Volume III

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EXPERIMENTAL METHODS FOR ASSESSING ENVIRONMENTAL BENEFITS

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ESTIMATING BENEFITS OF REDUCING COMMUNITY LOW-LEVEL OZONE EXPOSURE: A FEASIBILITY STUDY

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SECTION 1

INTRODUCTION AND EXECUTIVE SUMMARY

Previous research efforts aimed at estimating the dollar health benefits of reducing ozone levels have focused mainly on measures of illness. For example, Gerking, Stanley, and Weirick (27) 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 (59) analyzed the impact of ozone on health measures such as restricted activity days, bed disability days, and work loss days among respondents in the 1979 national Health Interview Survey. Studies in this vein, however, do not explicitly consider the health benefits arising from reductions in subclinical or minor symptomatic discomforts of ozone. Reducing these discomforts, which include chest pain, headache, and general malaise, is a potentially large source of dollar benefits for three interrelated reasons. First, as discussed more fully in section 2, minor symptomatic discomforts can occur even in healthy adults at ambient ozone levels below the present federal standard of .12 ppm. Second, even though these discomforts are less serious than illnesses such as asthma, emphysema, and chronic bronchitis, they do cause individuals to limit activities. Third, these discomforts and associated 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.

The purpose of this feasibility study is to show how to effectively pursue research into measuring the benefits of reduced minor symptomatic discomforts associated with ozone exposure. New benefit estimates are not provided here, although some existing estimates are applied. Instead, attention is directed to showing how an appropriate research methodology can be implemented using a sample drawn from participants in previous studies of chronic obstructive respiratory disease (CORD) conducted in the Los Angeles area. As a consequence, this feasibility study may be viewed as a proposal to implement Component 1-Phase 2 and Component 2 of the cooperative agreement application entitled, "Improving Accuracy and Reducing Costs of Environmental Benefit Assessments." These components call for new research in the area of valuing morbidity benefits and focus on the health effects of ozone. If supported, the resulting research project would be conducted jointly by economists, medical scientists, and epidemiologists, at the Universities of Colorado, Wyoming, and California (Los Angeles). Members of the medical science and epidemiology segments of the research group have been extensively involved in the various CORD studies conducted over the past ten years. Their vitae, together with those of the principal economists included, may be found in above mentioned cooperative agreement application.

The ultimate objectives of this proposed project are to: (1) measure the association between prevalence and intensity of minor symptomatic discomforts and ozone exposure and (2) estimate dollar values for the discomforts identified. The research would be conducted over the period 1 Feb 85 - 31 Mar 86, although all data would be collected and analyzed prior to 31 Dec 85. Key deliverables from the project include draft reports summarizing all findings to be forwarded to USEPA during the 1985 calendar year. The last three months of the project period would be devoted to final report preparation. Additional information concerning the time phasing of the project may be found in section 6 and a detailed budget for the project can be found in the cooperative agreement application.

As indicated above, investigators for this project would be drawn from the fields of medical science, epidemiology, and economics. From the viewpoints of medical science and epidemiology, the proposed research will address two broad questions concerning the relationship between symptoms and ozone exposure levels. These are: (1) what are the effects of ozone exposure on sensitive, vulnerable, and normal individuals that might be expected at low levels of ozone exposure? and (2) at what levels of ozone exposure are these effects likely to occur? Unfortunately, comparatively few answers are currently available on either of these questions. As discussed in section 2, most previous research on the health effects of ozone has focused on exposure levels that are between two and seven times the present national standard. In a sense, this situation parallels the previously noted tendency of economists to base benefit estimates for ozone control on reductions in illness. Yet, evidence of minor symptomatic discomforts appearing at much lower levels of exposure in health adults is not unknown even though the discomforts may be subtle and not readily apparent in usual clinical testing procedures. For example, Goldsmith (29) showed an increase in airways resistance in 2 of 4 persons studied at .10 ppm and Von Nieding (55) showed an increase in airways resistance at this level along with a change in blood PO2 levels. Moreover, in a recent telephone conference conducted to support the feasibility study (see transcript in Appendix D), acknowledged experts on the health effects of ozone stated that individual responses to that pollutant are highly variable, depending on factors such as extent of exercise, acclimatization, immediate history of exposure, and severity of existing respiratory or cardiovascular disease. This situation suggests that the levels of ozone exposure associated with the onset of symptoms may vary greatly across individuals as well.

These questions concerning the onset of symptoms are of immediate policy relevance. As explained in section 3, the exposure levels at which symptoms first begin to appear is a critical determinant of the magnitude of economic benefits. For example, suppose that for the "average" individual, the threshold ozone level at which symptoms first appear is .07 ppm. In this case, using estimates drawn from Schulze et al. together with some simplifying assumptions regarding the distribution of daily ozone levels, the benefits associated with meeting a .12 ppm standard would be roughly $170 per household per year. On the other hand, if the threshold level for health effects is instead .12 ppm, then the corresponding benefit calculation yields a much smaller figure of approximately $15 per household

per year. Using the lower of the two figures, section 3 also reports a conservative "guess" that the total national benefit of meeting the present ozone standard is $750 million annually. Given the disproportionately high ozone levels experienced in California, approximately 70 percent of those benefits would accrue to residents of that state. The remaining 30 percent, or about $200 million in benefits, would be principally distributed to residents of states in the New England, Middle Atlantic, and West South Central regions of the U.S. Consequently, although ozone pollution is concentrated in California, it remains an important national problem.

In the proposed research project, the improved knowledge of how and when low level ozone exposure contributes to minor symptomatic discomforts will become an important input to more precise calculations of the dollar benefits of ozone control. These benefit calculations, which are explained more fully in section 4, will be undertaken using three approaches: (1) the averting behavior method (ABM), (2) the contingent valuation method (CVM), and (3) the direct cost method (DCM). The particular ABM approach proposed is a generalization of the household production function framework used by Gerking, Stanley, and Weirick (27) in their study of ozone exposures in St. Louis. More specifically, section 4.1 presents a model in which individuals engage in averting activities in order to avoid ozone exposures and, thus, minor symptomatic discomforts. These activities, which include spending more time indoors and/or traveling to a less afflicted location, form the basis for splitting out the benefits of reduced minor symptomatic discomforts from benefits of reduced illness. Thus, the relative size of these two components of the total health bid to avoid ozone exposure can be compared. The benefit measure derived indicates that at constant utility levels, an individual's willingness to pay for a small reduction in ozone levels is determined by three factors: (1) the extent to which symptoms are reduced directly, (2) the efficiency with which averting activities can reduce symptoms, and (3) the cost of engaging in averting activities. Even though the method relies on a model in which utility is maximized, no utility terms appear in the benefit measure derived making the measure straightforward to implement empirically.

Second, the CVM approach to be applied is similar to the research design used by Loehman et al. (50). However, the proposed research will differ from the Loehman et al. study in three important respects: (1) pollutant concentrations will be measured using data on episodes which are fresh in the minds of respondents, rather than as annual averages, (2) separate benefit estimates will be obtained for reductions in specific minor symptomatic discomforts such as cough, chest pain, headache, throat irritation, depression, and sensitivity to bright light, and (3) separate dose-response estimates will connect the prevalence and severity of these discomforts to ambient ozone levels for the members of each of three subsamples. (The composition of each of these subsamples will be described momentarily.) Thus, individuals will be valuing only the symptoms which have been reported by members of <u>their group</u> at varying exposure levels.

Finally, although not a major focus of this study, some effort will be devoted to the direct costing of symptoms of ozone exposure. Once dose-response functions have been formulated by medical scientists costs of relieving the symptoms identified will be explored. Additionally, direct costs of restricted activity days and work loss days will be examined using procedures similar to the dose-response analyses of Portney and Mullahy (59).

These three benefit estimation methods will be applied to new data obtained from approximately 200 participants in prior CORD studies conducted by UCLA. This sample will be drawn from two CORD communities; Burbank and Glendora. The former community has moderate ozone levels while ozone pollution in Glendora is more severe. Additionally, the sample will be stratified into the following three groups (mentioned in the discussion of CVM): (1) 60 individuals with physician diagnosed respiratory diseases including asthma, chronic bronchitis, and emphysema, (2) 60 individuals who regularly engage in heavy recreational or occupational exercise, and (3) 80 "normal" individuals. In order to reduce confounding influences, all sample members will be nonsmoking adult (aged 25-59 years), full-time workers. The new data will be collected on the 200 respondents in two phases. First, extensive baseline data will be collected by home visit (see questionnaire in Appendix A). Second, each sample member will be telephoned about once per month according to a protocol determined so as to maximize days with ozone exposure and to balance weekday and weekend reports. These follow-up interviews will gather information concerning the day of the call and the two previous days (see questionnaire in Appendix B). This data collection method is expected to be superior to the diary approach. With the telephone follow-up interviews, the recall period is short and the time period of interest can easily be targeted. Additionally, entries in the diaries used in previous health studies often are completed on an irregular basis, thus turning them into de facto retrospective data collection instruments.

In summary, the proposed study will focus on how ozone exposure affects minor symptomatic discomforts including chest pain, headache, and general malaise. This focus is warranted because these discomforts limit activities and are experienced by a large share of the exposed population. Thus, willingness to pay to avoid them may be substantial and should be taken into account in the regulatory impact assessment process. The research will be undertaken jointly by a team of economists, medical scientists, and epidemiologists from the Universities of Colorado, Wyoming, and California (Los Angeles). They will pursue two closely interconnected objectives to: (1) measure the association between prevalence and intensity of minor symptomatic discomforts and ozone exposure and (2) estimate dollar values for the discomforts identified. Special emphasis will be placed on identifying the levels of ozone exposure at which particular symptoms begin to appear. Little medical or epidemiological research has been done in this area and the exact exposure levels that

trigger symptoms are a critical determinant of the magnitude of economic benefits. These estimates of economic benefits, in turn, will be obtained on the basis of extensive research in applying three approaches: (1) the averting behavior method, (2) the contingent valuation method, and (3) the direct cost method. Consideration of the case of ozone pollution, therefore, will advance the state of the art in developing benefit estimates, permit the cost-effectiveness of alternative methods to be compared, in addition to producing policy relevant benefit estimates.

SECTION 2

SYMPTOMS AND HEALTH EFFECTS OF OZONE EXPOSURE

2.1 Overview

The relationship between ozone and health has been studied by a number of means including clinical and epidemiologic studies. In the clinical studies, (see Table 2.1 and the corresponding references in the list of references) (1-4, 12, 20, 22-24, 28, 29, 31-35, 39, 43, 44, 47-49, 52, 55, 62, 64, 71), individuals are exposed to known concentrations of ozone and, on a separate occasion, to "clean" air, for specified periods of time, while at rest and/or engaging in intermittent light exercise or in moderate to severe exercise. The responses of the individual in terms of symptoms, physical signs and changes in lung function parameters, such as FEV_1, other forced expiratory flow rates, airway resistance, subdivisions of lung volume, dynamics of lung compliance, etc., are assessed during and following the exposure. In the epidemiologic studies (13-15, 37, 45, 60, 68, 69), groups of individuals exposed and unexposed to ambient levels of pollution are studied and compared, or groups of individuals intermittently naturally exposed to high and low levels of air pollutants are studied at those periods and compared across time.

Both clinical and epidemiologic studies have advantages and disadvantages and are better considered as complementary ways of addressing an extremely complex problem than as adversarial approaches. Clinical studies have the advantage that level and duration of exposure (and dose to the respiratory tract, if minute ventilation is measured), are known and that appropriate measurements can be made during and following the exposure according to predetermined protocol. In addition, clinical studies are likely to be performed on sensitive or vulnerable individuals, so that worst case response can be studied. The major disadvantage is that chamber exposure is, necessarily, a simplified model of that faced by free living populations. Epidemiologic studies deal with the naturally occurring exposure of free living individuals, but lack the precise characterization of personal exposure and the opportunity for timely observations and measurements available in the clinical study.

The research proposed falls into the epidemiologic category in that the response to ozone exposure among free living individuals will be studied. This section briefly summarizes what has been learned from clinical studies about the ozone and health relationship. The focus on clinical studies here is warranted because they provide a useful, though imperfect, guide to the symptoms that sensitive, vulnerable, and normal individuals might experience at particular exposure levels. Moreover, these results, together with previous field experience, lie behind the

construction of instruments for the present study that are designed to collect information on symptomatology. These instruments are described more fully in section 5 and draft versions of them are presented in Appendices A and B.

2.2. The Ozone and Health Relationship

Ozone is one of the major components of photochemical smog due to human activities and is usually present in ambient concentrations of about 0.05 ppm at sea level. In certain geographic regions, such as the Los Angeles area, hourly average concentrations of 0.2-0.35 ppm are occasionally reached during community air pollution episodes and peak concentrations 0.6-0.8 ppm have been recorded. As indicated previously, the federal air quality standard for ozone presently is set at .12 ppm. During episodes of photochemical pollution, respiratory symptoms are widely experienced. These are related to irritant effects of ozone and other components in the photochemical complex on mucous membranes of the nose, throat and lower airways, producing in some individuals cough, wheezing, and a sensation of chest constriction or burning. Effects on the lower airways are believed to be enhanced by physical activity because of the increased ventilation and tendency towards mouth breathing during the hyperpnea of exercise.

Toxic effects of ozone itself on the respiratory system have been investigated in a number of animal and human studies involving controlled exposure to ozone at levels that can be experienced in community air. Chronic continuous or intermittent exposure of experimental animals, including primates, to ozone concentrations in the range of 0.35 to 1 ppm have produced morphologic changes indicating toxic injury to the epithelium of proximal and peripheral airways and to type one alveolar epithelial cells (6, 9, 10, 12, 16, 17, 26, 40, 53, 57, 65-67, 70). Susceptibility to the toxic effects of ozone varies with species, age, and prior exposure, effects of chronic exposure being modulated by adaptive and repair mechanisms. Most human studies of ozone effects have involved only short-term challenges (5 min-6 h).

Selected studies of human exposures to ozone in environmental chambers are summarized in Table 2.1. Whereas acute exposures to ozone concentrations of less than 0.37 ppm have produced variable changes in lung function (5, 20, 24, 29, 31, 32, 34, 35, 47, 55, 64), human challenges with higher concentrations have generally led to definite decrements in forced expiratory volumes and flow (12, 20, 21, 33, 36, 41, 45, 64), and functional changes due to exposure to any given level of ozone have been accentuated by exercise (12, 20, 21, 23, 34, 35, 40, 45, 55, 64). Upon exposure to ozone concentrations of 0.37 or 0.5 ppm, normal volunteers have experienced cough, substernal pain, wheezing, and malaise not reported during control exposures (31, 32). The limited data available concerning effects in man of repeated intermittent exposure over a few days to several weeks suggested that tolerance to the effects of ozone on lung function can occur after only limited exposure (5, 24, 34, 35, 58).

The possibility of persistent changes due to longer term intermittent exposures has not been adequately investigated, however, there is some evidence that damage may be cumulative. Damage may be cumulative. Chamber studies (24, 33-35, 44, 49) indicate an acclimatization or habituation affect of higher levels of ozone exposure over the short term. Detels et al. [see reference attached here] report that a cohort exposed over five years to higher community levels of oxidant pollution (primarily) have greater decrement in lung function than a cohort exposed to much lower levels, indicating a cumulative effect of the exposure in the long term.

To assist in planning the proposed study, of the health effects of low level ozone exposures, a telephone conference was arranged. The invited participants are among the acknowledged experts and represented epidemiology, clinical medicine, experimental clinical medicine, and environmental sciences. Participants were:

Professor Rodney Beard, M.D.
Stanford University

Professor Timothy Crocker, M.D.
University of California, Irvine

Professor Carroll Cross, M.D.
University of California, Davis

Dean Roger Detels, M.D.
University of California, Los Angeles

Professor Steven Horvath, M.D.
University of California, Santa Barbara

Professor Mohammad Mustafa, Ph.D.
University of California, Los Angeles

Stanley Rokaw, M.D.
American Lung Association, Los Angeles

Gershen Schaeffer, M.D.
Riverside, California

Anne Coulson, Research Epidemiologist and Professor Donald P. Tashkin, M.D., both of UCLA planned and moderated the conference. The transcript of the conference is included as Appendix C. Symptoms which the panel agreed were most likely in response to ozone exposure were:

1) Cough, which was regarded as the most common symptom
2) Pain on deep inhalation
3) Nausea
4) Headache
5) Throat irritation
6) Moodiness
7) Distractability

8) Lethargy
9) Decrease in work capacity
10) Depression
11) Dampening effect on motivation
12) Irritability
13) Susceptibility to infection
14) Sensitivity to bright light

Eye irritation was mentioned as a common response to oxidant air pollution exposure. Technically, it is not due to ozone but to the presence of PAN in the total oxidant mix. However, it is a useful measure of oxidants, approximately 95 percent of which is ozone.

It was generally agreed that the effect of ozone exposure is considerably modified by the activity of the subject. Several of the expert panel reported that exposure of normal individuals in a quiet state of levels of .3 and .4 did not produce symptoms, whereas active individuals developed symptoms at levels of .14 - .18. Additionally, there is some indication in work currently underway (private communication from Henry Gong and Donald Tashkin) that trained athletes performing at high levels of exercise may be adversely affected at .12 ppm. Bates suggests that sensitive individuals may respond at 0.12, the Federal Air Quality Standard.

Lower levels at or below the federal standard may also have adverse effects. As previously noted, of the studies reported in Table 2.1, few reported any health measurements made at ozone levels below .12 ppm. Moreover, adverse health effects in this range of exposure may be subtle and not readily apparent in usual testing procedures. On the other hand Table 2.1 indicates that effects at .10 ppm are not completely unknown. for example, Goldsmith (29) showed an increase in airways resistance in 2 of 4 persons studied at .1 ppm and Von Nieding (55) showed an increase in airways resistance at this level along with a change in blood PO2 levels.

The acute effects at the low exposure levels may be indicated by subtle changes in behavior, possibly triggered in part by the odor, detectable at .04 ppm, and the appearance of air containing photochemical oxidants, 95 percent of which, as indicated above, is ozone. The individual may not be aware that the behavioral changes are associated with the ozone exposure levels. But if the changes are so associated, days with low levels of exposure should be more like the higher exposure days than the high air quality days in terms of outdoor activity.

Since adverse effects of exposure to even low levels of ozone are likely to exist, there may be substantial numbers of people in and outside California modifying their behavior, lifestyle, and activities in response. If these minor effects are compiled with idiosyncratic sensitivities of the individual such that a recognizable effect usually occurs when the two exposures occur together, the effect deriving from the ozone exposure may go unnoticed in the hay fever associated with, say, golden rod or roses.

A precise determination of the exposure levels at which particular symptoms appear, however, is complicated considerably by the tremendous variability in response across individuals. For example, at .4ppm, decrement in FEV_1, ranges from 5 percent to 45 percent. There is also variability depending on acclimatization: individuals from areas with very low or no ozone pollution are significantly more sensitive to lower levels of ozone than individuals who live in an area with continuing moderate exposure (18, 20). Similarly, there are differences in response to a given exposure depending on the immediate history of exposure. Response is minimal on the first day, rising on the second and third and then falling away, or disappearing completely on days 4 and 5 (18, 35, 58). If the initial day of a smog episode is followed by a single clear day, the response on the next day (if smoggy) is like the second day of the continuous smoggy days.

Sensitive individuals certainly react, on the average, at the same levels as normals. There is some disagreement as to whether they react at lower levels. The panel generally agreed that individuals with compromised respiratory systems with sensitive airways, (asthma, bronchitis, emphysema) would, on the average, be more sensitive to given levels of ozone exposure.

Short-term exposure to oxidant pollution can increase the sensitivity of the airways to non-specific bronchoconstricter substances, such as histamines (28, 42, 56). Therefore, individuals with persistently hyper-reactive airways, namely asthmatics, might be expected to be more vulnerable to asthmatic attacks after exposure to elevated concentrations of ozone; in some subjects, this increased vulnerability may persist for up to several days following the exposure.

Individuals with breathing problems caused by other diseases, such as shortness of breath associated with congestive heart failure, might be expected to respond at lower levels than normal.

Another group which would be expected to respond at lower levels or more strongly at the same level, is comprised of those who exercise heavily. The deep breathing of athletes and the resulting high minute ventilation exposes these individuals to more of the ambient ozone pollution than those with lower minute ventilation and the same exposure.

The possibility that children may be particularly vulnerable to ozone effects, in terms of symptomatic response, has not been studied. There may be serious problems of pulmonary growth and development associated with exposure, based on animal studies, but this might not be observable in overt symptoms. Children, however, may be especially exposed because of outdoor play and, like athletes, high levels of exertion and minute ventilation. The panel recommended that reports on children from the adults interviewed be obtained. However, no special sensitivity was remarked among the elderly. Persons over 70 have been exposed to levels of .4 ppm for one to two hours without the appearance of symptoms.

The levels of ozone exposure at which symptoms begin to appear turns out to be of critical importance in estimating benefits. That point is

demonstrated in section 3 to follow, which also presents some preliminary and necessarily approximate benefit estimates of ozone control.

TABLE 2.1

SUMMARY OF SELECTED OZONE (O_3) STUDIES PERFORMED IN ENVIRONMENTAL CHAMBERS

First Author (Reference)	No. Subjects	Activity	Exposure Conditions Duration	O_3 Conc. (ppm)	Results or Comments Increased	Decreased
1. Goldsmith (29)	4	Rest	1 hr	0.1 0.4 0.6 1.0	Raw (2 subjects) Raw (1 subject) Raw (1 subject) Raw (4 subjects)	
2. Young (71)	11	Rest	2 hr	0.6-0.8		VC, FEC 0.75 DLCO
3. Bates (4)	10 (2 smokers) 3	Rest Intermittent exercise (IE)	2 hr 2 hr	0.75 0.75	Raw Raw	$\dot{V}$max 50 Ptpmax VC, FEV_1, MMFR, Ptpmax (2 subjects) DLCO (1 subject)
4. Hazucha (39)	12 (6 smokers)	IE	2 hr	0.37 0.75	Both concentrations RV, closing capacity	FVC, FEV_1, MMFR $\dot{V}$max 50
5. Hackney (31)	4 normals (#1) 4 atopics (#2)	Rest	4.5 hr 31°C 35% r.h.	0.50	Group #1: No changes; symptoms Group #2: Raw ΔN2	TLC
6. Hackney (32)	? normals (#3) ? 'reactive' (#4) ? mixed (#5)	IE	>2 hr	0.50 (#3) 0.25 (#4) 0.37 (#5)	Group #3: Raw ΔN2 Group #4: No consist. changes Group #5: No consist. changes	FVC, FEV_1, $\dot{V}$max 50 VC, TLC

(continued)

Table 2.1 (continued)

First Author (Reference)	No. Subjects	Activity	Exposure Conditions: Duration	Exposure Conditions: O_3 Conc. (ppm)	Results or Comments: Increased	Results or Comments: Decreased
7. Golden (28)	8	Rest	2 hr Histamine bronchial challenge before and after O_3 exposure	0.60	No change in mean Raw-O_3, but significant increase of Raw occurred after post-O_3 histamine challenge. Atropine blocked ↑ Raw in 4 subjects.	
8. Von Nieding (55)	11	IE	2 hr 22°C 55% r.h.	0.10	Raw (A-a) PO2	PaO2
9. Linn (48)	12	IE	2 hr 31°C 35% r.h.	0.20		FRC No symptoms or arterial hypoxemia were noted.
10. Silverman (64)	28 (10 smokers)	2 protocols: a. Rest b. IE	2 hr	0.37 0.50 0.75	Symptoms (0.50-0.75)	FEV, $\dot{V}$max 50 (0.75 IE)
11. Kerr (47)	20 (10 smokers)	IE	6 hr 24°C 45% r.h.	0.50	Most changes in nonsmokers only: Raw; RV Symptoms	FVC, FEV_3; SGaw Cldyn
12. Folinsbee (20)	28 (10 smokers)	2 protocols: a. Rest b. IE up to 75% $\dot{V}$max in clean air	2 hr	0.37 0.50 0.75	Resp. rate (exercise only) Symptoms	Tidal volume FVC (0.75 rest; 0.50, 0.75 IE) $\dot{V}$max 50 (all levels) (No change in $\dot{V}$O2 or $\dot{V}$E at any O_3 conc.)

(continued)

Table 2.1 (continued)

First Author (Reference)	No. Subjects	Activity	Exposure Conditions: Duration	Exposure Conditions: O_3 Conc. (ppm)	Results or Comments: Increased	Results or Comments: Decreased
13. Folinsbee (23)	14	2 protocols: a. Rest x 1 hr Exercise (40% VO2max) x 30' Rest x 30' b. Rest x 30' Exercise x 30' Rest x 60'	2 hr 4 temperature and r.h. protocols 1. 25°C and 45% 2. 31 85 3. 35 40 4. 40 50	0.50		Both a, b: VC, IC, TLC Exercise caused greatest decrements in pulmonary function parameters (prot. b > a), which tended to return to pre-exposure levels despite continued O_3. Trend for greater PFT decrements with both O_3 and high temperature.
14. Folinsbee (22)	40	4 protocols: a. Rest b. IE ($\dot{V}E$ 30 L/min) c. IE ($\dot{V}E$ 50 L/min) d. IE ($\dot{V}E$ 75 L/min)	2 hr 25°C 45% r.h.	0.10 0.30 0.50	Resp. rate (prot. c & d)	FVC (0.3 & 0.5 ppm) FEV_1 (prot. a: 0.5 ppm prot. b, c, d: 0.3 or 0.5) Tidal volume (prot b, c, d)
15. DeLucia (12)	6	4 protocols: a. Rest b. 25% VO2max CE ($\dot{V}E$ 28 L/min) c. 45% CE ($\dot{V}E$ 43) d. 65% CE ($\dot{V}E$ 66)	1 hr	0.15 0.30	Resp. rate (prot. d) Symptoms (prot. c & d)	VC (prot. d; 0.30) FEV_1 (prot. c, d; 0.30) MMFR (prot. d; 0.30)
16. Adams (1)	8	2 CE protocols: a. $\dot{V}E$ 33 L/min b. $\dot{V}E$ 66 L/min	30 or 80 min 20 - 24°C 40- 60% r.h.	0.20 0.30 0.40	"general trend of increasing effective dose (ppm·L) on symptoms, pulmonary function, and exercise ventilatory pattern." Threshold for O_3 toxicity at $\dot{V}E$ 66 L/min: 0.20 - 0.30 ppm	

(continued)

Table 2.1 (continued)

First Author (Reference)	No. Subjects	Activity	Exposure Conditions: Duration	Exposure Conditions: O_3 Conc. (ppm)	Results or Comments: Increased	Results or Comments: Decreased
17. McDonnell (52)	135	IE with either $\dot{V}E$ 35 or 66 L/min	2.5 hr 22°C 40% r.h.	0.12 0.18 0.24 0.30 0.40	SRaw at ≥0.24 ppm symptoms at ≥0.24	FVC, FEV_1 at ≥0.24 ppm
18. Adams (2)	10	2 protocols: a. CE at $\dot{V}E$ 80 L/min x 60' b. CE: 50% $\dot{V}O_2max$ x 10'; Series of sprints (80% $\dot{V}O_2max$) x 7'; Rest x 7'; 85% $\dot{V}O_2max$ 30'	1 hr 23-26°C 45-60% r.h.	0.20 0.35	Both protocols: symptoms at both O_3 concentrations	Both protocols: FVC, FEV_1 $FEF_{25-75\%}$ at both O_3 concentrations
19. Avol (3)	50 (3 smokers)	CE at $\dot{V}E$ 55 L/min	1 hr 32°C 42-46% r.h.	0.08 0.16 0.24 0.32	Symptoms at ≥ 0.24 ppm	FVC, FEV_1 beginning at 0.16 ppm
STUDIES DEALING WITH MAXIMUM WORK PERFORMANCE:						
20. Folinsbee (21)	13 (4 smokers)	IE x 2 hr, maximal exercise in clean air	2 hr	0.75	Resp. rate (+45%) and symptoms during exercise	2-hr post-O_3 exposure: FVC, FEV_1, FEF 50 and 75%; ERV. Exercise: $\dot{V}O_2max$ (-10%) $\dot{V}E_{max}$ (-16%) work load (-10%) heart rate (-10%) tidal volume (-21%)

(continued)

Table 2.1 (continued)

First Author (Reference)	No. Subjects	Activity	Exposure Conditions: Duration	Exposure Conditions: O_3 Conc. (ppm)	Results or Comments: Increased	Results or Comments: Decreased
21. Savin (62)	9	Immediate exercise to $\dot{V}O_2max$ (~30')	30-40 min	0.15 0.30	$\dot{V}E$ No significant changes in $\dot{V}O_2max$ or pulmonary function detected statistically.	
22. Horvath (43)	15	Rest in O_3 x 2 hr, then either rest or exercise maximally in clean air	2 hr	0.25 0.50 0.75	2-hr post-O_3 exposure: resp. rate, $\dot{V}E/\dot{V}O_2$ at 0.75ppm Nonsignificant trend for reduced $\dot{V}O_2max$, total work time, and PFTs after maximal exercise test.	2-hr post-O_3 exposure: FVC, FEV_1 for 0.50 and 0.75 ppm
STUDIES DEALING WITH ADAPTATION:						
23. Hackney (33)	9 newcomers 6 LA res. (2 smokers; only 2 males)	IE	2 hr, 15 min (2 successive days)	Day 1: 0 Day 2: 0.40	Newcomers: more impaired FVC, FEV_1, compared to control exposure than LA residents. Tendency for newcomers to show more symptoms and and impaired FEV_1 and MMFR.	
24. Hackney (34)	5 LA res. (5 allergic)	IE	2 hr, 30 min (5 successive days) 31°C 35% r.h.	Day 1: 0 Days 2-4: 0.50	5 subjects: tendency for PFT decrement and increased symptoms on days 2-3 and recovery by day 4.	
25. Hackney (35)	4 LA res. 4 newcomers (5 smokers)	IE	2 hr (2 days) 21°C 50% r.h.	Day 1: 0 Day 2: 0.37	2 newcomers showed more clinical and physiological reactivity to exposure than the LA residents.	

(continued)

Table 2.1 (continued)

First Author (Reference)	No. Subjects	Activity	Exposure Conditions: Duration	Exposure Conditions: O_3 Conc. (ppm)	Results or Comments: Increased	Results or Comments: Decreased
26. Folinsbee (24)	30 divided into 3 groups (10 each)	IE	2 hr (5 successive days) 35°C 45% r.h.	Day 1: 0 Day 2: 0.20 Day 2: 0.35 Day 4: 0.50 Day 5: 0	one level for each group	0.20 ppm: No acute or cumulative effected noted. 0.35 ppm: PFT decrements on days 2-3, absent on days 4-5. 0.50 ppm: PFT decrements on days 2-3 and occ. on day 4. Symptoms worst on day 3, improved on day 4.
27. Horvath (44)	24	IE	2 hr (6 days, 5 consecutive; followed by at 1.2, or 3 weeks) 22°C	Day 1: 0 Day 2-5, retest day: 0.50	Greatest FEV_1 decrement on Day 2; recovery took 2-5 days. Adaptation persisted in O_3-sensitive subjects but marked individual variability and lasted on the average >2 weeks (range 7 days to 20 days). Duration of adaptation was shortest for the more sensitive subjects.	
28. Linn (49)	11	IE	2 hr (5 days consecutive, followed by retest exposure 7 days later x 5 weeks) 31°C 40% r.h.	Day 1: 0 Days 2-5, retest days: 0.47	Most subjects developed PFT impairment on days 2-3 and recovered by day 4. Adaptation was partly lost with a 4-day interval between successive exposure and more or less completely loss with a 7-day interval	

SECTION 3

GEOGRAPHIC DISTRIBUTION OF BENEFITS FROM OZONE REDUCTION

This section discusses the geographic distribution of the ozone problem in the United States and offers some rough, order-of-magnitude estimates of prospective benefits from abatement. The specific aims of this discussion are to: (1) demonstrate that while the ozone levels are highest in California, this pollutant still is a problem in other regions of the country as well and (2) show that dollar benefits even from small reductions in minor symptomatic discomforts of ozone are likely to be substantial. The geography of the ozone problem is presented in section 3.1 and the order-of-magnitude benefit calculations are given in section 3.2. As indicated in the introduction, these benefit calculations rely on estimates made in previous studies. The study drawn on most extensively here is Schulze et al. (7, 8).

