the dependent variable p in the model: $T(p) = 5 + 0.5[\ln(p/(1-p))]$. To obtain estimates of the true parameters of the logistic regression, multiply slope coefficients by 2; subtract 5 from the intercept and multiply by 2.

[b] t-statistics in parentheses.

[c]Variable excluded due to convergence problems.

TABLE 7.5. PAIN ON DEEP INHALbATION PRODUCTION FUNCTION: NORMAL SUBSAMPLE[a,b]

Explanatory Variable	Simultaneous Equation Estimates	Single Equation Estimates
FLEMCO	-.0348 (-.128)	-.0322 (-.143)
SHRTWHZ	.5669 (1.495)	.6112 (1.868)
HAYFEV	.7210 (3.256)	.6554 (3.360)
RESPINF	---[c]	---[c]
POOR	---[c]	---[c]
EDGRADE	-.0136 (-.431)	-.0123 (-.403)
AGE	.0084 (.750)	.0156 (1.441)
SEX	-.0611 (-.168)	-.0455 (-.136)
MARRIED	-.4126 (-1.429)	-.2364 (-.865)
CLEN1	1.8174 (4.852)	2.2466 (4.440)
GLEN2	.3419 (.676)	.7716 (1.281)
GLEN3	---[c]	---[c]
GLEN4	1.1366 (2.708)	1.5330 (2.869)
BURBO	.2477 (.415)	.3526 (.643)
BURBI	1.0868 (2.234)	1.7766 (3.330)
BURB2	-.0967 (-.140)	.7381 (1.034)
WRKESGV	.0607 (.349)	-.0261 (-.153)
EXPWRK	.3268 (1.552)	.4416 (2.605)
ACWRK	.0929 (.433)	-.1106 (-.579)
ACCAR	-.2091 (-1.077)	-.1345 (-.752)
ACHOME	.5326 (1.933)	.5306 (2.059)
APHOME	-.3474 -1.128)	-.0359 (-.137)
CASCOOK	.4772 (1.235)	.4910 (1.471)
MEDHAT	-1.4156 (-.827)	---
MED	---	-.2534 (-.453)
OUTHAT	.5002 (2.218)	---
OUTHRS	---	.1195 (2.150)
RECHAT	-1.0259 (-.516)	---

(continued)

Table 7.5, continued

Explanatory Variable	Simultaneous Equation Estimates	Single Equation Estimates
RECTRIP	---	-.1144
		(-.317)
S02	.2751	-.0648
	(.974)	(-.307)
OZO	-.0398	-.0020
	(-1.442)	(-.141)

[a]The dependent variable in the regression is a transformation, T(p), of the dependent variable p in the model: $T(p) = 5 + 0.5[\ell n(p/(1-p))]$. To obtain estimates of the true parameters of the logistic regression, multiply slope coefficients by 2; subtract 5 from the intercept and multiply by 2.

[b]t-statistics in parentheses.

[c]Variable excluded due to convergence problems.

TABLE 7.6. PAIN ON DEEP INHALATION PRODUCTION FUNCTION: IMPAIRED SUBSAMPLE[a,b]

Explanatory Variable	Simultaneous Equation Estimates	Single Equation Estimates
FLEMCO	.5211	.5075
	(1.879)	(1.950)
SHRTWHZ	.3163	.2595
	(1.126)	(.943)
HAYFEV	.0693	.0761
	(.283)	(.327)
RESPINF	.1159	.1032
	(.275)	(.251)
POOR	.4677	.4694
	(.793)	(.780)
EDGRADE	-.1572	-.1439
	(-2.481)	(-2.385)
AGE	-.0200	-.0174
	(-1.231)	(-1.168)
SEX	-.1414	-.1787
	(-.197)	(-.284)
MARRIED	-.7990	-.7083
	(-1.425)	(-1.393)
GLEN1	1.0748	1.1119
	(3.861)	(3.314)
CLEN2	.4137	.4492
	(1.301)	(1.230)
CLEN3	---[c]	---[c]
GLEN4	.7193	.7320
	(2.056)	(1.876)
BURBO	-.1141	-.0981
	(-.179)	(-.157)
BURBI	.8032	.8117
	(1.808)	(1.803)
BURB2	-.1019	-.0614
	(-.166)	(-.098)
WRKESCV	.3748	.4171
	(1.485)	(1.704)
EXPWRK	-.3015	-.3245
	(-1.067)	(-1.208)
ACWRK	.6055	.5758
	(1.420)	(1.582)
ACCAR	-.3729	-.3162
	(-1.276)	(-1.215)
ACHOME	.1673	.1384
	(.479)	(.408)
APHOME	-.0959	-.0395
	(-.234)	(-.101)
CASCOOK	.3128	.3305
	(.766)	(.835)
MEDHAT	.8499	---
	(.524)	
MED	---	.3533
		(.571)
OUTHAT	-.0113	---
	(-.072)	
OUTHRS	---	-.0029
		(-.051)
RECHAT	.7069	---
	(.646)	

(continued)

Table 7.6, continued

Explanatory Variable	Simultaneous Equation Estimates	Single Equation Estimates
RECTRIP	---	-.2287
		(-.410)
S02	-.8053	-.7479
	(-2.918)	(-2.836)
OZO	.0216	.0228
	(.627)	(1.047)

[a]The dependent variable in the regression is a transformation T(P), of the dependent variable p in the model: $T(p) = 5 + 0.5[\ln(p/(1-p))]$. To obtain estimates of the true parameters of the logistic regression, multiply slope coefficients by 2; subtract 5 from the intercept and multiply by 2.

[b] t-statistics in parentheses.

[c]Variable excluded due to convergence problems.

TABLE 7.7. OUT OF BREATH EASILY PRODUCTION FUNCTION: WHOLE SAMPLE[a,b]

Explanatory Variable	Simultaneous Equation Estimates	Single Equation Estimates
ASTHMA	-.0705	.0075
	(-.300)	(.033)
BRONCH	.4130	.4808
	(1.665)	(2.283)
OTHDIS	.0059	.0233
	(.021)	(.087)
FLEMCO	.2693	.2178
	(1.311)	(1.189)
SHRTWHZ	.5226	.4993
	(2.104)	(2.138)
HAYFEV	.4925	.5337
	(2.760)	(3.242)
RESPINF	.3125	.2547
	(.902)	(.760)
POOR	.8204	.8044
	(1.768)	(2.216)
EDCRADE	-.0243	-.0308
	(-.793)	(-1.000)
AGE	.0257	.0266
	(2.670)	(2.697)
SEX	.2969	.1135
	(.781)	(.348)
MARRIED	-.7274	-.6674
	(-2.517)	(-2.365)
GLENI	.1453	.4599
	(.634)	(1.534)
CLEN2	.6417	.9531
	(2.883)	(3.240)
CLEN3	.0917	.3396
	(.309)	(.964)
GLEN4	.3830	.6336
	(1.499)	(1.978)
BURBO	-.3277	-.1247
	(-.878)	(-.365)
BURB1	-.9468	-.5319
	(-1.636)	(-.902)
BURB2	-.7180	-.2785
	(-1.614)	(-.608)
WRKESGV	.0116	.0549
	(.065)	(.341)
EXPWRK	.1775	.2145
	(1.068)	(1.382)
ACWRK	.2474	.1411
	(1.096)	(.663)
ACCAR	.0396	.0098
	(.234)	(.060)
ACHOME	.0369	.1246
	(.201)	(.697)
APHOME	-.9669	-.8550
	(-2.362)	(-2.173)
GASCOOK	.4164	.5898
	(1.271)	(1.946)
MEDHAT	1.0296	---
	(.613)	
MED	---	.3455
		(1.179)

(continued)

Table 7.7, continued

Explanatory Variable	Simultaneous Equation Estimates	Single Equation Estimates
OUTHAT	.3471 (2.445)	---
OUTHRS	---	,0524 (1.475)
RECHAT	2.9385 (1.373)	----
RECTRIP	---	-.0851 (-.354)
SO2	.2653 (1.285)	.0803 (.454)
OZO	-.0032 (-.133)	.0343 (2.500)

[a]The dependent variable in the regression is a transformation, T(P), of the dependent variable p in the model: $T(p) = 5 + 0.5[\ell n(p/(1-p))]$. To obtain estimates of the true parameters of the logistic regression, multiply slope coefficients by 2; subtract 5 from the intercept and multiply by 2.

[b] t-statistics in parentheses.

TABLE 7.8. OUT OF BREATH EASILY PRODUCTION FUNCTION: NORMAL SUBSAMPLE[a,b]

Explanatory Variable	Simultaneous Equation Estimates	Single Equation Estimates
FLEMCO	.3076	.0317
	(.857)	(.098)
SHRTWHZ	-.1571	.2539
	(-.276)	(.511)
HAYFEV	.4249	.5198
	(1.525)	(2.030)
RESPINF	---[c]	---[c]
POOR	1.8404	1.2613
	(2.313)	(2.131)
EDCRADE	-.0002	.0019
	(-.005)	(-.049)
AGE	.0340	.0411
	(2.684)	(2.755)
SEX	.0381	-.2069
	(.084)	(-.480)
MARRIED	-.4632	-.4431
	(-1.325)	(-1.300)
GLEN1	.6647	1.0261
	(1.766)	(2:248)
CLEN2	1.2248	1.6018
	(3.409)	(3.623)
CLEN3	.6513	1.0216
	(1.413)	(1.938)
GLEN4	.3560	.7188
	(.735)	(1.285)
BURBO	1.0909	.8335
	(2.022)	(1.863)
BURB1	---[c]	---[c]
BURB2	.6361	.8267
	(1.093)	(1.471)
WRKESGV	.0180	-.0197
	(.077)	(-.088)
EXPWRK	.1857	.3820
	(.712)	(1.742)
ACWRK	.3962	.2431
	(1.301)	(.867)
ACCAR	-.0868	-.2038
	(-.333)	(-.848)
ACHOME	-.0593	.0521
	(-.203)	(.193)
APHOME	-.4954	-.2870
	(-1.022)	(-.659)
GASCOOK	.3618	.8124
	(.638)	(1.464)
MEDHAT	-1.2986	---
	(-.737)	
MED	---	.4933
		(1.353)
OUTHAT	.2370	---
	(.821)	
OUTHRS	---	.0734
		(1.302)
RECHAT	3.5142	---
	(1.590)	

(continued)

Table 7.8, continued

Explanatory Variable	Simultaneous Equation Estimates	Single Equation Estimates
RECTRIP	---	.0277
		(.096)
S02	.1124	-.0716
	(.323)	(-.289)
OZO	.0392	.0499
	(1.141)	(2.805)

[a]The dependent variable in the regression is a transformation, T(P)) of the dependent variable p in the model: $T(p) = 5 + 0.5[\ell n(p/(1-p))]$. To obtain estimates of the true parameters of the logistic regression, multiply slope coefficients by 2; subtract 5 from the intercept and multiply by 2.

[b] t-statistics in parentheses,

[c]variable excluded due to convergence problems.

TABLE 7.9. OUT OF BREATH EASILY PRODUCTION FUNCTION: IMPAIRED SUBSAMPLE[a,b]

Explanatory Variable	Simultaneous Equation Estimates	Single Equation Estimates
FLEMCO	.3193	.4210
	(1.254)	(1.737)
SHRTWHZ	.3458	.2509
	(1.322)	(.956)
HAYFEV	.5192	.5871
	(2.009)	(2.329)
RESPINF	.8195	.7563
	(1.936)	(1.822)
POOR	.5188	.5950
	(.904)	(1.069)
EDCRADE	-.0887	-.0845
	(-1.394)	(-l.380)
AGE	.0291	.0211
	(1.834)	(1.334)
SEX	-.9895	-.7856
	(-.921)	(-.748)
MARRIED	.5344	.3049
	(.514)	(.230)
GLEN1	.4332	.5982
	(1.395)	(1.550)
CLEN2	.8456	1.1161
	(2.782)	(2.916)
GLEN3	.4728	.5415
	(1.161)	(1.211)
CLEN4	1.0801	1.1057
	(3.132)	(2.789)
BURBO	---[c]	---[c]
BURB1	-.1820	-.0087
	(-.318)	(-.015)
BURB2	---[c]	---[c]
WRKESGV	.5198	.5196
	(1.930)	(1.996)
EXPWRK	-.4719	-.2967
	(-1.576)	(-1.042)
ACWRK	.4783	.1270
	(1.393)	(.429)
ACCAR	-.1656	.0658
	(-.546)	(.244)
ACHOME	-.1369	-.0237
	(-.431)	(-.076)
CASCOOK	1.0715	.8732
	(2.370)	(l.980)
MEDHAT	1.5806	---
	(1.167)	
MED	---	-.0350
		(-.058)
OUTHAT	.3484	---
	(2.406)	
OUTHRS	---	.0810
		(1.705)
RECHAT	-1.3463	---
	(-1.149)	

(continued)

Table 7.9, continued

Explanatory Variable	Simultaneous Equation Estimates	Single Equation Estimates
RECTRIP	---	-.7709
		(-1.346)
S02	.0374	-.0267
	(.128)	(-.094)
OZO	-.0243	.0361
	(-.708)	(1.611)

[a]The dependent variable in the regression is a transformation, T(p), of the dependent variable p in the model: $T(p) = 5 + 0.5[\ell n(p/(1-p))]$. To obtain estimates of the true parameters of the logistic regression, multiply slope coefficients by 2; subtract 5 from the intercept and multiply by 2.

[b]t-statistics in parentheses.

[c]Variable excluded due to convergence problems.

TABLE 7.10. WHEEZING/WHISTLING BREATH PRODUCTION FUNCTION: WHOLE SAMPLE[a,b]

Explanatory Variable	Simultaneous Equation Estimates	Single Equation Estimates
ASTHMA	.5115 (2.825)	.5286 (2.977)
BRONCH	.2238 (.953)	.2876 (1.431)
OTHDIS	-.2691 (-1.048)	-.1758 (-.720)
FLEMCO	.3207 (1.990)	.3475 (2.285)
SHRTWHZ	.5275 (2.775)	.7053 (4.142)
HAYFEV	.6342 (4.027)	.5247 (3.695)
RESPINF	1.0626 (3.798)	1.1108 (3.946)
POOR	.2107 (.393)	-.4671 (-1.061)
EDGRADE	.0206 (.671)	.0210 (.683)
AGE	.0183 (1.893)	.0221 (2.271)
SEX	-.1798 (-.422)	-.0066 (-.018)
MARRIED	.5862 (1.314)	.6133 (1.406)
GLEN1	.0599 (.290)	.2217 (.828)
CLEN2	.2471 (1.218)	.4234 (1.605)
GLEN3	.2149 (.920)	.3552 (l.244)
CLEN4	.2456 (1.085)	.3931 (1.390)
BURBO	---[c]	---[c]
BURBI	.1418 (.477)	.4069 (1.226)
BURB2	-.1342 (-.425)	.1977 (.566)
WRKESGV	.0706 (.393)	-.1165 (-.745)
EXPWRK	-.0595 (-.367)	-.0340 (-.268)
ACWRK	.1459 (.723)	.0338 (.175)
ACCAR	.1659 (.996)	.2463 (1.503)
ACHOME	-.2712 (-1.590)	-.3320 (-1.991)
APHOME	-.2937 (-1.281)	-.1891 (-.855)
GASCOOK	.4402 (1.546)	.4109 (1.540)
MEDHAT	-3.7379 (-1.481)	---
MED	---	-.0913 (-.231)

(continued)

Table 7.10, continued

Explanatory Variable	Simultaneous Equation Estimates	Single Equation Estimates
OUTHAT	.2352 (1.748)	---
OUTHRS	---	.0527 (1.542)
RECHAT	-2.6073 (-1.171)	---
RECTRIP	---	-.4500 (-1.601)
S02	.0077 (.040)	-.1965 (-1.118)
OZO	-.0129 (-.607)	.0091 (.658)

[a]The dependent variable in the regression is a transformation T(p), of the dependent variable p in the model: $T(p) = 5 + 0.5[\ell n(p/(1-p))]$. To obtain estimates of the true parameters of the logistic regression, multiply slope coefficients by 2; subtract 5 from the intercept and multiply by 2.

[b]t-statistics in parentheses,

[c]Variable excluded due to convergence problems.

