Health Effects of Air Pollution Measured by Outpatient Visits

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An association between air pollution and various diseases has been demonstrated over the last three decades by examining vital statistics, epidemiologic surveys, and hospital data. This study examines the association between air pollutants and diagnoses made at outpatient visits to a family practice center during an acute episode of air pollution. A strong positive correlation was found between average weekly pollutant levels and the percentage of diagnoses of respiratory tract and cardiac illnesses. Not only do these findings add to the growing evidence of untoward health effects of air pollution; they also suggest a simple method of monitoring such effects in an ambulatory setting.

Over the last three decades there has been increasing evidence of adverse health effects from air pollution. Categories of such ill effects include increased mortality, increased prevalence of chronic respiratory tract disease, exacerbation of disease in chronically ill people, increased incidence of asthmatic attacks, increased lower respiratory tract disease in adults, increased upper and lower respiratory tract disease in children, increased coronary artery disease symptoms, and sensory irritation.[1] Association between increased mortality and air pollution has been found both in acute episodes of air pollution and in chronic exposure to air pollutants. The largest acute episode occurred in London in 1952, when 4,000 excess deaths were attributed to pollution. These deaths occurred mostly in people with pre-existing cardiac and respiratory tract illnesses and were mainly attributed to bronchitis, pneumonia, and other respiratory tract and cardiac diseases. Other acute episodes were reported in Donora, Pennsylvania, in 1948, in New York City in 1953, and in London in 1962.[1] No other major episodes of acute mortality increases associated with air pollution have been reported since the early 1960s.

Increased mortality from chronic exposure to air pollution has been more difficult to demonstrate. In acute episodes a population may serve as its own control, but in evaluating long-term exposure, a different population must be found to serve this function. When this is done, many other dif-

ferences between the two populations then enter as confounding factors in the comparison. These factors include such variables as smoking, socio-economic status, length of residence, ethnic background, levels of pollutants over time, and pre-existing disease, all of which are important parameters that are difficult to measure and to collect. General trends, however, are discernible and have demonstrated a consistent association between long-term residence in a more polluted community and increased mortality rates.[2-4]

Increased morbidity has also been found to be related to increased levels of pollution. There is an association between disease exacerbations and air pollution in patients with chronic respiratory tract disease.[5-7] This relationship is particularly strong between the prevalence of symptoms and the levels of sulphur oxide and particulate matter in the air. Evidence for this association has been obtained from epidemiologic sampling and sampling of exposed populations, such as work forces at a particular industrial site.[6,7] Results from these studies have demonstrated a relationship between exposure to the sulphur oxide and particulate complex and disease, but it is difficult to identify threshold levels of pollution at which respiratory symptoms are definitely increased. Dose response curves are evident, and the higher the concentrations, the higher the rate of symptoms reported by patients. In addition, several studies have been done using ventilatory function tests on patients with chronic respiratory tract disease living in polluted areas.[8-11] Diminished ventilatory function was found in patients living in areas of higher pollution compared with patients living in cleaner air.

Patients with asthma demonstrate another health effect of air pollution. These patients appear to be particularly susceptible to high concentrations of pollution, even when exposed for a short time. Asthmatic patients have an individual and varying response to various factors such as allergens, respiratory tract infections, temperature, and psychological factors, and thus it is often difficult to demonstrate directly the specific effects of air pollution in these patients. However, several authors have reported increased respiratory tract symptoms, emergency room visits, and hospitalizations in asthmatics during episodes of air pollution.[12-15]

