

# The Relationship between Air Pollution, Weather, and Symptoms in an Urban Population

## Clarification of Conflicting Findings<sup>1-3</sup>

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### SUMMARY

Numerous studies have documented a relationship between air pollution, weather, and illness. Specific causes proposed to account for the effects have not stood up to critical examination, and the nature of the relationships has remained obscure. Indeed, contradictions and paradoxes are common within the general association between the environment and illness. The findings reported here support the belief that the environment—like some other modern health problems—must be examined differently than has been customary in the search for health effects, employing changed ideas of causality. The concept of the multiplex variable and some aspects of the philosophy of causality are discussed.

### Introduction

Previous reports have documented a relationship between air pollution, weather, and the occurrence of acute respiratory symp-

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oms in a panel of New York City residents (1-3). In general, the findings have suggested complex rather than simple associations and, not surprisingly, have failed to pinpoint single factors in the environment that might be held primarily responsible for illness. Indeed, the results have indicated considerable variation in the relationships from symptom to symptom, season to season, and year to year. Such contradictions and paradoxes within the general association between the environment and illness have also marked other investigations in which the subject has been examined in sufficient detail (4, 5). Notable in this regard is the literature on the relationship between air pollution and mortality (6-10).

The purpose of this paper is to re-examine some of these paradoxes within the framework provided by the concept of the environment as a multiplex variable, a variable seen as a cause that, although it may

consist of conceptually discrete parts, acts as a whole in terms of its effects. When the findings were reviewed in that light, a more realistic picture of the interaction between the ambient environment and health emerged. Further, a clearer direction for future work emerged.

### Materials and Methods

The Cornell Family Illness Study, which provided the data for the analyses recorded here, has been fully detailed previously (11, 12). A daily record of the prevalence of a number of common symptoms was maintained for 3 years for a panel of New York City residents living within a restricted geographic area. The 1,747 persons participating were followed by weekly interviews for an average of 48 weeks each. Air pollution data were obtained from a special monitoring station installed within the study area. Meteorologic information was obtained from that station and from the official U. S. Weather Bureau station located 4.5 miles away.

Using days as units, incidence and prevalence per 1,000 persons were calculated for the acute symptoms of headache, eye irritation, "common cold," sore throat, and cough.

Daily averages and changes from the preceding day were calculated for the following air pollutants: particulate matter, carbon monoxide (CO), sulfur dioxide (SO<sub>2</sub>), and hydrocarbons, as measured in the study area. In addition, daily measurements of 11 air pollutants were obtained from the New York City monitoring station approximately 110 blocks from the study area. Daily averages and changes from the preceding day were calculated for 6 of the meteorologic variables. In addition, 7 functions of barometric pressure were derived. The list of variables is given in table 1.

The analyses used stepwise multiple regressions from programs available for the IBM 1130 computer. Stepwise multiple regressions, where daily incidence and prevalence of specific acute symptoms are the dependent variables, provide a descriptive model of the relationships between these symptoms and the environmental factors that co-existed in time. The stepwise procedure has the property of entering the pollutant and meteorologic variables one at a time in order of their ability to "explain" the variation in the dependent variable as measured by the multiple correlation coefficient. Assuming that observations from day to day are essentially indepen-

dent and that the distributions of the relevant variables are at least continuous (except for missing information), the resulting models might also furnish a predictive tool to determine symptom response when environmental conditions are known. A more complete discussion of the use of this method for the data of this study was given by Thompson and associates (3).

### Results

The results of the regression analysis are shown in table 2; all regressions shown were significant. In table 2 the level of each of the environmental factors (independent variables) required to "explain" the average rate of the symptoms is also shown. Only 13 of 27 independent variables proved useful as explanatory factors. These were in approximate order of importance: daily averages of temperature, particulate matter, wind velocity, radiation, CO, hydrocarbons, and SO<sub>2</sub>; daily range and maximum of barometric pressure; daily average sky cover, and changes in averages from the preceding day of wind velocity and radiation. Most measures of change from the preceding day did not significantly contribute to the results. The multiple correlations between each symptom and the set of significant environmental factors ranged from 0.27 to 0.60.