TABLE 7.11. WHEEZING/WHISTLING BREATH PRODUCTION FUNCTION: NORMAL SUBSAMPLE[a,b]

Explanatory Variable	Simultaneous Equation Estimates	Single Equation Estimates
FLEMCO	-1.4678 (-2.863)	-1.2876 (-2.696)
SHRTWHZ	1.9389 (4.318)	1.7624 (4.519)
HAYFEV	.8816 (3.297)	.7661 (3.066)
RESPINF	---[c]	---[c]
POOR	---[c]	---[c]
EDGRADE	.0504 (1.078)	.0592 (1.360)
AGE	.0304 (1.678)	.0302 (1.903)
SEX	.7443 (1.263)	.9511 (1.830)
GLEN1	.5165 (1.474)	.5853 (1.327)
GLEN2	-.1557 (-.330)	-.0958 (-.177)
GLEN3	.3077 (.732)	.3733 (.770)
GLEN4	-.2797 (-.474)	-.2242 (-.347)
BURBO	---[c]	---[c]
BURB1	1.0681 (2.358)	.8461 (1.742)
BURB2	.4523 (.846)	.2352 (.429)
WRKESGV	-.5327 (-1.823)	-.5422 (-2.067)
EXPWRK	.7041 (2.239)	.3771 (1.397)
ACWRK	.7858 (1.850)	.6643 (1.804)
ACCAR	.0281 (.096)	.1392 (.482)
ACHOME	.3297 (1.064)	.2743 (.898)
MEDHAT	-3.1758 (-1.135)	---
MED	---	.3775 (.867)
OUTHAT	-.3341 (-1.105)	---
OUTHRS	---	-.0202 (-.278)
RECHAT	-1.8507 (-.757)	---
RECTRIP	---	.1064 (.301)
SO2	-.4736 (-1.212)	-.2396 (-.821)
OZO	.0489 (1.328)	.0137 (.663)

[a]The dependent variable in the regression is a transformation, T(p), of the dependent variable p in the model: $T(p) = 5 + 0.5[\ell n(p/(1-p))]$. To obtain estimates of the true parameters of the logistic regression, multiply slope coefficients by 2; subtract 5 from the intercept and multiply by 2.

[b]t-statistics in parentheses.

[c]Variable excluded due to convergence problems.

TABLE 7.12. WHEEZING/WHISTLING BREATH PRODUCTION FUNCTION: IMPAIRED SUBSAMPLE[a,b]

Explanatory Variable	Simultaneous Equation Estimates	Single Equation Estimates
FLEMCO	1.3077 (4.377)	1.2614 (4.594)
SHRTWHZ	.6130 (2.168)	.6515 (2.417)
HAYFEV	.9521 (3.579)	.9709 (3.895)
RESPINF	1.8025 (4.598)	1.8684 (4.835)
POOR	-.8894 (-1.508)	-.8073 (-1.417)
EDCRADE	.0171 (.274)	.0039 (.065)
AGE	.0194 (1.208)	.0132 (.875)
SEX	1.1163 (.827)	1.1745 (1.057)
MARRIED	.5530 (.416)	.5958 (.543)
GLEN1	-.0909 (-.327)	.2356 (.675)
GLEN2	.5067 (1.825)	.8861 (2.568)
GLEN3	.3655 (1.126)	.6935 (1.895)
CLEN4	.5912 (1.925)	.9103 (2.523)
BURBO	---[c]	---[c]
BURB1	---[c]	---[c]
BURB2	-.2540 (-.567)	.1602 (.326)
WRKESCV	-.0215 (-.070)	.0266 (.095)
EXPWRK	-.3879 (-1.378)	-.2218 (-.869)
ACWRK	-.1225 (-.320)	-.2300 (-.730)
ACCAR	.1074 (.366)	.0792 (.329)
ACHOME	-1.1916 (-3.899)	-1.2216 (-4.108)
APHOME	-.1425 (-.354)	-.2025 (-.591)
CASCOOK	.8045 (1.789)	.6360 (1.567)
MEDHAT	-.8814 (-.516)	---
MED	---	---
OUTHAT	.1114 (.713)	---
OUTHRS	---	.0968 (2.069)
RECHAT	-3.6452 (-2.861)	---
RECTRIP	---	-1.2318 (-1.966)

(continued)

Table 7.12, continued

Explanatory Variable	Simultaneous Equation Estimates	Single Equation Estimates
SO2	-.2437	-.4030
	(-.943)	(-1.563)
OZO	.0080	.0145
	(.236)	(.693)

[a]The dependent variable in the regression is a transformation, T(p), of the dependent variable p in the model: $T(p) = 5 + 0.5[\ell n(p/(1-p))]$. To obtain estimates of the true parameters of the logistic regression, multiply slope coefficients by 2; subtract 5 from the intercept and multiply by 2.

[b]t-statistics in parentheses.

[c]Variable excluded due to convergence problems.

TABLE 7.13. CHEST TIGHT PRODUCTION FUNCTION: WHOLE SAMPLE[a,b]

Explanatory Variable	Simultaneous Equation Estimates	Single Equation Estimates
ASTHMA	.3466	.2801
	(1.955)	(1.630)
BRONCH	.6089	.3281
	(2.645)	(1.669)
OTHDIS	-.3541	-.2310
	(-1.491)	(-1.025)
FLEMCO	.4408	.5575
	(2.740)	(3.840)
SHRTWHZ	.5083	.4640
	(2.817)	(2.696)
HAYFEV	.4610	.5308
	(3.056)	(4.044)
RESPINF	.6867	.5974
	(2.672)	(2.325)
POOR	-.0575	.3010
	(-.140)	(.880)
EDCRADE	.0425	.0410
	(1.671)	(1.596)
AGE	.0240	.0243
	(2.762)	(2.752)
SEX	-.9293	-.6442
	(-2.608)	(-2.188)
MARRIED	.5336.	.3268
	(1.688)	(1.086)
CLEN1	-.2938	.0410
	(-1.474)	(.157)
CLEN2	.2200	.5602
	(1.168)	(2.248)
GLEN3	-.4669	-.1346
	(-1.868)	(-.448)
GLEN4	.0016	.3391
	(.008)	(1.267)
BURBO	-.7202	-.2620
	(-2.064)	(-.815)
BURB1	-.6579	.0070
	(-1.872)	(.019)
BURB2	-.8821	-.1278
	(-2.383)	(-.340)
WRKESGV	-.0834	-.0558
	(-.523)	(-.388)
EXPWRK	-.2802	-.1246
	(-1.915)	(-.920)
ACWRK	.0334	.0383
	(.180)	(.212)
ACCAR	-.0852	-.0377
	(-.573)	(-.258)
ACHOME	.1890	.2607
	(1.028)	(1.441)
APHOME	.2317	.1386
	(1.207)	(.761)
GASCOOK	.3989	.2068
	(1.712)	(.991)
MEDHAT	4.0189	---
	(2.524)	
MED	---	.0404
		(.142)

(continued)

Table 7.13, continued

Explanatory Variable	Simultaneous Equation Estimates	Single Equation Estimates
OUTHAT	.3276 (2.657)	---
OUTHRS	---	.0676 (2.254)
RECHAT	-2.2962 (-1.091)	---
RECTRIP	---	-.2870 (-1.309)
SO2	.4751 (2.521)	.1727 (1.084)
OZO	-.0505 (-2.298)	.0073 (.566)

[a]The dependent variable in the regression is a transformation, T(p), of the dependent variable p in the model: $T(p) = 5 + 0.5[\ln(p/(1-p))]$. To obtain estimates of the true parameters of the logistic regression, multiply slope coefficients by 2; subtract 5 from the intercept and multiply by 2.

[b] t-statistics in parentheses.

[c]Variable excluded due to convergence problems.

TABLE 7.14. CHEST TIGHT PRODUCTION FUNCTION: NORMAL SUBSAMPLE[a],[b]

Explanatory Variable	Simultaneous Equation Estimates	Single Equation Estimates
FLEMCO	.3060 (1.077)	.5191 (2.323)
SHRTWHZ	.3874 (.753)	-.0661 (-.139)
HAYFEV	.7663 (3.087)	.4870 (2.300)
RESPINF	---[c]	---[c]
POOR	---[c]	---[c]
EDGRADE	.0756 (2.264)	.0794 (2.466)
AGE	.0091 (.636)	.0216 (1.606)
SEX	-1.8234 (-3.351)	-1.1785 (-2.574)
MARRIED	1.0346 (2.110)	1.0652 (2.181)
CLEN1	-.7825 (-1.890)	-.3075 (-.628)
GLEN2	.1581 (.573)	.6891 (1.814)
GLEN3	-.0126 (-.038)	.4469 (1.037)
GLEN4	.1387 (.456)	.6479 (1.616)
BURBO	-1.2866 (-2.080)	-.3859 (-.721)
BURB1	-1.1648 (-1.842)	.3308 (.586)
BURB2	-1.2819 (-2.129)	.2467 (.458)
WRKESGV	-.2328 (-1.051)	-.3129 (-1,445)
EXPWRK	-.1000 (-.387)	.0109 (.055)
ACWRK	.2444 (.796)	.1939 (.703)
ACCAR	-.5648 (-2.449)	-.3794 (-1.897)
ACHOME	1.4995 (2.884)	1.3055 (2.678)
APHOME	-.2134 (-.679)	.3098 (1.296)
GASCOOK	.3531 (.926)	-.0150 (-.051)
MEDHAT	.2173 (.124)	---
MED	---	-.0192 (-.047)
OUTHAT	.7916 (2.758)	---
OUTHRS	---	.1072 (2.386)
RECHAT	-7.0861 (-2.383)	---
RECTRIP	---	-.1603 (-.553)

(continued)

Table 7.14, continued

Explanatory Variable	Simultaneous Equation Estimates	Single Equation Estimates
SO2	.8467	.1479
	(2.362)	(.605)
OZO	-.0763	.0177
	(-2.080)	(.946)

[a]The dependent variable in the regression is a transformation, T(p), of the dependent variable p in the model: $T(p) = 5 + 0.5[\ln(p/(1-p))]$. To obtain estimates of the true parameters of the logistic regression, multiply slope coefficients by 2; subtract 5 from the intercept and multiply by 2.

[b]t-statistics in parentheses.

[c]Variable excluded due to convergence problems.

TABLE 7.15. CHEST TIGHT PRODUCTION FUNCTION: IMPAIRED SUBSAMPLE[a, b]

Explanatory Variable	Simultaneous Equation Estimates	Single Equation Estimates
FLEMCO	.9914 (3.704)	1.0599 (4.158)
SHRTWHZ	.7716 (2.872)	.8186 (3.006)
HAYFEV	.5492 (2.433)	.6119 (2.717)
RESPINF	.9144 (2.292)	.9758 (2.502)
POOR	.5066 (.863)	.4597 (.796)
EDCRADE	-.1174 (-1.810)	-.1317 (-1.966)
ACE	.0410 (2.577)	.0380 (2.505)
SEX	-1.3356 (-1.559)	-1.0920 (-1.353)
MARRIED	1.1723 (1.278)	1.0260 (1.153)
CLEN1	-.1131 (-.393)	.1456 (.393)
CLEN2	.2280 (.774)	.5318 (1.391)
GLEN3	-.9759 (-2.212)	-.7706 (-1.558)
GLEN4	.0006 (.002)	.2139 (.520)
BURBO	-.6876 (-l.290)	-.5038 (-.965)
BURB1	-.8360 (-1.575)	-.5420 (-.960)
BURB2	-1.1392 (-1.850)	-.7237 (-1.142)
WRKESCV	.2654 (.980)	.2453 (.940)
EXPWRK	-.9075 (-3.062)	-.8915 (-3.110)
ACWRK	.2133 (.561)	.0376 (.115)
ACCAR	-.4626 (-1.609)	-.3712 (-1.441)
ACHOME	-.4134 (-1.382)	-.4103 (-1.435)
APHOME	-.1550 (-.381)	-.3061 (-.823)
CASCOOK	1.4123 (3.110)	1.3821 (3.179)
MEDHAT	.5231 (.357)	---
MED	---	.5402 (1.244)
OUTHAT	.1743 (1.209)	---
OUTHRS	---	.0390 (.853)

(continued)

Table 7.15. continued

Explanatory Variable	Simultaneous Equation Estimates	Single Equation Estimates
RECHAT	-.6244	---
	(-.657)	
RECTRIP	---	-.3331
		(-.827)
SO2	.1641	.0869
	(.614)	(.327)
OZO	-.0485	-.0168
	(-1.436)	(-.745)

[a]The dependent variable in the regression is a transformation, T(p)S of the dependent variable p in the model: $T(p) = 5 + 0.5[\ln(p/(1-p))]$. To obtain estimates of the true parameters of the logistic regression, multiply slope coefficients by 2; subtract 5 from the intercept and multiply by 2.

[b]t-statistics in parentheses.

TABLE 7.16. COUGH PRODUCTION FUNCTION: WHOLE SAMPLE[a,b]

Explanatory Variable	Simultaneous Equation Estimates	Single Equation Estimates
ASTHMA	.2358 (1.634)	.1951 (1.420)
BRONCH	1.1135 (6.224)	.9459 (6.186)
OTHDIS	.6214 (4.350)	.6770 (4.924)
FLEMCO	.1382 (1.105)	.1872 (1.658)
SHRTWHZ	.0232 (.157)	.0133 (.094)
HAYFEv	.4045 (3.472)	.4686 (4.439)
RESPINF	.5594 (2.701)	.4965 (2.423)
POOR	.7049 (2.149)	.9692 (3.369)
EDGRADE	.0556 (2.814)	.0532 (2.681)
AGE	-.0108 (-1.613)	-.0119 (-1.761)
SEX	-.5190 (-2.283)	-.3445 (-1.865)
MARRIED	-.3983 (-2.307)	-.5163 (-3.257)
GLEN1	-.7815 (-3.903)	-.7057 (-3.030)
GLEN2	-.1980 (-1.167)	-.1372 (-.665)
GLEN3	-.1110 (-.601)	-.0373 (-.171)
GLEN4	-.0525 (-.306)	.0161 (.077)
BURBO	-.5758 (-2.341)	-.2642 (-1.192)
BURB1	-1.8587 (-4.349)	-1.5983 (-3.718)
BURB2	-.3176 (-1.400)	-.0192 (-.083)
WRKESGV	-.2329 (-1.980)	-.1924 (-1.733)
EXPWRK	.1338 (1.236)	.2303 (2.267)
ACWRK	.0223 (.166)	.0065 (.050)
ACCAR	-.2554 (-2.335)	-.2407 (-2.269)
ACHOME	.0077 (.061)	.0475 (.379)
APHOME	.3733 (2.444)	.3293 (2.248)
GASCOOK	.1355 (.787)	.0099 (.066)
MEDHAT	2.9377 (2.422)	---
MED	---	.3956 (2.188)
OUTHAT	.1780 (1.793)	---

(continued)

Table 7.16, continued

Explanatory Variable	Simultaneous Equation Estimates	Single Equation Estimates
OUTHRS	---	-.0152 (-.588)
RECHAT	-.7409 (-.516)	---
RECTRIP	---	.0070 (.050)
SO2	.0699 (.457)	-.0779 (-.581)
OZO	-.0599 (-3.259)	-.0252 (-2.134)

[a]The dependent variable in the regression is a transformation, T(p), of the dependent variable p in the model: $T(p) = 5 + 0.5[\ell n(p/(1-p))]$. To obtain estimates of the true parameters of the logistic regression, multiply slope coefficients by 2; subtract 5 from the intercept and multiply by 2.

[b]t-statistics in parentheses.

[c]Variable excluded due to convergence problems.