Acute respiratory tract illnesses are also increased with exposure to air pollution. Epidemiologic surveys of incidences, hospital admissions with diagnoses of respiratory tract illnesses, and absentee rates from work due to respiratory tract disease have all been associated with air pollution.[16-18] Even when confounding variables such as the season of the year are adjusted for, pollution levels correlate well with disease indices. In adults there are clear associations between pollution and such lower respiratory tract diseases as acute bronchitis and pneumonia.[1,18] The evidence is not as consistent, however, with respect to upper respiratory tract diseases. There is evidence of association between both upper and lower respiratory tract diseases in children, but again, the relationship is stronger for the lower respiratory tract.[19-21] In both adults and children the association with disease is particularly striking for the sulphur oxide and particulate complex. The cause for these respiratory tract diseases is probably an impaired resistance to infection, established in laboratory animals by many investigators.[1]

During episodes of pollution there has been a definite association between levels of sulphur oxide and particulates and the previously mentioned illnesses. However, the studies that have demonstrated this relationship have used expensive epidemiologic surveys and, occasionally, pulmonary function testing. These study designs have been necessary to ensure scientific accuracy in demonstrating the relationships between air pollution and disease entities. Given that there are adverse health effects from air pollution, an easier and less expensive way of monitoring pollution-related health parameters in the community is needed.

Family physicians are in an excellent position to do this monitoring. Since pollution levels are generally lower than in previous years, it is difficult to find increased mortality rates to measure health effects. However, outpatient visits would be one way of monitoring more subtle effects of pollution. To date, no studies have been done in the office setting.

During the winter of 1980-81, heavy smog conditions prevailed in the Salt Lake Valley in Utah. To determine whether a relationship existed between levels of pollutants and diseases seen in a physician's office during this time, a study was done on patient visits to the Family Practice Center at the University of Utah Medical Center in Salt Lake City.

Methods

The period from November 2, 1980, to January 31, 1981, was examined. Data were obtained as described below, including patient diagnoses, local climatological data, and pollutant levels. All data collected were averaged over a week's time for each of the 13 weeks of the study.

The patients studied were those seen in the Family Practice Clinic at the University of Utah. Ninety-seven percent were from the Salt Lake City area, where the air pollutants were monitored. The patient information from the center was obtained from computerized patient encounter data. Diagnoses defined as potentially related to pollution are given in Table 1. This list includes diseases known or thought to result from pollution.[1] For each week the total number of patients with these diagnoses was divided by the total number of patients seen for that week. Thus, the percentage of patients seen who had diseases related to pollution was obtained for the 13 weeks.

Local climatological data were obtained from the National Weather Service at the Salt Lake City airport (Table 2). Information was gathered on weather types, including the presence or absence of smoke and fog. Fog was divided into light fog, with a visibility of less than seven miles, and heavy fog, with a visibility of a quarter-mile or less. This breakdown between heavy and light fog was the standard way of reporting for the National Weather Service. A percentage of combined smoke and fog present for each week was then calculated. Information was also obtained on the amount of sky cover, and an average percentage of sky cover for each week was calculated.

Data on air pollutants were obtained from the Bureau of Air Quality on the daily levels of carbon monoxide (CO), ozone, and particulate matter. Sulphur oxide data were not obtained because of the long distance of the measuring apparatus from the patient care area. However, it is felt that sulphur oxides and particulates combine in the atmosphere and that this combined complex might be more reactive to the lungs than either alone.[1] Thus, the particulate count might indirectly measure some of the effects of sulphur oxides. These pollutant levels were reported as Pollutant Standards Index (PSI) values. A standard PSI value of 100 is set for each pollutant, and values above this level are felt to have adverse effects on human health. Levels of each pollutant were obtained on

Table 1. Pollution-Related Diseases	
Disease	**ICHPPC-2 Code**
Asthma	493
Cough	7862
Dyspnea	7860
Acute bronchitis	466
Pneumonia	286
Acute bronchiolitis	466
Emphysema or chronic lung disease	491
Acute upper respiratory tract infection	460
Laryngitis or tracheitis	464
Acute sinusitis	461
Conjunctivitis	3720
Ischemic heart disease	412

From *International Classification of Health Problems in Primary Care,* rev ed. New York, Oxford University Press, 1979

a daily basis, but each was then averaged over a week's time for the 13 weeks.