3.1. The Geography of the U.S. Ozone Problem

Certainly, California is the most publicized area with a significant ozone problem. However, the problem is not restricted to that state alone. Information from the National Aerometric Data Bank indicates that there are 51 counties in 17 states where five or more violations of the national ozone standard of .12 ppm were recorded during 1982. Table 3.1 contains a listing of these states and counties along with their populations. For counties with more than one recording site, the median number of days exceeding .12 ppm is recorded. Note that even though the median number of ozone standard violation days are generally higher for the afflicted California counties, the population in these counties accounts for less than 40 percent of the total for their counterparts, nationally.

As a consequence, a more informative figure for measuring the geographic distribution of the ozone problem would be the number of "person standard violation days" of exposure. For a rough estimate of this quantity, the median number of days was multiplied by the population for each county. Table 3.2 contains a summary of these figures. In this calculation, California accounts for about 70 percent of the "person standard violation days" among these 51 counties. Note that 30 percent of the problem is outside California, and this figure does not include any areas with monitoring stations recording fewer than five days in violation of the standard. Thus, while California has a disproportionately large share of the ozone problem, that problem cannot be ignored in other states. Moreover, these other states, which include Connecticut, New Jersey, and Texas, lie outside the Pacific Division. Thus, benefits from a program to reduce ozone levels will be experienced on a national level.

TABLE 3.1

OZONE VIOLATION DAYS AND POPULATIONS
BY CENSUS DIVISION, STATE AND COUNTY

State	County	Median No. Days > .12 ppm	Population	% Total
New England Division				
Conn.	Fairfield	16.0	807143	2.07
	Hartford	11.6	807766	2.08
	New London	27.1	238409	0.61
	New Haven	16.5	761337	1.96
	Middlesex	21.3	129017	0.33
	Tolland	13.1	114823	0.29
Maine	Cumberland	3.1	215789	0.55
Mass.	Essex	3.8	633632	1.63
Rhode Is.	Kent	8.0	154163	0.40
TOTAL			3862079	9.93
Middle Atlantic Division				
New Jersey	Hudson	5.3	556972	1.43
	Bergen	10.6	845385	2.17
	Hunterdon	9.6	87361	0.22
	Gloucester	8.3	199917	0.51
	Burlington	7.5	362542	0.93
	Mercer	10.2	307863	0.79
	Middlesex	9.4	595893	1.53
	Moris	9.5	407630	1.05
	Essex	5.1	850451	2.19
	Somerset	4.7	203129	0.52
New York	Queens	6.3	1891325	4.86
	Richmond	8.0	352121	0.91
	Westchester	8.2	866599	2.23
Penn.	Bucks	9.9	479211	1.23
	Washington	11.7	217074	0.56
	Philadelphia	4.4	1688210	4.34
TOTAL			9911683	25.48

(continued)

Table 3.1, continued

State	County	Median No. Days > .12 ppm	Population	% Total
East North Central Division				
Mich.	Oakland	5.5	1011793	2.60
	St. Clair	6.6	138802	0.36
Ohio	Montgomery	3.1	571697	1.47
	Preble	6.2	38223	0.10
TOTAL			1760515	4.53
South Atlantic Division				
Deleware	New Castle	5.1	399002	1.03
Wash. D.C.		4.8	637651	1.64
Florida	Hillsborough	1.7	646960	1.66
Maryland	Baltimore	3.9	665615	1.71
TOTAL			2349228	6.04
West South Central Division				
Louisiana	E. Baton Rouge	5.1	366164	0.94
Texas	Jefferson	8.3	250938	0.65
	Brazorra	5.6	169587	0.44
	Dallas	7.2	1556549	4.00
	Harris	13.4	414667	1.07
	Houston	18.1	1994877	5.13
	Galveston	22.9	195940	0.50
	Tarrant	5.5	860880	2.21
TOTAL			5809602	14.94
Mountain Division				
		4.1	146540	0.38
TOTAL			146540	0.38

(continued)

Table 3.1, continued

State	County	Median No. Days > .12 ppm	Population	% Total
Pacific Division				
Calif.	Orange	8.8	1931570	4.97
	Los Angeles	47.1	7477657	19.22
	Kern	13.4	403089	1.04
	Riverside	58.5	663923	1.71
	San Diego	14.5	1861846	4.79
	Fresno	6.3	515013	1.32
	Sacramento	18.0	783381	2.01
	San Bernardino	81.7	893157	2.30
	Ventura	22.1	529899	1.36
TOTAL			15059535	38.71

TABLE 3.2

DISTRIBUTION OF PERSON STANDARD VIOLATION DAYS BY CENSUS DIVISION

Census Division	Person Standard Violation Days (in millions)	Percent of National Total
New England	49.87	6.66
Middle Atlantic	71.59	9.56
East North Central	8.49	1.13
South Atlantic	8.79	1.17
West South Central	66.99	8.95
Mountain	0.60	0.08
Pacific	542.46	72.44
ALL	748.79	100

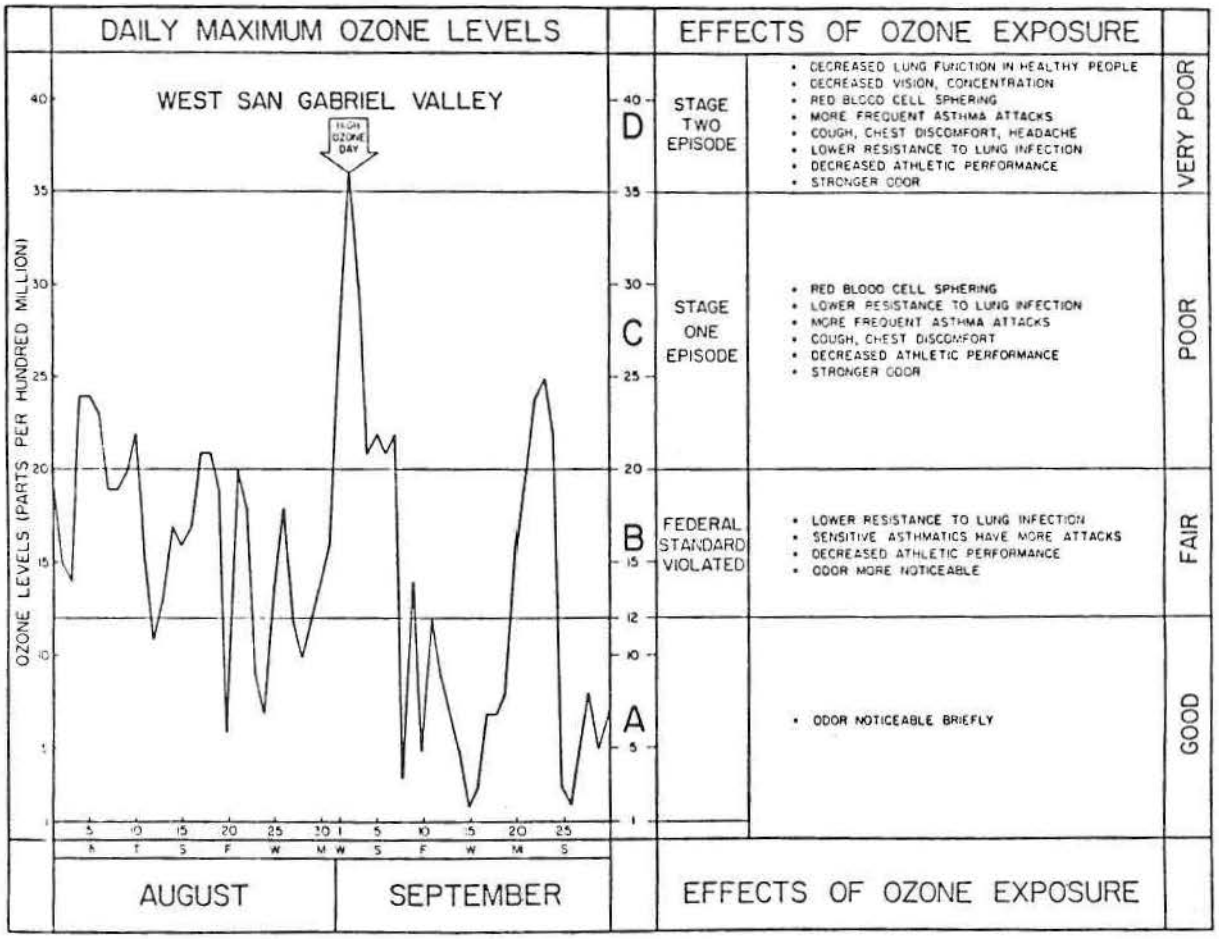
3.2 Implications of Past Ozone Benefits Research

A number of studies have attempted to broadly value the benefits of reducing photochemical air pollution. Studies undertaken by Brookshire et al. (7, 8) examined the willingness to pay to reduce smog levels (broadly defined) in the Los Angeles area both using the contingent valuation and property value approaches. Although the two methods gave comparable results, yielding benefits of $26-$42 per household per month in 1978 dollars, for a 30 percent reduction in ambient levels of air pollution (Brookshire et al., 7), the portion of these benefits attributable to a 30 percent reduction in ozone as opposed to commensurate 30 percent reductions in NO_2, TSP, etc. is impossible to break out. One might speculate that because ozone has some readily perceived effects, e.g., chest pain, that a significant fraction of these benefits would be attributable to reductions in ozone. However, no hard estimates can be derived on this basis. The property value study employed by Brookshire et al., used either NO_2 or TSP as the pollution variable obtaining similar results in either case. More than one pollution variable could not be run in the regression because of a severe collinearity problem among pollution variables. Thus, the single air pollution variable employed in the regressions likely picked up the effect of the entire pollutant mix on property values, again allowing little opportunity to split out the effect of ozone.

Loehman et al. (51) applied a similar methodology using both contingent valuation and property value methods for the San Francisco Bay Area. This area is of considerable interest because air quality is better than in Los Angeles and ozone levels in particular are more comparable to levels across the nation as a whole. Results, however, were quite similar to those obtained from the previous study when adjusted for pollution levels. Again, although an ozone measure was used in the property value study, no other pollutants were included in the analysis, so ozone served as an indicator variable for photochemical air pollution and the partial effect of ozone alone on property values is impossible to obtain from that study.

A contingent valuation study specifically focusing on the effects of ozone has been undertaken by Schulze et al. (63) for the South Coast Air Basin (SOCAB) in the state of California. That study prompted individuals to consider daily ozone levels occurring during the summer months (i.e., August and September) of 1982 and listed specific health effects of ozone exposure at various levels of ozone concentration. Individuals were then asked their willingness to pay to reduce the daily high ozone reading from a specific, landmark day of highest ozone concentration to a lower level. Figure 3.1 shows one of three diagrams used in the general SOCAB survey. This figure was used for residents of the West San Gabriel Valley in making their willingness to pay valuations. In the case of the West San Gabriel Valley three specific questions sought daily willingness to pay measures to lower ozone levels (as highlighted on the right-hand-side of the figure) from concentrations classified as very poor to poor, very poor to fair, and very poor to good. It was explained to individuals that their bid would

Figure 3.1


DAILY MAXIMUM OZONE LEVELS
WEST SAN GABRIEL VALLEY
HIGH OZONE DAY
OZONE LEVELS (PARTS PER HUNDRED MILLION)
40
35
30
25
20
15
10
5
1
5 10 15 20 25 30 1 5 10 15 20 25
R T S F W M W S F W M S
AUGUST
SEPTEMBER
EFFECTS OF OZONE EXPOSURE
D
STAGE TWO EPISODE
• DECREASED LUNG FUNCTION IN HEALTHY PEOPLE
• DECREASED VISION, CONCENTRATION
• RED BLOOD CELL SPHERING
• MORE FREQUENT ASTHMA ATTACKS
• COUGH, CHEST DISCOMFORT, HEADACHE
• LOWER RESISTANCE TO LUNG INFECTION
• DECREASED ATHLETIC PERFORMANCE
• STRONGER ODOR
VERY POOR
C
STAGE ONE EPISODE
• RED BLOOD CELL SPHERING
• LOWER RESISTANCE TO LUNG INFECTION
• MORE FREQUENT ASTHMA ATTACKS
• COUGH, CHEST DISCOMFORT
• DECREASED ATHLETIC PERFORMANCE
• STRONGER ODOR
POOR
B
FEDERAL STANDARD VIOLATED
• LOWER RESISTANCE TO LUNG INFECTION
• SENSITIVE ASTHMATICS HAVE MORE ATTACKS
• DECREASED ATHLETIC PERFORMANCE
• ODOR MORE NOTICEABLE
FAIR
A
• ODOR NOTICEABLE BRIEFLY
GOOD
40
35
30
25
20
15
12
10
5
1
EFFECTS OF OZONE EXPOSURE

lower ozone concentration and consequently reduce the intensity of the effects of ozone exposure.

The study found that individuals were willing to pay on the order of $7.75/day to reduce hourly average ozone concentrations from a level of 20 pphm down to 12 pphm, the federal standard. Although one can extrapolate the information from this study conducted in Los Angeles to evaluate benefits nationally of a 12 pphm (or other) national standard for ozone, such an extrapolation would be questionable for a number of reasons. First, households in different parts of the country are likely to have different tastes with respect to environmental quality and exposure to ozone in particular. Second, there is evidence that individuals become desensitized to ozone exposure (see the transcript of the telephone conference in Appendix C as well as National Academy of Sciences, Division of Medical Sciences, Assembly of Life Sciences, National Research Council, Ozone and Other Photochemical Oxidants, (54)). Since Los Angeles has the highest levels of ozone exposure in the nation, this desensitization may well lower the value individuals place on reduced exposure to ozone compared to individuals living elsewhere who are exposed less frequently to levels of ozone above the national standard.

However, taking these qualifications into account, the work does suggest that individuals might be willing to pay something on the order of $1.00 per pphm reduction in maximum ozone exposure per day. Further, since the Schulze et al. (63) study is the only work to focus specifically on ozone, it is worthwhile to show how results of that study might be used to estimate benefits of a 12 pphm ozone standard. In addition, a new property value study by Murdoch and Thayer included as part of this year's research (Volume V) does succeed in at least partly splitting out the effect of ozone from other pollutants (proxied by a visibility measure) for the San Francisco Bay Area. Thus, we can compare the Los Angeles contingent valuation results of the Schulze et al. study to the results of the Murdoch and Thayer property value study (Volume V) of San Francisco which implies that satisfying the federal ozone standard may be worth over $300 per year to an average household in the San Francisco Bay Area.

The first step in using the Schulze et al. study to estimate the benefits of the standard, which is defined as a daily maximum ozone level which will not be exceeded of 12 pphm, is to examine the frequency distribution of air quality. In general, the frequency, or the number of days, during the ozone "season" (presumed to be four months long or 122 days for this rough analysis) during which ozone achieves a maximum daily level of P is defined as f(P). Clearly then we require that

$$\int_0^{P_{max}} f(P)dP = 122$$

where P_{max} is the highest observed daily max (or extreme value) obtained over the season. If we assume for simplicity in calculation that f(P) is a downward sloping linear function we have

$$f(P) = \frac{122}{\frac{1}{2} P_{max}} \left(1 - \frac{P}{P_{max}}\right)$$

for $P \geq 0$ and $P \leq P_{max}$ as a linear approximate frequency distribution. Note also that we assume that

$$f(P) \equiv 0 \text{ for } P \geq P_{max}.$$

This simple distribution also has the property that the average daily maximum pollution level, $\overline{P}$, is $\frac{1}{3}$ of the maximum obtainable level, P_{max}, so

$$\overline{P} = \frac{1}{3} P_{max}$$

This characteristic is not far from reality for actual ozone frequency distributions during the ozone season. Figure 3.2 shows the distribution along with some key features. Note further that, as shown in Figure 3.3, to achieve a standard of 12 pphm we must shift P_{max} down to this level which causes the distribution to rotate in a clockwise direction, increasing the frequency of low pollution days and decreasing the frequency of high pollution days.

Another important measure of air quality is the number of violation days. In Figure 3.3 this would be the area under the initial frequency distribution to the right of the vertical dotted line. If we denote violation days as T we have

$$T = \int_{12}^{P_{max}} f(P)dP = \frac{122}{\frac{1}{2} P_{max}} \left[P - \frac{1}{2} \frac{P^2}{P_{max}} \right]_{12}^{P_{max}}.$$

If we use typical summer values for the South Bay Area, where average daily maximum O_3 is about 5 pphm, so P_{max} would be about 15 pphm, using the formula above we get T = 4.9 days, roughly consistent with the actual number of violation days in the South Bay Area.

To translate the frequency distribution into a damage estimate necessary to calculate benefits, we need a daily damage function, D(P). In other words, how much an individual would pay in dollars to avoid a day where O_3 reached a maximum level of P. Given that the Schulze et al. ozone study obtained both concave and convex bid curves we will assume a linear damage function which, however, begins at the threshold ozone level P_o below which it is assumed no damage occurs. Thus we have

$$D(P) = \begin{cases} V \cdot (P - P_o) & \text{for } P \geq P_o \\ 0 & \text{for } P \leq P_o. \end{cases}$$

Figure 3.2

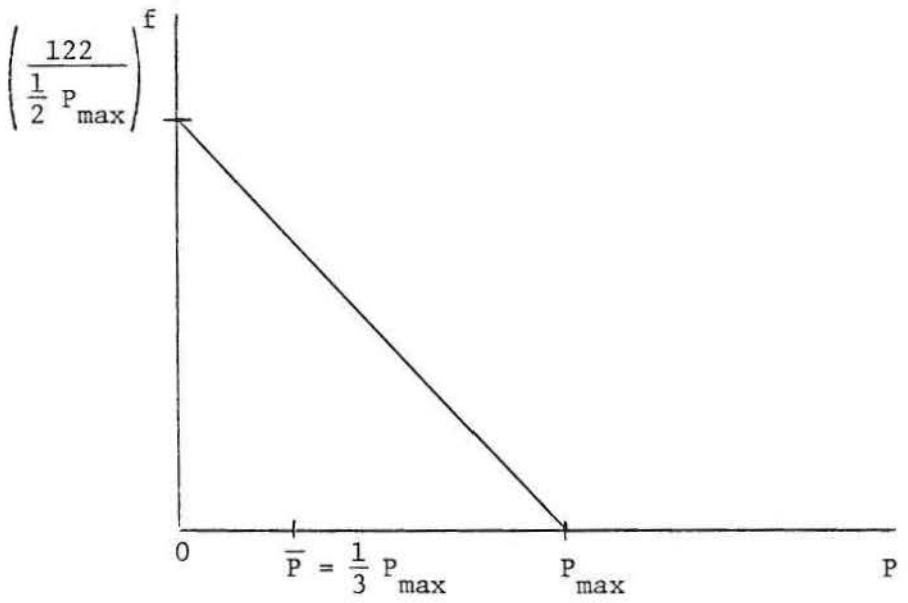
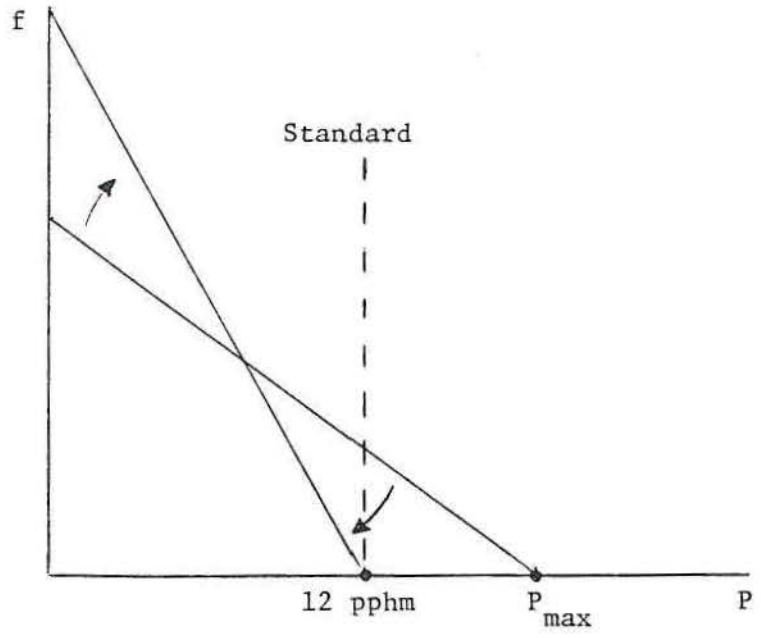


Figure 3.3



This function is graphed in Figure 3.4. The slope of the damage function to the right of P_o is \$V/pphm. From the Schulze et al. study we approximate V as \$1.00. Thus, an individual is presumed to be willing to pay \$1.00 a day to avoid a one pphm increase in daily maximum ozone exposure on that day. Unfortunately, although the Schulze et al. study provides some evidence on the value of V for levels of ozone above 12 pphm the study provides no information on P_o, the threshold at which ozone effects begin. The clinical and epidemiological evidence suggests that for some individuals the threshold may be below 12 pphm and for others it maybe substantially above this level and that the effects of low level exposures (below 12 pphm) are not well understood for the "average" individual relevant for our damage function. Thus, we will first try a very low threshold level for P_o of 7 pphm. Alternatively we will use 12 pphm as the threshold level to examine the effect of alternative thresholds on our benefit estimates.

What are individual annual damages from ozone in the South Bay Area based on the assumptions above and a threshold of 7 pphm? Annual damages are given by the following formula

$$\int_{P_o}^{P_{max}} f(P) \cdot D(P)dP$$

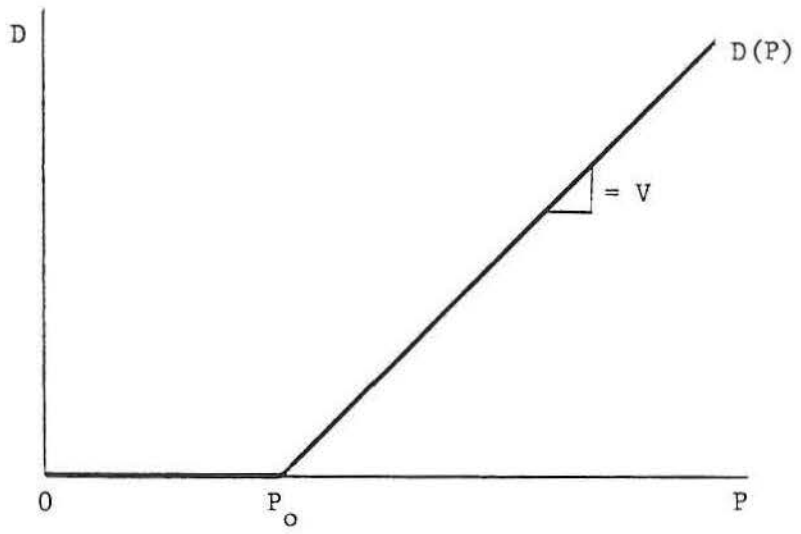
which is the sum (integral) over all relevant levels of pollution of the frequency weighted daily damages. Taking the integral for our specific formulation gives annual damages as

$$\frac{122 \cdot V}{\frac{1}{2} P_{max}} \left[\frac{1}{2}\left(1 + \frac{P_o}{P_{max}}\right)P^2 - \frac{1}{3P_{max}} P^3 - P_o P \right]_{P_o}^{P_{max}}.$$

If P_{max} is set at 15 pphm damages are \$92 per year. If P_{max} is set at the level of the national standard, 12 pphm, damages fall to \$35 per person per year. Thus, achieving the standard results in a reduction in damage or benefit of \$57 per person per year for an assumed threshold of 7 pphm. Since the pollution values used are typical of the South Bay Area, if 3 people occupy a household, the benefits of achieving the standard would be about \$171 per year per household based on a threshold of 7 pphm.

In contrast to this estimate which provides a very large benefit, consider the case where the threshold for ozone damages, P_o in our notation, is raised to 12 pphm. Damages per individual per year from the existing distribution of air quality would then be only \$4.87. If the standard of 12 pphm were obtained so P_{max} falls to 12 pphm, damages per person per year would be zero. Thus, the reduction in damages, or benefit per person per year of achieving the ozone standard would be only \$4.87. For a household with three individuals the annual benefit would be \$14.61.

Figure 3.4



This is roughly ten times smaller than the benefit estimate derived on the assumption of a 7 pphm threshold. Thus, the benefits of satisfying the national ozone standard depend critically on low level ozone effects and on the threshold for those effects. These estimates constitute a range of predicted benefits based on the Los Angeles contingent valuation study for reducing ozone exposures to the national standard for the South Bay portion of the San Francisco Area. These estimates can be contrasted to the property value study of Murdoch and Thayer (Volume V). However, we note that, although the assumptions of a linear frequency distribution for air quality and a linear damage function as used above may seem severe, for most areas in the United States, as in San Francisco, daily maximum ozone levels in a range of 7 to 15 pphm are relevant. The use of linear approximations for these functions in this range may in fact be reasonable.

The Murdoch and Thayer property value study (Volume V) uses visibility (strongly affected by a number of pollution variables including fine particulates) as a proxy explanatory variable for the aesthetic effects of air pollution and violation days per year of the ozone standard as a proxy explanatory variable to account for the health effects of air pollution. Multiplying the coefficient obtained on violation days by the average number of violation days in their sample implies that failure to achieve the ozone standard lowers property values by an annualized amount of around $300 per year per household in the San Francisco Bay Area (Volume V, page 85, footnote 8). There can be little doubt that this value likely includes the effect of pollutants other than ozone which are likely to show collinearity with ozone such as PAN. However, if the ozone standard is interpreted to be broadly aimed at controlling total oxidant then this broader benefit measure may be appropriate.

In contrast, the "predictions" made from the Schulze et al. study range from $14.61 per household per year, assuming a high threshold for ozone effects, to $171 per household per year assuming a low threshold for ozone effects. Obviously, the Murdoch and Thayer study (Volume V) supports the notion that a lower threshold than 12 pphm may be appropriate for estimating benefits, and further that great uncertainty surrounds benefit estimation because the frequency and occurrence of low level health effects is not completely understood by the medical and epidemiological communities so little guidance can be provided to economists at this time. Further research into the low level health effects of ozone exposures is necessary before credible benefit estimates can be made.

However, as a lower bound estimate for benefits we can use the assumption of a 12 pphm threshold. Noting that benefits per person per year were calculated as $4.87 and noting that the South Bay Area was calculated to have about 4.9 violation days, we get $4.87 ÷ 4.9 days ≅ $1 per person violation day as a rough lower bound estimate. The calculation of a lower bound "guess" at the national benefits of meeting the national ozone standard is then quite simple. Benefits are just equal in dollars to the number of person violation days. As shown in Table 3.2, this figure is on the order of 750 million.

SECTION 4

THEORETICAL BASIS FOR THE BENEFIT ESTIMATION METHODS TO BE APPLIED

As stated in section 1, three objectives of this research project are: (1) to develop policy relevant benefit estimates for ozone control, (2) to advance the state of the art in applying benefit estimation techniques, and (3) to develop cross-comparisons of their cost effectiveness. Three benefit estimation techniques will be employed; the averting behavior method (ABM), the contingent valuation method (CVM), and the direct costing method (DCM). The theory and methods of applying these techniques in order to obtain benefit estimates will now be discussed in detail.

4.1 Averting Behavior Method (ABM)

The ABM approach to valuing the health effects of ozone exposure relies on a theoretical economic model. While several alternative model specifications would be appropriate, the one presented below captures a number of essential features of the problem. This model, which is an extension of the theory presented in Gerking, Stanley, and Weirick (27), views individuals as producers of health capital in a utility maximizing framework and allows the individual to take averting action to reduce the minor symptomatic discomforts of ozone exposure. More specifically, the individual is able to adjust his behavior in the face of a change in ambient ozone levels in two ways. First, health producing activities such as medical care can be substituted for increased ozone levels. Second, the extent to which minor symptomatic discomforts are experienced can be altered by engaging in averting activities. Examples of averting activities include substituting indoor for outdoor activities and altering the location or time of day for participating in outdoor activities. These adjustments in activity patterns and the consumption of medical care form the basis for the approach taken in making the benefit or willingness to pay calculations. These two types of adjustments also form the basis for splitting the willingness to pay estimate into a clinical or illness component and a minor symptomatic discomfort component.

The model to be applied represents an adaptation of the approaches taken by Cropper (11), Grossman (30), Rosenzweig and Schultz (61) and Harrington and Portney (38). As shown in equation (1), individuals derive utility from consuming two classes of goods: (1) their own stock of health capital (H) and (2) goods that yield direct satisfaction but do not affect health (X). They also receive direct disutility from minor symptomatic discomforts (S) associated with ozone exposure.

$$U = U(X, H, S);\ U_X > 0,\ U_H > 0,\ U_S < 0 \qquad (1)$$

Minor symptomatic discomforts, however, can be controlled at least partially by engaging in averting activities (V). Note that in this formulation, the individual receives no direct utility from V. Instead, when ozone levels are high and the choice is made to spend more time indoors or travel to a less afflicted location, utility is altered only indirectly through the change in S. Equation (2) shows that symptoms are tentatively specified as a function of ambient ozone concentrations (β), concentrations of other air pollutants (α), averting activities (V), and the health stock (H). The word tentatively is emphasized here. Although the symptom production functions given in equation (2) might suffice in a purely economic analysis, its specification probably can be substantially improved after taking account of medical science input. One important source of this input will be the epidemiologic dose-response estimate for symptoms to be obtained in this study (see section 5.12).

$$S = S(V, H, \beta, \alpha);\ S_V < 0,\ S_H < 0,\ S_\beta > 0,\ S_\alpha > 0 \qquad (2)$$

Note that α is included because air pollutants other than ozone also produce minor symptoms and possibly interact with ozone to produce the synergistic effects that were discussed in section 2. Moreover, the health stock is included as an argument in equation (2) in order to account for the fact that symptoms are more likely to be experienced by those who are sensitive or vulnerable to ozone exposure; for example, persons who suffer from conditions such as asthma, chronic bronchitis, and emphysema.[1]

The health stock is treated in this model as an endogenous variable, whose value is determined by the production function

$$H = H(M;\ \beta, \alpha, \delta);\ H_M > 0,\ H_\beta < 0,\ H_\alpha < 0,\ H_\delta \lessgtr 0 \qquad (3)$$

where M denotes medical care (from which the individual again derives no direct utility) and δ denotes a set of variables, such as education and genetic factors governing predisposition to disease, that affect the efficiency with which an individual can produce H. The partial derivative H_β, then, is interpreted as capturing the clinical or illness effect of ozone exposure. Again, equation (3) is tentatively specified: the final version of this equation will be decided after consideration of available medical science information.

Utility then is maximized subject to equations (2) and (3) as well as the money and time constraints shown in equations (4), (5), and (6).

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[1] Possible extensions of this specification include allowing for goods, such as cigarettes or exercise, which yield direct satisfaction and also affects health or allowing V to directly affect utility. However, the added richness resulting from incorporating these dimensions is not pursued here since the expression giving willingness to pay for improved ozone levels would be left unchanged.

$$VP_V + XP_X + MP_M = I + A \tag{4}$$

$$VT_V + XT_X + MT_M + T_W + T_L = T \tag{5}$$

$$WT_W = I \tag{6}$$

In the above equations, P_i denotes the money price of commodity i (i = X,V, M), W denotes the wage rate, I denotes money income, A denotes an exogenously determined amount of asset income, T_i denotes the time required to consume one unit of commodity i (i = X, V, M), T_W denotes time spent working, and T_L denotes the time lost from market and non-market activities. T_L, in turn, is related to the health stock and to minor symptomatic discomforts according to

$$T_L = G(H, S) \tag{7}$$

where $G_H < 0$ and $G_S > 0$ reflecting the assumption that an improvement in health or a reduction in symptoms reduces time lost from market and non-market activities. Equations (4), (5), (6), and (7) can be combined into the "full income" budget constraint shown in equation (8).

$$Vq_V + Xq_X + Mq_M + WG(H) = WT + A \tag{8}$$

where $q_i = (P_i + WT_i)$, i = X, V, M.

