"CHANGES IN LUNG FUNCTION & EXPOSURE TO OXIDANTS"

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Executive Summary

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Submitted by: Roger Detels, M.D., M.S.
Professor of Epidemiology
School of Public Health
University of California at Los Angeles
Los Angeles, CA 90024
(213) 206-2837

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Introduction

Although animal studies strongly suggest that significant physiologic and pathologic lung damage is associated with long-term or repetitive exposure to oxidants, nitrogen dioxide and sulfur oxides, results of studies of lung function in populations in areas exposed to photochemical/oxidants pollutants have been equivocal. Chronic obstructive respiratory disease (CORD) and progressive decrement in lung function are probably caused by multiple factors acting either together or in a sequential pattern. These include such identified factors as smoking, recurrent childhood respiratory episodes, bronchospastic disease, and occupational exposure to respiratory irritants. Evidence has been accumulating that chronic exposure to SO_2 and particulates in the ambient air may also play a role in the initiation and/or aggravation of CORD. Although there are many reports of acute effects associated with high concentrations of photochemical oxidants, there are few reports of long-term effects.

Los Angeles County is an excellent natural laboratory for studying the respiratory effects of various pollutants because of its topography and numerous micro-climates. Studies there are also facilitated by the existence of a uniform network of air quality monitoring stations maintained by the South Coast Air Quality Management District which are reviewed by the California Air Resources Board.

The objective of the studies described herein was to determine if changes in lung function test results over time correlated with levels of pollutants occurring concurrently and historically at place of residence. The study was designed to include a community exposed to primary pollutants characterized by high levels of SO_2 and hydrocarbons and a community exposed to high levels of photochemical oxidants, the most characteristic group of pollutants in the Los Angeles basin.

Methodology

Study areas were selected in four areas of Los Angeles County. These areas were selected on 1) the basis of levels of air pollution, 2) proximity to one of the monitoring stations of the Southern California Air Quality Management Districts and 3) demographic similarity to each other according to the 1970 census. The four study areas were selected to include one area exposed to low levels of photochemical oxidants located in the Antelope Valley (Lancaster), one area exposed to high levels of primary pollutants (Long Beach), one area exposed to high levels of photochemical oxidants (Glendora), and one area exposed to moderate levels of photochemical oxidants (Burbank).

Prior to starting lung function testing in each study area, public service announcements were placed in the local media. Letters were sent to heads of households by obtaining names from reverse directories and voter registration files. Neighborhood representatives were recruited from the study community to enumerate households and to make appointments for all residents of the study area who were 7 years of age or older.

At the Mobile Lung Function Laboratory participants completed a) a questionnaire including questions on history of respiratory symptoms and diseases, occupational history, past exposures to substances associated with respiratory injury, smoking and residence histories, and b) a series of lung function tests including (in the sequence in which they were administered) (1) determination of expired carbon monoxide concentration, (2) lung volumes determined by whole body plethysmography, (3) ventilation efficiency using the single breath nitrogen and (4) respiratory flow rates using electronic volume spirometry.

A number of procedures were implemented to evaluate the reliability and to estimate the validity of the lung function test results. These included (1) immediate retesting of every tenth participant, (2) retesting of a 3% probability sample of participants at the UCLA Pulmonary Function Laboratories, (3) retesting in each area of 100 participants three times during the year, (4) calibration of the Mobile Lung Function Laboratory with the UCLA Pulmonary Function Laboratory before field testing in each study area using volunteers tested concurrently, and (5) comparison of lung function test results with levels of specific pollutants on day of testing.

The levels of air pollutants in the four study areas were concurrently monitored by stations of the Southern California Air Quality Management District. Each of these stations continuously recorded levels of total oxidants, nitric oxides, nitrogen dioxide, total oxides of nitrogen, total hydrocarbons (not in Long Beach), carbon monoxide, sulfur dioxide (not in Lancaster) and total particulates. Twenty-four hour sulfates were recorded in Burbank, Long Beach and Glendora from 1977. Participants completing lung function testing

at baseline were invited to undergo retesting five years later (six years in Long Beach) after baseline examination. The procedures and tests performed were the same as those used at baseline. Participants who had moved too far from the original study area to undergo lung function testing were asked to complete a questionnaire on respiratory symptoms, history of respiratory disease, smoking history and reasons for moving from the study area.

