



Project Summary

Air Pollution and Health Effects in Children Residing in Akron, Ohio

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The purpose of this study was to determine the effects of ambient air pollutants on respiratory function, incidence, and severity of acute respiratory illness, the nature of pulmonary epidemiology and trace element accumulation in fourth, fifth, and sixth grade children in Akron, Ohio.

Air pollutants were measured at three locations. These were sulfur dioxide (SO_2), nitrogen dioxide (NO_2), total suspended particulates (TSP), and from the Hi-vol filters, suspended sulfates (SO_4^{2-}) and nitrates (NO_3^-). The filters and bubblers were run on a daily 24-hour schedule, and chemical analyses were carried out by Community Health Assessment Monitoring Program (CHAMP) contractors.

All physiological and epidemiological data were collected at Seiberling and Betty Jane grade schools in Akron, Ohio, both of which are located on the eastern edge of the city and adjacent to industrial complexes.

The aerometric results indicate significant differences between the annual means for SO_2 and NO_2 with the Seiberling School having been exposed to the higher values.

The questionnaire results indicate that the Seiberling children report more wheezing in the chest and shortness of breath than the Betty Jane children. Daily symptoms reported by the students indicate that the Seiberling children report twice as many

incidences of upper respiratory symptoms including rhinitis, cough, and sore throat.

Trace metal analysis in hair showed that the Seiberling males have higher lead levels; both males and females have higher mercury levels but females have lower levels of cadmium when compared to Betty Jane children. However, none of the trace element levels can be considered abnormally high.

Baseline lung function testing did show that the ratio FEV_1/FVC was significantly lower ($p < .1$) at the Seiberling School. For both schools, there was a decrease in lung function during the symptomatic phase of an acute respiratory illness (ARI), and the tests further indicate that the ARI's in the Seiberling School were more severe and/or involved the small airways more so than the Betty Jane School. The ARI's were not complete after nine days with the Seiberling children showing slower recovery than the Betty Jane children.

On the basis of available aerometric information, SO_2 in combination with NO_2 is primarily responsible for the reduction in lung function tests and the exacerbations seen in the children at the Seiberling School.

This Project Summary was developed by EPA's Health Effects Research Laboratory, Research Triangle Park, NC, to announce key findings of the

research project which is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

Air pollution continues to be a problem confronting urban and industrial populations of the world. As the consumption of energy increases, the amount of pollutants produced by fossil fuel combustion will continue to increase. Furthermore, there will be a shift from oil toward coal which will increase total suspended particulates (TSP) and sulfur dioxide (SO_2). One of the perplexing problems facing our society is how much recovery or removal of these pollutants from stack gas is necessary to protect public health? Such pollutants have been shown to affect a number of human organ systems, the most susceptible being the respiratory system.

There is a large body of evidence that suggests that air pollutants are associated with an increased incidence of both upper and lower respiratory disorders. Early work by Rosenbaum showed that urban recruits suffered more respiratory infections than rural recruits. Work done in the United States and England has shown that both severity and incidence of acute respiratory illness (ARI) are related to high levels of one or more airborne pollutants.

Ventilatory functions have also been shown to be affected by air pollutants. These effects have been shown most dramatically in children. While many studies have shown significant losses of pulmonary function due to pollutant, others have not. This paradox could be due to a number of factors including the level of airborne pollutants, compounding factors such as cigarette smoking and secondary exposure to irritating substances, or dust which has not been controlled in the experimental design.

Of all the industrial emissions SO_2 , NO_2 , and TSP appear to be particularly detrimental to the upper and lower respiratory system and, as such, are of specific importance. Many studies have shown strong positive relationships between one or more of the pollutants to increased mortality and morbidity.

The purpose of this work is not to repeat other work, but to incorporate various data gathering procedures and facets of other studies into one comprehensive work. This study was designed to examine the morbidity rates of chil-

dren in areas with high and low levels of air pollution, to determine how illness affects lung functions, and to carefully monitor the air pollutants that may be producing exacerbations.

Experimental Procedure

In the Akron area two schools were selected for study. The Seiberling Elementary School is located in the east section of the city approximately two miles from the center of downtown and one-half mile from the closest factory. The Betty Jane Elementary School is located two miles east of the Seiberling School. There were approximately 140 fourth, fifth, and sixth grade children who volunteered to participate in the study. Participation was requested through the parents who were also asked to fill out and return with the child an epidemiologic questionnaire pertaining to acute and chronic respiratory symptoms.