TABLE 7.17. COUGH PRODUCTION FUNCTION: NORMAL SUBSAMPLE[a,b]

Explanatory Variable	Simultaneous Equation Estimates	Single Equation Estimates
FLEMCO	-.0928 (-.398)	.1429 (.805)
SHRTWHZ	.0210 (.055)	-.2681 (-.791)
HAYFEV	.8730 (4.572)	.7184 (4.369)
POOR	.4689 (.799)	.8900 (2.094)
EDGRADE	.0724 (2.674)	.0641 (2.440)
AGE	-.0271 (-2.696)	-.0229 (-2.288)
SEX	-.8313 (-3.195)	-.4787 (-2.146)
MARRIED	-.4920 (-2.291)	-.4948 (-2.477)
GLENI	-.6641 (-2.315)	-.3555 (-1.084)
GLEN2	-.1033 (-.429)	.1805 (.623)
CLEN3	-.0212 (-.083)	.3006 (1.000)
GLEN4	-.1842 (-.725)	.1554 (.521)
BURBO	-.9080 (-2.104)	.2489 (.841)
BURB1	-1.8178 (-3.279)	-.6671 (-1.408)
BURB2	-.8527 -2.026)	.3338 (1.004)
WRKESCV	-.4249 -2.516)	-.4016 -2.412)
EXPWRK	.3670 (2.031)	.4396 (2.975)
ACWRK	.1786 (.781)	.2477 (1.230)
ACCAR	-.7611 -4.343)	-.6247 -4.033)
ACHOME	.1223 (.651)	.0665 (.388)
APHOME	-.0147 (-.052)	.3579 (1.523)
CASCOOK	.9899 (2.884)	.5636 (2.030)
MEDHAT	3.5610 2.777)	---
MED	---	.5992 (2.749)
OUTHAT	.5493 2.460)	---
OUTHRS	---	.0039 (.104)
RECHAT	4.3276 (-2.470)	---
RECTRIP	---	-.2407 (-1.159)

(continued)

Table 7.17, continued

Explanatory Variable	Simultaneous Equation Estimates	Single Equation Estimates
SO2	.4033	-.1406
	(1.495)	(-.761)
OZO	-.1144	-.0249
	(-3.594)	(-1.570)

[a]The dependent variable in the regression is a transformation, T(p), of the dependent variable p in the model: $T(p) = 5 + 0.5[\ell n(p/(1-p))]$. To obtain estimates of the true parameters of the logistic regression, multiply slope coefficients by 2; subtract 5 from the intercept and multiply by 2.

[b]t-statistics in Parentheses.

TABLE 7.18. COUGH PRODUCTION FUNCTION: IMPAIRED SUBSAMPLE[a,b]

Explanatory Variable	Simultaneous Equation Estimates	Single Equation Estimates
FLEMCO	.4230	.4438
	(2.285)	(2.516)
SHRTWHZ	.4954	.4752
	(2.681)	(2.583)
HAYFEV	.2754	.2880
	(1.673)	(1.775)
RESPINF	1.2292	1.1899
	(4.207)	(4.147)
POOR	-.1772	-.1541
	(-.379)	(-.329)
EDGRADE	.0887	.0877
	(2.234)	(2.332)
AGE	.0276	.0211
	(2.423)	(1.999)
SEX	-.4524	-.2784
	(-.854)	(-.561)
MARRIED	-1.1782	-1.3969
	(-2.564)	(-3.287)
CLENI	-.5881	-.6147
	(-2.092)	(-1.939)
GLEN2	.0990	.0456
	(.428)	(.167)
GLEN3	.4163	.3289
	(1.642)	(1.188)
GLEN4	.6445	.5855
	(2.716)	(2.163)
BURBO	.2437	.1765
	(.807)	(.586)
BURB1	---[c]	---[c]
BURB2	.6416	.6243
	(2.432)	(2.205)
WRKESGV	.1477	.1495
	(.808)	(.835)
EXPWRK	-.4356	-.3245
	(-1.953)	(-1.598)
ACWRK	-.4119	-.5350
	(-1.871)	(-2.639)
ACCAR	-.2772	-.1807
	(-1.313)	(-.947)
ACHOME	.8274	.8859
	(2.726)	(3.078)
APHOME	.1249	.0179
	(.611)	(.089)
CASCOOK	.0617	-.0248
	(.245)	(-.105)
MEDHAT	.4315	---
	(.377)	
MED	---	-.6596
		(-1.517)
OUTHAT	.1668	---
	(1.593)	
OUTHRS	---	.0243
		(.700)
RECHAT	-.5161	---
	(-.658)	
RECTRIP	---	.2360
		(1.023)

(continued)

Table 7.18, continued

Explanatory Variable	Simultaneous Equation Estimates	Single Equation Estimates
SO2	-.2802	-.3252
	(-1.262)	(-1.514)
OZO	-.0169	.0108
	(-.672)	(.640)

[a]The dependent variable in the regression is a transformation, T(p), of the dependent variable p in the model: $T(p) = 5 + 0.5[\ell n(p/(1-p))]$. To obtain estimates of the true parameters of the logistic regression, multiply slope coefficients by 2; subtract 5 from the intercept and multiply by 2.

[b]t-statistics in parentheses.

[c]Variable excluded due to convergence problems.

TABLE 7.19. THROAT IRRITATION PRODUCTION FUNCTION: WHOLE SAMPLE[a,b]

Explanatory Variable	Simultaneous Equation Estimates	Single Equation Estimates
ASTHMA	.1861 (1.245)	.2063 (1.410)
BRONCH	.1375 (.688)	.1671 (.982)
OTHDIS	.4148 (2.560)	.3583 (2.296)
FLEMCO	.1064 (.793)	.0328 (.271)
SHRTWHZ	.2340 (1.450)	.1349 (.877)
HAYFEV	.1452 (1.173)	.2705 (2.334)
RESPINF	.5583 (2.399)	.4978 (2.177)
POOR	.2628 (.729)	.5366 (1.725)
EDCRADE	.0342 (1.657)	.0359 (1.730)
AGE	-.0041 (-.595)	-.0044 (-.640)
SEX	-.0672 (-.271)	-.2038 (-.972)
MARRIED	-.2528 (-1.347)	-.2196 (-1.256)
GLEN1	-.0047 (-.024)	-.2031 (-.100)
GLEN2	.3676 (2.029)	.3645 (1.665)
GLEN3	.2599 (1.242)	.2404 (.995)
GLEN4	.3522 (1.788)	.3172 (1.359)
BURBO	.3778 (1.522)	.4400 (1.983)
BURBI	-.5398 (-1.484)	-.5406 (-1.457)
BURB2	.1835 (.724)	.2129 (.832)
WRKESGV	-.1615 (-1.348)	-.0764 (-.683)
EXPWRK	.3875 (3.434)	.4265 (4.009)
ACWRK	.0804 (.588)	.0425 (.326)
ACCAR	-.2618 (-2.401)	-.3055 (-2.870)
ACHOME	-.0423 (-.339)	.0057 (.046)
APHOME	.1255 (.737)	.1210 (.737)
CASCOOK	.0027 (.014)	.0639 (.387)
MEDHAT	2.1174 (1.833)	---
MED	---	.3135 (1.602)
OUTHAT	.0885 (.843)	---

(continued)

Table 7.19. continued

Explanatory Variable	Simultaneous Equation Estimates	Single Equation Estimates
OUTHRS	---	-.0239 (-.841)
RECHAT	2.4529 (1.612)	---
RECTRIP	---	.2266 (-1.280)
SO2	-.1635 (-1.035)	-.1789 (-1.307)
OZO	-.0032 (-.177)	.0089 (.794)

[a]The dependent variable in the regression is a transformations T(p), of the dependent variable p in the model: $T(p) = 5 + 0.5[\ell n(p/(1-p))]$. To obtain estimates of the true parameters of the logistic regression, multiply slope coefficients by 2; subtract 5 from the intercept and multiply by 2.

[b]t-statistics in parentheses.

[c]Variable excluded due to convergence problems.

TABLE 7.20. THROAT IRRITATION PRODUCTION FUNCTION: NORMAL SUBSAMPLE[a,b]

Explanatory Variable	Simultaneous Equation Estimates	Single Equation Estimates
FLEMCO	-.1072 (-.496)	-.1904 (-1.032)
SHRTWHZ	.6489 (2.218)	.6097 (2.307)
HAYFEV	.5425 (2.857)	.5983 (3.424)
RESPINF	-.1763 (-.289)	-.1061 (-.174)
POOR	-.1172 (-.197)	.9206 (2.073)
EDCRADE	.0406 (1.526)	.0252 (.971)
AGE	-.0021 (-.217)	-.0085 (-.917)
SEX	.0239 (.079)	.0030 (.011)
MARRIED	.2863 (1.139)	.0313 (.139)
GLEN1	.2474 (.974)	.2306 (.761)
CLEN2	.4963 (1.994)	.5295 (1.796)
GLEN3	.1641 (.564)	.2483 (.748)
CLEN4	.1975 (.705)	.2489 (.768)
BURBO	.3730 (.931)	.4407 (1.454)
BURB1	-.1899 (-.415)	-.2307 (-.532)
BURB2	.2172 (.533)	.1924 (.543)
WRKESGV	-.1862 (-1.242)	-.0754 (-.521)
EXPWRK	.5850 (3.305)	.6257 (4.277)
ACWRK	.0407 (.206)	.2752 (1.534)
ACCAR	-.4688 (-3.086)	-.5322 (-3.682)
ACHOME	.0835 (.473)	.0806 (.467)
APHOME	.4155 (1.707)	.2195 (.999)
CASCOOK	.1498 (.551)	.1286 (.559)
MEDHAT	2.8546 (2.379)	---
MED	---	.1988 (.784)
OUTHAT	-.2270 (-1.079)	---
OUTHRS	---	-.0107 (-.289)
RECHAT	.3334 (.218)	---
RECTRIP	---	-.4734 (-1.863)

(continued)

Table 7.20, continued

Explanatory Variable	Simultaneous Equation Estimates	Single Equation Estimates
SO2	-.1712	.0227
	(-.651)	(.129)
OZO	.0178	.0082
	(.670)	(.600)

[a]The dependent variable in the regression is a transformation, T(p), of the dependent variable p in the model: $T(p) = 5 + 0.5[\ell n(p/(1-p))]$. To obtain estimates of the true parameters of the logistic regression, multiply slope coefficients by 2; subtract 5 from the intercept and multiply by 2.

[b] t-statistics in parentheses.

TABLE 7.21. THROAT IRRITATION PRODUCTION FUNCTION: IMPAIRED SUBSAMPLE[a,b]

Explanatory Variable	Simultaneous Equation Estimates	Single Equation Estimates
FLEMCO	-.0942	.0305
	(-.400)	(.137)
SHRTWHZ	.1653	.1073
	(.768)	(.497)
HAYFEV	-.0649	-.0025
	(-.319)	(-.012)
RESPINF	.8347	.7977
	(2.438)	(2.372)
POOR	.1743	.2648
	(.337)	(.513)
EDGRADE	.0216	.0305
	(.512)	(.752)
ACE	-.0032	-.0067
	(-.262)	(-.575)
SEX	-.5324	-.0664
	(-.867)	(-.112)
MARRIED	-1.1797	-1.6373
	(-2.590)	(-3.742)
GLENI	-.1724	-.1694
	(-.506)	(-.445)
CLEN2	.4944	.4612
	(1.724)	(1.400)
GLEN3	1.0094	.8821
	(3.149)	(2.588)
GLEN4	1.1669	1.0884
	(3.875)	(3.188)
BURBO	.6387	.7686
	(1.927)	(2.253)
BURB1	---[c]	---[c]
BURB2	.4614	.4453
	(1.353)	(1.199)
WRKESCV	.2207	.2350
	(1.068)	(1.158)
EXPWRK	.0544	.0816
	(.223)	(.346)
ACWRK	-.0841	-.2888
	(-.331)	(-1.231)
ACCAR	-.5682	-.4003
	(-2.266)	(-1.761)
ACHOME	.7617	.8450
	(2.005)	(2.187)
APHOME	.0312	-.0920
	(.119)	(-.351)
CASCOOK	.1152	.0814
	(.513)	(.284)
MEDHAT	1.8202	---
	(1.467)	
MED	---	.7262
		(1.960)
OUTHAT	.2185	---
	(1.689)	
OUTHRS	---	-.0442
		(-.918)
RECHAT	.2409	---
	(.227)	
RECTRIP	---	.2249
		(.760)

(continued)

Table 7.21, continued

Explanatory Variable	Simultaneous Equation Estimates	Single Equation Estimates
SO2	-.8524	-.8271
	(-3.306)	(-3.363)
OZO	-.0059	.0394
	(-.200)	(1.960)

[a]The dependent variable in the regression is a transformation, T(p), of the dependent variable p in the model: $T(p) = 5 + 0.5[\ell n(p/(1-p))]$. To obtain estimates of the true parameters of the logistic regression, multiply slope coefficients by 2; subtract 5 from the intercept and multiply by 2.

[b]t-statistics in parentheses.

[c]Variable excluded due to convergence problems.

TABLE 7.22. SINUS PAIN PRODUCTION FUNCTION: WHOLE SAMPLE[a,b]

Explanatory Variable	Simultaneous Equation Estimates	Single Equation Estimates
ASTHMA	.5153	.3566
	(3.798)	(2.766)
BRONCH	.6722	.1986
	(3.674)	(1.283)
OTHDIS	-.0331	.1349
	(-.208)	(.905)
FLEMCO	-.0189	.2146
	(-.156)	(1.940)
SHRTWHZ	.1155	.1145
	(.815)	(.840)
HAYFEV	.4724	.4849
	(4.104)	(4.938)
RESPINF	-.1028	-.1776
	(-.391)	(-.684)
POOR	-.5278	.0380
	(-1.181)	(.093)
EDCRADE	-.0118	-.0176
	(-.627)	(-.949)
AGE	.0022	.0007
	(.343)	(.110)
SEX	-.8491	-.2390
	(-3.628)	(-1.334)
MARRIED	.2545	-.1696
	(1.383)	(-1.085)
GLEN1	.1844	.0722
	(1.044)	(.340)
GLEN2	.2102	.1083
	(1.146)	(.501)
GLEN3	.2591	.2266
	(1.325)	(1.007)
CLEN4	.2141	.1669
	(1.122)	(.748)
BURBO	-.4721	.0406
	(-1.749)	(.168)
BURB1	.1464	.4258
	(.630)	(1.762)
BURB2	-.2697	.1684
	(-1.094)	(.685)
WRKESGV	.2161	.2293
	(1.975)	(2.338)
EXPWRK	-.2431	-.0484
	(-2.283)	(-.497)
ACWRK	.1034	.1905
	(.783)	(1.508)
ACCAR	-.2828	-.2062
	(-2.667)	(-2.044)
ACHOME	.0337	.0509
	(.282)	(.438)
APHOME	.1591	.0083
	(.955)	(.052)
GASCOOK	.1930	-.1322
	(1.213)	(-.971)
MEDHAT	4.5770	---
	(4.092)	
MED	---	-.1900
		(-.792)
OUTHAT	.2029	---
	(2.118)	

(continued)

Table 7.22, continued

Explanatory Variable	Simultaneous Equation Estimates	Single Equation Estimates
OUTHRS	---	-.0166
		(-.570)
RECHAT	-5.4859	---
	(-3.470)	
RECTRIP	---	-.3763
		(-2.039)
SO2	.2924	.0568
	(1.848)	(.417)
OZO	-.0569	-.0033
	(-3.243)	(-.316)

[a]The dependent variable in the regression is a transformation, T(p), of the dependent variable p in the model: $T(p) = 5 + 0.5[\ln(p/(1-p))]$. To obtain estimates of the true parameters of the logistic regression, multiply slope coefficients by 2; subtract 5 from the intercept and multiply by 2.

[b]t-statistics in parentheses.

[c]Variable excluded due to convergence problems.

TABLE 7.23. SINUS PAIN PRODUCTION FUNCTION: NORMAL SUBSAMPLE[a,b]

Explanatory Variable	Simultaneous Equation Estimates	Single Equation Estimates
FLEMCO	.3309 (1.634)	.3286 (1.797)
SHRTWHZ	-.2854 (-.802)	-.2926 (-.882)
HAYFEV	.5906 (3.666)	.6229 (4.203)
RESPINF	---[c]	---[c]
POOR	-.0387 (-.058)	.0888 (.156)
EDCRADE	.0051 (.227)	.0052 (.232)
ACE	.0262 (2.748)	.0261 (2.813)
SEX	-.4181 (-1.735)	-.4346 (-1.938)
MARRIED	-.1543 (-.799)	-.1855 (-.994)
GLEN1	.2809 (1.151)	.4898 (1.610)
CLEN2	.3266 (1.289)	.5460 (1.761)
GLEN3	.4029 (1.521)	.6527 (2.029)
GLEN4	.1613 (.577)	.4055 (1.213)
BURBO	.0594 (.147)	.0711 (.213)
BURB1	.4847 (1.387)	.6777 (1.944)
BURB2	.3094 (.844)	.5637 (1.623)
WRKESGV	.3312 (2.382)	.3468 (2.533)
EXPWRK	-.1789 (-1.102)	-.1510 (-1.079)
ACWRK	0.475 (.260)	.0741 (.432)
ACCAR	-.3955 (-2.686)	-.4170 (-2.965)
ACHOME	.0792 (.442)	.0797 (.458)
APHOME	-.3093 (-1.021)	-.3638 (-1.274)
CASCOOK	-.1966 (-.901)	-.1894 (-1.028)
MEDHAT	.4946 (.418)	---
MED	---	.1728 (.653)
OUTHAT	-.0117 (-.066)	---
OUTHRS	---	.0542 (1.415)
RECHAT	-.0392 (-.028)	---
RECTRIP	---	-.3997 (-1.596)

(continued)

Table 7.23, continued

Explanatory Variable	Simultaneous Equation Estimates	Single Equation Estimates
SO2	.1927	.2107
	(.780)	(1.169)
OZO	.0021	.0043
	(.088)	(.320)

[a]The dependent variable in the regression is a transformation, T(p), of the dependent variable p in the model: $T(p) = 5 + 0.5[\ell n(p/(1-p))]$. To obtain estimates of the true parameters of the logistic regression, multiply slope coefficients by 2; subtract 5 from the intercept and multiply by 2.