The model just presented, composed of equations (1), (2), (3), and (8), can be manipulated in order to derive a simple, compensating variation (CV) type expression for the marginal willingness to pay to avoid both the illness and minor symptomatic discomfort effects of ozone. This approach to calculating the marginal willingness to pay is taken because it explicitly holds utility levels constant in determining the maximum amount of money an individual would give up in order to enjoy improved air quality. The method of equivalent variation (EV) also would hold utility constant; however, since there may be only a minor difference in the numerical values of the bids produced by the two methods, the choice between them may not be important (Freeman, 25).

One way to find a suitable expression for the marginal willingness to pay for improved air quality is to totally differentiate the utility function and set dU = 0 as shown in equation (9)

$$dU = 0 = U_X dX + (U_H H_M + U_S S_H H_M)dM + U_S S_V dV + (U_H H_\alpha + U_S S_H H_\alpha + U_S S_\alpha)d\alpha$$
$$+ (U_H H_\beta + U_S S_H H_\beta + U_S S_\beta)d\beta + (U_H H_\delta + U_S S_H H_\delta)d\delta \tag{9}$$

Then, totally differentiate the full income budget constraint, as shown in equation (10), holding $dq_i = dW = dT = 0$ for i = X, M, V.

$$d(WT) = 0 = q_X dX + (q_M + WG_M H_M + WG_S S_H H_M)dM - dA + (Q_V + WG_S S_V)dV$$
$$+ W(G_H H_\beta + G_S S_H H_\beta + G_S S_\beta)d\beta + W(G_H H_\delta + G_S S_H H_\delta)d\delta$$

$$+ W(G_H H_\alpha + G_S S_H H_\alpha + G_S S_\alpha)d\alpha \tag{10}$$

Using the first order conditions from the model,

$$U_X - \lambda q_X = 0 \tag{11}$$

$$(U_H + U_S S_H)H_M - \lambda[q_M + WH_M(G_H + G_S S_H)] = 0 \tag{12}$$

$$U_S S_V - \lambda(q_V + WG_S S_V) = 0 \tag{13}$$

equation (9) can be solved for dX and then substituted into equation (10) to yield

$$\frac{\partial A}{\partial \beta} = - \frac{H_\beta q_M}{H_M} - \frac{S_\beta q_V}{S_V} \tag{14}$$

In equation (14), the first term on the right-hand-side denotes the maximum willingness to pay for reduced clinical or illness effects arising from lower ambient ozone levels while the second term denotes the maximum willingness to pay for the corresponding reduced minor symptomatic discomfort effects. The minor symptomatic discomfort term suggests that the individual will be willing to pay more (i.e., give up more asset income) for a given reduction in ozone levels, the greater the reduction in symptoms. That reduction in symptoms is measured by S_β. Also, that component of the bid will be higher, the lower the productivity of averting activities (S_V) and the higher their cost. As a consequence, if possible averting activities are an expensive and ineffective means of reducing symptoms, then quite naturally the individual will be willing to pay more for reduced ambient ozone levels. In that situation, reduced ambient ozone exposure becomes a more attractive mechanism through which to reduce minor symptomatic discomforts. The clinical or illness term on the right-hand-side of equation (14) has a similar interpretation. That is, if the medical care is an expensive but ineffective means of producing good health, then the individual would be willing to pay more for ozone control than in the reverse case.

Three additional features of equation (14) warrant further comment because they bear specifically on the question of how to obtain benefit estimates for ozone control in an applied setting. First, equation (14) is relatively straightforward to implement empirically since utility terms have been eliminated. Second, the expression for $\partial A/\partial \beta$ involves <u>partial</u> derivatives of the S and H functions. Therefore, the estimated <u>structural</u> equations for S and H (given in (2) and (3)), rather than their corresponding reduced forms in which these variables are functions only of the exogenous variables in the model, yields the quantities needed for estimating the marginal willingness to pay. This distinction is important since much previous empirical work on the air pollution-health question has involved estimating single equation, "dose-response" models. These equations are seldom derived from an explicit behavioral model and therefore the issue of structural vs. reduced form estimation usually is not considered. Nevertheless, the approach generally does leave the

mistaken impression that benefit measures are appropriately calculated from reduced form type equations. Third, and finally, the marginal willingness to pay expression in equation (14) is similar to that derived by Gerking, Stanley, and Weirick (27). In fact, the only difference between the two marginal bid expressions is the inclusion of a minor symptomatic discomfort component. Therefore, from an econometric standpoint, the methods that will be used to estimate willingness to pay to avoid ozone exposure are expected to be similar to those used in the earlier study.

4.2 Contingent Valuation Method (CVM)

Another approach to providing direct and separate valuations of the minor symptomatic discomforts of ozone exposure is provided by the contingent valuation method (CVM). The application of the CVM will proceed in three steps: (1) identifying members of the various sample groups (i.e. these are the five sensitive and vulnerable groups and the normal group discussed in section 5); (2) using medical science data, obtained during the course of the study to estimate the symptomatic health responses, by group, to varying doses of ozone concentrations; (3) asking survey respondents to value reductions in classes of symptoms established by the dose-response functions. This three-step procedure insures that benefit estimates are tied to actual exposure. This feature is important in any attempt to set standards based at least in part on health benefit estimates and is superior to simply asking respondents to value reductions in ozone concentrations directly, since the latter method forces people to implicitly estimate their own dose-response relations.

Alternatively, one might attempt to value only those symptoms which a given individual actually experienced during a recent ozone "episode". Again, however, this approach bypasses the use of medical science research. These and other ways of applying CVM which bypass step (2), and hence do not insure that benefit estimates correspond to actual exposure, are rejected. Rather, the proposed research relies heavily on epidemiologists and other medical science professionals to provide the crucial link between the contingently-valued symptom classes and scientifically measured ozone concentrations. While economists estimate the benefits of reduced symptomatic discomforts, medical scientists determine the dose-response functions which relate these symptoms to ambient ozone levels. Thus, the dollar values are linked to actual ozone levels.

Loehman et al. (50) have done pioneering work in applying CVM to air pollution-health issues. In that study, annual averages of pollutant concentrations and meteorological conditions were combined with an atmospheric dispersion model to determine ambient levels of pollution under alternative plant-emission control strategies. These ambient levels then became the inputs into a dose-response health relationship.

The dose index used was a function of SO_2, NO_2, CO, TSP, and O_x (taken to mean ozone) which allowed for synergistic effects and put each pollutant on an equal basis in terms of health effects. Incidence rates for five health effects (asthma, chronic bronchitis, lower respiratory illness in

children, chest pains, and eye irritation) were modelled as functions of the dose, age, and initial health.

Dollar values, however, were determined for symptoms of the above health effects rather than the effects themselves, since many people may not be familiar with specific diseases. The symptoms identified in the Loehman et al. study were shortness of breath, coughing/sneezing, and head congestion. These symptoms were further defined by severity (mild or severe) and duration (1, 7, or 90 days). The contingent valuation was then performed by asking the maximum amount the respondent would be willing to pay to avoid a symptom of given severity and duration. To associate these values with pollution reduction, the authors retrace their steps from symptoms and health effects to pollutant concentrations via the dose-response function, and finally to plant emissions via the dispersion model.

The proposed research will differ from the Loehman et al. study in the following respects. First, ozone will be the focus of the analysis although other pollutants, including other components of the oxidant mix, will be included in the dose-response relationship. Moreover, respondents will be matched to the closest air quality monitoring station so that ambient concentrations of ozone may be input directly into the health relationship, thereby eliminating the need for any dispersion model. Second, the sampling strategy (see section 5) will allow the use of "worst conditions" and episodes as measures of ozone concentrations, rather than the annual averages used in the Loehman et al. study. These episodes are widely believed to account for the most serious health effects. Third, the proposed research will obtain a separate estimate of benefits from reductions in minor symptomatic discomforts. As indicated in section 2, the discomforts to be examined include cough, chest pain, nausea, headache, throat irritation, moodiness, distractibility, lethargy, decrease in work capacity, depression, dampening of motivation, irritability, susceptibility to infection, and sensitivity to bright light. Finally the analysis will be carried out separately for the "sensitive and vulnerable" groups and the "normal" group. That is, a separate dose-response function will be formulated by medical scientists for each sample group, and individuals will be valuing symptoms which afflict people <u>in their group</u> at varying levels of ozone exposure. For example, if at any given level of exposure, asthmatics experience a different class of symptoms than other groups, then asthmatics will be asked to value that different class of symptoms, while other groups will not.

As previously indicated, medical science data will be collected throughout the sampling period. These data will be used to formulate the required dose-response relationships, one for each sample group. Because it will take some time to collect and analyze these data, the valuation portion cannot proceed until toward the end of the survey period (fall 1985). This is not a disadvantage, however, since fall is generally the season of peak ozone concentrations in the Los Angeles area. Thus, the respondents value information will be anchored in an event which will have occurred within the past 72 hours.

For each sample group, the dose-response relationships, formulated by medical science professionals, will give the symptoms experienced by that group at various levels of ozone concentrations. Figure 4.1, adapted from Schulze et al. (63), illustrates this approach. For example, the medical scientists indicate that at ozone concentrations of, say, .1 to .12 ppm, a certain sample group experiences one set of symptoms, while at concentrations of .20 to .35 ppm, the group experiences a second set of symptoms. Using a chart like Figure 4.1, these symptoms will be listed in the box on the right-hand side that corresponds to the appropriate levels of ozone. The various sets of symptoms may be labelled "Symptom Class 1", "Symptom Class 2", etc., for purposes of identification. The key difference with the Schulze et al. study is that the symptoms listed will be those identified by medical scientists as corresponding, by sample group, to particular levels of ozone concentrations.

Following Schulze et al., however, a chart like Figure 4.1 will be used in making the valuations. The left-hand side of the chart will be a graph of daily maximum ozone levels. One graph will be prepared for Burbank, another for Glendora. Thus, the left side of the chart varies by sample area (Burbank, Glendora), while the right side varies by sample group (the five sensitive and vulnerable groups and the normal group). Immediately after serious ozone episode occurs, the charts will be mailed to the survey respondents. Each person will receive a chart which indicates ozone levels in his sampling area and the corresponding symptoms his group experiences at those levels. After allowing only enough time for these charts to reach respondents through the mail, the respondents will be contacted and asked to value reductions in symptom classes. This is another key difference with the Schulze et al. study: respondents will be contacted as soon as possible after the ozone episode occurs. They will be asked their maximum willingness to pay to move from the symptom class that corresponds to their high ozone day to lower symptom classes.

The benefit estimates thus obtained have the following characteristics: (1) they are obtained at a time when the ozone episodes are fresh in the respondents' minds; (2) the symptoms valued are based on sound epidemiological information, so that the benefit estimates are clearly tied to actual exposure; and, (3) they can be used as checks on the values obtained with the ABM.

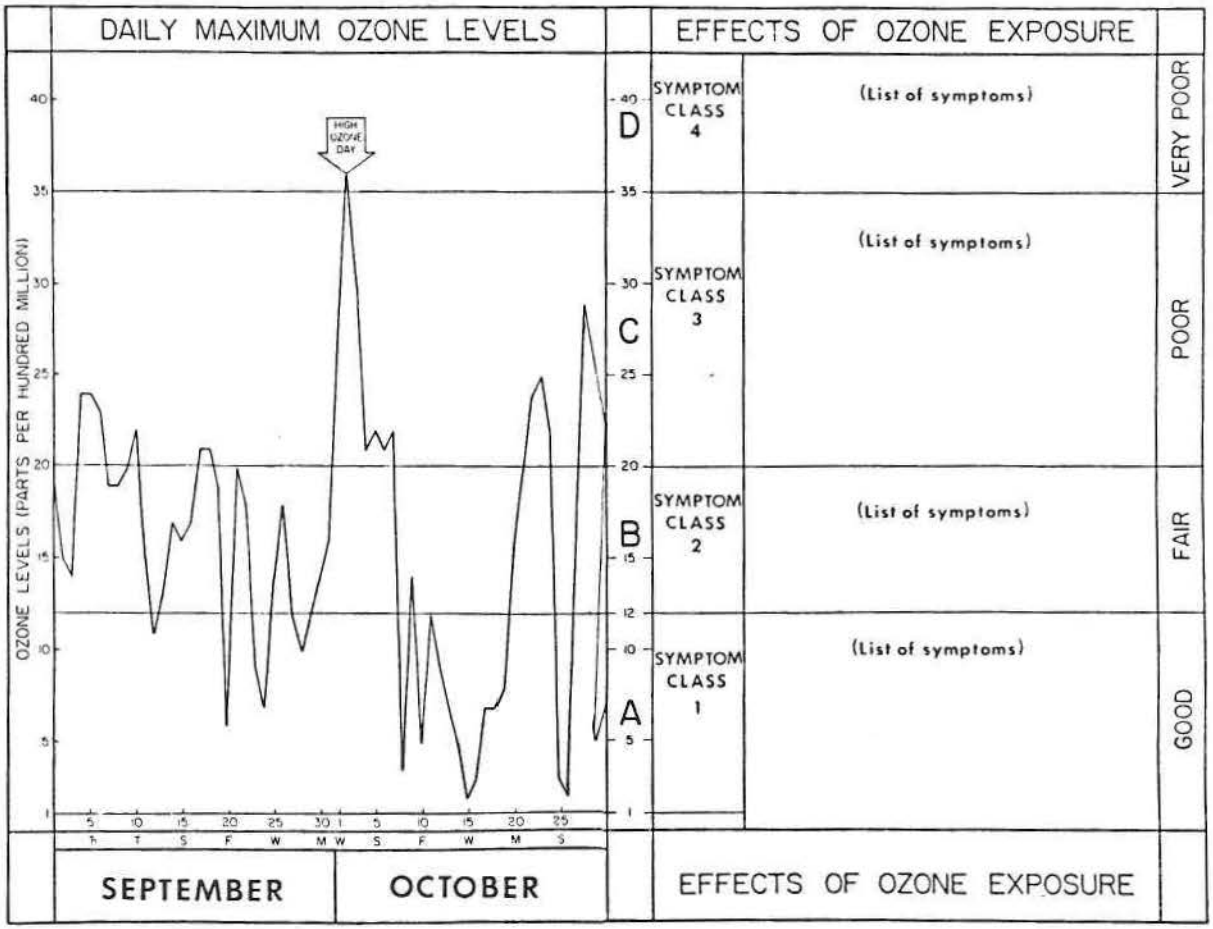
4.3 Direct Cost Method

Although not a major focus of the proposed research, some effort will be devoted to direct costing the symptoms of ozone exposure. Once the dose-response functions are formulated by the epidemiologists, the costs of relieving or alleviating these symptoms will be explored. The goal here is to identify the direct costs that are involved when an individual attempts to mitigate the effects of exposure to ozone.

Previous work in this area has been done by Portney and Mullahy (59). As in that study, the costs of restricted activity days and work loss days will be examined. These variables and their relation to the symptoms of

ozone exposure are identified in the survey instrument (see Appendices A and B). In addition, the survey asks whether any medical attention was sought to alleviate symptoms, so that these medical costs can be considered. Other possible direct costs include the costs of any drugs purchased to relieve symptoms such as headache, congestion, and eye irritation.

Figure 4.1: Example Adapted from Schulze et al. (63)



SECTION 5

DATA COLLECTION AND SAMPLING STRATEGIES

5.1 Source of Subjects

The population which will serve as a source of subjects for this proposed work is the population studied by Detels, et al. in the Chronic Obstructive Respiratory Disease (CORD) study (3-15, 60, 68). The principal and co-principal investigators for the proposed project have both participated in the CORD studies since their inception in 1972; Dean Detels is a co-investigator in the proposed study.

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 in a location convenient to the population to be studied. In general, the questionnaires used in the different communities were similar, with necessary changes relevant to the particular study (e.g., "How long have you lived in _____?" was changed to include the name of the particular area under study). Additionally, questions and coding schemes were modified or added as CORD experience and new findings in the literature indicated. For example, questions on the fuel used for cooking were added in the second visits to the communities.

Approximately five years after the first set of measurements in each community, a second round of measurements was performed. Measurements made were the same, 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 studied 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 studied in 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 studied in 1977, 2,117 of these in 1982.

5.2 Selection of Community

Among the four CORD communities, there are two candidates for inclusion in the proposed 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. Both of these studies involved payment of subjects.

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 5 years earlier, the population is five years older. No additional studies of sensitive individuals have been done by us. Burbank is closer to UCLA both in actual distance and telephone distance (cost for calls). This means that costs of doing the study in Glendora would be substantially higher in terms of personnel time, mileage and phone costs.

The panel of scientists, 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.

In the selection of the community, we are endeavoring to obtain information about a problem that is national in scope, albeit a particular problem in California. The levels of ozone pollution in Burbank are closer to those found elsewhere in the country. The levels in Glendora are high even for the South Coast Air Basin. Relative representativeness would be sacrificed to more clearly observable differences.

The frequency of poor air quality in Glendora may also 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. Residents of both communities should be studied, so that these questions could be answered.

Therefore, with serious attention to the panel's recommendation, we propose to use both the Glendora and the Burbank CORD population in this study. One hundred individuals from each community will be recruited and followed. By utilizing residents in both communities, the following advantages are available:

1) Burbank levels of air pollution are closer to those possible in other areas of the U. S. outside California, while Glendora offers the opportunity to study both more frequent and higher levels of ozone pollution.

2) Burbank levels of air pollution, and the number of pollution days, may have invoked less permanent accommodation; the existence of such permanent accommodation can be identified in Glendora.

3) The population in Burbank is less politically sensitized to the presence and problem of air pollution; the aversive behaviors induced by the politicization in Glendora can be explored.

4) Use of both communities will allow comparison of same day reports of individuals at different levels of pollution, thereby avoiding the compounding effect of time of year which itself could affect types of activities independent of pollution.

5.3 Sampling

Using the Burbank and Glendora CORD populations, individuals will be selected for recruitment into the study. Selection will be 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, will be 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 proposed 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, etc.,

Ages of persons eligible for recruitment will be 25-59 years. Children will be excluded as primary respondents because of the problems of interviewing them by phone. Age 25 has been 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 has been selected as the upper limit so as to restrict the sample to those drawn from the prime working population. The sample will be divided by age into 2 strata: less than 40 and 40-59.

Because of the economic nature of this study, one additional eligibility criterion will be imposed. All subjects will be household heads working at least 75 percent of the time. 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 section 4.1.

Sampling will also be stratified by measures of "sensitivity" or "vulnerability". A sample of size 120 persons will be selected from "sensitives", or "vulnerables," and 80 "normal" individuals will be randomly selected. "Sensitives" and "vulnerables" will be defined in two ways:

1) Individuals with respiratory disease such as adult asthma, chronic bronchitis or emphysema diagnosed and treated by a physician. (This is determined in part by existing CORD data, supplemented by baseline questionnaire.)

2) Individuals who engage regularly in outdoor occupational or recreational activity which results in high minute ventilation (deep and fast breathing). (This will be determined by baseline questionnaire.) Such individuals might be expected to be more vulnerable to possible adverse effects of air pollution.

A statistical power analysis designed to support the choices of total sample size as well as the sample sizes in each stratum is presented in Appendix F. Strata within the sensitive and vulnerable group will include 60 persons with physician-diagnosed CORD from group (1) and (2) 60 "athletes" from group (2).

In summary, sampling will be restricted to white, non-smokers who live within the original census tract or in the same proximity to the air quality monitoring station, who are employed and who have small or no transfer payment income. The 200 subjects will be stratified into 120 sensitives and 80 randomly selected "normal" individuals, stratified by age (<40, 40-59 - approximately 50% in each). Division between communities will be approximately 50-50 for each sensitivity and age stratum.

Those selected will, to some extent, be index cases for their households, the sample will in fact be larger. It will be possible to relate the household structure to the CORD population, but it would be extremely complex to utilize household characteristics in the sampling scheme. Therefore, the characteristics of this extended sample cannot be described in advance.

The method of sampling will utilize the most recent available CORD data for each individual in the CORD population. Smokers, persons outside the age range and persons who have moved away from the area will be deleted. The population of each community will be divided into known sensitives and the rest; each of these sub-populations will be subdivided into age strata. The population in each of these twelve subdivisions (sensitivity (2) x age (3) x community (2) will be randomized and printed out. Recruitment will start with the first individual on each list and will continue until the stratum is filled.

5.4 Recruitment

After the sampling procedures are completed, study participants will be recruited, in order from the sampling lists. Recruiting for a particular group will be stopped when the desired number of the group have agreed to participate.

The initial step in recruiting will consist 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 will be called in the next week regarding the new study.

The second step will be a phone call. During this call, the study will be more fully explained, any questions will be answered, required eligibility criteria will be ascertained (non-smoking, still live in the area, working full time, not more than 10 percent of income based on transfer payments) and agreement to participate will be obtained. Following the agreement, a household roster will be elicited, and an in-person baseline interview will be scheduled.

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

Recruitment of subjects will continue until the required group sizes are completed. To reduce waiting time, recruitment can proceed simultaneously on enough individuals to fill any specified group. However, to avoid bias involved in recruiting the "easier" subjects, no one on a randomized list, beyond the number needed for the group, may be recruited until a refusal, ineligibility or transfer occurs among those within the number needed. That is, if 60 persons are needed for a given group,

recruitment may proceed simultaneously on the first 60 persons on the randomized list. Person number 61 may not be recruited until it is known that one of the first 60 is not a participant.

Individuals definitely declining to participate on the first phone call will not be contacted further. Their identity will be retained only to preclude further contact in recruitment. Following recruitment, only a deeply encoded identification number, demographic and other CORD variables, and the fact of refusal will be maintained. This file will be used solely to characterize non-respondents and refusals. No cross-identification to the CORD files will be possible without the equation of the deep encoding, to which access is limited to the investigators only.

Individuals uncertain about participation on the first phone call will be sent appropriate additional material and will receive a home visit if appropriate. Should the uncertainty become refusal, they will be treated as specified above. If they agree to participate, then they will be treated as participants. Because of the time line in the study (see section 6), no more than 4 calendar weeks can be allowed for decision making. Individuals still undecided by that time will be regarded as non-respondents and dropped from further recruitment efforts.

5.5 Payment of Subjects

The number of contacts required with this panel of subjects necessitates paying them if continued participate is to be assured. We propose to pay each individual the sum of $51.00 for the full course of contacts. The subject will be $5.00 for the baseline interview, $4.00 for each of the anticipated 10 telephone follow-up interviews, with a bonus of $10.00 for those completing the series without missing more than 3 contacts. Checks will be sent after the baseline data collection and quarterly thereafter. The $10.00 bonus checks will be sent at the end of the study. (In calculating the $51.00, we have assumed that, on the average, each subject will miss one of the potential 10 contacts.)

5.6 CORD Measures

A great deal of information was collected on each of the potential study subjects during their two or three contacts with CORD and the mobile lung function laboratory. A copy of the questionnaire used in the second Burbank visit is included in Appendix C. As explained above under selection and sampling, certain of these measures and responses will be used to determine study eligibility and subgrouping. These include age, sex, smoking behavior, physician diagnosed asthma, chronic bronchitis, or emphysema, reported symptoms and FEV_1 as a percent of predicted FEV_1.

Other CORD measures will be used to determine the frequency and distribution of responses among these individuals. This information will be used to estimate possible frequency and distribution in the proposed study. Also, these variables can be used to characterize those not

selected, refusals and non-respondents in comparison with those who do participate.

CORD data available will be reviewed. Those variables which will not be repeated in the proposed study, especially physical measurement including common lung function tests, will be incorporated in the baseline file for the participants. Similarly, historic information on residence and occupation and exposure information, such as fuels used in heating and cooking, will be incorporated.

To the extent possible, transforms, scales and reclassified or reduced variables will be used, where these will be equally well or better serve the proposed study, thus protecting the primary cord data for further analysis by CORD investigators. Data collected in the proposed study which is useful in the analysis or interpretation of CORD data will be shared with CORD investigators.

5.7 Baseline

After recruitment, baseline data will be collected from participants by home visit. Items of data to be collected include information about the subject, the composition of the household, characteristics of other household members and characteristics of home environment that may affect respiratory function or exposure to ambient air.

Information about the subject includes confirmation of data of birth, length of stay in the East San Fernando Valley area, educational status, and occupational history. The NHLBI symptom and respiratory disease questions will be repeated. Detailed income and occupational information (current) will be collected, including location, method of commuting, indoor or outdoor work, air conditioning, filtering, materials handled at work and level of physical activity. Leisure activities will also be covered in the same kind of detail in attempt to measure the extent of averting behavior in response to ozone levels. A list of symptoms, including those which may result from ozone exposure and some which may not will be checked, as will a medical history of diseases and medications that may imply a special sensitivity. Information regarding recent contacts with the health care system and health insurance also will be gathered.

Composition of the household will include a roster of household members including age, sex, relationship to the subject, occupation, level of leisure time activities and history of respiratory disease. (If a household member was included in the CORD study, CORD records will be checked for special susceptibility indicators (asthma, bronchitis, emphysema, low FEV_1,) and background data.

Characteristics of the home environment will include presence and use of air conditioning, filtering, presence of ozone producing devices (ionizers), fuel used for cooking, heating, and cooling character and extent of insulation, extent of traffic within one block of the house, household ownership and use of air conditioned cars.

Draft baseline data collection instruments are included in Appendix A. These instruments have been developed based on our experience in previous studies, literature review, and the health and ozone telephone conference mentioned previously. The drafts are presently under review by the expert panel and by questionnaire experts. Final instruments will be based on the results of these reviews and a pretest in the field.

The time line for the proposed study allows for recruitment and baseline data collection in January, perhaps extending into February 1985. These months typically have the lowest air pollution levels of the year. Thus, the responses to the baseline data collection should reflect activities, health, and facilities independent of air quality problems.

5.8 Follow-up

Each subject will be phoned once within each calendar month. The calls will be approximately one month apart. A calling schedule will be computer designed for each day, to maximize days with ozone exposure and to balance weekday and weekend reports.

Data will be collected about the day of the call and the previous two days. We anticipate that if the day before the previous day was a weekend day, it will be better recalled by the subject than if it were another weekday. This is because of the change of activity associated with weekend days, which may be very different from one another. However, data will always be collected for the three day period; the day-of-the-week effect will be accounted for in the analysis.

Information will be collected on the subject's symptoms, work place, domestic, community and leisure-time activities, changes in activities occasioned by the weather or air quality, indoor/outdoor time, illness, disability, work loss and medication used or medical visits. A short version will be asked about each household member. At the end of each interview, the subject will be asked for his/her opinion of the air quality for each of the two or three days. Also, as stated in section 4.2, at the end of the series of follow-up telephone interviews, the CVM questions will be included that elicit willingness to pay for reduced ozone levels.

Data will be collected by study staff specifically trained to use the instrument. Time of day of collection will range from late afternoon into the evening and will be specifically negotiated with each individual. At each contact the data collector will ask if the time is convenient. If it is not, the data collector will arrange to call back, at another agreed upon time. Weekend calls will be made on Saturdays during the day, for the most part. A general idea of a convenient time for Saturday calls will be obtained at baseline; at each contact the data collector will first ascertain if the time is convenient. If it is not the data collector will call back.

A draft data collection instrument for telephone follow-up is included in Appendix C. This draft also is being circulated to the ozone and health

conferees and to experts in telephone data collection. The final version will be modified in accordance with their recommendations and will be subject to pretest, in the same manner as the baseline instrument.

In order to complete the study with as little inconvenience to the subjects as possible, thereby reducing the drop-out rate, we plan to have the follow-up contact take approximately 20 minutes for data collection. If the subject has a great deal to report, it may, of course, take longer to complete. Our experience has been that a data collection contact that is extended by the subject's information is not regarded as long by that subject.

Because of the time limitation, standard update items, independent of the air quality, may be asked only every other month. If a change has occurred, the time of that change will be ascertained.

5.9 Hot-line

A telephone line will be established for use by study subjects to call in concerning symptoms, activities, perception of air quality or other factors in themselves or members of their households. These calls will be independent of and in addition to the regular telephone follow-up. Subjects will be encouraged to call after 4 PM, and will record their messages on a telephone answering machine. A card will be given to the subjects. The card will include the special number and the procedure for its use. The tape will be transcribed each day, and responses will be coded and related to air quality on the day of the call.

We are indebted to Professor Carroll Cross who suggested this creative method for additional data collection during our health and ozone conference.

While data collected in this way are not consistent across individuals, they will provide information at extra points in time for some individuals.

5.10 Air Pollution Measures

The air pollution measures to be used will be those made at the site nearest to the census tract in Burbank and in Glendora. This station is not more than one mile from any point in the census tract. Data from surrounding stations, both Southern California Air Quality Management District (SCAQMD) and California Air Resources Board (ARB) will be used as appropriate to characterize the ambient air quality in the census tract.

The ozone and health conference members commented on the possibly poor relationship between personal pollutant exposure and the ambient air quality. It would indeed be interesting to take selected individuals, based on their baseline and follow-up data, and perform indoor/outdoor

and personal monitoring. This could make an important add-on to the proposed study.

However, the questions of greatest concern are those relating to ambient air quality which is measured at specific air quality monitoring stations and is regulated according to those measurements. Therefore, in the proposed study, modification of exposure to ambient air will not be directly measured but will be estimated based on home environment characteristics, time outdoors and time away from the area.

Ozone and other pollutant data will be obtained on a daily basis, by phone, from the SCAQMD. The measure used will be the maximum hourly average for pollutants measured on a continuous basis, and the most recent measurement for those measured over a time period. This initial information will allow planning for calls in the telephone follow-up for the evening and the next day as well as providing an initial air quality input into the data file.

Air quality data will also be obtained from the SCAQMD on a monthly basis. These output sheets, one per pollutant, are prepared once each month and have, where appropriate, hourly and summary pollution data for each air monitoring station for each day of the month. These data will be key entered for use in preliminary analyses.

Data tapes of air monitoring station measurements will be obtained as the become available on a quarterly basis. These tapes include additional information, are "cleaned" data and are, of course, computer readable. Data from these tapes will be identical with published air quality data. Cleaning and appropriate adjustment may result in some deviation from the daily and monthly figures described above.

These data tapes will be used as the source of air pollution information in the major analysis.

While the primary focus of the proposed study is ozone as a pollutant, the free living population in any area is exposed to other pollutants at the same time. There may be a combination of effects from these pollutants. It is, therefore, necessary to include other pollutants in the analysis. All measured pollutants will be examined for inclusions, which will be based on the inter-correlation of the pollutants in time and the potential confounding resulting from similar health effects associated with different pollutants.

Air pollution and its effects may be modified by changing climatologic conditions. Therefore, measurements of temperature, humidity, wind speed and direction, and barometric pressure will be added to the data set. These measures will be obtained from the National Weather Service. The site of the measurements will be the Burbank Airport, located within 2 miles of the census tract of the residence of the study subjects.

5.11 Data Collection Instruments

Data collection instruments will be used for recruitment, eligibility check, baseline information, and follow-up data collection for participants in the study. (It is anticipated that air pollution and meteorologic data will be obtained in computer readable form. If not, then data collection instruments will be designed for those purposes.)

Data collection instruments will be self coding to the extent possible. As the instruments will be completed by trained data collection staff, the usual trade offs between self coding and understanding by the untrained completer are not pertinent.

For those parts of the data collection instruments not self coding, such as attitude toward air pollution, reports of effects and the whole of of the "hot line" reporting system, initial codes will be established. These will be as complete as possible and hard copy registers in which actual responses are recorded will be maintained. As the study progresses, codes will be developed based on the frequency and content of the initial codes and the content and structure of the material in the registers. Instruments to be used in the study are listed below:

1. Recruitment
2. Eligibility check
3. Baseline interview schedule
4. Telephone follow-up interview schedule
5. "Hot Line" call-in recording form
6. CORD background data (questionnaire and lung function)
7. Air quality data
8. Meteorology data

Draft forms of instruments 3 and 4 are included in Appendices B and C. Instruments 1-4 are based on interaction with the participant. Instrument 5 will be used to extract data from relatively free form responses on voluntary call ins. Instruments 6, 7 and 8 are planned to be computer compilations of information necessary to the study from already available computer readable data sets. Some review of CORD files may be necessary, particularly for CORD updates through mailed questionnaires. Initial reports of air quality and meteorology, to assure timeliners, may be abstracted from non-computer readable material and key entered as part of the study.