Pulmonary function tests (PFT) were carried out on each child using a Warren E. Collins nine liter recording spirometer. The children were also asked to fill out a daily diary pertaining to the incidence of cough, sore throat, runny nose, eye irritation, and cold. This diary was used as a surveillance tool to determine when the children were suffering from acute respiratory illnesses (ARI).

On days when several symptoms were checked by a student, the child was called out of class and examined for symptom verification. If the child has a verified ARI, PFT was carried out at least two different times during the symptomatic phase of the disease and every other day up to nine days asymptomatic. All of the PFT data which included forced vital capacity (FVC), forced expiratory volume-one second (FEV_1), and maximal midexpiratory flow (MMF) were corrected to BTPS and adjusted for age, height, and weight using multiple linear regression. A 100 mg hair sample was also collected for trace elements, lead, mercury, arsenic, and cadmium.

Aerometric data were collected on a daily basis at each school. The 24-hour period began and ended at 8:00 a.m. Total suspended particulate (TSP) were collected and measured using a hi-volume sampler and standard techniques of weighing the filter before and after the 24-hour exposure.

The NO_2 and SO_2 values were determined using the liquid phase bubbler train. The bubblers were run on the

same 24-hour period as the hi-volume samplers.

These schools and the associated air pollution station were located in a walking school district. Ninety-five percent of the students walk to and live within one mile of the school.

Conclusions

The aerometric data collected at the station showed significantly higher levels of SO_2 and NO_2 in the Seiberling area. The annual mean values for SO_2 were $59.6 \mu\text{g}/\text{m}^3$ at Seiberling and $18.5 \mu\text{g}/\text{m}^3$ at Betty Jane. NO_2 values were $48.6 \mu\text{g}/\text{m}^3$ and $34.5 \mu\text{g}/\text{m}^3$, respectively. TSP values were also significantly different between the schools.

To reinforce these data, the values from the Seiberling School were compared with data collected by the Akron Air Pollution Control Board at a site a quarter mile south of the Seiberling station. These annual means were not significantly different.

Comparison of questionnaire responses between the two showed significant differences for cough, wheeze, and shortness of breath with the Seiberling School having the highest incidence of each.

Baseline PFT data did not show any significant differences except the ratio FVC/FEV_1 . This value was consistently lower at the Seiberling School and has been shown in previous studies to be sensitive to airway obstruction.

The daily symptoms were compiled for each school on a weekly basis and expressed as a percent of those students reporting a particular symptom. All of the symptoms, especially runny nose, sore throat, and cough were nearly doubled in percent reporting at the Seiberling School as compared to Betty Jane.

The results of the ARI component of the study was of particular interest. Not only did the Seiberling students report twice the incidence of verified ARI but the severity of the disease was greater as evidenced by FEV_1 and MMF during both the symptomatic and asymptomatic phases of the ARI indicate that airways of the Seiberling children were being compromised to a greater extent than the Betty Jane children.

Discussion

This work has succeeded in accomplishing its design objectives by: 1) measuring air pollutants within a given area, 2) measuring a variety of physio-

logical and epidemiological parameters within the selected areas, 3) repeating sampling procedures on the children under several conditions, and 4) utilizing a large sample size. It is felt that the design of this project optimized the study of the cause and effect relationship between air pollutants and health effects in children, where in the past this has not been accomplished.

The aerometric data proved to be an interesting find within this study design. The annual average for SO_2 at Seiberling School was about three times the value recorded at the Betty Jane School, and that for NO_2 was about twice the value recorded at Betty Jane. Both of these values are significantly different. Since these differences occurred within a geographical area of about 5 square miles, it provided an excellent opportunity to determine if any physiological differences exist.