Results

Reported symptoms and the results of spirometric tests and the single-breath nitrogen tests are given in this report. Results are not reported for the plethysmographic test because review of the comparisons between the Mobile Lung Function Laboratory and the UCLA Laboratory indicated that the plethysmographic measurements were not reliable at baseline testing. Thus, the change from baseline to retesting could not be determined. Except for the symptoms, the results of the tests are reported as the annualized rate of change. This rate is achieved by dividing the observed change in the test performance in the interval between baseline and retesting by the number of elapsed months and then multiplying by 12 months.

The results for the Burbank study area are not included in this report because the results were internally inconsistent and not in agreement with the UCLA laboratory. In the opinion of the investigators the results could not be corrected by a simple adjustment equation.

From 46% to 59% of those tested at baseline completed all of the lung function tests at the repeat examination. The major problem was not refusals to be

retested, but the relatively high proportion of individuals who had moved from the study area. Comparisons were made of the mean observed/expected (O/E%) FEV_1 among those retested and those not retested. The (O/E%) FEV_1 values at baseline were lower for individuals who refused to be retested but were similar among individuals who were and were not retested.

The potential effect of a number of factors to confound the results were considered. No correlations were seen between the level of specific pollutants on day of testing and lung function test results using a variety of analytic strategies, suggesting that the level of pollutants at the time of testing was probably not a major confounder of test results. The mean height and age among the participants in the three study areas were similar. Over 90% of the homes in each of the three study areas used gas heating. A higher proportion of participants in Lancaster, the clean area, had a history of working in an occupation associated with potential respiratory impairment. The majority of commuters from the Glendora study area commuted to areas of lower levels of pollutants whereas the small proportion of commuters in the Lancaster study area tended to commute to areas of higher levels of pollutants. This pattern would tend to reduce the probability of observing real differences between communities.

The symptoms included in analysis were cough, cough with sputum production, wheeze and diagnosis of asthma, bronchitis and/or emphysema. Although the incidence of symptoms tended to be greater among smokers than never-smokers, there was no consistent relationship for either the development of new symptoms or the loss of symptoms among the three study areas in either children or adults.

The mean annual change in the spirometric indices and the single-breath nitrogen test for never-smoking residents who were 7-24 years and 25-59 years of age at baseline and for smoking individuals who were 25-59 years of age at baseline were analyzed separately. For each of the pulmonary function variables reported, the mean change for Lancaster was compared with the mean changes for Glendora and for Long Beach. The changes in lung function test results for both males and females in the 19-24 age group were the most favorable in the Lancaster cohort for each of the six lung function tests reported (FEV_1, FVC, FEF_{25-75}, $\dot{V}_{75}$, $\dot{V}_{50}$, ΔN_2). In the groups between 7 and 18 years of age no consistent differences were noted between the three study areas except for the single-breath nitrogen test result which was consistently better among the Lancaster participants (except compared to males 19-24 in Long Beach).

Among participants 25-59 years of age at baseline, the rate of decline among smokers was greater than among never-smokers. The magnitude of the difference however, was less than might have been expected probably due probably to the fact that 23-34% of the males and 13-24% of the females had given up smoking in the interval between baseline and retesting and that a lower proportion of smokers, than never smokers were retested. With only two exceptions among smoking females, the rate of change in each of the pulmonary function tests was more favorable among Lancaster adult residents than among adult residents in the Long Beach or Glendora study areas. In 13 of the 24 comparisons of Glendora adults with Lancaster adults the mean change was significantly smaller in Lancaster, 9 of them at the $p < .01$ level. In 17 of the 24 comparisons of Long Beach with Lancaster the mean change was significantly smaller in Lancaster, 12 of them at the $p < .01$ level. In no instance where a

statistically significant difference was observed between study areas was the rate of change more favorable in the two polluted areas.

Conclusions

Population studies of the respiratory effects of long-term exposure to air pollutants are subject to many problems. This study is no exception. Nonetheless, the analysis of the impact of potential confounders and the consistency of the test results suggest that chronic exposure at place of residence is associated with unfavorable changes in lung function. These observations should be confirmed by additional studies. They raise sufficient questions, however, to suggest that current alert levels for air pollutants in the Southern California basin which are based primarily on acute responses may not be protecting residents from chronic respiratory effects of pollutants occurring at levels lower than the established alert levels. This, in turn, raises serious questions about the need for more stringent regulation of air quality.