For each week, five variables were then each compared with the percentage of pollution-related diagnoses: particulate level, CO level, ozone level, percentage of sky cover, and percentage of fog and smoke. Weighted simple linear regression and correlation analysis was then performed on each of these pairs of variables using the GENCAT computer program.[22]

Results

The overall presence of smoke and fog for the period under study is shown in Table 2. Smog conditions prevailed from November 20th through January 24th. The pollutant levels during this time were higher than usual, but not exorbitant. The average level exceeded the standard PSI for the particulate count for only one week, and for carbon monoxide, one other week. The average particulate count for each week is displayed in Figure

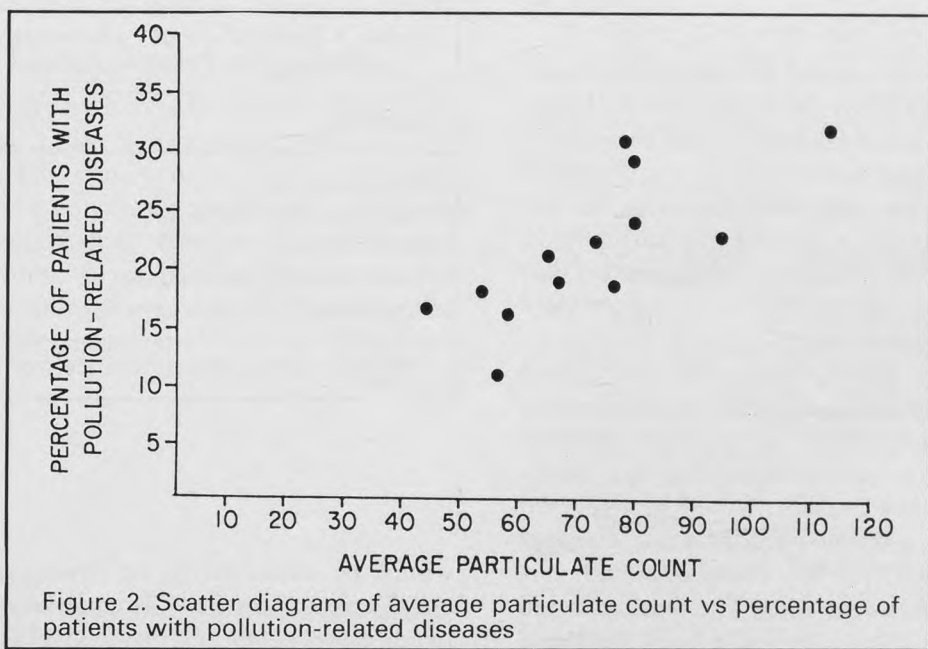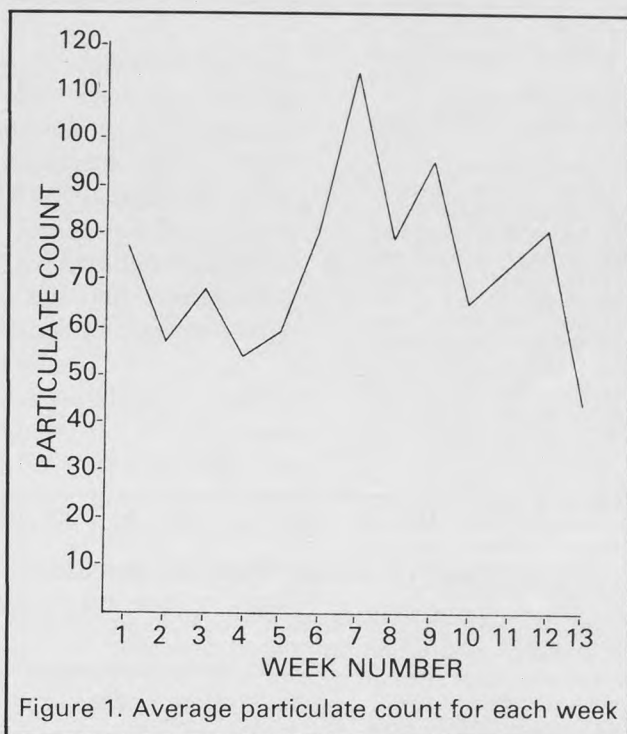| Table 2. Daily Local Climatological Data for Salt Lake City, Utah					
November 1980		**December 1980**		**January 1981**	
Date	Weather* Type(s)	Date	Weather Type(s)	Date	Weather Type(s)
1	8	1		1	2,6,8
2		2		2	2,6,8
3		3		3	2,6,8
4		4		4	2,6,8
5		5	1	5	2,8
6		6	8	6	1,8
7		7		7	1,8
8		8	1,8	8	1,8
9		9	1,8	9	1,8
10	8	10	1,8	10	1,8
11		11	1,8	11	8
12		12	2,8	12	8
13		13	2,8	13	1,8
14		14	2,8	14	8
15		15	2,8	15	1,8
16		16	2,8	16	1,8
17		17	2,8	17	1,8
18	8	18	2,8	18	1,8
19	8	19	2,8	19	2,8
20	1,8	20	2,8	20	2,8
21	1,8	21	2,6,8	21	2,8
22	1,8	22	1,8	22	2,8
23	1,8	23	1,8	23	2,8
24		24		24	2,3,8
25	8	25	1,8	25	2,3,8
26	1,8	26	8	26	
27	1,8	27	1,8	27	
28	1,8	28	2,8	28	
29	8	29	2,8	29	
30		30	2,8	30	
		31	2,8	31	