Data Management

After the data are collected, instruments will be visually checked for completeness to identify any problems in a timely manner. Any necessary coding and registering of responses will be completed at that time. All forms will be key entered by a professional key entry service and will be 100 percent verified. Subsequent to key entry, records will be entered into the mainframe computer where initial computer editing will be accomplished including range and consistency checks.

Errors discovered through any of these procedures will be referred back to the data collector, checked against the original instruments or checked with the respondent as appropriate. Unresolved, unacceptable values will be declared missing through error.

Newly collected data will be added to already collected data on the same subjects through computer linkage programs. Thus, the initial data file will include CORD and recruitment data; baseline date will be concatenated with it, as will monthly follow-up data, etc. Following linkage, consistency checks across time will be performed.

Subfiles of the main data tapes, including scales, transformation, specifically limited numbers of data items or subsets of subjects, will be created for analysis as needed.

A special subfile will be created and maintained for study management. Subject contact will be managed by computer. Lists of subjects to be contacted in a given time period, subjects overdue for contact, subjects requiring contact on some particular type of day, etc. will be printed out. This file will be separated from the main file and will include name, address, phone number and other identifiers. These confidential data will be protected by a deeply encoded identification number, thus preventing linkage of identifiers to personal data by unauthorized persons.

5.12 Analysis

Analysis will be an ongoing process throughout the study, starting with the characterization of the population to be recruited, continuing with the characterization, according to CORD variables, of the eligible residents, and the non-respondents and refusals.

Baseline data in combination with CORD data will be analyzed following the completion of intake of subjects. Frequency distributions will be done and differences among the subgroups will be explored.

Follow-up data will be analyzed as it is added to the data set. Differences in changes among the subgroups and, within the subgroups, between times of high and low oxidant exposure will be evaluated. The use of regression and discriminant analysis in assessing symptoms, activities and behavioral modifications associated with pollution levels will be evaluated on an ongoing basis.

Other types of analysis will be explored through the data collection period and will be utilized, as appropriate, in the major analyses. These data are extremely complex, involving chemical measurements, reporting of symptoms, background lung function measures, perceived changes in activity and other variables, all or most of these over time. We have had experience with a number of studies of this kind and have worked out some informal exploratory techniques which we will utilize in this study.

Major analyses will be done in the summer of 1985 on data collected through June 1985 and again in December of 1985 on data from the whole study. Analyses to be used will depend in part, on the exploratory analyses done concurrently with data collection. Multivariate techniques will be employed as appropriate.

The analyses described here are primarily epidemiologic in nature and will be used to relate health, activity, background, and personal data with air quality. There will, of course, also be economic analyses, resulting in an assessment of the willingness-to-pay for reduced ozone exposure. The approaches to be used (ABM, CVM, and DCM) are described in section 4 and that discussion is not repeated here. However, the direct link between the ongoing epidemiologic analysis, which will produce preliminary ozone dose-response functions during the study, and the estimation of the symptom functions needed in all three economic approaches should be noted.

SECTION 6

TIME LINE OF PERFORMANCE AND DELIVERANCE

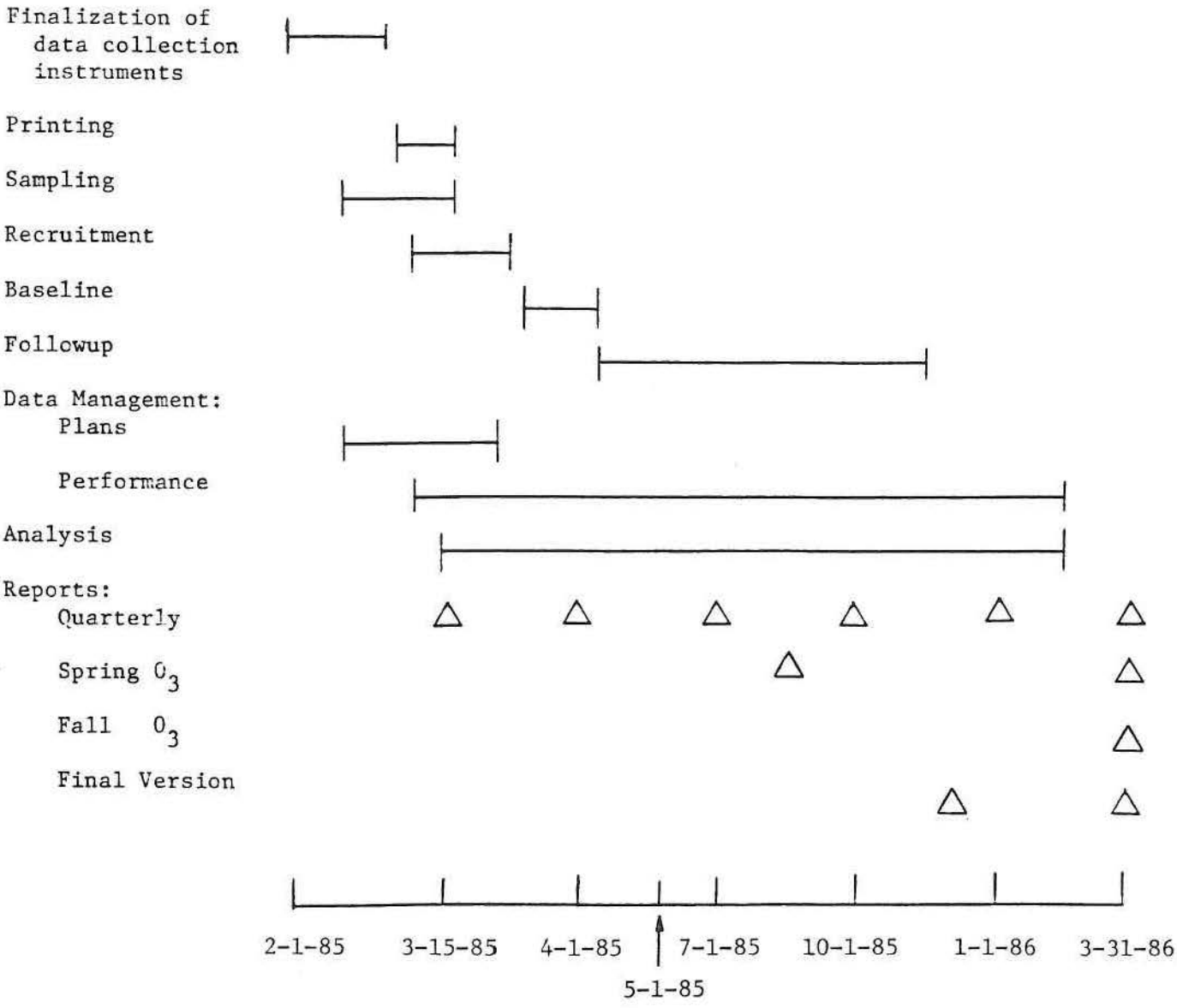
The period of the proposed study is February 1, 1985 - March 31, 1986.

During the first six weeks (February 1, 1985 - March 15, 1985) the questionnaires will be finalized and printed, potential subjects will be selected, data on those subjects will be transferred to a temporary file pending recruitment and agreement to participate and recruitment will be conducted.

In April 1985, recruitment will be completed, and baseline questionnaires administered. Regular follow-up contact for ozone experience and update of information will be initiated in May 1985 and will continue until Thanksgiving (November 28, 1985) or until the first November rain (signalling the end of the pollution season), whichever comes first.

During the period July 1, 1985 - August 31, 1985 while data collection is ongoing, the data collected through June 30, 1985 will be processed and analyzed for a preliminary major report to USEPA. This report which will relate to Spring episodes of ozone exposure and their effects on the population, should be of particular interest since Spring ozone levels in the Los Angeles area are more similar to national conditions in that they are lower than their fall counterparts. A second preliminary major, to be completed in December, 1985, will focus on the fall episodes of ozone exposure and their effects on the population. During the final quarter (January 1, 1986 - March 31, 1986), the final report will be prepared concerning the entire study time period, supplementing the October report (see above) in concentrating on the summer and fall ozone episodes.

PROJECT TIME LINE



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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		

R.I.D.#

NAME	NAME	NAME
A. Relationship:	A. Relationship:	A. Relationship:
B. Sex: Male.....1 Female....2	B. Sex: Male.....1 Female....2	B. Sex: Male.....1 Female....2

Good morning, afternoon, evening, I'm (...) from the _____. We're conducting a survey for the _____. You may recall that your household received a (letter/phone call) about this very important study. Please be assured that all the information is confidential and your name will not be identified with the study.

1. First, I'd like to make a list of all the persons who are permanent members of your household starting with yourself. Just give me the first names. RECORD FIRST NAMES ON CHART ABOVE.

   A. Who is the head of the household? INDICATE "HEAD" IN CHART ABOVE IN A.
   How is (...) related to the head of the household? INSERT NAME OF PERSON FOR (...) - INDICATE RELATIONSHIP. (SPOUSE, CHILD, PARENT, PARENT IN LAW, ETC.)
   INDICATE RESPONDENT - "R" OPPOSITE NAME.

   B. CODE SEX IN CHART ABOVE. ASK ONLY IF UNSURE.

   C. Is there anyone else who usually lives here, like a roomer or boarder? ADD TO ROSTER (CHART ABOVE) - ASK A & B.

   D. Have I missed anyone who is away temporarily? Any babies? ADD TO ROSTER - (CHART ABOVE) - ASK A & B. USE ADDITIONAL ROSTERS IF NECESSARY.

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 YEAR: _____

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, since (...), 1984, 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.

RECORD # OF TIMES: _____

8. When you do go for health care, how long do you usually have to wait to see your doctor? CODE ONE

30 MINUTES OR LESS 1
31 MINUTES TO 1 HOUR 2
1 - 2 HOURS 3
MORE THAN 2 HOURS 4

9. About how much does your doctor or health care provider usually charge for an office visit?

RECORD $: _____

10. On the average, how long does it take you to get to your doctor or clinic?

LESS THAN 15 MINUTES 1
16 - 30 MINUTES 2
31 - 60 MINUTES 3
MORE THAN 1 HOUR 4

11. How many times during the past year have you phoned your doctor for medical advice or assistance?

RECORD # OF TIMES: _____

Now I'd like to ask you some questions about health care insurance and health maintenance organizations.

12. Do you have any type of health insurance policies or belong to a health maintenance organization (HMO, like Kaiser) that cover outpatient expenses?

YES . . . ASK A 1
NO . . . SKIP TO Q14 2

A. How many do you have or belong to?

RECORD TOTAL #: _____

13. What type of coverage for outpatient health care is provided? Do you have a:

A. Deductible with coinsurance? (You pay to the amount of the deductible, then you pay some %.)

YES . . . ASK a 1
NO . . . SKIP TO B 2

a. What is the deductible?

RECORD $: _____

b. Is the deductible:

Per Year 1
Per Illness or Injury . . 2
Lifetime, or 3
Something Else? 4
Specify: _____

B. Deductible without coinsurance? (You pay to the amount of the deductible, then your insurance pays all costs.)

YES . . . ASK a 1
NO . . . SKIP TO C 2

a. What is the deductible?

RECORD $: _____

b. Is the deductible:

Per Year 1
Per Illness or Injury . . 2
Lifetime, or 3
Something Else? 4
Specify: _____

C. Coinsurance without deductible? (You pay a % of the costs. There is no deductible.)

YES . . . ASK a 1
NO . . . SKIP TO D 2

a. Is the coinsurance provision:

80-20, or 1
Something Else? 2
→ Specify: _____

D. An Insurance Policy or HMO that pays for all covered medical expenses. You or your employer only pay premiums?

YES 1
NO 2

E. Some other type of policy?

YES . . . Ask a 1
NO . . . SKIP TO Q14 2

a. Please tell me about this policy. PROBE

_____

_____

_____

14. In a typical year, about what percentage of your yearly medical expenses are paid by your insurance or health maintenance organization? Please include eye doctors, chiropractors and psychiatrists. Do not include dentists or orthodontists.

RECORD: _____%

15. (Does/Do) your policy(ies)

Cover only yourself 1
Cover yourself and your spouse, or . . . 2
Yourself, your spouse and children under 18 years old 3
Other 4
→ Specify: _____

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

RECORD TIME: _____
NEVER . . . SKIP TO Q17 90

A. What was the problem?

_____

_____

_____

17. During the last year, since _____, 1983/84, 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 Q18 2

A. How many times, separated by at least one day, were you admitted to a hospital to stay overnight or longer, since _____, 1983/84? 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.

18. Do you usually cough first thing in the morning in bad weather?

YES 1
NO 2
DON'T KNOW 8

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

YES 1
NO 2
DON'T KNOW 8

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

YES 1
NO 2
DON'T KNOW 8

21. Do you cough first thing in the morning (when you get up) on more than 50 days in a year?

YES 1
NO 2
DON'T KNOW 8

IF COUGH IS REPORTED (Q18 - Q21) . . . . ASK Q22
IF NO COUGH IS REPORTED (Q18 - Q21) . . . ASK Q23

22. How long have you had the cough -- about how many weeks, months or years?

WEEKS _____
MONTHS _____
YEARS _____

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

YES 1
NO 2
DON'T KNOW 8

24. 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
DON'T KNOW 8

25. 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
DON'T KNOW 8

26. Do you bring up any phlegm from your chest first thing in the morning on more than 50 days in a year?

YES 1
NO 2
DON'T KNOW 8

27. Do you bring up any phlegm from your chest later in the day on more than 50 days in a year?

YES 1
NO 2
DON'T KNOW 8

IF "YES" TO ANY - Q23 - Q27 . . . . . ASK Q28
IF "NO" TO ALL - Q23 - Q27 . . . . . SKIP TO INSTRUCTION BELOW Q28

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

WEEKS _____
MONTHS _____
YEARS _____

IF COUGH OR PHLEGM (MUCOUS) REPORTED - Q18 - Q27. . ASK Q29
IF NEITHER REPORTED - Q18 - Q27 . . . . . SKIP TO Q31

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

YES . . . ASK A 1
NO . . . SKIP TO Q30 2

A. When? CODE ALL MENTIONS

SUMMER 1
FALL 2
WINTER 3
SPRING 4
ALL YEAR 5

30. 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 Q31 2
DON'T KNOW . . SKIP TO Q31 . . 8

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

YES 1
NO 2
DON'T KNOW 8

31. Does your breathing ever sound wheezing or whistling?

YES . . . ASK A 1
NO . . . SKIP TO Q32 2
DON'T KNOW . . SKIP TO Q32 . . 8

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

RECORD DAYS: _____
DON'T KNOW 98

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

YES 1
NO 2
DON'T KNOW 8

33. 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 Q34 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

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

YES . . . ASK A 1
NO . . . SKIP TO Q35 2

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

RECORD DAYS: _____
DON'T KNOW 98

35. 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 Q36 . . . 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: _____
WEEKS: _____
MONTHS: _____
YEARS: _____

36. Do you have any symptoms when it's smoggy?

YES . . . . . ASK A 1
NO . . . . SKIP TO Q55 2
DON'T KNOW . . SKIP TO Q55 . . 8

A. What symptoms do you have?

_____

_____

_____

_____

37. Now I'd like to read you a list of symptoms other people sometimes have on smoggy days. As I read each one, please tell me if you have ever experienced this and if it bothers you today. READ a - z. CODE IN APPROPRIATE COLUMN.

	EVER		TODAY	
	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

	EVER		TODAY	
	YES	NO	YES	NO
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	2	1	2
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) 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 times 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 Q37 . . . . . ASK Q38 IF "NO" TO ALL SYMPTOMS IN Q37 . . . . . SKIP TO Q38A

38. You said that you do have some symptoms. ASK A-F; CODE IN COLUMN I OF CHART

	I
Please tell me if: A. You change your activities at all to <u>avoid</u> having any of these symptoms?	YES . . . Ask a . . . . 1 NO . . . Skip to B . . . 2 a. What do you do differently? _____ _____
B. Does having any of these symptoms prevent your going to work or from doing your regular chores?	YES . . . . . 1 NO 2
C. Does having any of these symptoms prevent you from doing something that would have required more effort?	YES . . . . . 1 NO 2
D. Do You take any medication or treatment for relief of these symptoms?	YES . . . . . 1 NO 2
E. Do you seek medical attention for these symptoms?	YES . . Ask a . . . . . 1 NO . . Skip to F . . . . 2 a. Where did you go? DOCTORS OFFICE . . . 1 EMERGENCY . . . . . 1 HOSPITAL 2
F. Does having any of these symptoms make you change your usual or planned activities?	YES . . Ask a . . . . . 1 NO . . Skip to Q38 . . . 2 a. In what way? _____ _____

38A. Now a few questions about the last three days. Thinking about the last 3 days did you: ASK A-D; CODE IN COLUMN A - IF "YES" ASK "B" AND "C" - If "NO" GO TO NEXT;

B. How many days? CODE IN COLUMN B

C. What was the problem? RECORD IN COLUMN C

	A	B Number of Days	C Specify Problem
A. Stay in a hospital or nursing home?	YES... 1 NO.... 2	Record #_____	_____ _____ _____
B. Stay in bed due to illness or injury?	YES... 1 NO.... 2	Record #_____	_____ _____ _____
C. Have to restrict your usual activity due to illness or injury?	YES... 1 NO.... 2	Record #_____	_____ _____ _____
D. Illness or injury keep you from: a. Work?	YES... 1 NO.... 2	Record #_____	_____ _____ _____
b. Work around the house?	YES... 1 NO.... 2	Record #_____	_____ _____ _____
c. Leisure time activities?	YES... 1 NO.... 2	Record #_____	_____ _____ _____

39. Please tell me about the activities you do most often. Think about a typical week. I would like to know the five you do most frequently. Below, a list of many popular activities is provided.

LIST OF ACTIVITIES

Backpacking
Badminton
Ballooning
Baseball/Softball
Basketball
Beekeeping
Bicycling
Billiards
Birdwatching
Boating
Bowling
Boxing
Camping
Computers
Canoeing
Crew
Cricket
Croquet
Cross Country Skiing
Dance
Diving
Doing Odd Jobs
Downhill Skiing
Drama
Driving for Pleasure
Fencing
Field Hockey
Fishing
Painting
Photography
Picnicking
Piloting/Flying
Ping Pong
Polo
Rafting
Raquet Ball
Rock Climbing
Rodeo Participation
Roller Skating
Running
Gymnastics
Handball
Hang Gliding
Hiking
Horseback Riding
Horse Racing
Home Repairs
Hunting
Ice Hockey
Ice Skating
Kayaking
Lacrosse
Martial Arts such as Karate
Mechanics
Metal Work
Meteorology
Motorbiking
Mountaineering
Movies
Music
Outings
Social Dancing
Spelunking
Sports Spectator
Squash
Sunbathing
Surfing
Swimming
Tennis
Touch Football
Track & Field
Travel/Tour
Sailing
Scuba
Sculpture
Shopping
Sightseeing
Skeet/Trap Shooting
Sketching
Skydiving
Snorkeling
Soccer
Visiting Friends
Walking
Walking the Dog
Water Polo
Water Skiing
Weight Lifting
Wind Surfing
Wrestling
Yard Work
Other, specify: _____

39A. My next questions are about activities people sometimes do. We are interested in the activities you do most often. Please look at this list (HAND #39). Now, thinking about a typical week in your life, please tell me the five activities you do most often. RECORD IN COLUMN A OF CHART BELOW--ASK B-K FOR EACH ACTIVITY.

B. About how many hours a week are you involved in (...)? INSERT ACTIVITY FOR (...) - RECORD IN COLUMN B.

C. How many times a week are you involved in (...)? RECORD IN COLUMN C.

D. What does it cost you to (...) each time? Fees, Tickets, Materials, etc. RECORD IN COLUMN D.

E. Where do you do (...), at home, work or somewhere else? CODE IN E.

F. Where do you leave from to go there? RECORD IN COLUMN F.

G. How long does it take you to get there? RECORD IN G.

H. How do you get there? CODE IN COLUMN H.

I. How much does it cost you to get there? RECORD IN I.

J. Do you do this (...) indoors or outdoors? CODE IN COLUMN J.

K. What time of the day do you usually do (...)? RECORD IN K.

A. ACTIVITY	B. HOURS PER WEEK	C. # TIMES PER WEEK	D. COST EACH TIME	E. LOCATION	F. WHERE LEAVE	G. TIME GOING	H. METHOD TO GO	I. COST TO GO	J. WHERE	K. TIME OF DAY
1.				HOME.....1 WORK.....2 OTHER.....3 SPECIFY IF AT HOME OR WORK--SKIP TO J ALL OTHERS - CONTINUE			CAR.....01 CARPOOL.....02 WALK.....03 VANPOOL.....04 BICYCLE.....05 MOTORCYCLE...06 PUB. TRANS...07 OTHER.....08 SPECIFY	$	OUTDOORS...1 INDOORS....2	AM PM

A. ACTIVITY	B. HOURS PER WEEK	C. # TIMES PER WEEK	D. COST EACH TIME	E. LOCATION	F. WHERE LEAVE	G. TIME GOING	H. METHOD TO GO	I. COST TO GO	J. WHERE	K. TIME OF DAY
2.				HOME.....1 WORK.....2 OTHER.....3 → SPECIFY IF AT HOME OR WORK--SKIP TO J ALL OTHERS - CONTINUE			CAR.....01 CARPOOL.....02 WALK.....03 VANPOOL.....04 BICYCLE.....05 MOTORCYCLE...06 PUB. TRANS...07 OTHER.....08 → SPECIFY	$	OUTDOORS...1 INDOORS....2	AM PM
3.				HOME.....1 WORK.....2 OTHER.....3 → SPECIFY IF AT HOME OR WORK--SKIP TO J ALL OTHERS - CONTINUE			CAR.....01 CARPOOL.....02 WALK.....03 VANPOOL.....04 BICYCLE.....05 MOTORCYCLE...06 PUB. TRANS...07 OTHER.....08 → SPECIFY	$	OUTDOORS...1 INDOORS....2	AM PM
4.				HOME.....1 WORK.....2 OTHER.....3 → SPECIFY IF AT HOME OR WORK--SKIP TO J ALL OTHERS - CONTINUE			CAR.....01 CARPOOL.....02 WALK.....03 VANPOOL.....04 BICYCLE.....05 MOTORCYCLE...06 PUB. TRANS...07 OTHER.....08 → SPECIFY	$	OUTDOORS...1 INDOORS....2	AM PM

A. ACTIVITY	B. HOURS PER WEEK	C. # TIMES PER WEEK	D. COST EACH TIME	E. LOCATION	F. WHERE LEAVE	G. TIME GOING	H. METHOD TO GO	I. COST TO GO	J. WHERE	K. TIME OF DAY
5.				HOME.....1 WORK.....2 OTHER.....3 → SPECIFY IF AT HOME OR WORK--SKIP TO J ALL OTHERS - CONTINUE			CAR.....01 CARPOOL.....02 WALK.....03 VANPOOL.....04 BICYCLE.....05 MOTORCYCLE...06 PUB. TRANS...07 OTHER.....08 → SPECIFY	$	OUTDOORS...1 INDOORS....2	AM PM

40. Now, I'd like to ask you some questions about you and other members of your household. ASK A-H FOR EACH PERSON. INSERT NAME FOR (...).

A. How old is (...)?	RECORD AGE: ______	RECORD AGE: ______	RECORD AGE: ______
B. (HAND CARD #40B) Please look at this card and tell me the letter of the ethnic or racial group that best describes (...)?	A. WHITE......01 B. BLACK......02 C. MEXICAN....03 D. OTHER LATIN.....04 E. ASIAN......05 F. NATIVE AM..06 G. OTHER......07 → SPECIFY ______	A. WHITE......01 B. BLACK......02 C. MEXICAN....03 D. OTHER LATIN.....04 E. ASIAN......05 F. NATIVE AM..06 G. OTHER......07 → SPECIFY ______	A. WHITE......01 B. BLACK......02 C. MEXICAN....03 D. OTHER LATIN.....04 E. ASIAN......05 F. NATIVE AM..06 G. OTHER......07 → SPECIFY ______
C. Is (...) currently employed?	YES...ASK a....1 NO..SKIP TO D..2 a. What does (...) do? ______	YES...ASK a....1 NO..SKIP TO D..2 a. What does (...) do? ______	YES...ASK a....1 NO..SKIP TO D..2 a. What does (...) do? ______
D. Does (...) have asthma?			
E. Does (...) have bronchitis?			
F. Does (...) have emphysema?			
G. Does (...) have hay fever?			
H. Does (...) have other respiratory disease?			

41. Now some questions about your home. Are you located within 2 blocks of a major street or freeway?

YES 1
NO 2

42. Do you live in a:

House/Single family unit 1
Apartment/Duplex/Triplex 2
Condominium/Townhouse 3
Mobile House, or 4
Something Else? 5
→ SPECIFY _____

43. How many bedrooms do you have?

RECORD _____

44. Is your home insulated?

YES . . . ASK A 1
NO . . . SKIP TO Q45 2
DON'T KNOW . . SKIP TO Q45 . . 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 Q45 . . 2

a. What was it?

_____

45. What fuel do you use for cooking? CODE ALL MENTIONS

GAS 1
ELECTRICITY 2
BOTTLED GAS 3
OTHER 4
→ SPECIFY _____

46. What fuel do you use for heating your home?

GAS 1
ELECTRICITY 2
BOTTLED GAS 3
SOLAR HEAT 4
OTHER 5
→ SPECIFY _____

47. Is your home air conditioned?

YES . . . ASK A 1
NO . . . SKIP TO Q48 . . 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

48. Do you have an ionizer or air energizing machine?

YES . . . . . ASK A 1
NO . . . . SKIP TO Q49 2
DON'T KNOW . . SKIP TO Q49 . . 8

A. How often do you use it?

RECORD_____

49. Is your car air conditioned?

YES . . . . ASK A 1
NO . . . SKIP TO Q50 . . 2

A. Do you <u>usually</u> use the air conditioning when driving?

YES 1
NO 2

50. I am going to read you some statements about the way people sometimes feel. Please look at this card (HAND CARD #50) and tell me the number which best describes how you felt the last three days. Starting with today: CONTINUE WITH YESTERDAY AND DAY BEFORE. CODE # IN APPROPRIATE COLUMN.

	I TODAY				II YESTERDAY				III DAY BEFORE YESTERDAY			
	Not at all	Slightly	Some-what	Very	Not at all	Slightly	Some-what	Very	Not at all	Slightly	Some-what	Very
A. (Do/Did) you feel irritable (today/yesterday/the day before yesterday)?	4 Ask about yes-ter-day	3 a. Did this affect your activities today? YES . . . 1 NO . . . 2	2	1	4 Ask about yes-ter-day	3 a. Did this affect your activities yesterday? YES . . . 1 NO . . . 2	2	1	4 Ask B	3 a. Did this affect your activities the day before? YES . . . 1 NO . . . 2	2	1
B. (Do/Did you feel depressed or down (today/yesterday/ the day before yesterday?	4 Ask about yes-ter-day	3 a. Did this affect your activities today? YES . . . 1 NO . . . 2	2	1	4 Ask about yes-ter-day	3 a. Did this affect your activities yesterday? YES . . . 1 NO . . . 2	2	1	4 Ask C	3 a. Did this affect your activities the day before? YES . . . 1 NO . . . 2	2	1
C. (Do/Did) you feel cheerful or enthu-siastic about life (today/yesterday/ the day before yesterday)?	4	3	2	1	4	3	2	1	4	3	2	1

51. Were you at home yesterday?

51A. 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 today?

RECORD #_____

52. Did the air quality cause you to do anything different today? Such as:

	YES	NO
a. Stay indoors more?	1	2
b. Get outdoors more?	1	2
c. Be more productive in work, school, chores?	1	2
d. Be less productive in work, school, chores?	1	2
e. Move my activities to a different place?	1	2
f. Cancel activities I would have done?	1	2

53. Do you feel that smog is harmful to your health?

YES 1
NO 2
DON'T KNOW 8

A. Please tell me why you say that?

PROBE - RECORD VERBATIM

_____

_____

_____

_____

54. Now I would like to ask you some background information about yourself.

A. What day, month and year were you born?

RECORD: ___/___/___
DAY/MONTH/YEAR

55. 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 diploma, 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., etc.) 06
NONE 90
OTHER 96
→ SPECIFY _____

56. What is your current employment status, are you:

Working full-time, ... SKIP TO B 1
Working part-time, ... SKIP TO B 2
Unemployed, ... ASK A 3
Retired, ... ASK A 4
Keeping house,. . . . . ASK A 5
In school, or . . . . . ASK A 6
Something else? . . . . . ASK A 7
→ SPECIFY _____

A. Have you ever been employed?

YES . . . . ASK ABOUT USUAL OR LAST EMPLOYMENT IN "B" . . . 1
NO . . . SKIP TO BOX BELOW Q56E 2

B. (Do/Did) you work as:

Self-employed in your own business not incorporated (or farm), ... 1
Self-employed in your own business incorporated, ... 2
For a private company, business or individual for wages, salary or commissions, . . . 3
For the government (federal, state, county, or local), or 4
Work without pay in a family business or farm? 5

C. What kind of business, industry, or organization is that? What (do/did) they do or make? (EXAMPLES: T.V. MANUFACTURING, RETAIL SHOE STORE, STATE LABOR DEPARTMENT) Is it wholesale, retail, manufacturing or what?

_____

_____

_____

D. What kind of work (do/did) you do? What was your main occupation? (EXAMPLES: ELECTRICAL ENGINEER, SHOE CLERK, TEACHER [SCHOOL LEVEL])

_____

_____

_____

E. What (are/were) your most important duties, or activities? What (do/did) you actually do? (EXAMPLES: TYPES, SELLS SHOES, KEEPS ACCOUNT BOOKS)

_____

_____

_____

IF "R" NOT CURRENTLY WORKING . . . SKIP TO Q64

IF "R" IS WORKING (PART OR FULL TIME) . . . ASK Q57

57. 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: _____		

58. 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

59. How many hours, on the average, do you spend at work each day?

RECORD HOURS: _____

60. How many hours, on the average, do you spend outdoors during your working day?

RECORD HOURS: _____

61. Do you travel during the day as part of your work?

YES . . . . ASK A 1
NO . . . SKIP TO Q62 . . 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 _____

62. Is your place of work air conditioned?

YES 1
NO 2

63. Are you exposed to anything at work which affects your breathing?

YES . . . . ASK A 1
NO . . . SKIP TO Q65 . . 2

A. What are you exposed to?

_____

_____

64. Are you currently:

Married, ... 1
Separated, ... 2
Divorced, ... 3
Widowed, or 4
Have you never been married? 5
OTHER 6
→ SPECIFY _____

65. Now, thinking about your family - those people in this household - how many people, including yourself received income from any source such as wages, or salary, social security, pensions, welfare or alimony in 1984?

RECORD #_____

A. Again, thinking about this household, was the total income from all sources and before taxes under $10,000 or over $10,000 in 1984?