[b]t-statistics in parentheses.

TABLE 7.24. SINUS PAIN PRODUCTION FUNCTION:IMPAIRED SUBSAMPLE[a,b]

Explanatory Variable	Simultaneous Equation Estimates	Single Equation Estimates
FLEMCO	.4496 (2.595)	.5644 (3.315)
SHRTWHZ	.0262 (.138)	.0980 (.542)
HAYFEV	.5018 (2.902)	.5309 (3.143)
RESPINF	.2084 (.670)	.2004 (.645)
POOR	-.5848 (-.903)	-.4564 (-.712)
EDGRADE	-.0566 (-1.485)	-.0663 (-1.817)
AGE	-.0197 (-1.752)	-.0309 (-2.818)
SEX	-.2757 (-.517)	.3627 (.769)
MARRIED	.6849 (1.434)	.2018 (.481)
CLEN1	.0612 (.226)	-.3716 (-1.206)
GLEN2	-.0804 (-.279)	-.4576 (-1.409)
CLEN3	.2298 (.746)	-.1826 (-.541)
GLEN4	.4355 (1.516)	-.0251 (-.079)
BURBO	-.1641 (-.412)	-.1386 (-.347)
BURB1	.4529 (1.291)	.1955 (.525)
BURB2	-.0526 (-.146)	-.2227 (-.589)
WRKESGV	.2611 (1.448)	.1558 (.899)
EXPWRK	-.1609 (-.843)	-.0718 (-.401)
ACWRK	.5024 (2.117)	.3714 (1.750)
ACCAR	-.0923 (-.459)	-.0521 (-.285)
ACHOME	-.4550 (-2.103)	-.4618 (-2.246)
APHOME	.2607 (1.024)	.1219 (.486)
GASCOOK	.0984 (.351)	-.0592 (-.237)
MEDHAT	-.9316 (-.653)	---
MED	---	---c
OUTHAT	.2030 (1.800)	---
OUTHRS	---	-.0982 (-2.032)
RECHAT	-1.9138 (-2.122)	---
RECTRIP	---	-.2999 (-.995)

(continued)

Table 7.24, continued

Explanatory Variable	Simultaneous Equation Estimates	Single Equation Estimates
SO2	-.1460	-.2273
	(-.634)	(-.994)
OZO	-.0493	-.0138
	(-1.797)	(-.743)

[a]The dependent variable in the regression is a transformation, T(p), of the dependent variable p in the model: $T(p) = 5 + 0.5[\ln(p/(1-p))]$. To obtain estimates of the true parameters of the logistic regression, multiply slope coefficients by 2; subtract 5 from the intercept and multiply by 2.

[b]t-statistics in parentheses.

[c]Variable excluded due to convergence problems.

TABLE 7.25. HEADACHE PRODUCTION FUNCTION: WHOLE SAMPLE[a,b]

Explanatory Variable	Simultaneous Equation Estimates	Single Equation Estimates
ASTHMA	.0402	.0452
	(.322)	(.371)
BRONCH	.1158	.1789
	(.709)	(1.261)
OTHDIS	.2569	.2073
	(1.940)	(1.653)
FLEMCO	.2408	.2138
	(2.273)	(2.245)
SHRTWHZ	.1955	.1689
	(1.498)	(1.385)
HAYFEV	.3000	.2918
	(2.999)	(3.218)
RESPINF	.2913	.3148
	(1.404)	(1.520)
POOR	-.4374	-.4580
	(-.978)	(-1.083)
EDCRADE	-.0061	-.0063
	(-.371)	(-.385)
AGE	.0089	.0079
	(1.539)	(1.403)
SEX	-.2142	-.3394
	(-1.090)	(-2.069)
MARRIED	-.2261	-.1560
	(-1.421)	(-1.088)
GLENI	-.0673	-.1408
	(-.478)	(-.823)
GLEN2	.0440	-.0212
	(.310)	(-.124)
GLEN3	-.0642	-.1187
	(-.400)	(-.637)
GLEN4	-.0719	-.1308
	(-.451)	(-.703)
BURBO	.1639	-.0347
	(.810)	(-.192)
BURB1	.1224	-.1012
	(.601)	(-.484)
BURB2	-.0481	-.2848
	(-.226)	(-1.336)
WRKESGV	-.0566	-.0369
	(-.601)	(-.426)
EXPWRK	.2879	.2211
	(3.195)	(2.660)
ACWRK	.2138	.2346
	(1.902)	(2.171)
ACCAR	-.0990	-.1132
	(-1.096)	(-1.282)
ACHOME	.0347	.0146
	(.337)	(.143)
APHOME	.2066	.1995
	(1.588)	(1.606)
CASCOOK	-.1336	-.1074
	(-1.018)	(-.906)
MEDHAT	-1.0000	---
	(-.939)	
MED	---	-.2327
		(-1.181)
OUTHAT	-.1926	---
	(-2.077)	

(continued)

Table 7.25, continued

Explanatory Variable	Simultaneous Equation Estimates	Single Equation Estimates
OUTHRS	---	-.0049 (-.230)
RECHAT	.6273 (.497)	---
RECTRIP	---	-.0567 (-.431)
SO2	-.0522 (-.394)	.0988 (.886)
OZO	.0243 (1.163)	-.0032 (-.354)

[a]The dependent variable in the regression is a transformation, T(p), of the dependent variable p in the model: $T(p) = 5 + 0.5[\ell n(p/(1-p))]$. To obtain estimates of the true parameters of the logistic regression, multiply slope coefficients by 2; subtract 5 from the intercept and multiply by 2.

[b]t-statistics in parentheses.

TABLE 7.26. HEADACHE PRODUCTION FUNCTION: NORMAL SUBSAMPLE[a,b]

Explanatory Variable	Simultaneous Equation Estimates	Single Equation Estimates
FLEMCO	.3635	.2568
	(2.343)	(1.914)
SHRTWHZ	.0550	.1498
	(.222)	(.671)
HAYFEV	.3091	.3767
	(2.281)	(3.012)
RESPINF	---[c]	---[c]
POOR	-.1558	-.0939
	(-.243)	(-.168)
EDGRADE	-.0139	-.0161
	(-.688)	(-.821)
AGE	.0141	.0103
	(1.856)	(1.433)
SEX	-.2983	-.4346
	(-1.386)	(-2.147)
MARRIED	-.0388	-.0609
	(-.209)	(-.342)
GLEN1	.0518	.0986
	(.271)	(.423)
GLEN2	.2309	.2891
	(1.224)	(1.259)
GLEN3	.2486	.3186
	(1.205)	(1.304)
GLEN4	.2083	.2542
	(1.017)	1.044)
BURBO	.5044	.2216
	(1.684)	(.914)
BURB1	.1982	.0181
	(.639)	(.060)
BURB2	.2228	-.0073
	(.690)	-.024)
WRKESGV	-.0391	-.0049
	(-.336)	(-.043)
EXPWRK	.2718	.2658
	(2.072)	(2.432)
ACWRK	.4552	.4510
	(2.766)	(2.919)
ACCAR	-.1631	-.2104
	(-1.394)	(-1.868)
ACHOME	.1785	.1845
	(1.166)	(1.234)
APHOME	.4854	.3836
	(2.866)	(2.454)
CASCOOK	-.2505	-.1494
	(-1.365)	(-.949)
MEDHAT	-.5632	---
	(-.547)	
MED	---	-.2016
		(-.817)
OUTHAT	-.1751	---
	(-1.144)	
OUTHRS	---	.0240
		(.849)
RECHAT	1.8171	---
	(1.578)	
RECTRIP	---	-.0548
		(-.336)

(continued)

Table 7.26. continued

Explanatory Variable	Simultaneous Equation Estimates	Single Equation Estimates
SO2	-.1383	.0350
	(-.688)	(.244)
OZO	.0269	.0043
	(1.344)	(.386)

[a]The dependent variable in the regression is a transformation, T(p), of the dependent variable p in the model: $T(p) = 5 + 0.5[\ell n(p/(1-p))]$. To obtain estimates of the true parameters of the logistic regression, multiply slope coefficients by 2; subtract 5 from the intercept and multiply by 2.

[b] t-statistics in parentheses.

[c]Variable excluded due to convergence problems.

TABLE 7.27. HEADACHE PRODUCTION FUNCTION: IMPAIRED SUBSAMPLE[a,b]

Explanatory Variable	Simultaneous Equation Estimates	Single Equation Estimates
FLEMCO	.4493 (2.655)	.3507 (2.214)
SHRTWHZ	.2803 (1.547)	.2984 (1.704)
HAYFEV	.2581 (1.558)	.2069 (1.299)
RESPINF	.8480 (3.204)	.8469 (3.176)
POOR	-1.2991 (-2.098)	-1.2924 (-2.094)
EDGRADE	.0261 (.793)	.0272 (.848)
AGE	.0047 (.496)	.0064 (.690)
SEX	.6975 (1.550)	.3316 (.812)
MARRIED	-.8290 (-2.130)	-.5704 (-1.645)
GLEN1	-.2263 (-1.015)	-.5861 (-2.119)
GLEN2	-.2550 (-1.087)	-.6088 (-2.119)
GLEN3	-.7049 (-2.456)	-.9402 (-2.872)
GLEN4	-.4745 (-1.725)	-.7412 (-2.339)
BURBO	.0367 (-.120)	-.2258 (-.747)
BURB1	.2119 (.697)	-.2744 (-.826)
BURB2	-.1039 (-.344)	-.5665 (-1.720)
WRKESCV	-.2665 (-1.555)	-.2248 (-1.356)
EXPWRK	.0310 (.178)	.0849 (.515)
ACWRK	-.2293 (-1.191)	-.0949 (-.548)
ACCAR	.0696 (.361)	-.0843 (-.485)
ACHOME	-.2894 (-1.428)	-.2719 (-1.435)
APHOME	-.2799 (-1.221)	-.2165 (-1.002)
GASCOOK	-.0758 (-.331)	-.0482 (-.217)
MEDHAT	-.4642 (-.406)	---
MED	---	-.2386 (-.633)
OUTHAT	-.2675 (-2.444)	---
OUTHRS	---	-.0657 (-1.844)
RECHAT	-.6986 (-1.053)	---
RECTRIP	---	-.0557 (-.222)

(continued)

Table 7.27, continued

Explanatory Variable	Simultaneous Equation Estimates	Single Equation Estimates
SO2	.1693	.1715
	(.834)	(.858)
OZO	.0259	-.0181
	(1.033)	(-1.098)

[a]The dependent variable in the regression is a transformation, T(p), of the dependent variable p in the model: $T(p) = 5 + 0.5[\ell n(p/(1-p))]$. To obtain estimates of the true parameters of the logistic regression, multiply slope coefficients by 2; subtract 5 from the intercept and multiply by 2.

[b] t-statistics in parentheses.

TABLE 7.28. AVERTING BEHAVIOR AND WTP: NORMAL SUBSAMPLE SIMULTANEOUS EQUATION ESTIMATES

Symptom	Averting Good	Change in Probability of Symptom	Expected Symptom-Days Avoided	WTP per Symptom-Day Avoided[a]
Could Not Breathe Deep	---[b]	---[b]	---[b]	---[b]
Pain on Deep Inhalation	GASCOOK*	.0079	2.88	$29.12
Out of Breath Easily	---[b]	---[b]	---[b]	---[b]
Wheezing/ Whistling Breath	---[b]	---[b]	---[b]	---[b]
Chest Tight	ACCAR***	.0116	4.25	$35.76
Cough	ACCAR***	.0287	10.47	$14.18
	GASCOOK***	.0866	31.63	$2.66
Throat Irritation	ACCAR***	.0291	10.63	$14.30
Sinus Pain	ACCAR***	.0300	10.94	$13.89
Headache	ACCAR*	.0211	7.69	$19.77

[a]WTP estimate includes direct utility effects for impure averting goods.

[b]No coefficients of averting goods were correctly signed and statistically significant at 10 percent using a one-tail test.

*Denotes significance at .01 (one-tail).

**Denotes significance at .05 (one-tail).

***Denotes significance at .10 (one-tail).

TABLE 7.29. AVERTING BEHAVIOR AND WTP: IMPAIRED SUBSAMPLE SIMULTANEOUS EQUATION ESTIMATES

Symptom	Averting Good	Change in Probability of Symptom	Expected Symptom-Days Avoided	WTP per Symptom-Day Avoided[a]
Could Not Breathe Deep	CASCOOK**	.0908	33.14	$2.53
Pain on Deep Inhalation	ACCAR*	.0258	9.41	$16.15
Out of Breath Easily	CASCOOK***	.0954	34.82	$2.41
Wheezing/ Whistling Breath	GASCOOK**	.0781	28.51	$2.94
	ACHOME***	.0677	24.70	$16.80
Chest Tight	ACHOME*	.0476	17.38	$23.87
	ACCAR*	.0709	25.88	$5.87
	GASCOOK***	.2376	86.71	$0.97
Cough	ACCAR*	.0536	19.56	$7.77
Throat Irritation	ACCAR**	.0685	24.99	$6.08
Sinus Pain	ACHOME**	.0505	18.45	$22.49
Headache	ACHOME*	.0629	22.96	$18.07
	APHOME*	.0634	23.41	$5.21

[a]WTP estimate includes direct utility effects for impure averting goods.

* Denotes significance at .01 (one-tail).

** Denotes significance at .05 (one-tail).

*** Denotes significance at .10 (one-tail).

TABLE 7.30. AVERTING BEHAVIOR AND WTP: WHOLE SAMPLE SIMULTANEOUS EQUATION ESTIMATES

Symptom	Averting Good	Change in Probability of Symptom	Expected Symptom-Days Avoided	WTP per Symptom-Days Avoided[a]
Could Not Breathe Deep	---[b]	---[b]	---[b]	---[b]
Pain on Deep Inhalation	---[b]	---[b]	---[b]	---[b]
Out of Breath Easily	APHOME***	.0151	5.51	$22.15
Wheezing/ Whistling Breath	ACHOME* GASCOOK*	.0114 .0207	4.16 7.57	$100.00 $11.09
Chest Tight	GASCOOK**	.0209	7.64	$11.00
Cough	ACCAR***	.0211	7.71	$19.71
Throat Irritation	ACCAR***	.0238	8.67	$17.53
Sinus Pain	ACCAR***	.0311	11.35	$13.39
Headache	---[b]	---[b]	---[b]	---[b]

[a] WTP estimate includes direct utility effects for impure averting goods.

[b] No coefficients of averting goods were correctly signed and statistically significant at the 10 percent level using a one-tail test.

*Denotes significance at .01 (one-tail).

** Denotes significance at .05 (one-tail).

*** Denotes significance at .10 (one-tail).

TABLE 7.31. AVERTING BEHAVIOR AND CONTINGENT VALUATION ESTIMATES OF WTP PER SYMPTOM-DAY AVOIDED[a]

	Whole Sample		Normal Subsample		Impaired Subsample	
Symptom	ABM	CVM	ABM	CVM	ABM	CVM
Could Not Breath Deep	---b	$329	---b	$32	$3	$271
Pain on Deep Inhalation	---b	109	$29	42	16	194
Out of Breath Easily	22	323	---b	256	2	374
Wheezing/ Whistling Breath	11 to 100	252	---b	12	3 to 17	334
Chest Tight	11	200	36	204	1 to 24	198
Cough	20	175	3 to 14	140	8	205
Throat Irritation	28	122	14	46	6	213
Sinus Pain	18	168	14	97	22	239
Headache	---b	138	20	126	6 to 18	154

[a]Estimates rounded to the nearest dollar.