Data from the National Weather Service Forecasting Office
*Weather types: 1—fog (visibility < 7 miles), 2—heavy fog (visibility < 1/4 mile), 3—thunderstorm, 6—glaze, 8—smoke

1, to show the variation in a pollutant over the period of the study. The percentage of patients with pollution-related diseases ranged from 13 percent to 34 percent during the time of the study.

Examination of the simple weighted regression and correlation analysis of each independent variable with the percentage of patients reveals a statistically significant association at the .01 level for all pairs except for carbon monoxide and sky cover. The correlation coefficients for each pair of variables are displayed in Table 3. The relationship of these variables is nearly linear, as the scatter diagrams of the two best correlated ones demonstrate (Figures 2 and 3).

The R^2 value in Table 3 indicates the amount of variability in the dependent variable (pollution-related diseases) explained by each of the independent variables. In this case, 62 percent of the

Figure 1. Average particulate count for each week

Figure 2. Scatter diagram of average particulate count vs percentage of patients with pollution-related diseases

variability seen in pollution-related diagnoses in patients can be explained by looking at the particulate levels measured in the atmosphere. Other percentages of variability accounted for by each independent variable examined separately are also indicated in Table 3.

Figure 3. Scatter diagram of percentage of possible smoke and fog vs percentage of patients with pollution-related diseases
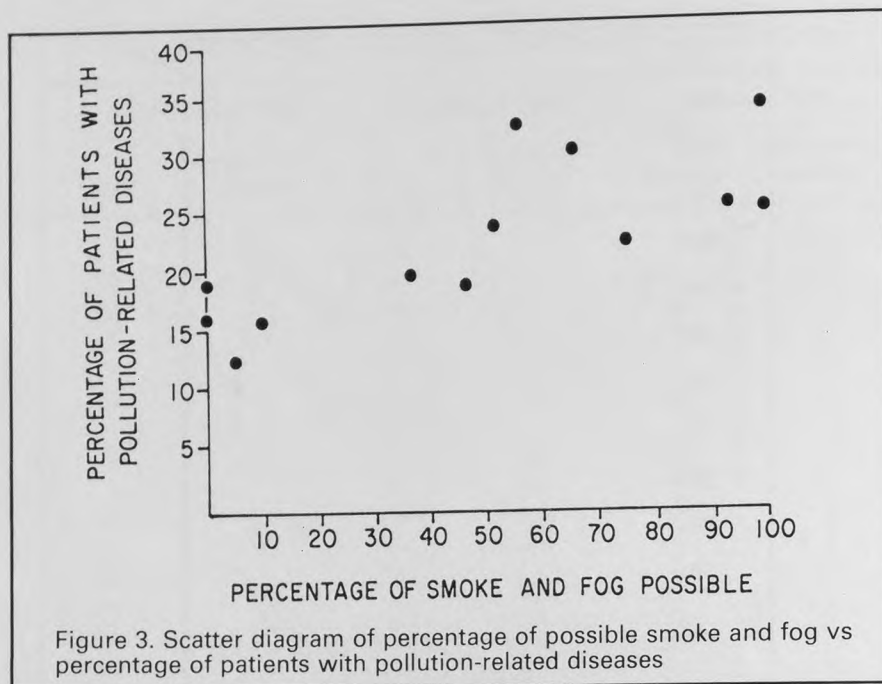
Discussion

All the diseases examined have multiple etiologies and multiple causes for exacerbation. Pollutants are considered to be only one of these contributing factors, and a relatively low correlation would therefore be expected. Correlations for weather and pollutant variables are surprisingly high. Adding further validity to this method is that the variables expected to correlate more strongly with disease do indeed do so.

The particulate count, which has the highest demonstrated association with the diseases examined, correlates most highly in this study. In addition, the percentage of smoke and fog, as a measurement of the smog present, would be expected to be associated with respiratory tract diseases and is so associated. The low correlation with carbon monoxide is not surprising. The demonstrated effects of carbon monoxide are mostly on those with coronary artery disease. Patients with complaints referable to the heart made up only 2 percent of the total number and therefore would not be expected to affect total percentages to a great degree. The negative correlation with the ozone level also is not surprising. The ambient levels of ozone are dependent on reaction with sunlight and