UNDER . . . . ASK B 1
OVER . . . . ASK B 2
REFUSED . . SKIP TO Q66 . . 7
DON'T KNOW . SKIP TO Q66 . 8

B. (HAND APPROPRIATE INCOME CARD. IF UNDER $10,000--USE CARD #65B-1. IF OVER $10,000--USE CARD #65B-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 #1:		CARD #2:	
	A 01		H 08
	B 02		I 09
	C 03		J 10
	D 04		K 11
	E 05		L 12
	F 06		M 13
	G 07		N 14
			O 15
			P 16
			Q 17

REFUSED 97
DON'T KNOW . . . 98

C. How many people, including yourself, are supported with this income?

RECORD #:_____

66. Please look at this card (HAND CARD #68) and tell me the sources of income last year, 1984, for this household. Just give me the letter. (CIRCLE ALL MENTIONS)

A. Your earnings 01
B. Spouses earnings 02
C. Other household member's earnings 03
D. Welfare (Public Assistance)/AFDC/ Blind/Disabled/Old Age 04
E. Social Security/OAS/DHI/SSI 05
F. Retirement benefits or pensions (Include VA payments) 06
G. Armed forces allotments 07
H. Alimony/Child support payments 08
I. Savings 09
J. Dividends, investment, inheritance earnings 10
K. Unemployment benefits 11
L. Other Source 12
→ SPECIFY _____

IF, MORE THAN ONE MENTION IN Q66, ASK A

IF ONLY ONE MENTION IN Q66, SKIP TO FINAL STATEMENT

CARD #65B-1

A. Less than 3,000
B. 3,000 - 3,999
C. 4,000 - 4,999
D. 5,000 - 5,999
E. 6,000 - 6,999
F. 7,000 - 8,499
G. 8,500 - 10,000

CARD #65B-2

H. 10,001 - 11,999
I. 12,000 - 13,999
J. 14,000 - 16,999
K. 17,000 - 19,999
L. 20,000 - 24,999
M. 25,000 - 29,999
N. 30,000 - 39,999
O. 40,000 - 49,999
P. 50,000 - 59,999
Q. 60,000 or more

A. Which of these was the largest source of income? Again, just give me the letter.

RECORD: _____

67A. As you recall, when I first interviewed you 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. Is there a day or time that is especially good for me to call?

RECORD DAY: _____

RECORD TIME: _____

B. Can you tell me the names and addresses of two people, not living at this address, who would always know how to reach you in case you should move and we cannot get in touch with you?

1. NAME: _____ RELATIONSHIP: _____

   ADDRESS: _____
   PHONE: ___/_____

2. NAME: _____ RELATIONSHIP: _____

   ADDRESS: _____
   PHONE: ___/_____

CARD #66

A. Your earnings
B. Spouses earnings
C. Other household member's earnings
D. Welfare (Public Assistance)/AFDC/Blind/Disabled/Old Age
E. Social Security/OAS/DHI/SSI
F. Retirement benefits or pensions (Include VA payments)
G. Armed forces allotments
H. Alimony/Child support payments
I. Savings
J. Dividends, investment, inheritance earnings
K. Unemployment benefits
L. Other Source
SPECIFY _____

R.I.D._____ /PRINT ON GOLD PAPER/

ASTHMA-BRONCHITIS-EMPHYSEMA SUPPLEMENT

You said the doctor told you that you have (asthma/bronchitis/emphysema). I'd like to ask you a few questions about your (...). INSERT CONDITION FOR (...). ASK ALL APPROPRIATE QUESTIONS.

ASTHMA

1. How old were you when the doctor told you that you have asthma?

RECORD AGE:_____

2. Have you taken medication for it in the past month?

YES 1
NO 2

3. When was your last asthma attack?

RECORD:_____/_____
MONTH YEAR

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

_____

_____

BRONCHITIS

1. How old were you when the doctor told you that you have bronchitis?

RECORD AGE:_____

2. Have you taken medication or done anything special for it in the past month?

YES 1
NO 2

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

RECORD:_____/_____
MONTH YEAR

EMPHYSEMA

1. How old were you when the doctor told you that you have emphysema?

RECORD AGE:_____

2. Have you taken medication or treatment for it in the past month?

YES 1
NO 2

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

RECORD:_____/_____
MONTH YEAR

RETURN TO MAIN QUESTIONNAIRE

APPENDIX B

FOLLOW-UP QUESTIONNAIRE

A1. INTERVIEWER: _____ I.D.#: _____

A2. TIME BEGINNING: _____ AM PM TIME ENDING: _____ AM PM

(INTRODUCTORY SCRIPT)

1. First, I would like to know about changes in your life since (...) when we last talked. INSERT DATE OF LAST INTERVIEW FOR (...). At that time you were (...). INSERT EMPLOYMENT STATUS FOR (...). Has your employment status changed?

YES . . . SKIP TO Q2 . . . 1
NO 2

IF R EMPLOYED, FULL OR PART TIME, ASK A IF R NOT EMPLOYED, SKIP TO Q3

A. Do you still work at the <u>same</u> job and place?

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

B. What kind of business, industry or organization do you work at. What do they do or make? Is it wholesale, retail manufacturing or what?

_____

_____

_____

C. What kind of work do you do? What is your main occupation? (EXAMPLES: ELECT. ENG., SHOE CLERK, TEACHER [SCHOOL LEVEL].)

_____

_____

_____

D. What are your most important duties, or activities? (EXAMPLES: TYPE, SELL SHOES, KEEP ACCOUNT BOOKS.)

_____

_____

_____

SKIP TO Q3

2. What is your current employment status; are you:

Working full time, . .	ASK A	1
Working part time, . .	ASK A	2
Unemployed, ...	SKIP TO Q3 . .	3
Retired, ...	SKIP TO Q3 . .	4
Keeping House	SKIP TO Q3 . .	5
In school, or	SKIP TO Q3 . .	6
Something else? . . .	SKIP TO Q3 . .	7

SPECIFY:_____

A. Do you still work at the same job and place?

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

B. What kind of business, industry or organization do you work at. What do they do or make? Is it wholesale, retail manufacturing or what?

_____

_____

_____

C. What kind of work do you do? What is your main occupation? (EXAMPLES: ELECT. ENG., SHOE CLERK, TEACHER [SCHOOL LEVEL].)

_____

_____

_____

D. What are your most important duties, or activities? (EXAMPLES: TYPE, SELL SHOES, KEEP ACCOUNT BOOKS.)

_____

_____

_____

TO TO OCCUPATION SUPPLEMENT [BLUE]

3. Do you still live at (...)? INSERT FULL ADDRESS FOR (...).

YES	SKIP TO Q4	1
NO	ASK A	2

A. What is your new address?

_____ / _____ / _____
/STREET /APT.

_____
CITY

B. When did you move?

RECORD: _____ / _____
MONTH YEAR

IF MOVED SINCE LAST INTERVIEW, ASK HOUSE Q [PINK]

4. What is your present marital status? Are you:

Married, ... 1
Divorced, ... 2
Living with a Partner, ... 3
Separated, ... 4
Widowed, or 5
Have never been married 6
OTHER 7
→ SPECIFY: _____

Now, some questions about your health.

5. Thinking of your health at present, would you say that your health is:

Excellent, ... 1
Good, ... 2
Fair, or 3
Poor? 4

6. Have you seen a doctor in the past month?

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

A. What did you see the doctor for?

_____

IF ASTHMA-BRONCHITIS-EMPHYSEMA . . . ASK SUPPLEMENT Q FOR ASTHMA-BRONCHITIS-EMPHYSEMA [GOLD]
ALL OTHERS -- CONTINUE

REFER TO INFO SHEET (COMPUTER)

IF ASTHMA-BRONCHITIS-EMPHYSEMA - LOW FEV - "ATHLETE" NOTED . . . ASK APPROPRIATE QUESTIONS IN Q7

IF NONE NOTED . . . . . SKIP TO Q8

7. 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 three 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 Q8

B. Thinking about the last three 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 your 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 Q8

C. Thinking about the last three 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

R.I.D.#:_____ FOLLOW UP CONFIDENTIAL

FOLLOW UP #:_____

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		

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 Q8

D. Thinking of the last three 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

IF "ATHLETIC" NOTED . . . . . CONTINUE
IF "ATHLETE" NOT NOTED . . . . SKIP TO Q8

E. During the last three days did you work out:

More than usual, ... ASK a 1
Less than usual, or . . ASK a 2
About the same? . . . . SKIP TO c . . 3

a. Why did you work out (...)? INSERT ANSWER FROM E FOR (...)
RECORD VERBATIM -- PROBE

_____

_____

_____

b. Was the change because of the air quality?

YES 1
NO 2

c. Was your work out at your usual time of day?

YES . . . . . SKIP TO Q8 1
NO . . . . . ASK aa 2

aa. Why did you change?

_____

_____

_____

bb. Was the change because of the air quality?

YES 1
NO 2

cc. Was your work out in the same place as usual?

YES . . . . . SKIP TO Q8 1
NO . . . . . ASK dd 2

dd. Where did you work out?

_____

_____

_____

ee. Why did you change the place you "work out"?

_____

_____

_____

ff. Was the change because of the air quality?

YES 1
NO 2

8. Now, I'd like to read you a list of symptoms people sometimes have on smoggy days. Thinking of the last three days please tell me if you experienced any of these symptoms. Lets start with today. CONTINUE WITH YESTERDAY AND DAY BEFORE YESTERDAY. READ a-z CODE IN APPROPRIATE COLUMN.

	TODAY		YESTERDAY		DAY BEFORE YESTERDAY	
	YES	NO	YES	NO	YES	NO
a. (Do/Did) your eyes feel irritated?	1	2	1	2	1	2
b. (Do/Did) you feel that you (can/could) not see as well as usual?	1	2	1	2	1	2
c. (Were/Are) your eyes unusually sensitive to bright light?	1	2	1	2	1	2
d. (Was/Is) your throat irritated?	1	2	1	2	1	2
e. (Was/Is) your voice husky or (did/do) you lose your voice?	1	2	1	2	1	2
f. (Did/Do) you have sinus pain or discomfort?	1	2	1	2	1	2
g. (Did/Do) you have a nosebleed?	1	2	1	2	1	2
h. (Was/Is) your nose dry and painful?	1	2	1	2	1	2
i. (Was/Is) your nose runny?	1	2	1	2	1	2
j. (Did/Do) you have pain when you (took/take) a deep breath?	1	2	1	2	1	2

	TODAY		YESTERDAY		DAY BEFORE YESTERDAY	
	YES	NO	YES	NO	YES	NO
k. (Did/Do) you feel that you (could/can) not take a deep breath?	1	2	1	2	1	2
l. (Did/Do) you get out of breath easily?	1	2	1	2	1	2
m. (Did/Do) you have a cough?	1	2	1	2	1	2
n. (Did/Do) you bring up sputum (Phlegm) from your chest?	1	2	1	2	1	2
o. (Did/Do) you have a headache?	1	2	1	2	1	2
p. (Did/Do) you get tired easily?	1	2	1	2	1	2
q. (Did/Do) you feel faint or dizzy?	1	2	1	2	1	2
r. (Did/Do) you feel spaced-out or disoriented?	1	2	1	2	1	2
s. (Did/Do) you feel nauseated (sick to your stomach)?	1	2	1	2	1	2
t. (Did/Do) you have chills or fever? Which one _____?	1	2	1	2	1	2
u. (Did/Do) you have pain in your ears?	1	2	1	2	1	2

	TODAY		YESTERDAY		DAY BEFORE YESTERDAY	
	YES	NO	YES	NO	YES	NO
v. (Did/Do) you have ringing in your ears?	1	2	1	2	1	2
w. (Did/Does) breathing sound wheezing or whistling?	1	2	1	2	1	2
x. (Did/Does) your chest feel tight?	1	2	1	2	1	2
y. (Did/Do) you feel that your heart was beating very fast at times when you were resting?	1	2	1	2	1	2
z. (Did/Do) you have swollen glands?	1	2	1	2	1	2

IF YES TO ANY IN Q8 . . . . . ASK Q9
IF "NO" TO ALL . . . . . SKIP TO Q10

9. Again, thinking of the last three days, did you do any of the following, let's start with today? CONTINUE WITH YESTERDAY AND THE DAY BEFORE YESTERDAY - READ A-F, CODE IN APPROPRIATE COLUMN.

	TODAY	YESTERDAY	DAY BEFORE YESTERDAY
A. Did you change your activities at all to avoid having any of these symptoms (today/yesterday/day before yesterday)?	YES ..... ASK a ..... 1 NO ... SKIP TO B ... 2 a. What did you do differently? _____ _____	YES ..... ASK a ..... 1 NO ... SKIP TO B ... 2 a. What did you do differently? _____ _____	YES ..... ASK a ..... 1 NO ... SKIP TO B ... 2 a. What did you do differently? _____ _____
B. Did having any of these symptoms prevent your going to work or from doing your regular chores (today/yesterday/day before yesterday)?	YES ..... 1 NO 2	YES ..... 1 NO 2	YES ..... 1 NO 2
C. Did having any of these symptoms prevent you from doing something that would have required more effort (today/yesterday/day before yesterday)?	YES ..... 1 NO 2	YES ..... 1 NO 2	YES ..... 1 NO 2

	TODAY	YESTERDAY	DAY BEFORE YESTERDAY
D. Did you take any medication or treatment for relief of these symptoms?	YES ..... 1 NO 2	YES ..... 1 NO 2	YES ..... 1 NO 2
E. Did you seek medical attention for any of these symptoms?	YES ..... ASK a ..... 1 NO ... SKIP TO B ... 2 a. Where did you go? Doctor's Office ... 1 Emergency ..... 2 Hospital 3	YES ..... ASK a ..... 1 NO ... SKIP TO B ... 2 a. Where did you go? Doctor's Office ... 1 Emergency ..... 2 Hospital 3	YES ..... ASK a ..... 1 NO ... SKIP TO B ... 2 a. Where did you go? Doctor's Office ... 1 Emergency ..... 2 Hospital 3
F. Did these symptoms make you change your usual or planned activities?	YES ..... ASK a ..... 1 NO .. SKIP TO Q10 .. 2 a. In what way? _____ _____	YES ..... ASK a ..... 1 NO .. SKIP TO Q10 .. 2 a. In what way? _____ _____	YES ..... ASK a ..... 1 NO .. SKIP TO Q10 .. 2 a. In what way? _____ _____

10A. Again, thinking about the last three days: ASK A - CODE IN COLUMN A - IF "YES" ASK "B" AND "C." IF "NO" - TO TO NEXT.

B. How many days (date)? RECORD IN COLUMN "B."

C. What was the problem? RECORD IN COLUMN "C."

	A.	B. DAYS/DATE	C. SPECIFY PROBLEM
A. Did you stay in a hospital or nursing home?	YES ..... 1 NO 2	RECORD: _____	_____ _____ _____ _____
B. Did you stay in bed due to illness or injury?	YES ..... 1 NO 2	RECORD: _____	_____ _____ _____ _____
C. Did you have to restrict your usual activity due to illness or injury?	YES ..... 1 NO 2	RECORD: _____	_____ _____ _____ _____
D. Did the illness or injury keep you from: a. Work?	YES ..... 1 NO 2	RECORD: _____	_____ _____ _____
b. Work around the house?	YES ..... 1 NO 2	RECORD: _____	_____ _____ _____
c. Leisure time activities?	YES ..... 1 NO 2	RECORD: _____	_____ _____ _____

11. Have you seen a doctor in the last three days for any illness, injury or symptom?

YES . . . . ASK a 1
NO . . . . SKIP TO Q12 2

a. Did your health insurance or health maintenance organization cover this medical expense?

YES 1
NO 2

b. If your health insurance has a deductible, has it been met yet?

YES 1
NO 2

12. Please tell me about the activities you do most often. Think about a typical week. I would like to know the five you do most frequently. Below, a list of many popular activities is provided.

LIST OF ACTIVITIES

Backpacking
Badminton
Ballooning
Baseball/Softball
Basketball
Beekeeping
Bicycling
Billiards
Birdwatching
Boating
Bowling
Boxing
Camping
Computers
Canoeing
Crew
Cricket
Croquet
Cross Country Skiing
Dance
Diving
Doing Odd Jobs
Downhill Skiing
Drama
Driving for Pleasure
Fencing
Field Hockey
Fishing
Painting
Photography
Picnicking
Piloting/Flying
Ping Pong
Polo
Rafting
Raquet Ball
Rock Climbing
Rodeo Participation
Roller Skating
Running
Gymnastics
Handball
Hang Gliding
Hiking
Horseback Riding
Horse Racing
Home Repairs
Hunting
Ice Hockey
Ice Skating
Kayaking
Lacrosse
Martial Arts such as Karate
Mechanics
Metal Work
Meteorology
Motorbiking
Mountaineering
Movies
Music
Outings
Social Dancing
Spelunking
Sports Spectator
Squash
Sunbathing
Surfing
Swimming
Tennis
Touch Football
Track & Field
Travel/Tour
Sailing
Scuba
Sculpture
Shopping
Sightseeing
Skeet/Trap Shooting
Sketching
Skydiving
Snorkeling
Soccer
Visiting Friends
Walking
Walking the Dog
Water Polo
Water Skiing
Weight Lifting
Wind Surfing
Wrestling
Yard Work
Other, specify: _____

12A. My next questions are about activities people sometimes do. We are interested in the activities you do most often. Please look at this list (HAND #12). Now, thinking about a typical week in your life, please tell me the five activities you do most often. RECORD IN COLUMN A OF CHART BELOW--ASK B-K FOR EACH ACTIVITY.

B. About how many hours a week are you involved in (...)? INSERT ACTIVITY FOR (...) - RECORD IN COLUMN B.

C. How many times a week are you involved in (...)? RECORD IN COLUMN C.

D. What does it cost you to (...) each time? Fees, Tickets, Materials, etc. RECORD IN COLUMN D.

E. Where do you do (...), at home, work or somewhere else? CODE IN E.

F. Where do you leave from to go there? RECORD IN COLUMN F.

G. How long does it take you to get there? RECORD IN G.

H. How do you get there? CODE IN COLUMN H.

I. How much does it cost you to get there? RECORD IN I.

J. Do you do this (...) indoors or outdoors? CODE IN COLUMN J.

K. What time of the day do you usually do (...)? RECORD IN K.

A. ACTIVITY	B. HOURS PER WEEK	C. # TIMES PER WEEK	D. COST EACH TIME	E. LOCATION	F. WHERE LEAVE	G. TIME GOING	H. METHOD TO GO	I. COST TO GO	J. WHERE	K. TIME OF DAY
1. _____				HOME.....1 WORK.....2 OTHER.....3 →SPECIFY _____ _____ IF AT HOME OR WORK--SKIP TO J ALL OTHERS - CONTINUE	_____	_____	CAR.....01 CARPOOL.....02 WALK.....03 VANPOOL.....04 BICYCLE.....05 MOTORCYCLE...06 PUB. TRANS...07 OTHER.....08 →SPECIFY _____	$_____	OUTDOORS...1 INDOORS....2	_____ AM PM

A. ACTIVITY	B. HOURS PER WEEK	C. # TIMES PER WEEK	D. COST EACH TIME	E. LOCATION	F. WHERE LEAVE	G. TIME GOING	H. METHOD TO GO	I. COST TO GO	J. WHERE	K. TIME OF DAY
2.				HOME.....1 WORK.....2 OTHER.....3 SPECIFY IF AT HOME OR WORK--SKIP TO J ALL OTHERS - CONTINUE			CAR.....01 CARPOOL.....02 WALK.....03 VANPOOL.....04 BICYCLE.....05 MOTORCYCLE...06 PUB. TRANS...07 OTHER.....08 SPECIFY	$	OUTDOORS...1 INDOORS....2	AM PM
3.				HOME.....1 WORK.....2 OTHER.....3 SPECIFY IF AT HOME OR WORK--SKIP TO J ALL OTHERS - CONTINUE			CAR.....01 CARPOOL.....02 WALK.....03 VANPOOL.....04 BICYCLE.....05 MOTORCYCLE...06 PUB. TRANS...07 OTHER.....08 SPECIFY	$	OUTDOORS...1 INDOORS....2	AM PM
4.				HOME.....1 WORK.....2 OTHER.....3 SPECIFY IF AT HOME OR WORK--SKIP TO J ALL OTHERS - CONTINUE			CAR.....01 CARPOOL.....02 WALK.....03 VANPOOL.....04 BICYCLE.....05 MOTORCYCLE...06 PUB. TRANS...07 OTHER.....08 SPECIFY	$	OUTDOORS...1 INDOORS....2	AM PM

A. ACTIVITY	B. HOURS PER WEEK	C. # TIMES PER WEEK	D. COST EACH TIME	E. LOCATION	F. WHERE LEAVE	G. TIME GOING	H. METHOD TO GO	I. COST TO GO	J. WHERE	K. TIME OF DAY
5.				HOME.....1 WORK.....2 OTHER.....3 → SPECIFY IF AT HOME OR WORK--SKIP TO J ALL OTHERS - CONTINUE			CAR.....01 CARPOOL.....02 WALK.....03 VANPOOL.....04 BICYCLE.....05 MOTORCYCLE...06 PUB. TRANS...07 OTHER.....08 → SPECIFY	$	OUTDOORS...1 INDOORS....2	AM PM

Now some questions about the other members of your household.

13. First, I'd like to read you the names of the people we have listed as members of your household from the last time we spoke. READ EACH NAME LISTED ON COMPUTER LIST. RECORD MEMBERS NAME IN APPROPRIATE SPACE - KEEP SAME ORDER AS COMPUTER LIST. IF A PERSON IS NO LONGER LIVING IN HOUSEHOLD - LIST NAME - RECORD INFOR - DO NOT ASK QUESTIONS ABOUT THIS MEMBER.

	NAME	NAME
A. Was (...) sick the last three days? INSERT NAME FOR (...)	YES .....ASK a.....1 NO 2	YES .....ASK a.....1 NO 2
a. What was the problem?	_____ _____	_____ _____
B. Did (...) see a doctor in the last 3 days for this?	YES ..ASK a.....1 NO ...SKIP TO C...2	YES ..ASK a.....1 NO ...SKIP TO C...2
a. Was that at the office or emergency?	OFFICE .....1 EMERGENCY 2	OFFICE .....1 EMERGENCY 2
C. Was (...) hospitalized in the last 3 days for this illness?	YES ...SKIP TO E..1 NO 2	YES ...SKIP TO E..1 NO 2
D. Did (...) stay in bed because of this illness?	YES .....1 NO 2	YES .....1 NO 2
E. Did (...) have to restrict activity because of this illness?	YES .....1 NO 2	YES .....1 NO 2
F. Did (...) stay home from work or school due to this illness?	YES .....1 NO 2	YES .....1 NO 2
G. Did (...) cancel activities because of this illness?	YES .....1 NO 2	YES .....1 NO 2

RECORD NAMES IN APPROPRIATE COLUMNS

NAME	NAME	NAME
YES ...ASK a.....1 NO 2	YES ...ASK a.....1 NO.....2	YES ...ASK a.....1 NO 2
_____ _____	_____ _____	_____ _____
YES ..ASK a.....1 NO ...SKIP TO C...2	YES ..ASK a.....1 NO ...SKIP TO C...2	YES ..ASK a.....1 NO ...SKIP TO C...2
OFFICE .....1 EMERGENCY 2	OFFICE .....1 EMERGENCY 2	OFFICE .....1 EMERGENCY 2
YES ...SKIP TO E..1 NO 2	YES ...SKIP TO E..1 NO 2	YES ...SKIP TO E..1 NO 2
YES .....1 NO 2	YES .....1 NO 2	YES 1
YES .....1 NO 2	YES .....1 NO 2	YES .....1 NO 2
YES .....1 NO 2	YES .....1 NO 2	YES .....1 NO 2
YES .....1 NO 2	YES .....1 NO 2	YES .....1 NO 2

RECORD NAMES IN APPROPRIATE COLUMNS

	NAME	NAME
H. Did (...) have any <u>other</u> health problem?	YES .....1 NO 2	YES .....1 NO 2
I. REFER TO COMPUTER LIST - FOR ALL NOTED WITH ASTHMA ASK: The last 3 days was (...) asthma:	Much Better,.....1 Somewhat better,...2 Same as usual, ...3 Somewhat worse, or.....4 Much worse than usual 5	Much Better,.....1 Somewhat better,...2 Same as usual, ...3 Somewhat worse, or.....4 Much worse than usual 5
J. Did (...) spend more time or less time indoors than usual the last 3 days?	MORE .....1 LESS 2	MORE .....1 LESS 2
K. Was (...) more active or less active than usual?	MORE .....1 LESS 2	MORE .....1 LESS 2
L. Was (...) more irritable or less irritable than usual the last 3 days?	MORE .....1 LESS 2	MORE .....1 LESS 2
M. Was (...) depressed or "down" more than usual the last 3 days?	YES .....1 NO 2	YES .....1 NO 2

RECORD NAMES IN APPROPRIATE COLUMNS

NAME	NAME	NAME
YES .....1 NO 2	YES .....1 NO 2	YES .....1 NO 2
Much Better,.....1 Somewhat better,...2 Same as usual, ...3 Somewhat worse, or.....4 Much worse than usual 5	Much Better,.....1 Somewhat better,...2 Same as usual, ...3 Somewhat worse, or.....4 Much worse than usual 5	Much Better,.....1 Somewhat better,...2 Same as usual, ...3 Somewhat worse, or.....4 Much worse than usual 5
MORE .....1 LESS 2	MORE .....1 LESS 2	MORE .....1 LESS 2
MORE .....1 LESS 2	MORE .....1 LESS 2	MORE .....1 LESS 2
MORE .....1 LESS 2	MORE .....1 LESS 2	MORE .....1 LESS 2
YES .....1 NO 2	YES .....1 NO 2	YES .....1 NO 2

Now a few final questions about you.

IF R WORKING . . . . . ASK Q14
IF R NOT WORKING . . . SKIP TO Q15

14. Again, thinking of the last three days. How would you rate your productivity at work. Would you say:

Much more than usual, ... 1
More than usual, ... 2
Somewhat less, ... 3
Much less than usual, or 4
The same as usual? . . . SKIP TO Q15 . 5

A. Why do you think it changed?

_____

_____

B. Do you think the air quality affected your work?

YES 1
NO 2

15. How about your productivity at home or your leisure time the last three days. Was that:

Much more than usual, ... 1
More than usual, ... 2
Somewhat less, ... 3
Much less than usual, or 4
The same as usual? 5

16. I'm going to read you some statements about the way people sometimes feel. As I read them please tell me to what degree you felt this way the last three days. Would you say not at all, slightly, somewhat or very. Let's start with today. READ A-C. CODE IN APPROPRIATE COLUMN - CONTINUE WITH YESTERDAY AND THE DAY BEFORE YESTERDAY.

	I TODAY				II YESTERDAY				III DAY BEFORE YESTERDAY			
	Not at all	Slightly	Some-what	Very	Not at all	Slightly	Some-what	Very	Not at all	Slightly	Some-what	Very
A. (Do/Did) you feel irritable (today/yesterday/the day before yesterday)?	4 Ask about yesterday	3 a. Will this affect your activities today? YES . . . 1 NO . . . 2	2	1	4 Ask about day before	3 a. Did this affect your activities yesterday? YES . . . 1 NO . . . 2	2	1	4 Ask B	3 a. Did this affect your activities? YES . . . 1 NO . . . 2	2	1
B. (Do/Did you feel depressed or down (today/yesterday/ the day before yesterday?	4 Ask about yesterday	3 a. Will this affect your activities today? YES . . . 1 NO . . . 2	2	1	4 Ask about yesbefore	3 a. Did this affect your activities yesterday? YES . . . 1 NO . . . 2	2	1	4 Ask C	3 a. Did this affect your activities? YES . . . 1 NO . . . 2	2	1
C. (Do/Did) you feel cheerful or enthusiastic about life (today/yesterday/ the day before yesterday)?	4	3	2	1	4	3	2	1	4	3	2	1

17. 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 today?

RECORD #:_____

18. Did the air quality cause you to do anything different today? Such as:

	YES	NO
a. Stay indoors more?	1	2
b. Get outdoors more?	1	2
c. Be more productive in work, school, chores?	1	2
d. Be less productive in work, school, chores?	1	2
e. Move my activities to a different place?	1	2
f. Cancel activities I would have done?	1	2

19. Do you feel that smog is harmful to your health?

YES 1
NO 2
DON'T KNOW 8

A. Please tell me why you say that?

_____

_____

_____

_____

20. Do you have any symptoms when it's smoggy?

YES . . . . . ASK A 1
NO . . . . . SKIP TO END 2
DON'T KNOW . . . SKIP TO END 8

A. What symptoms do you have?

_____

_____

_____

_____

_____

END

A. This completes the questionnaire. Thank you for taking the time for this very important study. Everything you've told me will be held in complete confidence. I'll be contact you again in about a month. Is this time and day convenient for you?

YES . . . . . THANK YOU 1
NO . . . . . ASK B 2

B. What day and time would be more convenient for me to call?

RECORD DAY:_____

RECORD TIME:_____

END TIME: _____ AM
PM

R.I.D.#:_____ /PRINT ON BLUE PAPER/

OCCUPATIONAL QUESTIONNAIRE

1. 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:_____		

2. 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

3. How many hours, on the average, do you spend at work each day?

RECORD HOURS:_____

4. How many hours, on the average, do you spend outdoors during your working day?

RECORD HOURS:_____

5. What fuel do you use for cooking? CODE ALL MENTIONS

GAS 1
ELECTRICITY 2
BOTTLED GAS 3
OTHER 4
→ SPECIFY:_____

6. What fuel do you use for heating your home?

GAS 1
ELECTRICITY 2
BOTTLED GAS 3
SOLAR HEAT 4
OTHER 5
→ SPECIFY:_____

7. Is your home air conditioned?

YES . . . . . ASK A 1
NO . . . . . SKIP TO Q8 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

8. Do you have an ionizer or air energizing machine?

YES . . . . . ASK A 1
NO . . . . . GO BACK TO Q4 OF Q 2
DON'T KNOW . . . GO BACK TO Q4 of Q 3

A. How often do you use it?

RECORD: _____

R.I.D.#:_____ /PRINT ON PINK PAPER/

HOUSE QUESTIONNAIRE

I'd like to ask you some questions about the home you are living in now.

1. Are you located within two blocks of a major street or freeway?

YES	1
NO	2

2. Do you live in a:

House/single family unit, ...	1
Apartment/Duplex/Triplex, ...	2
Condominium/Townhouse, ...	3
Mobile Home, or	4
Something else?	5
→ SPECIFY:_____	

3. How many bedrooms do you have?

RECORD:_____

4. Is your home insulated?

YES	ASK A	1
NO	SKIP TO Q5	2
DON'T KNOW . . .	SKIP TO Q5	3

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 Q5	2

a. What? _____

5. Do you travel during the day as part of your work?

YES	ASK A	1
NO	SKIP TO Q6	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: _____

6. Is your place of work air conditioned?

YES 1
NO 2

7. Are you exposed to anything at work which affects your breathing?

YES . . . . . ASK A 1
NO . . . . . SKIP TO BOX BELOW . . . 2

A. What are you exposed to?

_____

_____

RETURN TO QUEST. Q3

R.I.D. #_____ /PRINT ON GOLD PAPER/

ASTHMA-BRONCHITIS-EMPHYSEMA SUPPLEMENT

You said the doctor told you that you have (asthma/bronchitis/emphysema). I'd like to ask you a few questions about your (...). INSERT CONDITION FOR (...). ASK ALL APPROPRIATE QUESTIONS.