[b]No WTP calculation could be made.

TABLE 7.32. EFFECT OF TRIMMING CVM BIDS

Symptom	Normal		Impaired	
	Raw Mean	Five Percent Trimmed Mean	Raw Mean	Five Percent Trimmed Mean
Could not Breath Deep	32	5	271	161
Pain on Deep Inhalation	42	1	194	78
Out of Breath Easily	256	213	374	326
Wheezing/ Whistling Breath	12	---[a]	334	283
Chest Tight	204	2	198	130
Cough	140	30	205	160
Throat Irritation	45	5	213	104
Sinus Pain	97	23	239	188
Headache	126	90	154	105

[a]No calculation possible because of insufficient number of observations.

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APPENDIX A

BACKGROUND QUESTIONNAIRE

R. I.D. # : ________

CONFIDENTIAL

RESPONDENTS NAME : ________

RESPONDENTS PHONE #: ____ / ________
area code

RESPONDENTS ADDRESS ________

________ / ________
city zip code

INTERVIEWER: ________ I.D. #: ________

DATE	DAY	TIME	RESULT	COMMENTS
1.		AM PM		
2.		AM PM		
3.		AM PM		
4.		AM PM		
5.		AM PM		
6.		AM PM		
7.		AM PM		
8.		AM PM		
9.		AM PM		
10.		AM PM		
11.		AM PM		
12.		AM PM		

Good morning (afternoon, evening). I'm (...) from the ____________. We're conducting a survey for the ____________, which deals with

(i) how air pollution might affect you

(ii) how you might change your daily activities to avoid exposure on bad days.

You may recall that your household received a (letter/phone call) about this very important study. Please be assured that all information provided is confidential and your name will not be identified with the study.

First, I would like to ask you some questions about your health.

1. In general, would you say that your health is:

Excellent 1
Good 2
Fair, or 3
Poor? 4

2. Have you ever been told by a doctor that you had asthma?

YES . . . . ASK A 1
NO . . . SKIP TO Q3 2

A. How old were you when you were first told that you had asthma?

RECORD AGE: ________

B. Have you taken medication for it during the past year?

YES 1
NO 2

C. When was your last asthma attack?

RECORD ____________ / ____________
MONTH YEAR

IF LAST ATTACK WITH THE PAST 2 YEARS . . . . ASK D
IF LAST ATTACK 3 YEARS OR MORE . . . . SKIP TO Q3

D. Do you know what brings on your attacks? PROBE

____
____
____

3. Have you ever been told by a doctor that you had chronic bronchitis?

YES . . ASK A 1
NO . . . SKIP TO Q4 2

A. How old were you when you were first told you had chronic bronchitis?

RECORD AGE: ________

B. Have you taken medication or done anything special for the bronchitis during the past year?

YES 1
NO 2

C. When was the last time you were sick with bronchitis?

RECORD: ______ / ______ / ______
YEARS MONTHS WEEKS

4. Have you ever been told by a doctor that you had emphysema?

YES . . . ASK A 1
NO . . . SKIP TO Q5 2

A. How old were you when you were first told you had emphysema?

RECORD AGE: ______

B. Have you taken any medicine or had treatment for the emphysema during the past year?

YES 1
NO 2

C. When was the last time it really bothered you?

RECORD: ______ / ______ / ______
YEARS MONTHS WEEKS

5. Have you ever been told by a doctor that you had any other respiratory or lung disease?

YES . . . AsK A 1
NO . . . . SKIP TO Q6 2

A. What were you told? PROBE

____

____

B. How old were you when you were first told that you had other respiratory or lung diseases?

RECORD AGE: ______

C. Do you take medication for it?

YES 1
NO 2

6. Have you ever been told by a doctor that you had hay fever?

YES . . . ASK A 1
NO . . . . SKIP TO Q7 2

A. How old were you when you were first told you had hay fever?

RECORD AGE: ________

B. Do you take any medication for your hay fever?

YES 1
NO 2

7. In the past year, how many times have you visited a doctor or a health care facility as a patient? Please include visits to eye doctors, chiropractors, and psychiatrists. Do not include visits to the dentist.

OF VISITS ________

8. Was this a typical number of visits for you? How many visits to doctors or health care facilities do you typically make in a year?

OF VISITS ________

9. Do you have a regular doctor?

IF NO; SKIP TO Q13

YES 1
NO . . . . . . SKIP TO Q13 2

10. When you go to your regular doctor, how long do you usually wait for health care services?

OF MINUTES ____________

11. On average, how long does it take you to get to your regular doctor's office or clinic?

OF MINUTES ____________

12. About how much do you pay your regular doctor or health car provider for an office visit. Include only your out-of-pocket expenses.

$ ____________________

13. When was the last time you saw a doctor for a specific health problem, such as an illness, accident or injury?

OF MONTHS ________
NEVER . . SKIP TO Q14 . . 90

A. What was the problem?

____
____
____

IF R SAW A DOCTOR, YESTERDAY OR DAY BEFORE YESTERDAY ASK:

(a) Where did you go?

DOCTOR'S OFFICE 1
EMERGENCY 1
HOSPITAL 2
CALLED DOCTOR 3

(b) How much time did it take to get this medical attention?

____

(c) What will be your out-of-pocket expense for this medical attention?

$ ____________________

14. During the last year, since ______,1984, were you in the hospital as a patient overnight or longer? Do not include maternity, accident or injury.

YES . . . ASK A 1
NO . . . SKIP TO Q15. 2

A. How many <u>times</u>, separated by at least one day, were you admitted to a hospital to stay overnight or longer, since _____, 1984. Again, do not include maternity, accident or injury.

RECORD #: __________

B. What was the matter? RECORD UP TO THREE MENTIONS.

1. ____
2. ____
3. ____

Now some questions about your respiratory health.

15. Do you <u>usually</u> cough <u>first</u> thing in the morning in bad weather?

YES 1
NO 2

16. Do you usually cough at other times during the day or night in bad weather?

YES 1
NO . . . , ... 2

17. Do you cough on most days for as much as 3 months of the year?

YES 1
NO 2

IF COUGH IS REPORTED (Q15 - Q17) . . . . ASK Q18

IF NO COUGH IS REPORTED (Q15 - Q17) . . ASK Q19

18. How long have you had the cough -- about how many years?

YEARS ____________

19. Do you usually bring up phlegm, sputum or mucous from your chest first thing in the morning in bad weather?

YES 1
NO . . . . , . 2

20. Do you usually bring up phlegm, sputum or mucous from your chest at other times during the day or night in bad weather?

YES 1
NO 2

21. Do you bring up phlegm, sputum or mucous from your chest on most days for as much as 3 months of the year?

YES 1
NO 2

IF "YES" TO ANY Q19 - Q21 . . . . . . ASK Q22
IF "NO" TO ALL Q19 - Q21 . . . . SKIP TO INSTRUCTION BELOW Q22

22. How long have you raised phlegm, sputum or mucous -- about how many years?

YEARs ____________

IF COUGH OR PHLEGM (MUCOUS) REPORTED Q15 - Q21 . . ASK Q23
IF NEITHER REPORTED Q15 - Q21 . . . . SKIP TO Q24

23. Does most of this coughing and/or phlegm come during one season of the year?

YES . . . ASK A 1
NO . . . SKIP TO Q24. 2

A. When? CODE ALL MENTIONS

SUMMER 1
FALL 2
WINTER 3
SPRING 4
ALL YEAR 5

24. In the past three years, have you had a period of increased cough and phlegm lasting for three weeks or more?

YES . . . ASK A 1
NO . . . SKIP TO Q25. 2

A. Have you had more than one such three-week period?

YES 1
NO 2

25. Does your breathing ever sound wheezing or whistling?

YES . . . ASK A 1
NO . . . SKIP TO Q26 2

A. On how many days has this happened during the past year?

RECORD DAYS: ___________
DON'T KNOW 98

26. Have you ever had attacks of shortness of breath with wheezing?

YES 1
NO 2

27. Are you troubled by shortness of breath when hurrying on level ground or walking up a slight hill?

YES . . . ASK A 1
NO . . . SKIP TO Q28 2

A. Do you get short of breath walking with other people of your own age on level ground?

YES 1
NO 2

B. Do you have to stop for breath when walking at your own pace on level ground?

YES 1
NO 2

28. Do you suddenly become short of breath when taking it easy (not exercising)?

YES. . . ASK A. 1
NO . . . SKIP TO Q29 2

A. How many days did this happen during the past year?

RECORD DAYS ________
DON'T KNOW 98

29. During the past 3 years how much trouble have you had with illnesses such as chest colds, bronchitis or pneumonia? Would you say:

A LOT . . . . ASK A 1
SOME, OR . . . ASK A 2
VERY LITTLE? . SKIP TO Q30 . . . 3

A. During the past 3 years, how often were you unable to do your usual activities because of illness such as chest colds, bronchitis or pneumonia?

RECORD DAYS ________

Now I'd like to ask you about the things you do regularly in your leisure time.

30. A. What were your regular leisure or non-work related activities in the past month? list - (PROBE)

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________
5. ______________________________

(If more than 5, use the five that the respondent does most often)

Activity #1

B. About how many hours per week (including transportation) did you ______________________?

C. How many times a week did you ______________________?

D. Where do you usually ______________________?
(What area or community)

For "AT HOME" code "1"
For "GLENDORA" or "EAST SAN GABRIEL VALLEY" code "2"
All others leave blank ________

E. What is the usual time of day when you do this activity ________?

Morning only 1
Afternoon only 2
Evening only 3
Night only 4
Morning and Afternoon . . . 5
Afternoon and Evening . . . 6
Evening and Night 7
Morning and Evening 8
No particular time 9

F. What days of the week did you usually do this activity ________?

Monday . . . . l yes - 2 no
Tuesday . . . . 1 yes - 2 no
Wednesday . . . . . . 1 yes - 2 no
Thursday . . . . . . 1 yes - 2 no
Friday . . . . .1 yes - 2 no
Saturday . . . . . . 1 yes - 2 no
Sunday . . . . l yes - 2 no
No particular day . 1 yes - 2 no

G. What does it usually cost to do this activity (including transportation) per month? ____________
each time? ____________

H. How much of the time did you ______________________ outdoors?

1 . . . . Always
2 . . . . Most of the time
3 . . . . Half of the time
4 . . . . Some of the time
5 . . . . Never

(Interviewer - for questions I thru J record the response for "yesterday" in the appropriate column then repeat the questions for "day before yesterday".)

I. How many hours did you ___________ Yesterday/Day Before Yesterday?

	Yesterday	Day Before Yesterday

(Interviewer - if zero GO TO J) ________ ________

i. What did it cost you to ___________ Yesterday/Day Before Yesterday? ________ ________

ii. Did you put significantly less effort than planned or usual into ___________ Yesterday/Day Before Yesterday?

1 yes - 2 no   l yes - 2 no

iii. Did you change the planned or usual time of day of ___________ Yesterday/Day Before Yesterday?

1 yes - 2 no   1 yes - 2 no

iv. Did you change the planned or usual location of ___________ Yesterday/Day Before Yesterday?

1 yes - 2 no   1 yes - 2 no

J. How many hours had you planned to ________

	Yesterday	Day Before Yesterday

________ ________

Activity #2

B. About how many hours per week (including transportation) did you _______________________?

C. How many times a week did you _______________________________?

D. Where do you usually _______________________________________?
(What area or community)

For "AT HOME" code "l"
For "GLENDORA" or "EAST SAN GABRIEL VALLEY" code "2"
All others leave blank __________

E. What is the usual time of day when you do this activity _________?

Morning only 1
Afternoon only 2
Evening only 3
Night only 4
Morning and Afternoon . . . 5
Afternoon and Evening . . . 6
Evening and Night 7
Morning and Evening 8
No particular time 9

F. What days of the week did you usually do this activity __________?

Monday . . . . l yes - 2 no
Tuesday . . . . l yes - 2 no
Wednesday . . . . . 1 yes - 2 no
Thursday . . . . . . 1 yes - 2 no
Friday . . . . l yes - 2 no
Saturday . . . . . . 1 yes - 2 no
Sunday . . . . l yes - 2 no
No particular day . 1 yes - 2 no

G. What does it usually cost to do this activity (including transportation) per month __________?
each time __________?

H. How much of the time did you __________ outdoors?

1 . . . . Always
2 . . . . Most of the time
3 . . . . Half of the time
4 . . . . Some of the time
5 . . . . Never

(Interviewer - for questions I thru J record the response for "yesterday" in the appropriate column then repeat the questions for "day before yesterday.)

I. How many hours did you __________ yesterday/day before yesterday? — Yesterday __________ Day Before Yesterday __________

(Interviewer - if zero GO TO J)

i. What did it cost you to __________ Yesterday/Day Before Yesterday? — __________ __________

ii. Did you put significantly less effort than planned or usual into __________ Yesterday/Day Before Yesterday?

1 yes - 2 no 1 yes- 2 no

iii. Did you change the planned or usual time of day of __________ Yesterday/Day Before Yesterday?

1 yes - 2 no 1 yes - 2 no

iv. Did you change the planned or usual location of __________ Yesterday/Day Before Yesterday?

1 yes - 2 no l yes 2 no

J. How many hours had you planned to __________ — Yesterday __________ Day Before Yesterday __________

Activity #3

B. About how many hours per week (including transportation) did you ________________?

C. How many times a week did you ________________________?

D. Where do you usually ____________________________?
(What area or community)

For "AT HOME: code "1"
For "GLENDORA" or "EAST SAN GABRIEL VALLEY" code "2"
All others leave blank ______

E. What is the usual time of day when you did this activity ______?

Morning only 1
Afternoon only 2
Evening only 3
Night only 4
Morning and Afternoon . . . 5
Afternoon and Evening . . . 6
Evening and Night 7
Morning and Evening 8
No particular time 9

F. What days of the week did you usually do this activity ________?

Monday . . . . l yes - 2 no
Tuesday . . . . l yes - 2 no
Wednesday . . . . . . 1 yes - 2 no
Thursday . . . . . . 1 yes - 2 no
Friday . . . . l yes - 2 no
Saturday . . . . . . 1 yes - 2 no
Sunday . . . . l yes - 2 no
No particular day . 1 yes - 2 no

G. What does it usually cost to do this activity (including transportation) per month ________?
each time ________?

H. How much of the time did you __________________ outdoors?

1 . . . . Always
2 . . . . Most of the time
3 . . . . Half of the time
4 . . . . Some of the time
5 . . . . Never

(Interviewer - for questions I thru J record the response for "yesterday" in the appropriate column then repeat the questions for "day before yesterday".)

I. How many hours did you __________ Yesterday/Day Before Yesterday?

Yesterday	Day Before Yesterday
__________	__________

(Interviewer - if zero GO TO J)

i. What did it cost you to __________ Yesterday/Day Before Yesterday? __________ __________

ii. Did you put significantly less effort than planned or usual into __________ Yesterday/Day Before Yesterday?

l yes - 2 no   1 yes - 2 no

iii. Did you change the planned or usual time of day of __________ Yesterday/Day Before Yesterday?

l yes - 2 no   1 yes - 2 no

iv. Did you change the planned or usual location of __________ Yesterday/Day Before Yesterday?

1 yes - 2 no   1 yes - 2 no

J. How many hours had you planned to __________

yesterday	Day Before Yesterday
__________	__________

31. Regarding yesterday and the day before, were there any other major changes in the activities you had planned?

(If Yes) What were they? ______________________________

____

YES 1
NO 2

32. Are there any activities that you do regularly most of the year but not in the summer (June-September)?

(If Yes) What? ______________________________

____

YES 1
NO 2

Why not in summer? Is it due to heat, humidity, smog or something other than weather? ______________________________

____

____

____

Heat . . . . . . l yes - 2 no
Humidity . . . . 1 yes - 2 no
Smog . . . . l yes - 2 no
Other . . . . . 1 yes - 2 no

33. A. How many hours do you spend outdoors on a typical

Workday ____________ hours
Nonworkday ____________ hours

B. Did you spend the usual amount of time outside?

Yesterday Yes 1
No . . ASK C . 2

Day Before Yes 1
No . . ASK C . 2

C. How many hours did you spend outdoors?

Yesterday ____________ hours
Day Before ____________ hours

D. Did you stay in bed any more or less than usual yesterday?

More 1
Less 2
No 3

(a) How much more (or less)? ______________________________

(b) Why did you spend more (less) time in bed yesterday? ________

____

DAY BEFORE YESTERDAY?