The levels of SO_2 are not exceedingly high, but the annual average value does approach the Federal secondary annual standard of $60 \mu\text{g}/\text{m}^3$. Available literature seems to indicate that values of at least $80 \mu\text{g}/\text{m}^3$ are effective in producing only minor irritations and, most likely, would not produce any reductions in pulmonary functions. This same value of $80 \mu\text{g}/\text{m}^3$ is assumed to be associated with aggravating chronic obstructive lung disease (COLD). Baseline pulmonary function testing done in this work is in agreement with the above statements, since no differences were found in any of the PFT parameters recorded during asymptomatic conditions. However, reductions were found in the value FEV_1/FVC in the Seiberling children. This ratio represents that portion of the vital capacity that can be forcefully expired within the first second of a forced expiration. It is quite sensitive to changes in small airway integrity and, in the past, it has been a very effective predictor of small airway disease. This reduction of the FEV_1/FVC ratio is considered to be a significant find in this study. As stated before, the levels of pollutants are not alarmingly high and, as such, would not be expected to adversely affect lung functions. However, in testing these children over a two year period of time, a reduced FEV_1/FVC ratio was consistently found for children in the area with the highest pollutant levels. This particular parameter, when considered alone, might be overlooked as a minor effect since the differences are small, and the levels of statistical

significance are at the 0.1 level of probability. However, when these data are coupled with the results of the ARI work, problems can occur.

The ARI data produced several significant findings. The first was the number and severity of the ARI's in the children at the Seiberling School. A higher number of children reported ARI's at Seiberling as compared to Betty Jane. This fact also corresponded with the daily symptoms data where a high incidence of daily symptoms at Seiberling was also found.

In both schools a significant reduction in FVC, FEV_1 , and MMF was founded when compared to baseline values. Of greater significance, when these differences were compared from baseline values between the two schools, the Seiberling children had a significantly greater reduction in FEV_1 and MMF than the Betty Jane children. Examination of the PFT data histograms would indicate that lung functions were slower to return to the original baseline values, especially for MMF. MMF was the parameter most affected by the ARI's. In the past, this value was used as a sensitive indicator of changes in small airway function. From the results of this study, ARI appears to have had a most profound effect on the small airways of the Seiberling children. It seems that the higher levels of SO_2 and NO_2 exerted a low level chronic effect on these children and produced the reduction in the ratio FEV_1/FVC . The superimposition of the ARI produced a compounding of the exacerbation which reflected itself in the highly significant reduction of FEV_1 and MMF values.

A second substantiating find was the number of reported daily symptoms and questionnaire responses in the Seiberling children. On a daily percentage basis, the Seiberling children reported nearly twice as many upper and lower respiratory symptoms than the Betty Jane children. In filling out the questionnaires, the Seiberling parents reported that their children had more wheezing and shortness of breath than their counterparts at the Betty Jane School.

Selection processes are constantly occurring in communities with high levels of air pollution. Those adults with a chronic respiratory problem are often advised to leave the area in favor of a more moderate climate and, preferably, one with lower levels of air pollutants. Thus, in studies dealing with adults it

should be determined whether the population being studied is a true cross section or a selected group which is resistant to the pollutants and free of obstructive pulmonary diseases.

In children, this is usually not the case as they take up residence in the area of parental employment, and only in cases of severe pediatric respiratory problems do parents move the family away. Low level chronic symptoms or high incidences and an increase in the severity of ARI's are usually tolerated, overlooked, assumed to be peculiar to a given child. However, these subclinical chronic symptoms associated with air pollution could well be the forerunner of other more complicated and debilitating problems of COLD in adulthood.

The term threshold is one which is often used in air pollution research. There are many variations of threshold as evidenced by the Primary and Secondary Standards as well as the Pollution Standard Index. Of primary interest within the context of this report is the lowest threshold or the Primary Standards for SO_2 and NO_2 . The data reported in this study all point to the fact that the Primary Standard for both of these variables are capable of producing low level pulmonary abnormalities and therefore are currently too high. The annual average for SO_2 that the Seiberling children were exposed to are closer to the Ohio Standard than the Primary Standard, but there are still significant pulmonary problems.

NO_2 values reported in this work are much lower than the Primary Standard and, at this level, there are no health effects reported in the literature. It is suggested that the effects could be synergistic with SO_2 and, as such, the problem deserves serious consideration.

Recommendations

It is recommended that the annual average for SO_2 be no higher than $80 \mu\text{g}/\text{m}^3$ or, more ideally, be lowered to $60 \mu\text{g}/\text{m}^3$. In this study the level of NO_2 , although quite low, does appear to be affecting the children. This may be either a synergistic effect with SO_2 or an individual effect. On the basis of these findings it is recommended that the health effects of NO_2 be given careful consideration but the Primary Standard should not be changed.

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Wilson Riggan is the EPA Project Officer (see below)

The complete report, entitled "Air Pollution and Health Effects in Children Residing in Akron, Ohio," (Order No. PB 81-152 498; Cost: \$12.50, subject to change) will be available only from:

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