ASTHMA

1. How old were you when the doctor told you that you have asthma?

RECORD AGE:_____

2. Have you taken medication for it in the past month?

YES 1
NO 2

3. When was your last asthma attack?

RECORD:_____/_____
MONTH YEAR

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

_____

_____

BRONCHITIS

1. How old were you when the doctor told you that you have bronchitis?

RECORD AGE:_____

2. Have you taken medication or done anything special for it in the past month?

YES 1
NO 2

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

RECORD:_____/_____
MONTH YEAR

EMPHYSEMA

1. How old were you when the doctor told you that you have emphysema?

RECORD AGE:_____

2. Have you taken medication or treatment for it in the past month?

YES 1
NO 2

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

RECORD: ____/____
MONTH YEAR

RETURN TO MAIN QUESTIONNAIRE

APPENDIX C

ENVIRONMENTAL EFFECTS EVALUATION PROGRAM QUESTIONNAIRE

Card [0][3] (1 2) UCLA I.D. [ ][ ][ ][ ][ ][ ][ ] (3 4 5 6 7 8 9) MLRL I.D. [ ][ ][ ][ ][ ][ ] (10 11 12 13 14 15) 1-15

ENVIRONMENTAL EFFECTS EVALUATION PROGRAM

Interview Schedule

Status in Program [ ] (16) 16

NAME _____

Street _____ Relation to Head [ ] (17) 17

City & Zip _____

Telephone Number _____

Has your address changed since the last time you participated in this program? 1 Yes 2 No [ ] (18) 18

Sex: 1 Male 2 Female [ ] (19) Birthdate: [ ][ ] (20 21) [ ][ ] (22 23) [ ][ ] (24 25) BIRTHPLACE: [ ][ ] (26 27) 19-27

City: _____

Name of Interviewer _____ [ ] (28) 28

State: _____

Informant: 1 Subject 2 Parent 3 Guardian 4 Other relative 5 Other [ ] (29) Race/Ethnicity: [ ] (30) 29-30

1 White
2 Black
3 Spanish Surname
4 Chinese
5 Japanese
6 Other (specify)

Date of Interview: Mo. [ ][ ] (31 32) Day [ ][ ] (33 34) Yr. [ ] (35) Time of Interview: [ ][ ] (36 37) 31-37

Preamble: I am first going to ask you some questions about your respiratory health.
(INTERVIEWER: Note that all N/A responses receive a code of "9")

A. COUGH (All questions must be asked)

1. Do you usually cough first thing in the morning in bad weather? 1 Yes 2 No [ ] (38) 38

2. Do you usually cough at other times during the day or night in bad weather? 1 Yes 2 No ☐ 39 — 39

3. Do you cough on most days for as much as 3 months of the year? 1 Yes 2 No ☐ 40 — 40

4. Do you cough first thing in the morning (when you get up) on more than 50 days in a year? 1 Yes 2 No ☐ 41 — 41

(If no cough reported, code 9 for col. 42)

If cough is reported, ask:

5. For how many years have you had this cough? — 42

(9) N/A
1. Less than 2 years
2. 2 to 5 years
3. 6 to 10 years
4. More than 10 years

☐ 42

B. SPUTUM (All questions must be asked. If YES to any SPUTUM questions, ask Q.11)

6. Do you usually bring up phlegm, sputum or mucous from your chest first thing in the morning in bad weather? 1 Yes 2 No ☐ 43 — 43

7. Do you usually bring up phlegm, sputum or mucous from your chest at other times during the day or night in bad weather? 1 Yes 2 No ☐ 44 — 44

8. Do you bring up phlegm, sputum or mucous from your chest on most days for as much as 3 months of the year? 1 Yes 2 No ☐ 45 — 45

9. Do you bring up any phlegm from your chest first thing in the morning on more than 50 days in a year? 1 Yes 2 No ☐ 46 — 46

10. Do you bring up any phlegm from your chest later in the day on more than 50 days in a year? 1 Yes 2 No ☐ 47 — 47

11. For how many years have you raised phlegm, sputum or mucous from your chest? — 48

(9) N/A
1. Less than 2 years
2. 2 to 5 years
3. 6 to 10 years
4. 10 yrs. or more

☐ 48

(INTERVIEWER: If subject reports neither cough nor phlegm, code 9 for cols. 49-50 , and ask question 13.)

12. Does most of this coughing (or phlegm) come during just one season of the year? (INTERVIEWER: Check 1. cough, 2. phlegm, 3. cough and phlegm) ☐ 49

(9) N/A
1. Summer
2. Fall
3. Winter
4. Spring
5. Fall & Winter
6. Spring & Fall
7. Winter & Spring
8. All the time

☐ 50 — 49-50

13. In the past three years have you had a period of INCREASED cough and phlegm lasting for <u>three weeks</u> or more? 1 Yes 2 No ☐ 51 — 51

14. Have you had more than one such three week period? 1 Yes 2 No (9) N/A ☐ 52 — 52

C. <u>WHEEZING</u>

15. Does your breathing ever sound wheezing or whistling? 1 Yes 2 No ☐ 53 — 53

(INTERVIEWER: If no, col. 54 coded 9; ask question 17.)

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

(9) N/A
1. less than 5
2. 5 to 10
3. 11 to 20
4. 21 to 50
5. over 50

☐ 54 — 54

17. Have you ever had attacks of shortness of breath with wheezing? 1 Yes 2 No ☐ 55 — 55

D. BREATHLESSNESS

18. Are you troubled by shortness of breath when hurrying on level ground or walking up a slight hill? 1 Yes 2 No ☐ 56 — 56

(INTERVIEWER: If NO, cols. 57 and 58 are coded 9, skip to Q.21.)

19. Do you get short of breath walking with other people of your own age on level ground? 1 Yes 2 No (9) N/A ☐ 57 — 57

20. Do you have to stop for breath when walking at your own pace on level ground? 1 Yes 2 No (9) N/A ☐ 58 — 58

21. Do you suddenly become short of breath when taking it easy (not exercising)? 1 Yes 2 No ☐ 59 — 59

IF yes to 21, ask:

22. On how many days did this happen during the past year? (9) N/A; 1. less than 5; 2. 5 to 10; 3. 10 to 20; 4. 20 to 50; 5. over 50 ☐ 60 — 60

23. INTERVIEWER: Does subject appear to be disabled (crippled) by reason other than shortness of breath? Note here _____ 1 Yes 2 No ☐ 61 — 61

24. Do you now have ANY serious illness? Note here _____ 1 Yes 2 No ☐ 62 — 62

E. CHEST ILLNESS

25. During the past 3 years, how much trouble have you had with illnesses such as chest colds, bronchitis or pneumonia? 1. great deal of trouble; 2. some trouble; 3. no trouble ☐ 63 — 63

IF a great deal or some trouble, ask:

26. 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? (9) N/A; 1. one time; 2. 2 to 5 times; 3. more than 5 times; 4. no times ☐ 64 — 64

27. Has a doctor ever told you that you had asthma, chronic bronchitis, or emphysema? 1 Yes 2 No ☐ (65) — 65

(INTERVIEWER: If no, cols. 66-75 are coded "9"; go to question 35)

28. If yes, which one(s)? — (9) N/A; 1 Asthma; 2 Chronic Bronchitis; 3 Emphysema; 4 Asthma & Bronchitis; 5 Emphysema & Bronchitis; 6 Asthma & Emphysema; 7 All three illnesses — ☐ (66) — 66

29. At what age was this first diagnosed? (Record age in years) . . . . . ☐☐ (67 68) yrs — 67-68

30. Have you taken medicine or treatment for this in the last year? 1 Yes 2 No (9) N/A ☐ (69) — 69

31. If yes, for which one(s)? (Use code above) . . . . . ☐ (70) — 70

32. Have you taken any medication for asthma, bronchitis, or emphysema in the last 6 hours? 1 Yes 2 No (9) N/A ☐ (71) — 71

33. If yes, what is the name of the medication(s)?

_____

_____

1 Antibiotics; 2 Bronchodilators; 3 Steroid; 4 Other _____; (9) Not specified — ☐ (72) — 72

34. (If no to Q. 30): At what age was your last experience with this disease?

1 0-5 yrs.; 2 6-11 yrs.; 3 12-17 yrs.; 4 18-29 yrs.; 5 30-39 yrs.; 6 40-49 yrs.; 7 50-59 yrs.; 8 60+ yrs.; (9) N/A

Asthma	Bronc.	Emphy.	
☐ (73)	☐ (74)	☐ (75)	73-75

35. Do you think you have ever had any of these chest disorders: asthma, any kind of bronchial trouble, or emphysema?

1 Yes
2 No
3 I don't know
☐ 76

76

36. Have any of your "blood relatives" ever had persistent asthma, bronchitis, or emphysema?

1 Yes
2 No
3 I don't know
☐ 77

77

37. Has a doctor ever told you that you had TB or any OTHER CHRONIC lung condition?

1 Yes, TB
2 Yes, other
3 No
☐ 78

78

If yes, note condition _____
(no code)

38. Have you had treatment for this?

1 Yes 2 No (9) N/A ☐ 79

79

39. Do you have an allergic disease?

If YES, what is the allergic disease?

1 Eczema
2 Hayfever
3 Hives
4 Asthma
5 Alergic Conjunctivitis
6 Other _____
(9) N/A
☐ 80

80

Card 04 1-2

1-2

UCLA I.D. ☐☐☐☐☐☐☐ 3 4 5 6 7 8 9

3-9

40. Do you have cold or flu symptoms now?

1 Yes 2 No ☐ 10

10

41. If no, when did you last have cold or flu symptoms?

1 1 - 3 days ago
2 4 - 7 days ago
3 1 - 3 weeks ago
4 4 - 6 weeks ago
5 more than 6 weeks ago
(9) N/A
☐ 11

11

F. SMOKING

42. Do you now smoke cigarettes regularly, occasionally or never? (INTERVIEWER: ask about little cigars or brown cigarettes)

1 regularly
2 occasionally (code 9 for cols. 13-23 if usually less than one per day)
3 never (code 9 for 13-23)

☐ 12 — 12

43. Do you inhale?

1 Yes 2 No (9) N/A

☐ 13 — 13

44. Do you smoke cigarettes with filters or without filters?

(9) N/A
1 with filters
2 without filters
3 smoke both

☐ 14 — 14

45. How many cigarettes do you usually smoke each day at the present time?

(9) N/A
1 less than 5
2 5 to 10
3 11 to 15
4 16 to 20
5 21 to 30
6 over 30

☐ 15 — 15

46. In past years, did you usually smoke more cigarettes than you do at present?

1 Yes 2 No (9) N/A

☐ 16 — 16

47. If yes, what was the usual number you smoked then? (Please give best estimate)

(9) N/A
1 less than 5
2 5 to 10
3 11 to 15
4 16 to 20
5 21 to 30
6 over 30

☐ 17 — 17

48. Have you ever attempted to stop smoking?

1 Yes 2 No (9) N/A

☐ 18 — 18

49. If yes, what was the longest period of time you were able to stop? _____

1 Days
2 Weeks
3 Months
4 Years

Time Unit ☐ 19

Number ☐☐ 20 21 — 19-21

50. How old were you when you began to smoke cigarettes?

(Interviewer: Record age in years)

(99) N/A

☐☐ 22 23 Yrs. — 22-23

(INTERVIEWER: If Subject is presently smoking, code 9 for cols. 24-33 and ask question 59.)

51. If you do not smoke cigarettes now, did you ever smoke them regularly or occasionally?

(9) N/A
1 regularly
2 occasionally (code 9 for 25-33 if usually less than one per day)
3 never smoked cigarettes (code 9 for 25-33)

☐ 24 — 24

52. What was the usual number of cigarettes you smoked per day?

(9) N/A
1 less than 5
2 5 to 10
3 11 to 15
4 16 to 20
5 21 to 30 (1-1½ packs)
6 over 30

☐ 25 — 25

53. Did you inhale?

1 Yes 2 No (9) N/A

☐ 26 — 26

54. Most of the time that you smoked did you smoke cigarettes with filters or without filters?

(9) N/A
1 with filters
2 without filters
3 smoked both

☐ 27 — 27

55. How old were you when you stopped smoking cigarettes regularly?

(Interviewer: Record age in years)

(99) N/A

☐☐ 28 29 Yrs. — 28-29

56. How old were you when you began to smoke cigarettes?

(Interviewer: Record age in years)

(99) N/A

☐☐ 30 31 Yrs. — 30-31

57. What was the main reason you stopped smoking?

(9) N/A
1 doctor's advice
2 advice of others
3 fear of health effects
4 other (specify)

_____

☐ 32 — 32

58. Were you also influenced to stop because you had a cough, wheezing or shortness of breath?

1 Yes 2 No (9) N/A

☐ 33 — 33

59. Do you now smoke pipes or cigars regularly, occasionally or never?

1 regularly
2 occasionally (code 9 for 35-39 if usually less than one per day)
3 never (code 9 for 35-39)

☐ 34 — 34

60. Which do you smoke?

(9) N/A
1 pipe
2 cigar
3 both

☐ 35 — 35

61. How many pipefuls or cigars do you usually smoke each day?

No. of pipefuls _____

No. of cigars _____

(9) N/A
1 less than 5
2 5 to 10
3 10 to 15
4 over 15

☐ 36 — 36

62. How old were you when you first smoked pipes or cigars? (INTERVIEWER: Record age in years)

(99) N/A

☐☐ Yrs. — 37 38 — 37-38

63. Do you usually inhale when you smoke pipes or cigars?

1 Yes 2 No (9) N/A

☐ 39 — 39

(INTERVIEWER: If Subject is presently smoking pipe or cigar, code 9 for cols. 40-46 and ask question 69.)

64. If you do not smoke pipes or cigars now, did you ever smoke them regularly or occasionally?

(9) N/A
1 regularly
2 occasionally (code 9 for 41-46 if usually less than one per day)
3 never (code 9 for 41-46)

☐ (40) — 40

65. How many pipefuls or cigars did you usually smoke each day?

No. of pipefuls _____

No. of cigars _____

(9) N/A
1 less than 5
2 5 to 10
3 10 to 15
4 over 15

☐ (41) — 41

66. How old were you when you stopped smoking pipes or cigars?

(99) N/A

☐☐ (42 43) Yrs. — 42-43

67. How old were you when you began to smoke pipes or cigars?

(99) N/A

☐☐ (44 45) Yrs. — 44-45

68. Did you usually inhale when you smoked either pipes or cigars?

1 Yes 2 No (9) N/A

☐ (46) — 46

69. FOR SMOKERS ONLY: How long has it been since your last: 1 Cigarette 2 Pipe 3 Cigar (9) N/A

☐ (47) — 47

(Record time in minutes - highest is 600)

Minutes ☐☐☐ (48 49 50) — 48-50

PREAMBLE: I am now going to ask you some questions about your education, residential and work history.

#Time
<1=1
1=2
2-5=3
6-10=4
11-15=5
16-20=6
21-25=7
25=8

G. OCCUPATION

70. Are you presently employed? 1 = Yes, full-time 2 = Yes, part-time

If NO:

3 = Student (22 or under) 4 = Student (22+)

5 = Housewife 6 = Unemployed

7 = Retired for health reasons 8 = Retired

[ ] 51 — 51

71. What is your present occupation?

(INTERVIEWER: If Q. 70 coded 3 to 8, record the last occupation held, if any within the past 10 yrs., if none, cols. 52-79 & 10-13 are coded 9.)

Kind of business or industry _____ Work [ ][ ] 52 53 — 52-53

Kind of work done _____ Location _____ *Location [ ][ ] 54 55 #Time [ ] 56 — 54-56

Dates of employment: From _____ to _____

72. How far do you live from your place of work? (Record no. of miles) Miles [ ][ ] 57 58 — 57-58

73. How do you get to your place of work?

1 Automobile
2 Bus
3 Walk
4 Other
5 Work at home

[ ] 59 — 59

74. How much time do you spend travelling to and from work each day? (Record time in minutes) Minutes [ ][ ][ ] 60 61 62 — 60-62

** Location Code - See map of APCD source areas.

75. Does your job involve travelling from one place to another during the work day? 1 Yes 2 No (9) N/A ☐ (63) — 63

76. If yes, where do you travel to? _____ (Use Location Code on APCD source area map.) *Location ☐☐ (64 65) — 64-65

77. How much time do you spend in travelling to these other locations on an average day? (Record time in minutes) Minutes ☐☐☐ (66 67 68) — 66-68

Now, I'm going to ask you some questions about your work schedule.

78. Do you usually work days, evenings or nights?
1 Days (6AM-6PM)
2 Evenings (3PM-12AM)
3 Nights (9PM-6AM)
4 Other combination _____ (specify)
☐ (69) — 69

79. What days of the week do you work?
1 Mon-Fri only
2 Sat & Sun + 3 other days
3 Other combination
☐ (70) — 70

80. How much time do you spend at your work location on an average day? (Record time spent in hours.) Hours ☐☐ (71 72) — 71-72

81. While at work, how much time do you spend outdoors on an average day? (Record time spent in hours.) Hours ☐☐ (73 74) — 73-74

** Location Code - See map of APCD source area.

82. At your place of work, are there any air modifiers, such as air conditioners, humidifiers, or filters?

1 Yes
2 No
3 I don't know
(9) N/A

☐ 75 | 75

83. Have you ever worked at a job in which you noticed changes in your breathing ability? (e.g. shortness of breath, more coughing or sneezing than usual, greater incidence of chest colds?)

1 Yes 2 No (9) N/A

☐ 76 | 76

If YES:

Kind of business or industry: _____

Kind of work done: _____

Dates of employment: From _____ to _____

Work ☐☐ 77 78 | 77-78

#Time ☐ 79 | 79

Card No. 0 5 | 1-2

UCLA I.D. No. ☐☐☐☐☐☐☐ 3 4 5 6 7 8 9 | 3-9

84. Have you ever changed occupations because of a breathing (lung) problem?

1 Yes 2 No (9) N/A

☐ 10 | 10

If YES:

Kind of business or industry: _____

Kind of work done: _____

Dates of employment: From _____ to _____

Work ☐☐ 11 12 | 11-12

#Time ☐ 13 | 13

I am now going to read several lists concerning materials you may have worked with as well as jobs you may have held. When I come to an item that applies to you, please tell me the number of months or years appropriate to that item. If any of the items apply to your work while in military service, please include them.

(INTERVIEWER: Code months as nearest quarter fraction (e.g. 1/4, 1/2, 3/4) of year and add to total)

85. Have you ever worked at a job handling any of the following materials?

(INTERVIEWER: If more than one material is named, ask if the materials were on the same or different jobs.)

1	Paints and solvents	___ yrs.	8	Tobacco leaves	___ yrs.
2	Dry cleaner for clothes	___ yrs.	9	Handling fluorescent lights	___ yrs.
3	Gasoline and oils	___ yrs.	10	Asbestos	___ yrs.
4	Asphalt and tar	___ yrs.	11	X-ray equipment	___ yrs.
5	Creosote	___ yrs.	12	Fiberglass	___ yrs.
6	Dyes and stains	___ yrs.	13	Plastics	___ yrs.
7	Crop dusts and sprays	___ yrs.	14	Powders	___ yrs.

	Material	Years	
	□□ (14 15)	□□ (16 17)	14-17
	□□ (18 19)	□□ (20 21)	18-21
	□□ (22 23)	□□ (24 25)	22-25
	□□ (26 27)	□□ (28 29)	26-29
Total no. of materials handled	□□ (30 31)		30-31
Total years		□□ (32 33)	32-33

86. Have you ever worked in a:

1	Steel mill	□□ (34 35) yrs.
2	Smelter or Foundry (If yes, ask #3)	□□ (36 37) yrs.
4	Grain elevator or silo	□□ (41 42) yrs.
5	Chemical plant (If yes, ask #6)	□□ (43 44) yrs.
7	Road construction or maintenance crew	□□ (48 49) yrs.
8	On a farm or ranch	□□ (50 51) yrs.
9	Textile mill (if yes, ask #10)	□□ (52 53) yrs.

3 What metal(s)? _____
_____
_____

Number of Metals: □ (38) — Metals: □□ (39 40) — 34-35, 36-40, 41-42

6 What chemical(s)? _____
_____
_____

Number of Chemicals: □ (45) — Chemicals: □□ (46 47) — 43-44, 45-47, 48-49

10 What textile(s)? _____
_____
_____

Number of Textiles: □ (54) — Textiles: □□ (55 56) — 50-51, 52-56

Total years: □□ (57-58) — 57-58

87. Have you ever worked as a:

1	Fry cook	_____ yrs.	
2	Miner (If yes, ask #3)	_____ yrs.	
3	What kind of mining? _____		
4	Carpenter or sawmill worker	_____ yrs.	
5	Mechanic (any type)	_____ yrs.	
6	Sand blaster	_____ yrs.	
7	Metal worker (If yes, ask #8)	_____ yrs.	
8	What metal(s)? _____		
9	Welder	_____ yrs.	
10	Stone worker	_____ yrs.	
11	Cotton ginner	_____ yrs.	
12	Beautician	_____ yrs.	
13	Baker	_____ yrs.	
14	Plasterer	_____ yrs.	

88. Have you ever worked at any other dusty job?

What job? _____ Years _____

Job	Years	
□□ (59 60)	□□ (61 62)	59-62
□□ (63 64)	□□ (65 66)	63-66
□□ (67 68)	□□ (69 70)	67-70
Total no. of jobs □□ (71 72)		71-72
Total years □□ (73 74)		73-74
Mining □ (75)	Metals □□ (76 77)	75-77
1 Yes 2 No □ (78)		78
Years □□ (79 80)		79-80
Card No. 0 6 (1 2)		1-2
UCLA I.D. □□□□□□□ (3 4 5 6 7 8 9)		3-9

H. DEMOGRAPHIC

89. What is the highest grade (or year) of regular school that you have completed? (Code numerically, e.g., completed 8th grade = 08; completed high school = 12; college graduate = 16. Code all degrees beyond the level of college graduate as 18.) ☐☐ (10 11) 10-11

90. What is your social security number? SS# ☐☐☐ ☐☐ ☐☐☐☐ (12 13 14 / 15 16 / 17 18 19 20) 12-20

91. Where did you spend most of your childhood? SMSA ☐☐ (21 22) 21-22

1 Urban 2 Rural ☐ (23) 23

_____ Residence _____ Nearest Metropolitan City

92. How long have you lived in Burbank? (Record no. of years.) Yrs ☐☐ (24 25) 24-25

93. How long have you lived in the East San Fernando Valley? (Record years.) Yrs ☐☐ (26 27) 26-27

94. Have you ever lived outside the East San Fernando Valley for one year or more at a time? (Please include military service and residence overseas.) 1 Yes 2 No ☐ (28) 28

If NO to Q.94, cols. 29-78 are coded 9.

If YES to Q.94, ask:

95. Have any of these places been within 50 miles of a big city (population 1/2 million or more?) 1 Yes 2 No ☐ (29) 29

If YES to Q.95, ask:

96. Starting with your residence at age 18, please tell me all of these places. Please include military service and residence overseas , but do not include moves made within the same community.

INTERVIEWER: For "Miles to City" use the following code: 1 = 0 to 25 miles
2 = 26 to 50 miles
3 = Over 50 miles

For "Work Location" ask: Did you work in the Metropolitan City? Code: 1. Yes, 2. No, 9. N/A

	RESIDENCE	NEAREST METROPOLITAN CITY	SMSA	MILES TO CITY	WORK LOCATION	FROM AGE	TO AGE	
1.			30 31	32	33	34 35	36 37	30-37
2.			38 39	40	41	42 43	44 45	38-45
3.			46 47	48	49	50 51	52 53	46-53
4.			54 55	56	57	58 59	60 61	54-61
5.			62 63	64	65	66 67	68 69	62-69 62-69
6.			70 71	72	73	74 75	76 77	70-77

How many places are listed? [ ] (78) — 78

Card No. [0 7] (1 2) — 1-9

UCLA I.D. No. [ ] (3 4 5 6 7 8 9)

97. Have you ever changed residence because of a breathing (lung) problem? 1 Yes 2 No [ ] (10) — 10

If YES: Where did you live _____

SMSA 1 [ ] (11 12) Time [ ] (13 14) — 11-14

How long had you lived there _____ yrs.

How old were you when you moved _____ yrs.

AGE [ ] (15 16) SMSA 2 [ ] (17 18) — 15-18

Where did you move to _____

Did it make a difference?

1 Yes, better
2 Yes, worse
3 No difference

[ ] (19) — 19

98. Do you presently have any type of air conditioner, humidifier or filter system in your home?

1 Yes, air cond.
2 Yes, humidifier
3 Yes, filter
4 Yes, air cond & humidifier
5 Yes, air cond & filter
6 Yes, humid. & filter
7 All three
8 None

☐ 20

20

99. If YES, how often is it in use?

1 Rarely
2 Summer only - occasionally
3 Summer only - often
4 Yearround - occasionally
5 Yearround - often
(9) N/A

☐ 21

21

100. What type of heating system do you have in your home?

1 Forced air
2 Radiant
3 Floor or wall furnace (gas)
4 Radiator (steam)
5 Other _____

☐ 22

22

101. What kind of fuel is used in this?

1 Oil
2 Natural gas
3 Bottled gas
4 Electricity
5 Other _____
6 Don't know

☐ 23

23

102. On an average weekday (6AM-6PM, Mon-Fri), how much time do you spend in the Burbank/East San Fernando Valley area?

1 Less than 1 hr. (<10%)
2 1 - 3 hours (11-25%)
3 4 - 6 hours (26-50%)
4 7 - 9 hours (51-75%)
5 More than 9 hrs. (>75%)

☐ 24

24

102. On an average weekday, how much of that time do you spend outdoors?

(same code as above)

☐ 25

25

103. On an average weekend day (6AM-6PM, Sat-Sun), how much time do you spend in this area?

1 Less than 1 hr. (<10%)
2 1 - 3 hours (11-25%)
3 4 - 6 hours (26-50%)
4 7 - 9 hours (51-75%)
5 More than 9 hrs. (>75%)

☐ 26

26

104. On an average weekend day, how much of that time do you spend outdoors?

(same code as above)

☐ 27

27

Now, I am going to ask you some questions about your health.

105. When was the last time you saw a physician?

1 less than 6 months
2 6 mos. to 1 year ago
3 more than 1 year ago

☐ 28 — 28

106. What was the problem? _____

1 Check-up, routine
2 Acute condition (infection)
3 Accident
4 Heart
5 Respiratory _____ specify
6 Gastrointestinal
7 Surgery _____ specify
8 Other _____ specify

☐ 29 — 29

107. Which of the following describes the way you usually respond to episodes of air pollution? (You may indicate more than one.)

	Upper Respiratory	Lower Respiratory	Other
Do you experience:	___Sore throat	___Wheezing	___Eye irritation
	___Running nose	___Coughing	___Headache
	___Sneezing	___Breathlessness	___Tiredness
	___Sinus irritation	___Chest tightness	___Depression

UR	LR	Other	
☐ 30	☐ 31	☐ 32	30-32

108. Do you usually stay indoors on smoggy days?

1 Yes 2 No

☐ 33 — 33

109. Are you now pregnant? (If YES, how many months?)

1 No
2 2 months
3 3 months
4 4 months
5 5 months
6 6 months
7 7 months
8 8 months+
(9) N/A

☐ 34 — 34

Card No. [0][8] (1 2)

[ ][ ][ ][ ][ ][ ][ ] (3 4 5 6 7 8 9) 1-9

end closing v. [ ][ ][ ][ ] (10 11 12 13) 10-13

% N_2 [ ][ ].[ ] (14 15 . 16) 14-16

ease of reading [ ] (17) 17

complete tracing [ ] (18) 18

est FVC (spirom) [ ][ ][ ][ ] (19 20 21 22) 19-22

Standing Ht. (in.) [ ][ ].[ ] (35 36 . 37) 35-37

Sitting Ht. (in.) [ ][ ].[ ] (38 39 . 40) 38-40

Wt. (nearest lb.) [ ][ ][ ] (41 42 43) 41-43

Blood pressure [ ][ ][ ] / [ ][ ][ ] (44 45 46 / 47 48 49) 44-49

$CO_{end\ exp}$ [ ][ ][ ] (50 51 52) 50-52

$CO_{ambient}$ [ ][ ][ ] (53 54 55) 53-55

N_2 Done? [ ] (56) 56

begin. plateau v. [ ][ ][ ] (57 58 59) 57-59

% N_2 [ ][ ].[ ] (60 61 . 62) 60-62

750 cc % N_2 [ ][ ].[ ] (63 64 . 65) 63-65

1250 cc % N_2 [ ][ ].[ ] (66 67 . 68) 66-68

1750 cc % N_2 [ ][ ].[ ] (69 70 . 71) 69-71

begin. closing v. [ ][ ][ ][ ] (72 73 74 75) 72-75

% N_2 [ ][ ].[ ] (76 77 . 78) 76-78

BODY PLETHYSMOGRAPHY

	Open	Closed		
reading 1	[ ].[ ][ ] (23 24 25)	[ ].[ ][ ] (26 27 28)	ERV 1 (L)	[ ][ ][ ][ ] (29 30 31 32) 23-3
reading 2	[ ].[ ][ ] (33 34 35)	[ ].[ ][ ] (36 37 38)	ERV 2	[ ][ ][ ][ ] (39 40 41 42) 33-4
reading 3	[ ].[ ][ ] (43 44 45)	[ ].[ ][ ] (46 47 48)	ERV 3	[ ][ ][ ][ ] (49 50 51 52) 43-5
reading 4	[ ].[ ][ ] (53 54 55)	[ ].[ ][ ] (56 57 58)	ERV 4	[ ][ ][ ][ ] (59 60 61 62) 53-6
reading 5	[ ].[ ][ ] (63 64 65)	[ ].[ ][ ] (66 67 68)	ERV 5	[ ][ ][ ][ ] (69 70 71 72) 63-7

APPENDIX D

TRANSCRIPT OF OZONE AND HEALTH TELEPHONE CONFERENCE

TRANSCRIPT OF CONFERENCE CALL

August 7, 1984
4:00 pm

This is Anne Coulson at UCLA and I have with me Stan Rokaw, Don Tashkin, Roger Detels and Mohammad Mustafa. I will call the roll of the people who are not here at UCLA.

Coulson: Dr. Beard?

Coulson: Not on?

Coulson: Dr. Cross?

Dr. Cross: Yes.

Coulson: Dr. Crocker?

Dr. Crocker: Yes, here.

Coulson: Dr. Horvath?

Dr. Horvath: Right.

Conference Operator: Dr. Beard got disconnected.

[static]

Beard: Hello? This is Rodney Beard

Coulson: Ema?

Ema: Yes I'm here.

Coulson: We are all present except Dr. Schaeffer who will join us later and Dr. Gerking. The purpose of this conference call is to talk about, as I told you in the letter, ozone and health. The background of this is that in concert with the University of Wyoming and the University of Colorado we are putting together a proposal to contact some 200 people several times in a year looking for some of the lesser health effects of ozone, leaving it to other studies to deal with the more major ones. This will not involve any respiratory function tests or but we need to know what kinds of effects we can expect at what levels. We have put together a set of questions which I will read over I would like you to break in whenever you wish with any information. Would you please identify yourself each time you do. We

are having a transcript made of this entire conference which will be sent to you for your approval, additions, and deletions, so it would be nice to be able to record who was saying what.

Okay, this is Rodney Beard and I did not receive anything in advance.

Coulson: The information that we sent was very limited, about what I have already said. We have come up with the questions since we sent out the letter on Friday. I will now read them to you. I would like to read them all the way through so that we'll know what is coming up. We may not get all the way through them in this conference. We may also cover more than one question in answering a single one. These are the questions.

1. What kinds of symptoms might be experienced by an ordinary free-living individual with exposure to ozone?

2. At what levels of ozone might this be experienced?

3. What effect modifiers might influence the experience of symptoms: age, sensitivity, exercise, time out-of-doors, anything else?

4. What effects would you expect ozone exposure or the resulting symptoms to have on activities such as work, commuting, recreational activities?

5. Is the effect of ozone or smog greater or less on succeeding days of a three to five day episode?

6. Which day is best and worst?

7. What would you expect the range of indoor values of ozone to be for given levels of outdoor ozone?

8. What impact on exposure would be expected given the air conditioning of just about everything?

9. Do such levels produce health effects with indoor activities, for example, indoor tennis, indoor health clubs, etc.?

10. Does ozone exposure apart from any other effects alter the affect or mood of exposed individuals or their motivation to do things and at what levels?

Coulson: The first question is: What kinds of symptoms might be experienced by an ordinary free-living individual with exposure to ozone? Do I have a taker?

Dr. Horvath: We'll I'll start. I think the major ones are the subjective symptoms as I gather is all you're trying to find out. The first is pain on deep inspiration, in other words when they take a deep breath they will complain of pain. There will be cough. The cough seems to be the most common symptom which occurs in all most all subjects. They also may

complain of substernal pain even without taking a deep breath. Some subjects will experience a little nausea. Those are the four major symptoms.

Beard: I would have added complaints of headache, from what I have read, but perhaps that's an oxidant effect.

Stan Rokaw: I think that in Los Angeles headache and eye irritation are clearly frequent complaints, often preceding the levels of the onset of the substernal pain and coughing and chest discomfort.

Horvath: The eye irritation is probably due to PAN and now unless you are talking about more than just ozone, if you're talking about total oxidants in that environment, then you may have a problem.

Stan Rokaw: I think that we have had some preliminary discussion and I have been uncomfortable with this being an ozone-limited standard ever since it was changed. The whole mix needs measuring because ozone alone certainly does not account for all the things that we get in typical Los Angeles air pollution episodes.