More 1
Less 2
No 3

(a) How much more (or less)? ______________________________

(b) Why did you spend more (less) time in bed day before yesterday? ______________________________

E. Did you take any more medication than usual?

Yesterday?

YES 1
NO 2

Day Before Yesterday? YES 1
NO 2

F. How many hours did you spend at work?

YESTERDAY ____________ HOURS
DAY BEFORE ____________ HOURS

FOR EACH DAY NOT WORKED, ASK G

G. Did you make a recreation trip outside the area, such as to the mountains, or to the beach or some other recreational area?

YES . . . ASK i and ii . . 1
NO . . . SKIP TO Q34 . . . 2

i. Where did you go? Please name the community or area.

____

ii. How many nights were you away from home? ____________ NIGHTS

Now I would like to ask you some questions about symptoms you may have when it's smoggy.

34. Do you have any symptoms when it's smoggy?

YES . . . ASK A 1
NO . . . SKIP TO Q35 . . . 2
DON'T KNOW . SKIP TO Q35 . 8

A. What symptoms do you have?

____
____

35. Were you at home yesterday? (More than 4 hours between 10-4)

1 yes - 2 no

A. Now, using a scale of 1-10, 10 being the very best and 1 the very worst, how would you rate the air quality outside your home yesterday?

RECORD # _____

36. Now I'd like to read you a list of symptoms other people sometimes have. As I read each one, please tell me if you yesterday or the day before yesterday. READ A-Z. CODE IN APPROPRIATE COLUMN.

	YESTERDAY		DAY BEFORE YESTERDAY	
	YES	NO	YES	NO
a. (Did/Do) your eyes feel irritated?	1	2	1	2
b. (Did/Do) you feel that you (could/do) not see as well as usual?	1	2	1	2
c. (Were/Are) your eyes unusually sensitive to bright light?	1	2	1	2
d. (Was/Is) your throat irritated?	1	2	1	2
e. (Was/Is) your voice husky or (did/do) you lose your voice?	1	2	1	2
f. (Did/Do) you have sinus pain or discomfort?	1	2	1	2
g. (Did/Do) you have a nosebleed?	1	2	1	2
h. (Was/Is) your nose dry and painful?	1	2	1	2
i. (Was/Is) your nose runny?	1	2	1	2
j. (Did/Do) you have pain when you (took/take) a deep breath?	1	2	1	2
k. (Did/Do) you feel that you (could/can) not take a deep breath?	1	2	1	2
l. (Did/Do) you get out of breath easily?	1	2	1	2
m. (Did/Do) you have a cough?	1	2	1	2
n. (Did/Do) you bring up sputum (phlegm) from your chest?	1	2	1	2
o. (Did/Do) you have a headache?	1	2	1	2
p. (Did/Do) you get tired easily?	1	2	1	2
q. (Did/Do) you feel faint or dizzy?	1	2	1	2
r. (Did/Do) you feel spaced-out or disoriented?	1	2	1	2
s. (Did/Do) you feel nauseated (sick to your stomach)?	1	9	1	2

	YESTERDAY		DAY BEFORE YESTERDAY	
	YES	NO	YES	NO
t. (Did/Do) you have chills or fever? Which one ____________?	1	2	1	2
u. (Did/Do) you have pain in your ears?	1	2	1	2
v. (Did/Do) you have ringing in your ears?	1	2	1	2
w. (Did/Does) your breathing sound wheezing or whistling?	1	2	1	2
x. (Did/Does) your chest feel tight?	1	2	1	2
y. (Did/Do) you feel that your heart was beating very fast at time when you were resting?	1	2	1	2
z. (Did/Do) you have swollen glands?	1	2	1	2

IF "YES" TO ANY SYMPTOM IN Q36 . . . ASK Q37

IF "NO" TO ALL SYMPTOMS IN Q36 . . . SKIP TO Q37

37. A. How much of the day did __________ bother you? (Code all mentions)

Letter of Symptom											
Morning	YES	1	1	1	1	1	1	1	1	1	1
	NO	2	2	2	2	2	2	2	2	2	2
Afternoon	YES	1	1	1	1	1	1	1	1	1	1
	NO	2	2	2	2	2	2	2	2	2	2
Evening	YES	1	1	1	1	1	1	1	1	1	1
	No	2	2	2	2	2	2	2	2	2	2
Night	YES	1	1	1	1	1	1	1	1	1	1
	NO	2	2	2	2	2	2	2	2	2	2

B. During the time you had ________________ would you say it was constant or on-and-off?

Letter of Symptom										
Constant	1	1	1	1	1	1	1	1	1	1
On-and-Off	2	2	2	2	2	2	2	2	2	2

C. In general how heavily were you exerting yourself when you first noticed ______________________________?

Letter of Symptom										
At rest	1	1	1	1	1	1	1	1	1	1
Lightly exerting yourself	2	2	2	2	2	2	2	2	2	2
Moderately exerting yourself . . .	3	3	3	3	3	3	3	3	3	3
Heavily exerting yourself, or . . .	4	4	4	4	4	4	4	4	4	4
Other . . . . → SPECIFY ______________	5	5	5	5	5	5	5	5	5	5
Don't Know	9	9	9	9	9	9	9	9	9	9

READ SENTENCE BELOW FIRST

D. How much would you pay?

RECORD LETTER ______________

E. What do you think caused it?

Letter of Symptom										
Weather . . . . , ...	1	1	1	1	1	1	1	1	1	1
Smog	2	2	2	2	2	2	2	2	2	2
Both	3	3	3	3	3	3	3	3	3	3
Other	4	4	4	4	4	4	4	4	4	4

One way to find out how valuable better health is to you is to ask you how much you are willing to pay for it. Suppose you could have avoided the symptom(s) you have experienced by the payment of a sum of money. Please look at this card (HAND CARD Q6D).

Which sum of money most closely represents the maximum amount you would have been willing to pay to have avoided (...) yesterday/day before yesterday? INSERT EACH SYMPTOM IN TURN FOR (...). When you have decided, give me the letter next to the amount.

Did you answer $0.00 because you feel avoiding the symptom has no value to you?

YES 1
NO 2

38. Did the air quality yesterday affect what you did?

	YESTERDAY			DAY BEFORE YESTERDAY		
	A LOT	A LITTLE	NO	A LOT	A LITTLE	NO
	1	2	3	1	2	3

PROBE ______________________________

39. As I mentioned at the beginning of the interview, we are interested in how people change their activities when pollution is bad. When the air is smoggy, do you normally change your activities at all? For example, do you stay indoors more, or use air conditioning more? Do you travel to less polluted areas, like the beach? Do you buy or use any products, or do anything at all to try to avoid air pollution or the symptoms of air pollution?

A. What do you do differently?

____

The next questions I have today are about your home.

40. How large is your house? (apt.) (Number of bedrooms) ____________

41. Is your home insulated?

YES . . . ASK A 1
NO . . . SKIP TO Q42 2
DON'T KNOW SKIP TO Q42 8

A. Is it insulated in:

The attic, or 1
the walls? 2
BOTH 3

B. Do you know what material was used?

YES . . . . . ASK a 1
NO . . . . . . SKIP TO Q42 . 2

a. What was it? ______________

42. What fuel do you use for cooking? CODE ALL MENTIONS

GAS 1
ELECTRICITY 2
BOTTLED GAS 3
OTHER 4
SPECIFY __________________

43. What fuel do you use for heating your home?

GAS 1
ELECTRICITY 2
BOTTLED GAS 3
SOLAR HEAT 4
OTHER 5
SPECIFY __________________

44. Is your home air conditioned?

YES . . . ASK A 1
NO . . . . SKIP TO Q45 . . . 2

A. Is it:

Central Air, or . . SKIP TO C 1
Room by Room Air? . ASK B 2

B. How many units do you have?

RECORD ____________

C. Is it:

Refrigerated, or 1
Evaporative (swamp)? 2

D. How much do you use your air conditioner during the summer?

Almost all the time 1
Usually 2
Sometimes 3
Almost never 4

E. Does your air conditioning system include some type of special air purifyfng unit?

YES . . . ASK F 1
NO . . . SKIP TO Q45 2
DON'T KNOW . SKIP TO Q45 3

F. What type of special air purifying unit do you have? (CODE ALL MENTIONS)

Electronic air purifier 1
High particulate filter 2
Charcoal filter 3
Something else 4
→ SPECIFY ____________________
Don't Know 9

G. Is regular maintenance performed on your purifying system?

YES 1
NO 2

H. Did you obtain a tax deduction for the installation of your air purifying system?

YES . . . . ASK a 1
NO 2

a. Approximately, how much did this deduction reduce your taxes?

$ ____________________

I. Can you operate your air purification system without running your air conditioner or heater?

YES . . . . ASK a 1
NO 2

a. How often do you operate your purifying system without the air conditioner or heater?

RECORD ____________

45. Do you have a portable air purifier?

YES . . . . ASK a 1
NO . . . . SKIP TO Q46 2

a. How often do you use it?

RECORD ____________

46. Do you have an ionizer or air energizing machine?

YES . . . . ASK a 1
NO . . . . SKIP TO Q47 2
DON'T KNOW . SKIP TO Q47 8

a. How often do you use it?

RECORD ____________

47. What kind of car do you usually drive?

MAKE ______________________________

YEAR ______________________________

A. About how many miles per gallon does this car get?

RECORD ________ mpg

48. Is your car air conditioned?

YES . . . . ASK A 1
NO . . . . SKIP TO Q48B 2

A. How often do you use the air conditioning when driving in summer?

ALMOST ALL THE TIME 1
USUALLY 2
SOMETIMES 3
ALMOST NEVER 4

B. About how many miles do you drive your car during a typical week?

RECORD ____________

The last set of questions is about you and your job.

49. What is your date of birth? ____________________

50. Are you currently:

MARRIED 1
SEPARATED 2
DIVORCED 3
WIDOWED, OR 4
NEVER MARRIED, OR 5
SOMETHING ELSE? 6
→ SPECIFY ________________

51. What is the highest grade in school you completed and received credit for? CODE ONE

00 01 02 03 04 05 06 07 08 09 10 11 12

COLLEGE/OTHER POST HIGH SCHOOL SCHOOLING 13 14 15 16

POST GRADUATE SCHOOL 17 18 19 20 OR MORE

A. Have you had any trade, technical or vocational training?

YES 1
NO 2

B. ASK EVERYONE: what degrees or diplomas, if any, do you have? CODE HIGHEST DEGREE

High School Degree (Equivalent) . . 01
Junior College Degree (A.A.) 02
Bachelors Degree (B.A., B.S.) . . . 03
Masters Degree (M.A., M.S.) 04
Doctorate (Ph.D.) 05
Professional (M.D, J.D., D.D.S.,) . 06
None 90
Other 96
→ SPECIFY ______________________

52. What is your current employment status, are you:

Working full-time 1
Working part-time 2
Unemployed and looking for work 3
Unemployed and not looking for work . . . 4

53. Our next set of questions is about your job. If you have more than one job, we only need to know about your main job.

A. What kind of business or industry do you work in?

RECORD RESPONSE ______________________

CIRCLE CORRECT CATEGORY

AGRICULTURE OR FORESTRY 1
MINING 2
CONSTRUCTION 3
MANUFACTURING 4
WHOLESALE OR RETAIL TRADE 5
TRANSPORTATION, COMMUNICATIONS, OR PUBLIC UTILITIES. 6

FINANCE, INSURANCE, OR REAL ESTATE 7
SERVICES 8
GOVERNMENT 9
OTHER 10
→ SPECIFY ____________________

B. What type of work do you do in your job?

RECORD RESPONSE ____________________

CIRCLE CORRECT CATEGORY

SERVICE WORKER	(Food service workers, Cleaning service workers, Dental assistants, Policemen) 1
LABORER	(Longshoremen, Construction workers, Loggers, Garbage collectors) 2
TRANSPORTATION OPERATOR	(Bus drivers, Taxicab drivers, Truck drivers, Railroad switch operators) 3
EQUIPMENT OPERATOR	(Textile workers, Drillers, Photographic processors, Smelters) 4
CRAFT WORKER	(Carpenters, Machinists, Bakers, Tailors, Repairmen, Mechanics) 5
CLERICAL WORKER	(Cashiers, tellers, Secretaries, Receptionists, Telephone operators, Dispatchers) 6
SALES WORKER	(Advertising agents, Real estate agents, Sales clerks, Sales representatives, Vendors) . . . 7
MANAGER OR ADMINISTRATOR	(Bank officers, Purchasing agents, Restaurant managers, School administrators) 8
PROFESSIONAL OR TECHNICAL	(Accountants, Engineers, Physicians, Teachers, Entertainers) 9
FARMWORKER	(Farmers, Farm laborers, Farm Supervisors) 10

C. Please name the community where you place of work is located.

____

For "AT HOME" code "l"
For "GLENDORA" or "EAST SAN GABRIEL VALLEY" code "2"
All others leave blank __________

D. How many weeks per year do you actually work on your main job? (Or, if this is a new job, how many weeks of work per year does your main job require?)

________ WEEKS

E. How many hours do you work each day of the week?

Monday	________
Tuesday	________
Wednesday	________
Thursday	________
Friday	________
Saturday	________
Sunday	________

54. How do you usually go to and from work? Do you:

	YES	NO
Drive?	1	2
Carpool?	1	2
Vanpool?	1	2
Motorcycle or Moped?	1	2
Public transportation?	1	2
Walk?	1	2
Bicycle?	1	2
Some other way?	1	-

SPECIFY: ____________________

55. How long do you spend commuting each day? Would you say:

Less than 15 minutes	1
16 to 30 minutes	2
31 to 60 minutes, or	3
over 60 minutes?	4

56. How many hours, on the average, do you spend outdoors during your working day?

RECORD HOURS ______

57. Do you travel during the day as part of your work?

YES . . . ASK A 1
NO . . . SKIP TO Q57 . . . 2

A. When you travel, do you use:

A car, ... 1
Publtc transportation, or . 2
Walk? 3
Other 4
→ SPECIFY ________________

B. How long do you usually spend traveling during a working day?

RECORD ______________________

58. Is your place of work air conditioned?

YES 1
NO 2

59. Are you exposed to anything at work which affects your breathing?

YES . . . ASK A 1
NO . . . SKIP TO Q60 . . . 2

A. What are you exposed" to? ____

____

60. How are paid?

1 HOURLY WAGE
2 SALARY
3 OTHER (i.e., Piece Work, Commissions, Tips, etc.)

(IF SALARY OR OTHER) Please look at this card (HAND CARD Q51FSAL) and tell me the letter of the income category that includes your <u>annual</u> gross (i.e., before deductions and taxes) income from your main job.

RECORD LETTER _____

If you work more hours than average during some week, do you get paid anything at all for those hours?

1 YES
2 NO

(IF YES) Which of the following best describes how you get paid for those overtime hours?

1 EQUIVALENT TO STRAIGHT TIME HOURLY WAGE
2 EQUIVALENT TO TIME AND A HALF
3 EQUIVALENT TO DOUBLE TIME
4 EQUIVALENT TO TRIPLE TIME

Approximately, how many hours of overtime do you work in an average week?

_____________ HOURS

SKIP TO Q61

(IF HOURLY) please look at this card (HAND CARD 051FWAGE) and tell me the letter of the wage category that includes your hourly wage for regular or “straight” time work.

RECORD LETTER _____

Do you ever have the opportunity to work overtime on your main job?

l YES
2 NO

(IF YES) Which of the fOllowing most closely describes your hourly wage rate for those overtime hours?

1 STRAIGHT TIME
2 TIME AND A HALF
3 DOUBLE TIME
4 TRIPLE TIME

Approximately, how many hours of overtime do you work in an average week?