Two features of the regressions were most notable. First, each symptom correlated with an environment whose features differed from the environments in which the other symptoms occurred. Second was the fact that no one environmental variable stood out in its ability to "explain" the presence of a symptom. Both important findings were underlined by the considerable differences in the regression drawn when the symptom "common cold" was examined separately by its prevalence, incidence, and incidence after three days.

### Discussion

Viewed as an attempt to determine what in the ambient environment of air pollution and weather was causally related to symptoms in a normal urban population, the results were disappointing and conflicting.

TABLE 1  
MEANS AND STANDARD DEVIATIONS OF ENVIRONMENTAL  
VARIABLES AND ACUTE SYMPTOMS, CORNELL FAMILY  
ILLNESS STUDY, NEW YORK CITY, 1962-1965

Description	Mean	SD
Days with no inversion, %	0.49	0.50
Days with inversion, %	0.46	0.50
Days with isotherm, %	0.05	0.22
Headache prevalence, %	2.83	1.54
Headache incidence, %	1.02	0.53
Eye irritation prevalence, %	1.79	0.98
Eye irritation incidence, %	0.30	0.34
Cold prevalence, %	7.61	3.61
Cold incidence, %	0.88	0.72
Sore throat prevalence, %	1.91	1.23
Sore throat incidence, %	0.43	0.45
Cough prevalence, %	5.00	2.39
Cough incidence, %	0.60	0.54
Particulate matter (COH) average	1.73	0.87
Particulate matter (COH) change*	0.00	0.75
CO average, ppm	3.72	2.49
CO change, ppm	-0.04	2.31
Hydrocarbons average, ppm	4.54	1.94
Hydrocarbons change, ppm	0.00	1.25
SO <sub>2</sub> average, ppm	0.16	0.10
SO <sub>2</sub> change, ppm	0.00	0.09
SO <sub>2</sub> , ppm†	0.20	0.16
Ammonia, ppm†	0.03	0.02
Aldehyde, ppm†	0.05	0.03
Oxidant (A. M.), ppm†	10.83	13.90
Oxidant (P. M.), ppm†	10.13	14.15
CO (A. M.), ppm†	2.95	1.72
Nitrogen dioxide, ppm	10.74	7.99
Sodium chloride, ppm†	5.52	5.79
Dust count†	2.71	1.58
Particle matter (COH)†	248.74	158.86
Organic acid†	6.04	5.80
Nitrogen monoxide, ppm†	6.27	6.34
Wind velocity average, mph	9.34	3.69
Wind velocity change, mph	-0.03	4.05
Precipitation average, (inches)	0.03	0.10
Precipitation change, (inches)	0.00	0.14
Radiation average	0.30	0.15
Radiation change	0.00	0.15
Temperature average, °F	51.29	16.76
Temperature change, °F	-0.02	6.11
Relative humidity average, (%)	60.08	15.53
Relative humidity change, (%)	-0.02	15.88
Sky cover average	4.50	3.18
Sky cover change	0.00	3.69
Barometric pressure (maximum R), mm Hg	0.03	0.02
Barometric pressure (maximum F), mm Hg	0.03	0.02
Barometric pressure (maximum), mm Hg	30.14	0.21
Barometric pressure (minimum), mm Hg	29.91	0.25
Barometric pressure (range), mm Hg	0.22	0.15
Barometric pressure change, mm Hg	0.00	0.21
Barometric pressure average, mm Hg	30.03	0.23

\*"Change" is change of average from preceding day; average is daily average.

†Measured at the New York City Station. The other measurements were within the Cornell Family Illness Study Area (lower east side of Manhattan).