Horvath: I agree I think that you have to talk about oxidants. I don't know what the set up is.

Beard: I feel that I am in agreement with both of the others.

Crocker: I am too. I agree with the observation of symptoms that Stan Rokaw refers to and maybe along with them goes sensitivity to bright light. Tendency to eye irritation plus that, I also know that Horvath is referring correctly to eye irritation as being due to the whole oxidant mix. Even the oxidant mix may be undergoing some change in current times as compared to earlier times. If we are going to focus on oxidants then we ought not to limit ourselves to ozone. Though at the moment ozone stands as the surrogate for other oxidants, it may not be adequate.

Horvath: We have been doing some work with PAN and we are pretty well convinced that unless you take into account all the oxidants you are not really getting the full picture of the way people respond, in particular because of the fact that one of the oxidants goes up another one is building up and then you get sort of an overlap and then you get a variation in absolute concentrations of the various oxidants. Unless you have some appreciation of the variability, which raises an interesting question, I think probably a most important question is if you are going to start doing this in a number of homes and so forth, what kind of measurement devices are you going to use?

Crocker: Measurement devices, what are you going to measure and what tools are you going to use? There is another detail maybe, but I don't think we're beating a dead horse at all. That is that one of the oxidant gases is NO_2.

Horvath: Yes.

Beard: Absolutely.

Crocker: NO_2 is not measured when we measure oxidants in the ordinary way and we usually separate NO_2 and NO_x. When we combine ozone and NO_2 in any kind of laboratory setting, we find a synergism which is surprising and possibly dependent on the coexistence of particles. In addition, the product of O_3 and NO_2 may be an acidic very fine particle which increases the effect of ozone.[2] Now I am not all sure where to quit in identifying oxidants. If we try to be very clean about just using ozone as the standard against which to measure symptoms we are not going to include a variety of oxidant air pollutants. These oxidants include PAN and NO_2 as part of the overall symptom-producing mixture; possibly even particulates contribute to symptoms. So it is very hard to satisfy ourselves that ozone is the only pollutant contributing to symptoms.

Horvath: But in the ambient environment you really can't test whether ozone alone is responsible for symptoms because you're working with low levels of any one of these pollutants and the interaction among them may be more important than ozone alone in causing symptoms.

Rokaw: It strikes me that we have to look ahead in terms of the world around us and that an ozone standard is probably coming up for a review. Should that single substance standard be continued, should we not be raising these issues (as new standards come up) that there is a clear need to look at the whole complex that possibly affects people's health adversely (they would be comprised in terms of either activity or actual onset of illness).

Crocker: Yes, I think's that a good point, Stan.

Beard: I do, too. This I am sure you will recall we said all these things at the time that EPA decided to abandon the oxidant standard in favor of an ozone standard.

Mohammad Mustafa: This is a time to bring up something you brought up, namely synergism. I am talking with respect to the outdoor environment that we have. We have ozone and oxides of nitrogen and the fact that we have synergism that would mean that neither ozone or NO_2 can be considered independently because their health effects are very likely created by interaction. For example their interaction may produce free radicals such as nitrate radical and the free radicals may be the species responsible for the health effects and the "synergistic" effects.

Horvath: I think you're asking the question again, that is what are you going to be measuring. You have got to make up your mind in terms of this project as to what you are going to measure. If you want to measure all of these things you will probably have a houseful of equipment and no room for the subjects.

Mustafa: Going back to the question of total oxidants or ozone if we don't measure "total oxidants" we may be missing something that is more reactive and just because it was not in the book.

Cross: I would like to return to the question as to what kind of subjective symptoms you want to catalogue. It occurs to me that you might have to collect two batches. One for pure ozone exposures based on observations of Horvath and others who have actually exposed people to pure doses of ozone for periods of time and noticed what symptoms they get when exposed to pure O_3 either in chambers or masks, and design a different symptom complex in another group where the catalogued symptomatology has been designed to assess for symptoms such as eye irritation which probably relates to other non-O_3 species present in real life "oxidant" environments. And one of the symptoms that we haven't mentioned and which I am sure the study will be addressing is psychological testings of mood, motivation, etc. approached in much the way we in chest medicine in the past have approached rehabilitation programs etc. I think that it is an area that has been relatively poorly studied and which could be looked at. I would also point out that Dr. Tashkin's laboratory has been studying symptoms of airline stewardesses who have been flying high at high altitudes where they are getting relatively pure ozone and that further study of the symptoms that the stewardesses complained of might be a helpful way to characterize symptoms of ozone exposure in a healthy working population.

Tashkin: My subjects in the stratosphere also complained of throat irritation and discomfort that we thought were probably ozone related but let me qualify or rather clarify the scope of the study which Anne didn't have the opportunity to explain in any detail yet. We are going to be looking at a free-living population of people. We haven't decided on the community yet, that will be the basis of another question. It will probably be either Burbank, which is exposed to moderate levels of oxidant pollution or Glendora, near Azusa, which is heavily exposed to oxidants. Our measurements will be carried out for us the by the Southern California Air Quality Management District (SCAQMD) to which the monitoring station which is close to the community of interest, whether it be Burbank or Glendora belongs. We will have an opportunity to look at ozone, NO_X, and particulates.

Horvath: I think you're wasting your time. I don't think the monitoring stations are worth a hoot in the beginning. ... They don't represent what is happening in the homes, they don't represent what is happening in any local part of the community. They just give you a false impression of what you are measuring. I think that if you are going to do any measurement you are going to have to do it where your free-living people are.

Tashkin: Are you talking about personal monitoring, Dr. Horvath?

Horvath: Absolutely. I think its the only opportunity.

Tashkin: That would be ideal but I think that it would be economically not feasible for us within the scope of this particular study. I think you are absolutely correct in that if you wanted a precise measure of the impact of air pollution on health and on activities, you would need to measure the pollutants where the people are but given the available funds, we are stuck with outside ambient levels. I guess that we might ask you a terminal

question at the end of this conference as to whether or not the study is worthwhile to pursue at all but why don't we proceed with the next question. (See Appendix E: Beard note #1.)

Horvath: I thought you were talking about doing some studies in Colorado and Wyoming.

Coulson: It is a consortium of Colorado, Wyoming and UCLA that will doing it but it will done here because this where 70% of the ozone is.

Horvath: Oh, okay, because it raises a couple of other interesting questions if you are going to do the studies elsewhere.

Cross: You mentioned in the letter that you sent out and then in your little protocol that you are very interested in indoor measures. I don't understand, Don. Are you saying that you don't plan any indoor monitoring.

Tashkin: Given the budget that would be impossible. Basically ... [(interruption)]

Cross: Monitoring for ozone indoors may be feasible in representative houses, workplants or other worksites.

Tashkin: Yes, but even so, our budgetary restrictions would not allow for that type of activity. Perhaps we can get back to this very basic issue later on.

Coulson: I think that we are interested in more than just the project within this particular conference. I think that we ought to learn from you the kinds of things that we might expect or not expect to find as a consequence of our being able to measure or not measure these things. This is an ideal opportunity for all of us to say the things that should be said in terms of making the measurements and doing the studies.

Crocker: In that case, I would support Horvath's position that one of the weakest elements, if not the weakest element in the proposal is the absence of measurement closer to the point of exposure of the person both indoors and out. Unless we can emphasize to whoever is the supporting agency that measurements made at a point in the locality are subject to high variation and that any kind of generalization from them to personal exposure is difficult, we are in trouble.

Horvath: I would add one other word to that, I'd say a generalization about symptoms associated with oxidant pollution is impossible without close personal monitoring.

Crocker: We are especially in trouble when we are looking for transitory symptoms. For example, the UCLA study in which Anne, Don, Roger and Stan were participants, you had the advantage of pollutant monitoring over a period of time such that you might assume that the outcome would be dependent upon cumulative exposure experience over some period. But if you are looking for transitory symptoms associated with current exposure you

much more close correlations between the measurement of oxidants and the finding of symptoms because you are not looking, presumably, at chronic manifestations as you have in your previous studies. I would recommend strongly that you identify to the agency the urgency of making your measurements close to the subject. You have a fairly small number of subjects so you might be able to do this for at least some subsample of the group.

Horvath: This is more and more evidence that short exposure to high concentrations of ozone or NO_2 do more damage and cause more severe immediate symptoms than the overall mean average of one hour, 24 hours or one year. This is true for NO_2, very true for CO and it may be also true for ozone.

Beard: I agree with that and I think that attention must be given to the question of interaction between ozone and nitrogen dioxide particularly. The variation of NO_2 concentrations inside houses is considerable depending on the kinds of cooking fuel. It occurs to me I certainly would like to see the NO_2 level monitored in the houses.

Mustafa: Is not it a fact that depending on the economic status, some people have air conditioning in their houses and there are others who don't? On a hot, smoggy day those who have air conditioning may be in somewhat better conditions because they are not being exposed to outdoor ozone taken in by open windows. But the others who open their windows and doors for so-called "fresh" air will be getting a bigger dose of the ambient air. For them the difference between outdoor and indoor air probably won't matter, but for the people with air conditioning it will.

Horvath: We have noticed that a number of people are buying ozone generators. Really, the old story is coming back. The ions are important. You can buy ozone generators. All you have to do is look at some of the ads in some of the airplane magazines. There is a big executive ozone generator that you can put on your desk and a few others. You may have people in your sample that may have a fetish for "bright air" or whatever that is. But that is true, it is a big product now.

Cross: I would like to ask those planning the study how they were planning to approach the characterization and categorizing of symptoms. It appeals to me that headache may be appearing in those predisposed to headaches. For nausea it sounds like we may not be able to identify a peroxide that circulates and causes nausea, but these may be people in whom nausea is a manifestation of psychosomatic state or mood change or a frustration or whatever. In looking back at symptoms is there anything else to be said on it or can we close this up to move to one of the other areas that you mentioned.

Tashkin: I think that perhaps we might move on. Assume we realize that the effects of oxidant air pollution exposure are related to more than just ozone. Thinking just about ozone, at what levels would you expect that the symptoms that were just mentioned to be experienced.

Beard: We have had laboratory exposures to ozone alone, nominally at 0.4 parts per million with no associated symptoms. I think somewhere around 0.5 to 0.6 other people have reported observing symptoms.

Tashkin: How/what was the duration of the exposure to .4 or .5 parts per million before the symptoms were reported?

Beard: Well as I said we had no symptoms, these were one hour exposures.

Tashkin: Oh you're referring to other published data. I'm sorry, you indicated that no symptoms were experienced up to those levels, up to .4 for one or two hours.

Beard: For one or two hours.

Tashkin: Dr. Horvath, you mentioned headache and you mentioned substernal pain without taking a deep breath or pain on breathing. Now at what level were those symptoms experienced?

Horvath: The question you are asking and in all the questions we have asked there is a modifier: that is, you have people sitting around and being absolutely quiet. I think that I agree with Rod that probably up to .3 we wouldn't see anything; but if there was any degree of activity so that breathing increases, you are going to start seeing effects depending upon the level of ventilation and level of activity. These effects go down as low as 0.18.

Tashkin: That was the next question, what effect modifiers might influence the experience of symptoms. You mentioned activity. This is light activity sufficient, say, to increase oxygen consumption two or threefold or more.

Horvath: If you are doing this for only two or threefold increase which is ventilation of about 25 liters per minute you will see symptoms probably at about .22 ppm.

Tashkin: About .22. Do you feel that age is an important effect modifier?

Horvath: Well if you had asked me that a couple of weeks ago I would have said yes, but I am not too sure right now.

Tashkin: You are intriguing us about the reason for this switch.

Horvath: The first six subjects that we did were age 70 and above. They exhibited no symptoms and they had nothing at all. We have them up to .4 and they were doing moderate activity which isn't a great deal. They were at about 15 or 16 liters minute ventilation. Last week we did more subjects and showed that they were responders. Which brings up really the biggest question which I think is going to be a serious problem. That is simply, there is a tremendous variability in sensitivity, at least to ozone; and I am sure it is true for all the others. You will have individuals who have no response, and individuals who will have a

tremendous response. For example, at 0.4 we have had individuals who vary in response from maybe 5 percent decrements of FEV_1 which is the simplest of measures. Others have as great as 45 percent decrements. So you have a range of individuals from those you can call nonresponsive, to individuals whom you would call very sensitive responders. When your FEV_1 is decreased by 45 percent you're not very happy.

Tashkin: Did you correlate the degree of response to ozone to other indices of nonspecific hyper reactivity?

Stan Rokaw: The measurable responses such as pulmonary function are certainly being called out at appropriate concentration levels. I can't escape concern about the ones that Carroll Cross was relating and reflect on the study that Doug Hammer completed. It is old literature by now, but seemed to correlate the headache, the distractability, the irritability at ozone levels in this community. The response curve began to rise at about .14 parts per million, of what was then an oxidant measurement. If we could find a reasonable way to tabulate these symptoms would such numbers seem appropriate to the rest of you. Is that a set of "symptoms in which we should have great confidence."

Horvath: I think that you will find individuals who will respond to .14. If you take an average, you know, you will find nothing happening but if you look at the distributions of the population you will find that there are some individuals who have responded and most of them will not, both in terms of these things that Hammer did and some of the things that ... and I did years ago where we looked the EEG for example of the effects of CO and changes in the EEG. It is hard to say if we statistically average it out there is nothing. You look at the variability you will find some individuals who are just horribly responsive. I think that is going to be your biggest problem, individual variability.

[static]

Roger Detels: On the individual variability though, isn't each person his own control? (See Appendix E, Beard note #2.)

Crocker: Yes, I would say each person could be his own control if you had the opportunity to grade the sequence and times of exposure by individual according to the concentrations measured. This emphasizes the importance of measuring right at the subject and not in the vicinity. The use of the person as his own control is valid if you can identify the range of concentrations of exposure over several different observation times. Is that possible?

Tashkin: Let me indicate what the rough study design is. It hasn't been described in any detail yet. We plan to select 200 people from one of the populations that have already been defined by Roger's study, the CORD study, so that we know a lot about these people already. We know whether or not they are cigarette smokers, we know their age, sex, race, occupation. We know whether or not they have respiratory symptoms or a history of respiratory disease. We also know their lung function. We are

not sure how to segregate or stratify the community, but that will be the subject of another question. We have data on three or four thousand people in each of these communities. Once having selected our study sample, we also want to stratify on airways sensitivity. We intend to contact each individual about once a month. Sometimes study participants will be contacted on smoggy days and at other times on days when the air quality is good. During these contacts we will query them about their symptomatology, their activities during that day and about their feelings concerning whether or not they might have done something differently had the weather been better. Some of these days will be weekend days. We know that weekend days will be less smoggy, but those are days when people engage in more recreational activities, so that if the weather is bad then there may be less inclination to engage in vigorous outdoor activities, such as tennis or other sports. We will be inquiring about the proportion of time spent indoors and outdoors, about commuting, etc. We will have the data from the monitoring station concerning outdoor pollutants and we might be able to relate those data to the kinds of activities that people do or do not do when they have the discretion to alter their behavior based on the weather. Now during the week it is clear that people have to do certain things like go to work, but they might conceivably modify their commuting patterns depending on the presence or absence of air pollution. Or they might modify their after-work activities. Basically the design of the study is to follow each person prospectively over the course of a year during which we would administer a telephone questionnaire on several different days, some days being smoggy and some being clear. We are interested in activities not only on the day of the questionnaire but on the two days preceding the questionnaire. One question about this design that we have is whether or not we should try to choose bad days that are <u>not</u> the first day of an episode, but rather the second or third day because of possible delayed effects of air pollution.

Horvath: Certainly, we know pretty well now that the second and more likely the third day of a repeat exposure is going to be the worst and we also have evidence now that if you have the first day and then a clear day and a second day comes up with a certain level of ozone, that the response is again exaggerated on the second day even though there is an intervening day of clearness. You really have another complication there as well. That is a so-called desensitization to ozone by four or five days depending on the absolute levels. We find people that report no symptoms and they also have no demonstrable pulmonary detriments(?).

Tashkin: You are saying that if there is an episode of air pollution that lasts four or five days, the symptoms on the fourth or fifth day would be less that on the first day due to adaptation. But if there is a bad day then a good day followed by a bad day then the symptoms will be exaggerated on that second bad day?

Horvath: That's right.

Tashkin: Because of sensitization?

Horvath: Well, the answer to that is unknown. I don't know whether it's desensitization or adaptation. I think the question is a moot point because we don't really know what it is. The real question is that although there is subjective and objective signs of ones that we can measure disappear we don't really know whether or not there is a secondary effect still going on. After all, the contaminant is still getting in the lung. And whether or not it does destroy various things, it may destroy them much more effectively now that you don't know that it has been doing it.

Tashkin: That's a confounder that we will have to deal with.

Horvath: Yes.

Tashkin: We will have some control over the days we select. If you were designing a study such as this and you wanted to know about effects of air pollution, you would contact the study subjects not on the first day, but on one of the subsequent days of a string of "polluted" days. This strategy would also have the advantage of alleviating the problem of selecting days on which air pollution is present since we might not otherwise be able to predict accurately when air pollution is going to occur.

Horvath: I wouldn't even do that. My own feeling on it is that if I were going to do this kind of study I would take a family or two or five or ten, or whatever it is, and follow them everyday.

Tashkin: And call them everyday?

Horvath: Absolutely. You have no way of telling people's recall at ... I mean we have done nutritional surveys tried to do three-day recall or 24 hour recall of days and that is something that people I know they do and their recall is just not that good. I think that if you have this recall a month apart you don't know whether what they are telling you today is a reflection of what happened a week ago or what happened today or what happened the day before or what they thinks going to happen tomorrow. (See Appendix E, Beard note #3.)

Tashkin: We agree with you Dr. Horvath. We would like to call these people up every day given that they would be patient enough to agree to that and that we would have the funds to do so. However, we feel that it is more realistic to contact subjects about one day a month and to query them only about that particular day and the preceding day or two. We realize that their memory would be rather or imperfect if we were to ask them about how they felt or what they did more than a couple of days ago. That is the same reason why we feel that diaries would be a poor way of assessing the possible impact of air pollution on behavior because people don't fill diaries out except before they are ready to hand them in and then they often "dry lab" them and rely on their imperfect memory.

Horvath: You know, if Roger has, and I am sure he must have, a very definitive evaluation of such a small number I would think that my own personal feelings would be I would rather devote my resources to [static] following a small number of people with close monitoring of exposure rather than following a large number.

Detels: I didn't hear you completely Steve, but I think you are talking about the argument of following a small number intensively versus a larger number more sporadically and there is something that you said on both sides of that argument.

Horvath: In one case you spend more on statistics and perhaps this is good enough for you. In the other case more will be spent on a few people and this will require cooperative people. I think that it would be preferable to get a smaller group that you could follow very intensively both for symptoms and exposure monitoring and then have a larger group on which to use the less rigorous follow-up pattern that you suggested. But it certainly would be an opportunity to look really closely at what happens in the life of a family or two families ...

Detels: I think that there are really two different kinds of studies though, Steve. The problem is that if you are going to look at a small family or a family or a number of families very intensively then I think that you are probably right you then probably want to be much more intensive about getting the most accurate air pollution measurements that you really get. Whereas if you deal with a larger population more sporadically then I think that you can get by with less accurate measurements or less closely monitored measurements as long as you realize the limitations that you are involved with.

Beard: I don't understand that argument. Sounds to me as if you are saying as long as you have a big enough number it doesn't matter whether you are accurate or not.

Detels: No, that isn't really quite what I am saying. I think that if you have got a larger number that the--well maybe I am saying that. Maybe I think that the errors will tend to smooth out. I think you are making rougher correlations on a larger number.

Beard: But don't you recognize that you are dealing with phenomena in which there is already extreme degree of variation in human responses and you already have very difficult problems of getting information about what the exposures amount to and to say we'll just measure more and these are going to balance out. It's not going to produce convincing epidemiological reports. More garbage is still garbage.

Detels: You may be right, I guess part of what concerns me is that if you had the misfortune to pick ten families to follow intensively who in fact did not react very much to air pollution you might make a wrong conclusion. Whereas if you pick a large population of people you are more likely to get, at least some of those people in that larger population, who are going to react more sensitively. (See Appendix E, Beard note #4.)

Crocker: Is it possible to consider that you might pick your people with that variability in mind. In short, try to select as you remember we used to do in the very old days when we had panels of people who were asked to give a response to such questions as: Do you have eye irritation today? Are you experiencing smog symptoms today? Dr. Haagen-Smit proposed the use of such response panels of ten to twelve people and they were selected in a fairly meaningful fashion. A large number of people were asked if they had commonly found themselves affected by air pollution or whether they did not find themselves affected. The panel was selected from the respondents to these questions and gathered as a group that was supposed to represent a spectrum of the general population response. I suggest that you could come a little bit closer to a defined group if you selected them on their past history of response based on records you have from previous studies in these cities. This might help you focus a little bit better, Roger, than if you were to select a group of representative responders on other criteria. I am not sure what criteria you are going to use to select responders, but Don mentioned a possibility of some kind of bronchial-constrictive test of responsiveness. Was there a plan to test subjects with methylcholine?

Tashin: Well, we would like to do that but we don't have previous methylcholine data on our prospective subjects from the CORD population and we do not have the funds to do additional testing at this time. We do have a history of allergies and asthma so that we are able to choose a sensitive population which will probably include allergic or asthmatic individuals.

Beard: We also have pulmonary function data but unfortunately we do not have even bronchodilator response data which would be another way of getting at airways reactivity.

Detels: How would you feel about starting this study by looking at a larger number of individuals not quite so frequently and from those identify some subunits or sub-groups of that population. One sub-group could be persons who appear to be reacting in correlation with levels of air pollution and another group could be those persons who appear not to be reacting. More intensive observations could be made thereafter on these two sub-groups.

Horvath: We have done some studies on multiple pollutants and what we have done is a preliminary ... we have given them an ozone challenge and we find that the people who respond or at least are challenged are also the ones that react markedly to the mixture and the ones that don't respond to the challenge, don't respond to the mixture. So you could possibly pick out a group that is actually representative of this population.

Tashkin: So what you just said there is that ozone is a reasonable marker of response to total oxidants. Is that, did I hear you correctly?

Horvath: Roughly.

Crocker: No that's not what he said. He said that those who are responsive to ozone on a screening challenge will later be also responsive

on later exposures. I think he is indicating that if you find a group who are responsive and a group who are not responsive to ambient pollutants then you can sub-divide your population into responders and nonresponders somewhat along the same line as his (Horvath's) laboratory subjects except that in this case you are using the experience of ambient exposures as a natural challenge. You would set up a comparison with Horvath's experience in which he uses a deliberate challenge.

Detels: Also, we are suggesting perhaps a little bit more than that. By looking at the larger group you can identify those people who would seem to have onset of symptoms which correlated with levels of pollutants. You may want to take that group and try to define them further by making more measurements following them more intensively.

Horvath: But Roger, I thought you were going to take individuals from that long study of yours already. In other words, you have a preliminary screen.

Detels: Well we only have two measurements on those individuals we studied previously; a baseline measurement and then a measurement five years later. So we really do not have an estimate of their acute responsiveness in terms of symptoms but on their rate of decline in lung function--FEV_1, FVC, single breath nitrogen, etc. and change in their history of symptoms.

Horvath: Yes, I thought you had more.

Detels: Well we asked about a lot of symptoms but we really didn't have much faith in what we found.

Horvath: Well I go along with it except it would be nice if you learned very quickly whether some people in that large population are sensitive. If you learned that within, say, a month or two, then at the same time that you were doing the long term one you could conduct a little more intensive one going along simultaneously on the sensitives. I think that if you wait a year or two you may find that the environment will change or that you will lose your people, things like that.

Detels: Well it depends on how you do it, I think we do have some experience in that we followed a group of 35 asthmatics very intensively for a period of about 10 months and I think we were able to identify a few of those individuals who seemed to have exacerbations that correlated with levels of sulfates.

Horvath: Yes.

Beard: You may know I have been spending a lot of my time working on air quality standard questions and I find that the useful information seems to come almost exclusively from observations in a handicapped or compromised subjects.

Detels: Well they're motivated to cooperate, that's true.

Beard: I would encourage you to give attention to compromised subjects being of the greatest value.

Tashkin: What percentage of the study sample, if we have 200, would you suggest that we include as a sensitive sub-sample?

Beard: Well I would think very seriously about trying to make the whole study on compromised subjects.

Crocker: I think that what Dr. Beard is talking about is compromised in the fashion of having sensitive reactors, persons with airway constriction, as in the case of asthma or other broncho-constrictive responses. Is that true Rod?

Beard: There's that, but I would also consider that people who are exercising heavily would come into the category, also the very young, and persons with various chronic diseases.

Crocker: Okay.

Tashkin: That's good so if you so you would stratify on sensitivity and an athletic activity or tendency to engage in vigorous or physical activity. Would you stratify on any other variables? These are design questions, obviously.

Rokaw: I think Dr. Horvath has raised a very interesting and important point. That is the gadgetry that people are acquiring in their houses which for some other chemical reason may be affecting airway performance. We really need to identify such confounders in the homes or workplaces of the subjects. A similar problem troubles me when I walk into a gymnasium and sniff the air because of the use of aerosols or other fumes that are related to peoples' bodies. I worry if this is not another confounder, during peoples' exercise activities.

Tashkin: People spend about 90 percent of their time indoors on the average, though this isn't true for everybody. The question is, although there are certain number of noxious substances found indoors or generated indoors, to what extent would you expect outside pollutants to intrude into such interiors as gym clubs or sports stadiums?

[interruption]

Cross: I would like to comment on your selection of patients. I gather that you are not planning to monitor indoor oxidant levels. It should be emphasized, as Garfield pointed out in a recent issue of Current Contents about sixth months ago on indoor pollution,that indoor oxidant levels vary largely depending on such variables as gas exchanges per hour, ventilation and recirculation systems and sites of indoor energy generating systems. Indoor "oxidant" levels probably vary to such a degree, even in the same community, even in adjacent buildings, that unless you are focusing your study on indoor pollutants and the measurement of their levels (and you are not going to be making any indoor measurements), you will have no idea of

what levels of oxidants your subjects are exposed to while working indoors. Therefore, I would pick those that were working outdoors and doing some degree of physical exercise. You can find literature on indoor oxidants that go from 10 percent of the outdoor level to 40 percent of the outdoor level. Thus if you were to study indoor workers you will have such a variability in their oxidant exposure levels that you just won't be able to handle your data--that is, if you want to relate symptoms experienced back to actual oxidant exposure levels.

Tashkin: That variability in the "leakage" of outdoor pollutants into the interior, plus the variable added effect of indoor pollutants that we are not planning to monitor, would not be experimentally manageable in your view.

Cross: I would pick outdoor workers who are working at oxygen consumption levels considerably above baseline. (See Appendix E, Beard note #5.)

Tashkin: That's a good point. But lets move on to another question. Do you feel that ozone exposure, apart from any other effects, alters the mood of exposed individuals or their motivation to do things. We hear a lot about how bad weather makes people irritable. Do you really think that exposure to oxidants has a specific effect on irritability?

[Dr. Schaeffer joined the conference]

--end of a tape--

Horvath: There is no question that these people don't like exercising at a high enough level; they don't want to do anything. In fact, one of their most frequent comments was that "I'll never do this study for you again." They also feel very lethargic and their attitude towards getting any work done or what they have to do is definitely decreased. That is, "why should I do it, I'm too tired," whatever that word "tired" means.

Cross: In one sense I think that the phone survey that you are doing is questioning all these things. It's not a good technique. You almost need to get a uniform questionnaire to look at things like motivation and mood and maybe for lassitude and some of these things. You need to get down to sort of sophisticated evoked potential responses and look at the nervous system in an objective way.

Horvath: I would agree with that but I don't think from what they have been saying that they have any way of doing that.

Cross: You could use telemetry to get the evoked potentials.

Mustafa: Is it a fact that because of publicity, people do get discouraged about some of the activities they wanted to do? Their spirit is dampened and in parts of California we find that the sea/ocean beaches get crowded, instead.

Coulson: Dr. Schaeffer are you on?

Schaeffer: Yes.

Coulson: Welcome to the conference.

Schaeffer: If I can put my two cents in.

Coulson: Sure.

Schaeffer: We in Riverside, that is the Lung Association several years ago, had an open telephone which was advertised. Individuals were asked to call in their responses to air pollution. Two of the most common ones that we heard were irritability and depression. And this was recorded very very frequently. It was, as a matter of fact, more common than tightness of the chest or itchy eyes or burning.

Beard: I agree the irritation is one thing.

Mustafa: What I was saying that people do change their plans when they hear that there is going to be smoggy days ahead of them. Whereas they could have done something more useful but because of the situations, i.e., the publicity of smog, they changed minds and did something else. That is a dampening effect on the motivation.

Tashkin: Of course, that's exactly what we want to find out, at least what the EPA wants to find out is whether or not people alter their activity because of the weather in a way that will have an adverse impact on the economy, irrespective of whether they are doing any short term or long term damage to their own health. That is, irrespective of the biochemical or cellular nature of tissue changes.

Crocker: Mohammad brings up a good point you have got to be able to separate the difference between the threat of the air pollution and the actual presence of the air pollution.

Tashkin: Threat of air pollution, does that really mean that people are worried or concerned that they will experience symptoms related to adverse health effects and so they are taking evasive action or is it due to some subtle effect of pollution on the central nervous system that may alter behavior.

Horvath: I don't think they are. I think they are more worried with the interference with whatever activity they had planned.

One could ask.

Tashkin: There is some design questions that we wanted to ask. Maybe Anne could do those quickly.

Coulson: The question that we are being asked to deal with in this study is one that presumably has to do with the country as a whole, though, since

this is where much of the ozone is, this is where the study will be. If you were doing something of this sort would you be looking more for a place with a high level of ozone such as the East San Gabriel Valley (Glendora), a moderate area in the San Fernando Valley, or lighter ozone in the rural area of the Mohave Desert?

Crocker: My tendency would be to focus on Glendora, but we do know that we are going to have nitrate, sulfate and NO_2 as well as ozone there. At least Glendora gives us the major photochemical pollution mixture and, in the earlier UCLA studies, Glendora people seemed to have a greater cumulative health effect than either Burbank or Lancaster. Are you thinking of Lancaster?

Coulson: Yes.

Crocker: Long Beach had its own separate sulfur-based air pollution issue but monitoring there is still not enough, is it?

Detels: No.

Crocker: Since Long Beach is such a valuable pollution study area but with inadequate monitoring, I regret we can't use it until the monitoring is improved.

Detels: That may be the rationale for the monitoring situation.

Crocker: Yes. Well the comparison between two communities might still be usefully done between Lancaster and Glendora.

Detels: There is one problem. Lancaster is no longer clean, I'm afraid we have contaminated it.

Crocker: Yes, I expect so.

Detels: The ozone levels have really crept up in the 10 years that we have been working with that community.

Mustafa: I would like to clarify one point. Are we talking about or referring to a day time situation or are we including the night time also, because in a smoggy situation there slight reactions and that produces things that could go inside the home and can do almost as much damage as ozone can. These are recent measures and well publicized.

Schaeffer: Are they doing a lot of monitoring at night in those areas? I know that we started monitoring the Palm Springs area, we found out that the elevated photochemical oxidants were high past midnight.

Mustafa: They are high at midnight.

Rokaw: That's because of the way the wind blows in the basin. The levels accumulate down there without much ventilation in the neighborhood of Palm Springs.

Schaeffer: Yes, they don't have the solid objects to break down ozone.

Crocker: There are some night time persistences of some of these pollutants. Those that are formed actively on a photochemical basis, such as ozone, decline at night. NO_2 declines but some residual levels are present. The question about night time versus day time is related to NO_2 more than to ozone. You are going to be measuring both NO_2 and O_3 I take it, although I gather you are not really going to relate your data to anything but ozone. Ozone levels will tend to decline more than NO_x. Is this not your experience, Gerschen?

Schaeffer: Yes, that's right. Also, it is true as far as sulfates are concerned, but we have just such a poor monitoring system throughout the whole state for that.