_____________ HOURS

CARD Q51FSAL

A. Less than $6,000
B. $ 6,000 - 6,999
C. $ 7,000 - 7,999
D. $ 8,000 - 8,999
E. $ 9,000 - 9,999
F. $10,000 - 10,999
G. $11,000 - 11,999
H. $12,000 - 12,999
I. $13,000 - 13,999
J. $14,000 - 14,999
K. $15,000 - 17,499
L. $17,500 - 19,999
M. $20,000 - 22,499
N. $22,500 - 24,999
O. $25,000 - 27,499
P. $27,500 - 29,999
Q. $29,999 - 34,999
R. $35,000 - 39,999
S. $40,000 - 44,999
T. $45,000 - 49,999
U. $50,000 - 54,999
V. $55,000 - 59,999
W. $60,000 - 69,999
X. $70,000 - 79,999
Y. $80,000 - 89,999
Z. $90,000 - 99,999+

CARD Q51FWAGE

A. Less than $3.00
B. $ 3.00 - 3.49
C. $ 3.50 - 3.99
D. $ 4.00 - 4.49
E. $ 4.50 - 4.99
F. $ 5.00 - 5.49
G. $ 5.50 - 5.99
H. $ 6.00 - 6.49
I. $ 6.50 - 6.99
J. $ 7.00 - 7.49
K. $ 7.50 - 7.99
L. $ 8.00 - 8.49
M. $ 8.50 - 8.99
N. $ 9.00 - 9.49
O. $ 9.50 - 9.99
P. $10.00 - 10.49
Q. $10.50 - 10.99
R. $11.00 - 11.49
S. $11.50 - 11.99
T. $12.00 - 12.99
U. $13.00 - 13.99
V. $14.00 - 14.99
W. $15.00 - 15.99
X. $16.00 - 16.99
Y. $17.00 - 17.99
Z. $18.00 - 18.99
AA. $19.00 - 19.99
BB. $20.00 - 20.99
CC. $21.00 - 21.99
DD. $22.00 or more

61. A. Now, thinking about the members of this household, how many people, including yourself, received income from any source such as wages, salary, social security, pensions, welfare, or alimony during 1984?

RECORD # _______ PERSONS

B. (HAND APPROPRIATE INCOME CARD - USE CARD #52B-2)
Please look at this card and tell me the letter of the income group that includes the total income for your entire family, in this household, before taxes in 1984?

CARD #l:

A	01	N	14
B	02	0	15
C	03	P	16
D	04	Q	17
E	05	R	18
F	06	S	19
G	07	T	20
H	08	U	21
I	09	V	22
J	10	W	23
K	11	X	24
L	12	Y	25
M	13	Z	26

C. How many people, including yourself, are supported with this income?

RECORD # __________

CARD Q6D

A.	$0.00	K.	$5.00	V.	$16.00	FF.	$45.00	PP.	$200.00
B.	$ .50	L.	$6.00	W.	$18.00	GG.	$50.00	QQ.	$250.00
C.	$1.00	M.	$7.00	X.	$20.00	HH.	$60.00	RR.	$300.00
D.	$1.50	N.	$8.00	Y.	$22.00	II.	$70.00	SS.	$350.00
E.	$2.00	O.	$9.00	Z.	$24.00	JJ.	$80.00	TT.	$400.00
F.	$2.50	P.	$10.00	AA.	$26.00	KK.	$90.00	UU.	$450.00
G.	$3.00	R.	$11.00	BB.	$28.00	LL.	$100.00	VV.	$500.00
H.	$3.50	S.	$12.00	CC.	$30.00	MM.	$125.00	XX.	$1000.00
I.	$4.00	T.	$13.00	DD.	$35.00	NN.	$150.00	ZZ.	More than $1000.00
J.	$4.50	U.	$14.00	EE.	$40.00	OO.	$175.00		

62. A. As you recall, we mentioned that we're interested in people's health over time. We will be contacting you again in the next month to ask you briefly about your health and your activities. Is there a day or time that is especially good for me to call?

Record Day ________________
Record Time ________________

B. Can you tell me the name of someone not living at this address who would know how to reach in case you move?

NAME ____________________________

ADDRESS ____________________________

____

PHONE # ____________________________

C. Is there an alternate phone number at which we could reach you?

( ) ____________________________

For Interviewer Only

COMMENTS:

Anything unusual about respondents health or activities?

____
____
____
____

SEX: Male . . 1 Female . . 2

RACE: Caucasion . . 1 Black . . 2 Oriental . . 3 Hispanic . . 4

Other . . 5

HOUSING TYPE: House . . 1 Apt . . 2 Condominium . . 3 Other . . 4

Specify _____

WITHIN 2 BLOCKS OF MAJOR STREET: Yes . . 1 No . . 2

APPENDIX B

FOLLOWUP QUESTIONNAIRE

I would like to know about changes in your life since (. ..) when we last talked. (INSERTDATE OF INTERVIEW FOR (...).)

1. Do you still live at (...)? (INSERT FULL ADDRESS FOR (...).)

YES . . . . . . 1 GO TO Q2
NO . . . . . . 2 GO TO A

A. What is your new address?

____ / ____________________ / ____
\# / STREET / APT. #

____
CITY

B. When did you move?

____ / ____ / ____
DAY / MONTH / YEAR

C. How large is your house (apt.)? (number of bedrooms) ________

D. Is your home insulated?

YES . . . . ASK a 1
NO . . .SKIP TO E . . .2
DON'T KNOW . SKIP TO E . . 8

a. Is it insulated in

The attic, or 1
the walls? 2
BOTH 3

b. Do you know what material was used?

YES . . . . ASK (i) 1
NO . . . SKIP TO E 2

(i) What was it? ____________________

E. What fuel do you use for cooking? CODE ALL MENTIONS

GAS 1
ELECTRICITY 2
BOTTLED GAS 3
OTHER 4
→ SPECIFY ____________________

F. What fuel do you use for heating your home?

GAS 1
ELECTRICITY 2
BOTTLED GAS 3
SOLAR HEAT 4
OTHER 5
→ SPECIFY ____________________

G. Is your home air conditioned?

YES . . . . . ASK a 1
NO . . . . SKIP TO Q2 . . . 2

a. Is it:

Central air, or . . . SKIP TO c 1
room by room air? . . ASK b 2

b. How many units do you have?

RECORD ___________

c. Is it:

Refrigerated, or 1
Evaporative (swamp)? 2

d. How much do you use your air conditioner during the summer?

Almost all the time 1
Usually . . . . . . , ... 2
Sometimes . . . . , ... 3
Almost never 4

e. Does your air conditioning system include some type of special air purifying unit?

YES . . . . ASK f 1
NO . . . . . SKIP TO Q2 2
DON'T KNOW . . SKIP TO Q2 3

f. What type of special air purifying unit do you have? (CODE ALL MENTIONS)

Electronic air purifier 1
High particulate filter 2
Charcoal filter 3
Something else 4
→ SPECIFY ______________________________
Don't Know 9

g. Is regular maintenance performed on your purifying system?

YES 1
NO 2

h. Did you obtain a tax deduction for the installation of your air purifying system?

YES . . . . ASK (i)	1
NO	2

(i) Approximately, how much did this deduction reduce your taxes? $__________

i. Can you operate your air purification system without running your air conditioner or heater?

YES . . . . ASK (i)	1
NO	2

(i) How often do you operate your purifying system without the air conditioner or heater? RECORD __________

2. A. Since we talked last, have you either seen or talked with a doctor for any medical problem?

YES . . . . GO TO (i) . . .	1
NO . . . . SKIP TO B . . .	2

(i) What was the problem? ____________________

____

(ii) Did you see or talk with a doctor yesterday or the day before yesterday?

	YES	NO
YESTERDAY.	1	2
DAY BEFORE YESTERDAY . .	1	2

(iii) Where did you go?

	YESTERDAY	DAY BEFORE YESTERDAY
Doctor's Office . . .	1	1
Emergency	1	1
Hospital	2	2
Called Doctor	3	3

(iv) How much time did it take to get this medical attention? Please include time spent waiting to see the doctor and time spent driving to his/her office.

__________MINUTES

(v) What is your out-of-pocket expense for this medical attention?

$__________

B. Did you take any more medication than usual

YESTERDAY	YES	1
	NO	2
DAY BEFORE	YES	1
	NO	2

> IF ASTHMA-BRONCHITIS-EMPHYSEMA - LOW FEV - "ATHLETE" NOTED . . . ASK APPROPRIATE QUESTIONS IN Q3
>
> IF NONE NOTED . . . . SKIP TO Q4

3. At the time of the first interview you mentioned that you (have/are) (asthma/bronchitis/emphysema/lung condition/athletic). I would like you to think about the last two days and tell me if:

A. Your asthma was:

- Much better than usual, ... 1
- Better than usual, ... 2
- The same as usual, ... 3
- Not as good as usual, or . . . 4
- Much worse than usual? 5

a. Did you take:

- More medication than usual, ... 1
- Less medication than usual, or . . . 2
- About the same amount of medication? 3
- NO MEDICATION TAKEN 4

b. Did you get in touch with the doctor or doctor's office about your asthma?

- YES . . . . ASK aa 1
- NO . . SKIP TO BOX BELOW aa . 2

aa. Did you:

- Talk on the phone, ... 1
- Visit your doctor's office, ... 2
- Visit the emergency room, or 3
- Go to the hospital? 4

> IF OTHER CONDITIONS . . . CONTINUE WITH APPROPRIATE QUESTIONS
>
> IF NO OTHERS . . . . SKIP TO Q4

B. Thinking about the last two days was your chronic bronchitis:

Much better than usual, ... 1
Better than usual, ... 2
The same as usual, ... 3
Not as good as usual, or . . . 4
Much worse than usual? 5

a. Did you cough or bring up:

More phlegm than usual, or . . 1
Less phlegm than usual? . . . 2
SAME AS USUAL 3

b. Was you sputum (phlegm):

More discolored than usual, . . 1
Less discolored than usual, or 2
The same as usual? 3

c. Did you get in touch with your doctor or doctor's office about your bronchitis?

YES . . . .ASK aa 1
No . . SKIP TO BOX BELOW aa . 2

aa. Did you:

Talk on the phone, ... 1
Visit your doctor's office, ... 2
Visit the emergency room, or 3
Go to the hospital? 4

IF OTHER CONDITIONS . . . CONTINUE WITH APPROPRIATE QUESTIONS
IF NO OTHERS . . . . SKIP TO Q4

C. Thinking about the last two days was your emphysema:

Much better than usual, ... 1
Better than usual, ... 2
The same as usual, ... 3
Not as good as usual, or . . . 4
Much worse than usual? 5

a. During the last three days, when exerting yourself did you feel:

More short of breath, or . . . 1
Less short of breath? 2
NEITHER 3

b. Did you get in touch with your doctor or doctor's office about your emphysema?

YES . . . . ASK aa 1
NO . . SKIP TO BOX BELOW aa . 2

aa. Did you:

Talk on the phone, ...1
Visit your doctor's office, ...2
Visit the emergency room, or 3
Go to the hospital? 4

IF OTHER CONDITIONS . . . CONTINUE WITH APPROPRIATE QUESTIONS

IF NO OTHERS . . . . SKIP TO Q4

C. Thinking of the last two days were your lungs:

More congested than usual, or . . . 1
Less congested? 2

a. Did you get:

Out of breath more easily than usual, or . . . 1
Less than usual? 2

Now, I would like to ask you about the things you do regularly in your leisure time.

4. A. What were your regular leisure or non-work related activities in the past month? LIST - PROBE

1. ____________________
2. ____________________
3. ____________________

____
____

(IF MORE THAN 5 USE THE FIVE THAT THE RESPONDENT DOES MOST OFTEN)

Activity #1

B. About how many hours per week (including transportation) did you ____________________?

C. How many times a week did you ____________________?

D. Where do you usually (area or community) ____________________?

FOR "AT HOME" CODE "1"
FOR "GLENDORA" OR EAST SAN GABRIEL VALLEY CODE "2"
ALL OTHERS LEAVE BLANK ________

E. What is the usual time of day when you did this activity?

Morning . . . . l YES - 2 NO
Afternoon . . . . 1 YES - 2 NO
Night . . . . l YES - 2 NO
No particular time . . 1 YES - 2 NO

F. What days of the week did you usually do this activity?

Monday . . . l YES - 2 NO
Tuesday . . .1 YES - 2 NO
Wednesday. . 1 YES - 2 NO
Thursday . . 1 YES - 2 NO
Friday . . . . l YES - 2 NO
Saturday .. . . 1 YES - 2 NO
“Sunday . . . . l YES - 2 NO
No particular day . . 1 YES - 2 NO

G. What does it usually cost to do this activity (including transportation) per month? Each time?

$____________PER MONTH
$____________EACH TIME

H. How much of the time did you ______________________ outdoors?

Always 1
Most of the time 2
Half of the time 3
Some of the time 4
Never 5

(INTERVIEWER - FOR QUESTIONS I THROUGH J RECORD THE RESPONSE FOR “YESTERDAY” IN THE APPROPRIATE COLUMN THEN REPEAT THE QUESTIONS FOR “DAY BEFORE YESTERDAY.”)

	Yesterday	Day Before Yesterday
I. How many hours did you ____________ yesterday/day before yesterday?	______	______
(INTERVIEWER - IF ZERO GO TO J)		
i. What did it cost you to ____________ yesterday/day before yesterday?	______	______
ii. Did you put significantly less effort than planned or usual into ____________ yesterday/day before yesterday?	1 YES-2 NO	1 YES-2 NO
iii. Did you change the planned or usual time of day of ____________ yesterday/day before yesterday?	1 YES-2 NO	1 YES-2 NO
iv. Did you change the planned or usual location of ____________ yesterday/day before yesterday?	1 YES-2 NO	1 YES-2 NO

	Yesterday	Day Before Yesterday
J. How many hours had you planned to ______________ yesterday/day before yesterday?	______	______

Activity #2

B. About how many hours per week (including transportation) did you ______________________________?

C. How many times a week did you ______________________________?

D. Where do you usually (area or community) ______________________?

FOR "AT HOME" CODE "1"
FOR "GLENDORA" OR EAST SAN GABRIEL VALLEY CODE "2"
ALL OTHERS LEAVE BLANK ________

E. What is the usual time of day when you did this activity?

Morning . . . . 1 YES - 2 N0
Afternoon . . . . 1 YES - 2 NO
Night . . . . 1 YES - 2 N0
No particular time . . 1 YES - 2 NO

F. What days of the week did you usually do this activity?

Monday . . . 1 YES - 2 N0	Friday . . . . 1 YES - 2 N0
Tuesday . . 1 YES - 2 NO	Saturday . . . . 1 YES - 2 N0
Wednesday. . 1 YES - 2 NO	Sunday . . . . 1 YES - 2 N0
Thursday . . 1 YES - 2 NO	No particular day . . 1 YES - 2 NO

G. What does it usually cost to do this activity (including transportation) per month? Each time?

$____________PER MONTH
$____________EACH TIME

H. How much of the time did you ________________________ outdoors?

Always 1
Most of the time 2
Half of the time 3
Some of the time 4
Never 5

(INTERVIEWER - FOR QUESTIONS I THROUGH J RECORD THE RESPONSE FOR "YESTERDAY" IN THE APPROPRIATE COLUMN THEN REPEAT THE QUESTIONS FOR "DAY BEFORE YESTERDAY.")

	Yesterday	Day Before Yesterday
I. How many hours did you ________ yesterday/day before yesterday?	____	____

(INTERVIEWER - IF ZERO GO TO J)

	Yesterday	Day Before Yesterday
i. What did it cost you to ________ yesterday/day before yesterday?	____	____
ii. Did you put significantly less effort than planned or usual into ________ yesterday/day before yesterday?	1 YES-2 NO	1 YES-2 NO
iii. Did you change the planned or usual time of day of ________ yesterday/day before yesterday?	1 YES-2 NO	1 YES-2 NO
iv. Did you change the planned or usual location of ________ yesterday/day before yesterday?	1 YES-2 NO	1 YES-2 NO

	Yesterday	Day Before Yesterday
J. How many hours had you planned to ________ yesterday/day before yesterday?	____	____

Activity #3

B. About how many hours per week (including transportation) did you ________?

C. How many times a week did you ________?

D. Where do you usually (area or community) ________?

FOR "AT HOME" CODE "l"
FOR "GLENDORA" OR EAST SAN GABRIEL VALLEY CODE "2"
ALL OTHERS LEAVE BLANK ____

E. What is the usual time of day when you did this activity?

Morning . . . . 1 YES - 2 NO
Afternoon . . . . 1 YES - 2 NO
Night . . . . 1 YES - 2 NO
No particular time . . 1 YES - 2 NO

F. What days of the week did you usually do this activity?

Monday . . . 1 YES - 2 NO	Friday . . . . 1 YES - 2 NO
Tuesday . . . 1 YES - 2 NO	Saturday . . . . 1 YES - 2 NO
Wednesday. . 1 YES - 2 NO	Sunday . . . . 1 YES - 2 NO
Thursday . . 1 YES - 2 NO	No particular day . . 1 YES - 2 NO

G. What does it usually cost to do this activity (including transportation) per month? Each time?

$__________ PER MONTH
$__________ EACH TIME

H. How much of the time did you ____________________

Always 1
Most of the time 2
Half of the time 3
Some of the time 4
Never 5

(INTERVIEWER - FOR QUESTIONS I THROUGH J RECORD THE RESPONSE FOR "YESTERDAY" IN THE APPROPRIATE COLUMN THEN REPEAT THE QUESTIONS FOR "DAY BEFORE YESTERDAY.")

