

POWER PLANT EMISSIONS AND CANCER MORTALITY RATES

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ABSTRACT

Atmospheric emissions from coal-fired electrical generating stations contain several carcinogens, as well as other non-carcinogenic substances such as SO₂. In areas where the main sources of SO₂ are coal-fired generating stations, the SO₂ may be used as an indicator of general air pollution levels from these plants. Coal-fired power plants are the main source of atmospheric SO₂ in Ohio. Significant associations were found between county Cancer and Respiratory Cancer mortality rates and estimated annual SO₂ emissions in Ohio. Linear regression demonstrated that the associations were of considerable magnitude. Living near a conventional coal-fired power plant, therefore may be a cancer risk factor.

INTRODUCTION

Sulfur dioxide levels can be utilized as an indicator for the general degree of atmospheric pollution (National Air Pollution Control Association, 1969; Wark and Warner, 1976). Where SO₂ levels are high, it can be reasonably expected that other pulmonary irritants, e.g., particulates, are also present in large concentrations.

A study was undertaken, using SO₂ emissions estimates from coal-fired power plants as a surrogate for air pollution levels, to ascertain whether any relationships exist between pollution levels and chronic disease mortality rates in the state of Ohio. Specifically, the study examined disease-specific mortality rates in Ohio counties with coal-fired power plants and counties without such installations in order to determine whether or not these two groups of mortality rates differed.

METHODOLOGY

Ohio was selected for investigation because steam-electric power plants are responsible for at least 70% of all SO₂ emissions in that state (Park, 1974). Twenty-

seven Ohio counties served as the sample. Twenty counties contained at least one coal-fired power plant whose installed generating capacity exceeded 50 megawatts electricity. Seven counties had no such power plants. In total, the sample accounted for 29 of the 49 Ohio power plants operating for at least five years prior to 1974.

Mortality data were derived from *Vital Statistics of the United States* for the years 1971-1974. Rates were age-adjusted to the 1974 (mid-year) population of Ohio. Disease categories were selected based on reviews by Lave and Seskin (1970) and Goldsmith (1974). The categories employed were: 1) Cancer (140-209); 2) Respiratory Cancer (160-163); 3) Major Cardiovascular Diseases (390-448); and 4) Bronchitis-Emphysema-Asthma (490-493).

Sulfur dioxide emissions were estimated from power plant data issued by the Federal Power Commission. Estimates were based on an emissions factor of approximately 3.4 kg (7.4 lbs.) of SO₂ produced by the burning of one ton of coal in Ohio power plants (Park, 1974). No data were located for counties without power plants, so it was assumed that SO₂ emissions in these counties were very much less than the emissions in power plant counties.

On the surface, there exists one potential problem encountered in the use of SO₂ stack emissions in this study. The behavior of plumes, e.g., dispersal distance, has not been considered. While it is possible that emissions from tall stacks could be carried out of the county of origin by air movements, the dilution factor $\frac{x}{q}$ is so great that most of the noxious agents originally in the plume will reach the ground relatively close to the point of origin. Therefore, it is believed that stack emissions can serve as surrogates for general air pollution contributions from coal fired generating plants.

Statistical analysis commenced with two-sample t-tests to determine whether differences in disease-specific mortality rates existed between the power plant counties and those without power plants. Next, Pearson product-moment correlation coefficients were computed to determine associations between SO₂ emissions and mortality rates. While correlation provides an adequate initial measurement of association, the correlation coefficient provides no indication of the magnitude of an effect. Therefore, regression was performed on statistically significant associations.

ANALYSIS AND DISCUSSION

Table 1 presents the results of two-sample t-tests. The null hypothesis postulates that for each disease category no difference existed between the mean rates of the power plant counties and the non-power plant counties. The null was rejected in the cases of cancer and respiratory cancer, indicating that Ohio's power plant counties have, on the average, significantly higher death rates for these diseases than do counties without power plants. It might be argued that the power plant counties are more urbanized and that this is merely an "urban effect"; however, eight of the power plant counties have populations that are less than 50% urban.

Table 2 lists the correlation coefficients between disease mortality rates and SO₂ emissions. Estimated SO₂ emissions were moderately associated with both cancer and respiratory cancer mortality rates ($r = .546$ and $.491$, respectively). Unlike other studies, no associations were found between SO₂ emissions and Major Cardiovascular Diseases or the category Bronchitis-Emphysema-Asthma.