Beard: You mentioned some thought of using more rural observation and if I heard you correctly I would caution you.

Coulson: Well not very rural. We were speaking of Lancaster.

Beard: Well, I was concerned about introducing another variable of urban versus rural.

Coulson: No, we are talking about Lancaster which has a lot more space but I don't think it can be precisely called rural.

Cross: I would certainly focus on the high level ambient "oxidant" locations. If you're focusing on the non-pulmonary complaints and trying to do a survey and see how these might track your oxidant level, would additionally seem sensible to design two study areas. Obviously a high and low would be good, but I suspect that you will decide to put all of your resources into collecting the maximum amount of subjects and information from the high level area. Were you considering doing two separate areas?

Tashkin: If there were funds available we thought of that because that would control for such non-pollution related variables as the time of the year, aero-allergens, etc.

Coulson: The next question we have is what consideration should we give to meteorologic variables in connection with ozone levels?

Beard: I'll take a crack at that. I have already made a note that you should take into account temperature, humidity, wind velocity and direction and sunlight intensity. At a minimum, those should be observed and probably on a short term basis, that is, preferably hour by hour and should be taken into account and if attention is given to mood changes, season and phase of moon should be considered. On the previous point, multiple locations don't control for allergens; indeed, multiple locations introduce more confounding variables.

Crocker: I think the additional point is that you must monitor all the other available pollutants that you can measure, including NO_2, wherever

possible. If you could introduce an oxidant measurement by the old wet chemical method that would be desirable, but I suppose SCAQMD is not going to have that. I'd also be very interested if you plan to measure particulates. The combination of the various classes of pollutants creates the symptom complex since the whole abmient pollutant mixture is greater than the sum of its parts. It is desirable to have as many of the parts in place as possible.

Coulson: Thank you.

Tashkin: Can the oxidant measurements of the old style be derived by some mathematical manipulation of the data on the individual pollutants?

Beard: I would not have confidence in that.

Horvath: No, I wouldn't either.

Crocker: No, you would just have to use the old liquid sampling methods that were used in the past which takes account of essentially all oxidant species, including aldehydes.

Horvath: There have been some great discrepancies in the amount of ozone and other photochemical oxidants present to put them together and call them all photochemical oxidants.

Schaeffer: I think that what Dr. Beard said is very important particularly with temperature and humidity because many of the symptoms are attributable to that rather than air pollution itself.

Crocker: I think that it's extremely important to have respirable particulate size cuts as well as total suspended particulates (TSP). We have to decide if this is being done and what size sample systems are available or in use.

Rokaw: Would someone describe for us the monitoring equipment that is available for fractionating particulates.

Rokaw: Rod, what do you think about that?

Beard: Hello, I'm sorry.

Rokaw: Rod, I was saying that the ARB is encouraging a particulate size sampling system that is probably available in this area. Is that correct?

Beard: I don't know. Not yet.

Schaeffer: I know, was that Stan who was talking?

Rokaw: Yes, right.

Schaeffer: As of about a year ago the advisory committee of the air quality management district were planning on doing particulates, and for

the achievement plan for the government. They were very uncertain and did not have any definite cut points they were monitoring.

Rokaw: Okay, we can verify with the district and the ARB whether they do have particulate dichotomous size samplers in the study area. Dr. Beard may know.

Beard: I think that this is probably pretty well in hand at the 10 micron level. Certainly this is what has been adopted by the California ARB and I pretty sure this is what EPA is doing as well.

Crocker: Rod, I think the question at this moment is whether dichotomous samplers are available in the Glendora area or anywhere else in the South Coast Air Quality Management District?

Beard: Well if they aren't they certainly could be made available for very little expense. It's not a fancy instrument.

Crocker: Well this might be a chance to help the SCAQMD move toward installing such samplers.

Coulson: I think that the Air Resources Board station is in Glendora.

Detels: I think that they did that in response to our request because Glendora was one of our sites.

Coulson: It was also the site for Henry Gong's asthma study and Stan Roakw's asthma study.
Beard: I think that getting the dichotomous samplers is of extremely high importance. If you are not going to do that I think that it is almost a waste to do a TSP.

Horvath: But if you were to do the dichotomous sample then it would be good to do TSP as well.

Beard: Correct.

Horvath: Because you really would like to carry over the comparison with your older TSP data from previous studies. So really it is ideal to have both.

Beard: Quite so.

Coulson: If we assume that we are going to call these people up and ask them questions, how often would you feel it necessary to contact them, bearing in mind irritability on their part about phone calls as well as air pollution. What mix of good and bad days would you use?

Rokaw: Gersch, do have some recollection of the frequency that you used to do phoning?

Schaeffer: Yes, Stan, we did it once a week. You have to remember these were people who initiated it themselves and so you know that these were motivated people.

Rokaw: Was there a falling away because of that frequency do you think or was it more or less tolerated.

Schaeffer: No, it was very well tolerated and the significant changes were surprising even with the ones that we followed.

Rokaw: Was that always on the same day of the week or was it geared to what the day was like out there.

Schaeffer: Almost always the same day.

Tashkin: What time of the day did you phone them?

Schaeffer: Usually we would phone them about two to four in the afternoon.

Tashkin: Then you questioned them about that day and about the preceding the day? How far did you go back?

Schaeffer: We had really asked them to keep a diary.

Tashkin: Oh, a weekly diary.

Schaeffer: That's right.

Tashkin: Did you have any sense for the reliability or validity of the answers concerning the earlier part of that week.

Schaeffer: No, I don't. We had a select group of people who had called in complaining of problems who were then entered into the study. Because I felt a lot of the problems were in knowing what the various levels were, of pollutants that were measured in this area. These did not necessarily correspond and that was unfortunate. But there again there were other things that we did not consider or enter into the analysis that Dr. Beard mentioned such as temperature, humidity and wind direction and so forth.

Coulson: How often would you suggest contacting these people and what mix of good and bad days would you use if we were able to pick them? What we were thinking about was calling them on the good or bad day. That is, selecting the time to call based on the air quality and weather.

Schaeffer: One of the difficulties you are going to have with this is what we have experienced within the last 15 or 20 years that we have been involved in this. It is that sometimes you may suppose that it is the height of an air pollution season. And two, three, three and a half weeks with practically no amount of significant elevation will occur depending upon the meteorologic conditions. In other years, it is going to be unusually high and you will have, such as certain times of this year so far, 10, 11, 12 days of elevated levels in a row. So I think that it has

to based on more than high and low days. There has to be some time interval.

Crocker: You are saying Gersch that if they call, that if you call on a regular basis, it may be more valuable than if you just wait for good and bad days?

Schaeffer: That's right. I think that if there are unusually good or bad days they should be included. But to do it just on good and bad days, I think that you might miss a lot.

Crocker: Yes, it is difficult to decide, which of these is better other than that your arrangements with your people might be a little easier if you have a fixed schedule of calling.

Rokaw: We tried to modify our study of people in the Glendora area so that when we were running through a string of bad days we could actually call them to come to the mobile lab an extra time in that week. There was not very much resistance to that. I think people can be phoned on a schedule with the understanding that they might get a second phone call if you are running through a streak of bad days, with no problem.

Schaeffer: Do plan to have your station located in the community that you are going to work with?

Rokaw: This isn't going to be a testing station Gersch. This is going to be more an inquiry program, as I understand the protocol thus far, rather than a pulmonary function evaluation program.

Horvath: I think the easiest answer to that question is that it all depends on the subjects that you use, some will be very cooperative and some will not be. You can base your frequency of calls on the responses at the beginning of the study. Few people will resist you if you call once a week or two weeks, but if you are going to do it for three, four or five days in succession then you have to select your subjects based upon how they respond at the beginning.

Mustafa: I have a comment. Isn't it a fact that in the community there will be at least two groups of people. One group that will be health conscious and normally they will cooperate probably to the fullest extent and you will be in luck to contact them. Then there are those who don't care one way or another and they will be the non-respondents.

Cross: You have a problem of group bias if you pick the most polluted days and the air pollution index on the radio and TV stations are talking about the terrible pollution on this particular day or other days and you call patients. It seems to me that you have a built-in bias where the patient is sort of set up with it and is almost going to be giving you misinformation or be feeling bad because he/she is being told he/she should feel bad. I believe that information collected on a regular basis would probably yield more scientifically believable data. Considering the phone calls, you might give thought to designing a couple of strategies. In one,

use your regular calling questionnaire routine. In the other, have subjects call at their leisure and answer you standardized questions into a recorder, giving the subjects options as to what time they call and not necessarily having to have a person at the other end of the line.

Coulson: That's an excellent suggestion.

Crocker: I like that suggestion, I would re-raise the point that Carroll raised a little earlier when he talked about a questionnaire that would be directed at mood and attitude changes. If you could generate the questionnaire and let study participants keep it on a card by the phone, they could re-read the questions each time they are phoned and try to respond to each item while looking at the questions; this might reduce bias arising from the reaction of the subject to the voice of the interviewer when the questions are given over the phone.

Horvath: If they can find the questionnaire.

Crocker: Yes, you may have to keep re-issuing it.

Beard: I think that this is an idea that probably is doomed to failure because I think that a key element is the interviewer. If you are going to ask people to respond repeatedly, 10 to 20 times over a period of time, a great deal is going to depend on who talks to them on the telephone, and how that talking is done. It would be difficult to mechanize this. I think that the drop-off rate would be excessive if the interviewers were passive. The bias on the other side is that if you have really good interviewers who know what they are talking about and who can answer some questions, and if questions are raised, will keep the people interested in what is going on. That will of course inject some bias into the observation. But faced with one or the other, I think I would go for the interviewers who are interested in the project, interested in the people, and who show it in the way they talk on the phone.

Tashkin: It is our intention to use trained interviewers. We are aware of the fact that could introduce a bias. That is something that we will have to deal with.

Crocker: I agree with the suggestion by Rod that subjects could answer the questionnaire by talking on to an answering machine tape. That idea was good, as Cross mentioned it, if the responders were making a voluntary call as they did for Schaeffer. Dr. Beard's idea of a direct call by a good interviewer is also valuable. My idea was that the questionnaire might be in front of the subject for him/her to read at the same time that he/she is responding to the interviewer. This might help the two of them to cover each question a little better. I thought the availability of the questions in the hands of the person being telephoned might help the interview. Do you think that is a reasonable idea?

Cross: It seems to me that it could depend on how objectively focused your questions are. If you are asking for responses on a scale of one to ten each day, as we do visual analogs scale for breathlessness on exercise

testing, etc., with a list of 10, 20, or 30 questions, for example, were your eyes watery today, the answer is 2 or 8 whether the patient phones in the 2 or the 8 or gets asked the question. The cost of individual interviewers is going to add significantly to your cost and the inconvenience of having to be available at a given time may interfere with their life enough to make them a little bit fed up with the study. I assume that you are going to pay these patients in order to increase compliance?

Coulson: It is in negotiation at the moment.

Cross: If you are negotiating paying them they just don't get paid if they don't make their phone calls on a regular basis. Payment should be given at the concludion of the study.

Coulson: The human subjects people won't let us withhold it all for completion. Considering the scope of the project, what we have been talking about, the information we have discussed in this conference, are there other important questions that we could address?

Schaeffer: One of the things that I wonder about, in your initial questioning of these people are you finding out if they have air conditioning, refrigerated or not, whether they have been in the house or out of the house a certain part of the day?

Tashkin: Yes, we plan to ask questions of that nature.

Schaeffer: And whether they have charcoal filter in their air conditioning system?

Tashkin: They will receive an initial questionnaire that will try to define their environment, their health history, and their occupation, commuting patterns, recreational activities, and proclivities, etc. There will be follow-up, interval questionnaires that will deal with specific symptoms and activities, some mood questions and also a question as to their perception of air quality which will be asked at the end of the interview.

Coulson: Anybody else on other important questions that we could address.

Horvath: No one commented at all on one of your questions which is the potential health effects of indoor activity.

Coulson: Oh yes.

Horvath: That seems to me to be an important question because it could also relate to outdoor activities, too, or the combination of the two. I don't know how your questionnaire is going to handle that. How can you tell what activities they do, how are you planning to evaluate whether they are playing tennis or whether they are taking a long walk.

Coulson: We would plan to ask them for a resume of their days activity to be sure, particularly in this area, whether it was indoor or outdoor. A tremendous amount of things are now going under domes, especially here.

Cross: It may be totally crazy but why don't you Holter-monitor these people and determine the number of heartbeats per 24 hours? That could be easily related to the pollution index as a measurement of overall activity?

Tashkin: The heartrate could go up with excitement without necessarily increasing ventilation but it is an interesting idea.

Coulson: We are actually doing this in the field in Kenya to get some idea of activity as a function of nutritional status. We are actually doing 24 hour monitoring on some people.

Tashkin: But obviously that would be quite expensive.

I don't think it would be expensive if you had to monitor and just scanned it for the total beats.

Rokaw: The trouble is that you have the people being convinced that they shouldn't go out and exercise when they get a smog announcement so they might actually have a lesser stress rate on a bad day because of their chosen inactivity.

Cross: Oh yes. That's what I would be scoring is the fact that they really did change their activity. The questionnaire might pick that up.

Beard: I think that if I had to make a choice between doing monitoring the physiological responses in the patient versus some more careful monitoring of the exposure, I would choose the latter. I think patient monitoring would be useful if affordable, but not high on my priority list.

Crocker: I buy that.

Cross: I would certainly add the recommendation that all studies of ambient air pollution have monitoring of the indoor exposure as well as of the outdoor air.

Schaeffer: Some of the things that we have done is, that inside buildings where all the windows are closed, as far as ozone is concerned at least, that 50 percent of the ambient air level of the ozone is present inside the building.

Horvath: That depends on the rate of exchange and how much they mixed their air. A lot of groups not are not even mixing outdoor very much.

Schaeffer: We did some hospital work and found out that where at that time by law it was necessary to have rapid exchange of air in the intensive care units and in nursery and surgery, in these areas the inside air had 65 to 70 percent of what was out in the ambient air.

Horvath: It all depends on the type of air conditioning systems they put in. A lot of them don't mix indoor and outdoor air.

Schaeffer: That's right

Horvath: Some of them just continue to circulate the indoor air and others have find it more profitable to mix with the outdoor air. But that is one of the problems, how much of the outdoor air is actually pulled in. So you could have pretty high levels.

Rokaw: The average residence of this area is so leaky that I think that there is a constant influx of ambient air. Whereas industrial or hospital installations may be better protected.

Beard: I think that you should not put too much reliance on your casual observation about the leakiness of modern houses. Changes are taking place very rapidly with emphasis on air conditioning and conservation of energy and places that used to have five air changes an hour now have only one or less.

Horvath: The conditioning of the air is cheaper for them. They can recycle that same air than, to pull in outside air which has to be reconditioned.

Rokaw: Is that a phenomena applicable to the ordinary residence or are you talking about apartments new installations or...

Beard: I'm talking about apartment, condominiums and those. People are living in those they are becoming very conservative in terms of the cost and therefore, when you have air that is brought down to some temperature, say, 28°C or something like that, 28°C is going to cost you a lot more if you are pulling air from the outside which is, say, 35°C. The tendency is to recirculate that air and depending on what you brought in with it, you could have some very high concentrations or very low concentrations. It all depends on what is brought in.

Crocker: I would agree with Beard and with Horvath that the indoor concentration of any pollutant cannot be assumed to be a standard fraction of the outdoor concentration for all of those reasons including one other: reactant pollutants are absorbed in the fabrics and other materials of the indoor environment. Mustafa's good suggestion about free radicals as harmful pollutants is important but I suggest that such reactant pollutants will be absorbed on fabrics. The indoor penetration of outdoor pollutants will produce a less biologically active atmosphere for that reason. The reason for monitoring indoor atmospheres is that they contain pollutants generated indoor as well as some pollutants from outdoor sources.

Tashkin: Are there any other questions that we should address?

Horvath: How about children?

Tashkin: We could inquire about the children's activity through the adult, but we would be reluctant to do so. I think it would be a little awkward to query the children themselves unless perhaps they were teenagers. There might also be a reliability problem. What do you think?
Horvath: I asked the question originally my response to that is that I think it is necessary to know more about them because in some ways they also influence the activities of the parents. I mean if the children are outdoors and the parents will have to go outdoors or if the parents listen carefully to the radio and TV say don't put them outdoors that seems to leave the decision up to the whole family. And if you are going to study one end of it of a family you might as well study the family.

Tashkin: We were actually planning on asking questions about family activities as well as individual activities including the activities of the children but we were reluctant to actually consider the child to be the respondent.

Horvath: Oh, I think that would be difficult. But as long as you get some information about them it is important.

Schaeffer: Would you also be asking questions about respiratory infections?

Tashkin: Yes.

Beard: Okay, I was going to raise that point. I think the susceptibility to infection question is one which should be looked at quite closely and perhaps not only respiratory infections but infectious disease of all kinds.

Horvath: Do you have a questionnaire you have already designed?

Coulson: No. We are in the planning stages. We have some of it derived from other questionnaires and we are in the process of designing one. Today's conference was one of the landmarks in that design process, namely getting your opinions on this. We will have one probably within a short time.

Horvath: Will we be able to see it?

Coulson: Yes indeed. That is part of what we want you to do.

Horvath: Oh, okay.

Cross: Great.

Coulson: We want you to see it and tear it apart.

Cross: And to put it back together again.

Coulson: In fact if you willing we may soon make this an iterative process.

Tashkin: I apologize about mentioning that ... if any of you have problems with the questionnaire, or don't have the time to review it we will understand.

Coulson: You will also receive copies as soon as they are ready of the transcript for your review. Anything else that we should be doing?

Coulson: I want to thank you all very very much for a most enlightening, slightly discouraging, but in other ways, very encouraging conference with all of you in terms of our learning from you about what is known about ozone and its health effects and what we should be doing on this project. I had no desire to make the ultimate sponsor of this a secret, this is the economics section of EPA which is interested in this information. Working with economists is an interesting activity.

Crocker: You should tell them then that the economic approach here was inadequate. The agency needs to realize that you need funds sufficient to do good monitoring in order to give them data regarding the ozone concentrations at which to expect illness or symptoms that will cause people to do, or not do, actions that affect the economy.

Coulson: Very good. Actually part of the problem is that their budget got cut and so we will be using, if this goes through, the lions share of their budget. They were perhaps uneconomic in terms of their interactions with the Office of Management and Budget.

Coulson: Thank you all very very much.

APPENDIX E

FURTHER NOTES ON THE TELEPHONE CONFERENCE

In his reading of the transcript, Dr. Beard volunteered a number of notes that illuminate and enhance some of the discussion during the conference. We reproduce those notes here. Reference to them is made at the appropriate points in the transcript (Appendix D).

NOTE 1

Horvath's point is a good one, and the response that "we are stuck with outside ambient levels" may be dangerous: dangerous because the ambient levels alone may be grossly misleading. A possible approach could be to exclude subjects who occupy homes where indoor pollution levels are likely to be high, especially with respect to NO_2 and oxidants, and perhaps other irritant gases such as formaldehyde. For starters, homes with gas cookstoves and houses that are poorly ventilated and have formaldehyde sources such as urea-formaldehyde foam insulation and plywood paneling. I would review data on indoor pollution to see if it is possible to set up some simple discriminations by which to identify a population that is relatively unexposed to indoor pollution. Occupational exposures (e.g., welders) and smokers should be taken into account, of course.

NOTE 2

It will be most valuable to have each subject be his own control. It will also be important to treat the data in ways that will not lose sight of the highly susceptible individuals. If only 1/200 of subjects has symptoms at a low level, e.g., .14 ppm, this would be important for community health--one-half percent of the population of Los Angeles is a lot of people. One would, of course, want to know if that one subject reacted consistently to low levels.

Granted that a conclusion that the lowest mean concentration that is associated with symptoms is half the population is an interesting statistic, and if a standard deviation is appended, one can approximate the level that affects one-half percent of the population, or any other proportion, but it's more helpful to state the number and proportion of subjects affected at various levels.

NOTE 3

I think Steve forgot the stated plan on page 162--I share his distrust of symptom reports or even activity reports made several days later.

I would set up a schedule of contacts by the calendar and get symptom and activity reports for the day of the call and one day before, and then relate these to the a.p. indices (with due regard for T, H, etc.), for that day and several days (5, maybe) before.

I agree with Steve that intensive study of a small group of subjects is most likely to yield useful information. I suspect that he is remembering the highly productive studies by Professor Yaglou on effects of T and H and insolation on physical activity, where only four subjects were used--they had not statistical validity for the population, but the guidelines thus developed were quite satisfactory when applied to large numbers of men.

I like the suggestion that intensive study of a small group should be combined with a less intensive study of a large group.

NOTE 4

Roger is right to be concerned about the choice of subjects for intensive followup. Yaglou was inspired when it came to choosing his subjects; he was also systematic, large and small (not average), southerners and northerners (long term climatic conditioning), and more. The choice, in this study, should be to get representation from susceptible subjects--asthmatics, bronchitics, hypochondriacs, age extremes, economic extremes, and more.

The observations will probably not be statistically valid--the study will be more clinical than epidemiological. But the observations should lead to better understanding of the phenomena and thus to the design of effective epidemiologic studies.

NOTE 5

As I indicated in Note 1, I think it worthwhile to explore the possibility that one can identify homes where indoor pollution is minimal. I'd start by reading the NRC report on indoor a. p., which I have not yet done. However, I don't reject the notion of limiting the study to outdoor workers. But they'll still spend more than half their time in homes. Also, it may be hard to find a sufficient number of outdoor workers who are asthmatic, bronchitic or otherwise compromised.

In response to the next paragraph with its question regarding psychic irritability: I am aware of only one observation that suggests a direct effect of oxidant or NO_x on psychic or emotional state. There may be such an effect, but it will be hard to separate it from the secondary psychic response to various forms of discomfort. The one observation was made by

Netta Grandstaff, in my lab, about ten years ago, in a signal-detection task with four or five subjects exposed to 0.4 ppm O_3 (nominal, probably closer to 0.3 ppm) for an hour (or two?): The subjects experienced no symptoms and were unaware of ozone. No effect on peripheral visual perception was seen, but there was a non-significant trend to shorter response latencies, too uncertain to merit reporting. In view of this, I cannot say there are no data to suggest a direct effect of ozone on brain function. Intuitively, I expect such an effect, but it would be too slight to be of practical importance.

APPENDIX F

POWER ANALYSIS IN THE DETERMINATION OF SAMPLE SIZES
FOR THE PROPOSED OZONE-HEALTH STUDY

The purpose of this appendix is to provide further analysis of the sample sizes to be used in our proposed research project on ozone and health. As described more fully in, "Estimating Benefits of Reducing Community Low-Level Ozone Exposure: A Feasibility Study," this project will estimate the dollar benefits attributable to the improvements in human health that occur when ozone levels are reduced. This feasibility study indicates that benefit estimates will be based on data collected from 200 previous participants in studies of chronic obstructive respiratory disease (CORD) conducted by the UCLA Schools of Medicine and Public Health. The data collection instruments to be used include an extensive in-person background interview for each respondent, as well as a series of monthly telephone follow-up interviews.

In a previous version of this feasibility study submitted to USEPA on 1 Sep 84, the 200-person sample was stratified as follows: 80 "normal" individuals were to be included along with 120 sensitive or vulnerable persons. The sensitive or vulnerable group were to be drawn from the following five categories:

(i) 30 individuals with asthma, chronic bronchitis, or emphysema diagnosed and treated by a physician;

(ii) 20 individuals with Forced Expired Volume in one second (FEV_1) less than 75% of expected FEV_1;

(iii) 10 individuals with definite respiratory symptoms according to the National Heart, Lung, and Blood Institute modification of the British Medical Research Council questionnaire;

(iv) 30 individuals who regularly engage in heavy occupational or recreational activity which results in high minute ventilation; and

(v) 30 individuals who report themselves to be "responders" to air pollution.

At least four issues emerge in evaluating the above sampling strategy. First, assume that adverse health effects of ozone exposure are present, but difficult to detect, in normal individuals. Is a sample size of 80 large enough to sufficiently reduce the probability of not rejecting a null hypothesis stating that ozone exposure has no health effects in such individuals? Second, what is the role of both monthly follow-up interviews

used in data collection and regression methods used in data analysis in determining this probability? Third, assume that adverse health effects of ozone exposure are greater among sensitive and vulnerable individuals than among normal individuals. Is a sample size of 80 normals and 120 sensitive and vulnerables large enough for this difference to be discerned? Fourth, assume that adverse health effects of ozone exposure differ among the five groups of sensitive and vulnerable individuals. Are the sample sizes proposed for each group large enough for these differences to be discerned? Each of these questions will be addressed sequentially from the standpoint of statistical power analyses. This discussion will be followed by some recommendations concerning changes in the sampling design.

(1) The probability of not rejecting a null hypothesis stating that ozone exposure has no health effects in normal individuals when in fact that null hypothesis is false can be computed as shown in equation (1).

$$Z(1-\beta) = \frac{\xi}{\sigma/\sqrt{N}} - Z(1-\alpha) \qquad (1)$$

In equation (1), $Z(1-\beta)$ denotes the probability of not making a Type II error (i.e., the power of the test) assuming that the sample mean of the health effect measure used is normally distributed about ξ (not equal to zero) with variance σ^2/N. Further, N denotes the sample size and $Z(1-\alpha)$ denotes the probability of making a Type I error in a one tail test. For further details on this approach to making power calculations, see J. Cohen, Statistical Power Analysis for the Behavioral Sciences (revised edition): New York, Academic Press, 1977; especially Chapter 2. Table F.1 shows power calculations assuming that $\alpha = .05$. In that table, three alternative sample sizes are considered (N = 80, N = 120, and N = 160). Also, two alternative assumptions are considered regarding the relationship between ξ and σ. In the most conservative power calculations, ξ/σ is assumed to equal .2 and in less conservative calculations, ξ/σ is assumed to equal .5. These two values for ξ/σ correspond to the "small" and "medium" effect sizes considered by Cohen. As shown in the table, the power of the test using a sample of N = 80 is quite high at effect size $\xi/\sigma = .5$. However, if an effect size $\xi/\sigma = .2$ is considered, a sample size of either N = 120 or N = 160 probably should be used in order to increase the power of the test to an acceptable level.

(2) The power calculations reported in Table F.1 are based on the assumption that one observation is available for each respondent. However, the monthly follow-up interviews will serve to reduce the "within-person" variation in the sample, thus increasing the precision of any estimates made. As a consequence, all power calculations reported in Table F.1 should be viewed as conservative. That interpretation holds especially if, as indicated in the feasibility study, the follow-up interviews are scheduled so as to maximize the measured variation in ozone exposure. For an individual, the variance of health effect measures derived from a dose-response type regression equation are inversely related to the sum of squares in the independent variable.

TABLE F.1

POWER OF TEST AGAINST

H_0: $\xi = 0$

	N		
ξ/σ	80	120	160
.2	.557	.709	.811
.5	.996	>.999	>.999

Source: derived (see text).

Against the gain in power from the use of monthly follow-up interviews must be balanced a loss in power resulting from the use of regression methods in data analysis. That is, to explain the observed variation in a health measure, covariates in addition to ozone will be used. The inclusion of each additional covariate results in a loss of one degree of freedom; i.e., the effective sample size is reduced by one observation for each additional covariate employed. To illustrate, if N = 160, ξ/σ = .2 and fifteen covariates are used to explain health, then the power estimate in Table F.1 should be adjusted downwards from .811 to .777.

(3) Whether the sample sizes are large enough to detect a difference between mean health measures in the normal and sensitive and vulnerable groups can be analyzed from the perspective of an equation similar to equation (1). Equation (2) gives the appropriate formula, in which $Z(1-\beta)$ again denotes the power of the test assuming that the difference between two sample means of the health effect measure used is normally distributed with variance of $2\sigma^2/N^*$.

$$Z(1-\beta) = \frac{\xi_1 - \xi_2}{\sqrt{2\sigma^2/N^*}} - Z(1-\alpha/2) \qquad (2)$$

Note that this approach implicitly assumes that an observation drawn from either of the two groups has the same variance σ^2. Consequently, the variance of the difference between any pair of observations drawn will equal $2\sigma^2$. Further N^*, interpreted as the effective sample size, is the harmonic mean of the sample sizes drawn from each of the two groups. If N_A = 80 denotes the number of normal respondents and N_B = 120 denotes the number of sensitive and vulnerable respondents, then

$$N^* = 2N_AN_B/(N_A + N_B) \qquad (3)$$

In the case at hand, N^* = 96. Finally, $Z(1-\alpha/2)$ denotes one-half the probability a Type I error using a two tail test. A five percent significance level is used in the calculations shown here.

Power calculations are shown in Table F.2 for the parallel cases considered in Table F.1. That is, two values of the standardized mean difference $(\xi_1 - \xi_2)/\sigma$ are considered (.2 and .5) along with three effective sample sizes computed from N_A = 80, 120, 160 and N_B = 120, 180, 240. The calculations shown indicate that if $(\xi_1 - \xi_2)/\sigma \geq .5$, then the original sample sizes considered N_A = 80 and N_B = 120 probably are large enough to ensure adequate power. Additionally, the case where $(\xi_1 - \xi_2)/\sigma \geq .5$ may be more relevant to consider here for two reasons. First, the response to ozone in normal individuals compared to those, for example, with impaired respiratory function may be substantial. Second, if this conjecture is wrong (i.e., differences in health responses are slight) then for policy purposes, the exact magnitude of the difference may not be worth knowing.

(4) Comparing the means between any pair of the five groups of sensitive and vulnerable individuals, however, is more troublesome.

TABLE F.2

POWER OF A TEST AGAINST

H_0: $\xi_1 - \xi_2 = 0$

	N^*		
$(\xi_1 - \xi_2)/\sigma$	96	144	192
.2	.284	.397	.500
.5	.933	.988	.999

Source: derived

Calculations based on equations (2) and (3) reveal that when comparing means from, for example, groups (i) and (iv), which would have $N_A = N_B = N^* = 30$, $Z(1-\beta) = .492$ assuming that $(\xi_1 - \xi_2)/\sigma = .5$. Clearly, if a more conservative assumption were made concerning the standardized mean difference or if another example comparison was selected in which sample sizes were smaller, the value of $Z(1-\beta)$ would be lower. Moreover, further calculations reveal that even if $(\xi_1 - \xi_2)/\sigma = .5$ and all individual group sample sizes are doubled, none of the $Z(1-\beta)$ values would exceed .8; a generally accepted rule of thumb for a minimum power value. Simply stated, given the total sample size of 120, the feasibility study proposed too many different groups of sensitive and vulnerable individuals for analysis.

On the basis of these power analyses, two recommendations appear warranted. These are:

(i) Fewer groups of sensitive and vulnerable individuals should be considered. In fact, two such groups now are proposed and this alteration is reflected in the proposal text. These groups would be: (1) those with respiratory impairments including individuals with asthma, chronic bronchitis, and emphysema and (2) those engaging in regular heavy occupational or recreational activity. Equal size samples would be drawn for each group, thus $N_A = N_B = N^*$. Power calculations are shown in Table F.3 for two values of the standardized mean difference (.2 and .5) and for three values of N^* (60, 90, 120). These calculations show that if $(\xi_1 - \xi_2)/\sigma \geq .5$, then sample sizes in the range of $N_A = N_B = 60$ to $N_A = N_B = 90$ probably are adequate.

(ii) In light of all power analyses reported here, it would be prudent to increase the total sample size from 200 to 300. This sample size increase would allow the number of normal respondents to grow from 80 to 120 and would allow the number of sensitive and vulnerable respondents to grow from 120 to 180. In this case, if the standardized mean difference for all tests considered was greater than or equal to .5, then the value of $Z(1-\beta)$ always would exceed .9. Also, the additional 100 observations would allow for situations where: (1) some regressions performed in analyzing the data may have a large number of covariates and (2) the mean standardized difference for some tests performed may be less than .5.

TABLE 3

POWER OF A TEST AGAINST

$H_0: \xi_1 - \xi_2 = 0$

$(\xi_1 - \xi_2)/\sigma$	N^*		
	60	90	120
.2	.195	.271	.341
.5	.782	.917	.971

Source: derived