	Yesterday	Day Before Yesterday
I. How many hours did you ________________ yesterday/day before yesterday?	______	______
(INTERVIEWER - IF ZERO GO TO J)		
i. What did it cost you to ____________ yesterday/day before yesterday?	______	______
ii. Did you put significantly less effort than planned or usual into ________ yesterday/day before yesterday?	1 YES-2 NO	1 YES-2 NO
iii. Did you change the planned or usual time of day of ______________ yesterday/day before yesterday?	1 YES-2 NO	1 YES-2 NO
iv. Did you change the planned or usual location of ________________ yesterday/day before yesterday?	1 YES-2 NO	1 YES-2 NO

	Yesterday	Day Before Yesterday
J. How many hours had you planned to ____________ yesterday/day before yesterday?	______	______

5. Regarding yesterday and the day before were there any other major changes in the activities you have planned?

YES 1
NO 2

(IF YES) What were they? ______________________________

____

6. A. How many hours did you spend outdoors

YESTERDAY ____________ hours
DAY BEFORE ____________ hours

B. Did you stay in bed any more or less than usual yesterday?

	YESTERDAY	DAY BEFORE YESTERDAY
MORE . . .	1	1
LESS . . .	2	2
NO . . .	3	3

a. How much more (or less)? Yesterday ____________
Day Before ____________

b. Why did you spend more (less) time in bed yesterday or the day before ______________________________

C. How many hours did you spend at work

YESTERDAY ____________ hours
DAY BEFORE ____________ hours

FOR EACH DAY NOT WORKED, ASK D

D. Did you make a recreational trip outside the area, such as to the mountains or to the beach or some other recreational area?

YES . . . . ASK i and ii 1
NO . . . . SKIP TO Q7 2

i. Where did you go? Please name the community or area.

____

ii. How many nights were you away from home? ____________ NIGHTS

IF R WAS NOT AT WORK OR ON A RECREATIONAL TRIP YESTERDAY, ASK Q7

7. Were you at home yesterday? 1 YES 2 NO
(More than 4 hours between 10-4)
Now, using a scale of 1-10, 10 being the very best and 1 the very worst, how would you rate the air quality outside your home yesterday?

RECORD #________

8. As you know, we are interested in how people change their activities when pollution is bad. When the air is smoggy, do you or other members of your household change their activities in any way? For example, do you or other members of your household:

(i) Stay indoors more

(ii) Use air conditioning more

(iii) Travel to less polluted areas like the beach

(iv) Buy or use any products

(v) Do anything at all to avoid air pollution

What exactly do you do?

PROBE: ________________________________

____

____

____

9. Now I'd like to read you a list of symptoms other people sometimes have. As I read each one, please tell me if it bothered you yesterday or the day before yesterday. READ a - z. CODE IN APPROPRIATE COLUMN

	YESTERDAY		DAY BEFORE YESTERDAY	
	YES	NO	YES	NO
a. Did your eyes feel irritated?	1	2	1	2
b. Did you feel that you could not see as well as usual?	1	2	1	2
c. Were your eyes unusually sensitive to to bright light?	1	2	1	2
d. Was your throat irritated?	1	2	1	2

	YESTERDAY YES	YESTERDAY NO	DAY BEFORE YESTERDAY YES	DAY BEFORE YESTERDAY NO
e. Was your voice husky or did you lose your voice?	1	2	1	2
f. Did you have sinus pain or discomfort?	1	2	1	2
g. Did you have a nosebleed?	1	2	1	2
h. Was your nose dry and painful?	1	2	1	2
i. Was your nose runny?	1	2	1	2
j. Did you have pain when you took a deep breath?	1	2	1	2
k. Did you feel that you could not take a deep breath?	1	2	1	2
1. Did you get out of breath easily?	1	2	1	2
m. Did you have a cough?	1	2	1	2
n. Did you bring up sputum (phlegm) from your chest?	1	2	1	2
0. Did you have a headache?	1	2	1	2
p. Did you get tired easily?	1	2	1	2
q. Did you feel faint or dizzy?	1	2	1	2
r. Did you feel spaced-out or disoriented?	1	2	1	2
s. Did you feel nauseated (sick to your stomach)?	1	2	1	2
t. Did you have chills or' fever? Which one? ______________	1	2	1	2
u. Did you have pain in your ears?	1	2	1	2
v. Did you have ringing in your ears?	1	2	1	2
w. Did breathing sound wheezing or whistling	1	2	1	2
x. Did your chest feel tight?	1	2	1	2

	YESTERDAY YES	YESTERDAY NO	DAY BEFORE YESTERDAY YES	DAY BEFORE YESTERDAY NO
y. Did you feel that your heart was beating very fast at times when you were resting?	1	2	1	2
z. Did you have swollen glands?	1	2	1	2

IF "YES" TO ANY SYMPTOM IN Q9 . . . . . . ASK Q10
IF "NO" TO ALL SYMPTOMS IN Q9 . . . SKIP TO Q10

10. A. How much of the day did ________ bother you?
(CODE ALL MENTIONS)

LETTER OF SYMPTOM		___	___	___	___	___	___	___	___	___	___	___	___	___
Morning	YES	1	1	1	1	1	1	1	1	1	1	1	1	1
	NO	2	2	2	2	2	2	2	2	2	2	2	2	2
Afternoon	YES	1	1	1	1	1	1	1	1	1	1	1	1	1
	NO	2	2	2	2	2	2	2	2	2	2	2	2	2
Evening	YES	1	1	1	1	1	1	1	1	1	1	1	1	1
	NO	2	2	2	2	2	2	2	2	2	2	2	2	2
Night	YES	1	1	1	1	1	1	1	1	1	1	1	1	1
	NO	2	2	2	2	2	2	2	2	2	2	2	2	2

B. During the time you had _____ would you say it was constant or off-and-on?

LETTER OF SYMPTOM													
Constant	1	1	1	1	1	1	1	1	1	1	1	1	1
Off-and-On	2	2	2	2	2	2	2	2	2	2	2	2	2

C. In general how heavily were you exerting yourself when you first noticed ________?

LETTER OF SYMPTOM													
At rest	1	1	1	1	1	1	1	1	1	1	1	1	1
Lightly exerting yourself	2	2	2	2	2	2	2	2	2	2	2	2	2
Moderately exerting yourself	3	3	3	3	3	3	3	3	3	3	3	3	3
Heavily exerting your-self, or	4	4	4	4	4	4	4	4	4	4	4	4	4
Other . . . . Specify ________	5	5	5	5	5	5	5	5	5	5	5	5	5
Don't know	9	9	9	9	9	9	9	9	9	9	9	9	9

CARD Q10D

A.	$0.00	K.	$ 5.00	V.	$16.00	FF.	$ 45.00	PP.	$ 200.00
B.	$0.50	L.	$ 6.00	W.	$18.00	GG.	$ 50.00	QQ.	$ 250.00
C.	$1.00	M.	$ 7.00	X.	$20.00	HH.	$ 60.00	RR.	$ 300.00
D.	$1.50	N.	$ 8.00	Y.	$22.00	II.	$ 70.00	Ss.	$ 350.00
E.	$2.00	P.	$ 9.00	Z.	$24.00	JJ.	$ 80.00	TT.	$ 400.00
F.	$2.50	Q.	$10.00	AA.	$26.00	KK.	$ 90.00	Uu.	$ 450.00
G.	$3.00	R.	$11.00	BB.	$28.00	LL.	$100.00	Vv.	$ 500.00
H.	$3.50	s.	$12.00	CC.	$30.00	MM.	$125.00	xx.	$1000.00
I.	$4.00	T.	$13.00	DD.	$35.00	NN.	$150.00	YY.	More than $1000.00
J.	$4.50	u.	$14.00	EE.	$40.00	00.	$175.00		

D. One way to find out how valuable better health is to you is to ask you how much you are willing to pay for it. Suppose you could have avoided the symptom(s) you have experienced by the payment of a sum of money. Please look at this card (HAND CARD Q10D). Which sum of money most closely represents the maximum amount you would have been willing to pay to have avoided (...) yesterday/day before yesterday? INSERT EACH SYMPTOM IN TURN FOR (...). When you have decided, give me the letter next to the amount.

a. Did you answer $0.00 because you feel avoiding the symptom has no value to you?

YES 1
NO 2

LETTER OF SYMPTOM													
RECORD LETTER OF AMOUNT													

E. What do you think caused it?

LETTER OF SYMPTOM													
Weather	1	1	1	1	1	1	1	1	1	1	1	1	1
Smog	2	2	2	2	2	2	2	2	2	2	2	2	2
Both	3	3	3	3	3	3	3	3	3	3	3	3	3
Other	4	4	4	4	4	4	4	4	4	4	4	4	4

11. Did the air quality yesterday affect what you did?

	YESTERDAY?			DAY BEFORE YESTERDAY?		
	A LOT	A LITTLE	NO	A LOT	A LITTLE	NO
	1	2	3	1	2	3
PROBE						

12. Since we last talked to you (in the last month) have you changed your main job in any way such as:

A. Different company or organization
YES 1
NO 2

B. Different job in the same company
YES 1
NO 2

C. Different work in location
YES 1
NO 2

IF YES TO EITHER B OR C, GO TO D. OTHERWISE, GO TO Q13

D. What kind of business or industry do you now work in?

RECORD RESPONSE ____________________

CIRCLE CORRECT CATEGORY

Agriculture or Forestry 1
Mining 2
Construction 3
Manufacturing 4
Wholesale or Retail Trade 5
Transportation, Communications, or Public Utilities 6
Finance, Insurance, or Real Estate 7
Services 8
Government 9
Other 10
→ Specify ____________________

E. What type of work do you now do in your main job?

RECORD RESPONSE ____________________

CIRCLE CORRECT CATEGORY

SERVICE WORKER	(Food service workers, Cleaning service workers, Dental assistants, Policemen)	1
LABORER	(Longshoremen, Construction workers, Loggers, Garbage collectors)	2
TRANSPORTATION OPERATOR	(Bus drivers, Taxicab drivers, Truck drivers, Railroad switch operators)	3
EQUIPMENT OPERATOR	(Textile workers, Driller, Photographic processors, Smelters)	4
CRAFT WORKER	(Carpenters, Machinists, Bakers, Tailors, Repairmen, Mechanics)	5
CLERICAL WORKER	(Cashiers, Tellers, Secretaries, Receptionists, Telephone operators, Dispatchers)	6
SALES WORKER	(Advertising agents, Real estate agents, Sales clerks, Sales representatives, Vendors)	7
MANAGER OR ADMINISTRATION	(Bank officers, Purchasing agents, Restaurant managers, School administrators)	8
PROFESSIONAL OR TECHNICAL	(Accountants, Engineers, Physicians, Teachers, Entertainers)	9
FARMWORKER	(Farmers, Farm laborers, Farm Supervisors)	10

F. Please name the community where your place of work is located.

____

FOR "AT HOME" CODE "1"
FOR "GLENDORA" OR EAST SAN GABRIEL VALLEY CODE "12"
ALL OTHERS LEAVE BLANK

____

G. How many weeks per year do you actually work on your main job? (Or if this is a new job, how many weeks of work per year does your main job require?)

__________WEEKS

H. How many hours do you work each day of the week?

Monday	______	Friday	______
Tuesday	______	Saturday	______
Wednesday	______	Sunday	______
Thursday	______		

I. How do you usually go to and from work? Do you:

	YES	NO
Drive?	1	2
Carpool?	1	2
Vanpool?	1	2
Motorcycle or Moped?	1	2
Public Transportation? . . .	1	2
Walk?	1	2
Bicycle?	1	2
Some other way?	1	--
→ SPECIFY ______________		

J. How long do you spend commuting each day? Would you say:

Less than 15 minutes, ... 1
16 to 30 minutes, ... 2
31 to 60 minutes, or 3
over 60 minutes? 4

K. How many hours, on the average, do you spend outdoors during your working day?

RECORD HOURS: __________

L. Do you travel during the day as part of your work?

YES . . . . ASK a 1
NO . . . . SKIP TO M . . . 2

a. When you travel, do you use:

A car, ... 1
Public transportation, or 2
Walk? 3
Other 4
→ SPECIFY ______________________

b. How long do you usually spend traveling during a working day?

RECORD ________

M. Is your place of work air conditioned?

YES 1
NO 2

N. Are you exposed to anything at work which affects your breathing?

YES . . . . ASK a 1
NO . . . SKIP TO O . . . 2

a. What are you exposed to?

____

____

0. How are you paid?

1 HOURLY WAGE
2 SALARY
3 OTHER (i.e., Piece work, Commissions, Tips, etc.)

→(IF SALARY OR OTHER) please look at this card (HAND CARD Q12SAL) and tell me the letter of the income category that includes your annual gross (i.e., before deductions and taxes) income from your main job.

RECORD LETTER______

If you work more hours than average during some week, do you get paid anything at all for those hours?

1 YES
2 NO

→(IF YES) which of the following best describes how you get paid for those overtime hours?

1 EQUIVALENT TO STRAIGHT TIME HOURLY WAGE
2 EQUIVALENT TO TIME AND A HALF
3 EQUIVALENT TO DOUBLE TIME
4 EQUIVALENT TO TRIPLE TIME

Approximately, how many hours of overtime do you work in an average week? _________HOURS

SKIP TO Q13

→(IF HOURLY) Please look at this card (HAND CARD Q12WAGE) and tell me the letter of the wage category that includes your hourly wage for regular or "straight" time work.

RECORD LETTER _____

Do you ever have the opportunity to work overtime on your main job?

1 YES
2 NO

→(IF YES) Which of the following most closely describes your hourly wage rate for those overtime hours?

1 STRAIGHT TIME
2 TIME AND A HALF
3 DOUBLE TIME
4 TRIPLE TIME

Approximately, how many hours of overtime do you work in an average week ________HOURS

CARD Q12SAL

A. Less than $6,000
B. $ 6,000 - 6,999
C. $ 7,000 - 7,999
D. $ 8,000 - 8,999
E. $ 9,000 - 9,999
F. $10,000 - 10,999
G. $11,000 - 11,999
H. $12,000 - 12,999
I. $13,000 - 13,999
J. $14,000 - 14,999
K. $15,000 - 17,499
L. $17,500 - 19,999
M. $20,000 - 22,499
N. $22,500 - 24,999
O. $25,000 - 27,499
P. $27,500 - 29,999
Q. $29,999 - 34,999
R. $35,000 - 39,999
S. $40,000 - 44,999
T. $45,000 - 49,999
U. $50,000 - 54,999
V. $55,000 - 59,999
W. $60,000 - 69,999
X. $70,000 - 79,999
Y. $80,000 -89,999
Z. $90,000 - 99,999+

CARD Q12WAGE

A. Less than $3.00
B. $ 3.00- 3.49
C. $ 3.50 - 3.99
D. $ 4.00 - 4.49
E. $ 4.50 - 4.99
F. $ 5.00 - 5.49
G. $ 5.50 - 5.99
H. $ 6.00 - 6.49
I. $ 6.50 - 6.99
J. $ 7.00 - 7.49
K. $ 7.50 - 7.99
L. $ 8.00 - 8.49
M. $ 8.50 - 8.99
N. $ 9.00 - 9.49
0. $ 9.50 - 9.99
P. $10.00 - 10.49
Q. $10.50 - 10.99
R. $11.00 - 11.49
S. $11.50 - 11.99
T. $12.00 - 12.99
U. $13.00 - 13.99
V. $14.00 - 14.99
W. $15.00 - 15.99
X. $16.00 - 16.99
Y. $17.00 - 17.99
Z. $18.00 - 18.99
AA. $19.00 - 19.99
BB . $20.00 - 20.99
CC. $21.00 - 21.99
DD . $22.00 or more

13. Have there been any other major changes in your life that you would like to tell us about?

____

____

____

____