Regression equations were developed for the two statistically significant associations to determine the magnitude of the effects SO₂ emissions had on the cancer variables:

$$\text{Cancer Mortality Rate} = 122.4 + 21.5 (\log_{10} \text{SO}_2)$$

$$\text{Respiratory Cancer Mortality Rate} = 24.2 + 6.0 (\log_{10} \text{SO}_2)$$

These equations showed that as SO₂ emissions rise by a factor of 10, the cancer mortality rate increases by more than 14% (e.g., from 155 to 177 per 100,000 per year) and the respiratory cancer mortality rate increases by 16% (e.g., from 37.5 to 43.5 per 100,000 per year). It should be emphasized here that there is no evidence that the air-borne oxides of sulfur are carcinogenic and that the SO₂ emissions are used here only as a general measure of air pollution from power plants. However, since the emissions from coal-fired power plants are known to include carcinogens such as polyaromatic hydrocarbons and naturally occurring long-lived radioactivity, these findings are consistent with studies finding associations between air pollution and various cancers (Hagstrom et al., 1967; Winkelstein and Kantor, 1969).

It was thought that large urban centers in certain counties might have presented problems of colinearity, so another set of correlation coefficients was computed, omitting highly urbanized counties. The associations were similar (Cancer and SO₂, $r = .588$; Respiratory Cancer and SO₂, $r = .507$), thus showing that urbanization was not a confounding factor.

CONCLUSIONS

Statistical associations were found between power plant annual SO₂ emissions in Ohio and county mortality rates for Cancer (140-209) and Respiratory Cancer (160-163). No similar relationships were found for Major Cardiovascular Diseases (390-448) or Bronchitis-Emphysema-Asthma (490-493). There was a significant difference in cancer and respiratory cancer mortality rates between coal-fired power plant counties and counties without coal-fired power plants.

While SO₂ itself is not carcinogenic, power plant emissions contain various carcinogens. Information presented here suggests that SO₂ levels might serve well as indicators of general pollution. In areas where coal-fired power plants are the single greatest source of SO₂, emissions estimates from power plant data may be excellent surrogates for general air pollution. Since coal-fired power plants are the main source of most SO₂ emissions and because power plant plumes contain various carcinogens, further research should be undertaken on the local level to examine the degree to which living near a coal-fired power plant is a cancer risk factor.

REFERENCES

- Federal Power Commission: *Steam-electric Plant Construction Cost and Annual Production Expenses* — 27th Annual Supplement. Washington, 1974.
- Goldsmith, J.R.: Health hazards from power plant emissions. IN: Finkel, A.J. (ed): *Energy, the Environment, and Human Health*. Publishing Sciences Group, Acton, Massachusetts, 1974.
- Hatstrom, R.M., Sprague, H.A. and Landav, E.: The Nashville Air Pollution Study, Part VII: Mortality from Cancer in Relation to Air Pollution. *Arch. Env. Health* 1967, 15:237-48.
- Lave, L.B., Seskin, E.P.: Air pollution and human health. *Science* 19970; 169:723-733.
- National Air Pollution Control Administration: *Air Quality Criteria for Sulfur Oxides*. AP-50, 1969.
- Park, W.R.: The Economic Impact of SO₂ Emissions in Ohio. Kansas City: Midwest Research Institute, 1974.

U.S. Dept. of Health Education and Welfare: *Vital Statistics of the United States Vol II: Mortality* Part B. Washington, 1973, 1974, 1975, 1976.

Wark, K., Warner, C.F.: *Air Pollution: Its Origin and Control*. New York: Harper and Row, 1976.

Winkelstein, W., Kantor, S.: Relationship of air pollution to cancer of the stomach. *Arch. Env. Health* 1969, 18:544-547.

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Table 1. Mortality rate differences between counties with and without power plants.

CANCER	N	Mean*	± S.D.
Power plant counties	20	177.7	27.8
No power plant counties	7	127.2	25.5
t = 4.233 (significant at $\alpha = .05$)			
RESPIRATORY CANCER	N	Mean	SD
Power plant counties	20	39.1	8.7
No power plant counties	7	25.2	8.4
t = 3.729 (significant at $\alpha = .05$)			
MAJOR CARDIOVASCULAR**	N	Mean	SD
Power plant counties	20	491.6	31.7
No power plant counties	7	492.0	42.0
t = .023 (not significant)			
BRONCHITIS***	N	Mean	SD
Power plant counties	20	2.7	.03
No power plant counties	7	2.7	.04
t = .010 (not significant)			

*Mean age-adjusted death rate

**Major Cardiovascular Diseases

***Bronchitis-Emphysema-Asthma

Table 2. Correlation coefficients between log of SO₂ emissions* and disease incidence.

Disease Variable	Correlation Coefficient
Cancer	.546**
Respiratory Cancer	.491**
Major Cardiovascular Disease	.127***
Bronchitis-Emphysema-Asthma	.212***

*log₁₀ of estimated annual power plant SO₂ emissions (tons/year)

**significant at p < .05

***not significant