Table 3. Correlation of Pollutant and Weather Variables with Pollution-Related Diseases

Variable	R Value	R²
Particulate level	.79*	.62
Carbon monoxide level	.43	.19
Ozone level	−.67*	.46
Percentage of cloud cover	.33	.11
Percentage of smoke and fog	.79*	.62

*P < .01 significant difference from zero

would be expected to be lower with increased cloud cover.[23] In fact, a negative correlation between cloud cover and ozone level was found (correlation coefficient, −.77). Similarly, ozone had a negative correlation with both particulate counts and with smoke and fog (−.40 and −.73, respectively), two variables positively correlated with morbidity. This relationship probably explains the negative correlation between ozone and disease, further corroborating the data.

diseases would not always be expected to hold, but when smog levels have reached a certain value, it may indeed be possible to follow health effects by monitoring outpatient visits. Both climatological data from the National Weather Service and the *Pollution Standards Index* from the Bureau of Air Quality are standardized information generally available. The only confounding variable would be the distance of the measuring sites from the patient care area.

The problem of physician variability in coding diagnoses should also be minimized. Whether one coded a disease "bronchitis," "pneumonia," or even "influenza" would matter little, as they all would be considered respiratory tract diseases. It would, however, be necessary to avoid labeling one of these into a classification for another organ system.

Tabulation of outpatient diagnoses during acute episodes of smog would be a simple method of monitoring health effects of air pollutants. This study of one such episode suggests that such monitoring might be possible. If so, it would be an excellent possibility for future studies in family practice settings.

At present, attempts are being made to correlate these findings with data from subsequent winters in the Salt Lake Valley when pollution was not so severe. This comparison should help clarify the effects of the confounding factor of season on respiratory tract diseases. Similar comparisons are being made with other geographic sites. It is hoped the effects of different types of pollutants can be elucidated by such studies.

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