This paper reports an association between prostatic cancer and suspended particulate air pollution, thus replicating findings in the Nashville Air Pollution Study. This finding appears to be independent of economic status.

PROSTATIC CANCER: RELATIONSHIP TO SUSPENDED PARTICULATE AIR POLLUTION

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Introduction

ONE way of testing an epidemiologically determined "association" is to replicate it. Thus, it has been interesting to compare observations made in the Nashville Air Pollution Study[1] with those made in the Erie County Air Pollution Study.[2] In both, extensive community-wide aerometric measurements were made and compared with the health status of the total population or representative samples of it. In both, the investigators attempted to segregate the possible health effects of air pollution from confounding attributable to social and economic influences. With respect to cancer, neither study revealed an association between cancer of the bronchus, trachea, and lung and suspended particulate air pollution; while both revealed a positive association between gastric cancer and particulate air pollution.[3-5] In this paper, the only other positive association between air pollution and a particular cancer present in data from both studies is reported. This is an association between prostatic cancer and suspended particulate air pollution.

There is much reason to investigate prostatic cancer by epidemiological methods. In 1962, this cancer cause of death was second only to cancer of the lung among American men. Between 1930 and 1960, the age-adjusted death rates for prostatic cancer almost doubled for white males and more than tripled among nonwhite males. The long-term case-fatality rate (complement of the five-year survival rate) has not seemed to improve much over time.[6] Furthermore, occupational exposure to cadmium oxide dust has recently been reported to be associated with an excess risk of prostatic cancer.[7,8] Since cadmium has been demonstrated to be a component of air pollution in some urban areas, airborne carcinogenesis for prostatic cancer may be a reasonable hypothesis.[9,10]

Method of Study

The relationship of suspended particulate air pollution to mortality has been under study for several years in Erie County, New York. The study area includes the city of Buffalo and its immediate environs. Suspended particulate levels were determined by high volume samplers located at 21 air-sampling stations randomly scattered over the study area. Air samples were obtained during the two-year period from July, 1961, through June, 1963. Subsequently, iso-

pleths were constructed for four pollutant levels. Average annual age-specific death rates according to residence at time of death were then computed for the pericensal period, 1959-1961.

Since economic status and air pollution levels are frequently inversely associated in particular geographic areas and since economic status has long been thought to affect health, an attempt has been made to control for economic factors in all of the analyses of data from the Erie County Air Pollution Study. Thus, the study population was also classified into five economic areas on the basis of median family income of each census tract. This permitted the comparison of mortality rates between areas of essentially the same economic status but differing air pollution levels. Unfortunately, the relatively small number of deaths from prostatic cancer made it necessary to collapse the five economic levels into two. In order to compare the Erie County findings with those from Nashville, the data have also been analyzed for a "middle" economic classification which has previously been shown to generate a population comparable to the middle class grouping used for summary analyses in the Nashville Air Pollution Study.

In the present study, nonwhites were excluded since their numbers in the study area are too small to produce meaningful rates.

Results

The over-all age-specific death rates from prostatic cancer in white males in the study area are not inconsistent with the 1960 rates for the United States as a whole. For the study area, the rates are 27 per 100,000 for ages 50-69 and 230 per 100,000 for ages ≥ 70 (Table 1). For the United States, the comparable rates are 23 and 222, respectively.

Suspended particulate pollution levels of the ambient air in the study area were positively associated with prostatic cancer in white males 50-69 years of age as well as in those 70 years of age or more, as shown in Table 1. Among those 50-69 years, the mortality rate in the highest air pollution zone was more than twice that in the lowest; while for those 70 years of age and older, the relative risk of prostatic cancer mortality between the two zones was 1.7. In the age group 50-69 years, the mortality rates increased in a stepwise fashion over the four air pollution zones. However, in those 70 years of age and older, the two intermediate zones experienced essentially the same prostatic cancer mortality.

Table 2 shows the relationship of prostatic cancer to both suspended particulate air pollution and economic level of the census tract of residence for each of the two age groupings. It is inter-

Table 1—Average annual death rates per 100,000 population for prostatic cancer according to air pollution level* and age: white males, Buffalo and environs, 1959-1961

	Air pollution level				
Age	1 (Low)	2	3	4	Total
50–69	18 (9)†	24 (23)	36 (21)	41 (8)	27 (61)
≥70	177 (20)	235 (62)	232 (38)	309 (17)	230 (137)

* Based on two-year average suspended particulate levels:
1 = <80 $\mu g/m^3$/24 hours
2 = 80–100 $\mu g/m^3$/24 hours
3 = 100–135 $\mu g/m^3$/24 hours
4 = >135 $\mu g/m^3$/24 hours
† Figures in parentheses indicate numbers of deaths.

Table 2—Average annual death rates per 100,000 population for prostatic cancer according to economic* and air pollution levels and age: white males, Buffalo and environs, 1959-1961

Median family income	Air pollution level				Total
	1 (Low)	2	3	4	
		50–69 years			
$3,005–$ 6,004	18 (2)	26 (8)	38 (14)	39 (6)	32 (30)
$6,013–$11,792	18 (7)	23 (15)	33 (7)	51 (2)	24 (31)
		70 years and over			
$3,005–$ 6,004	61 (2)	143 (15)	204 (23)	356 (16)	189 (56)
$6,013–$11,792	224 (18)	295 (47)	297 (15)	99 (1)	296 (81)

* Based on median family income of census tract of last residence.

esting to note that for the total 50-69-year group, the mortality rate is almost a third higher in the lower economic group than in the higher; while in the older group, the relationship is reversed with the upper economic group having a mortality rate 1.6 times that of the lower. However, in the 50-69-year age group, the differences in the mortality rates between the two economic levels for any particular air pollution zone are neither consistent nor large. It may also be noteworthy that with increasing age (70 and over) the apparent effect of air pollution on prostatic cancer mortality increases in the lower economic group but decreases in the upper. This observation will be discussed subsequently.

Figure 1 has been prepared in order to compare the Erie County findings with those of the Nashville Air Pollution Study. The data for the "middle" economic levels have been graphed for both age groupings. Again, the trends are clear. The ratio of age-adjusted mortality rates from prostatic cancer in Nashville, between the highest and lowest air pollution levels, is 1.4; while for the Erie County middle economic grouping it is 2.7 in white males 50-69 and 1.8 in those 70 years of age or older. It should be noted that the Nashville data are not limited to white male mortality. However, it is unlikely that large numbers of Negroes, among whom prostatic cancer rates are reported higher than whites, would have been residing in average socioeconomic neighborhoods in Nashville at the time of the air pollution study there (1949-1960).

Comment

It would be presumptuous to place great emphasis on the findings presented here, in view of the small numbers of occurrences upon which they are based and the many possible ways in which unknown factors might be influencing the distributions. Nevertheless, the observation of an association between an important disease, prostatic cancer, and an important environmental influence, suspended particulate air pollution, in two independent studies merits attention and, hopefully, further attempts at replication.

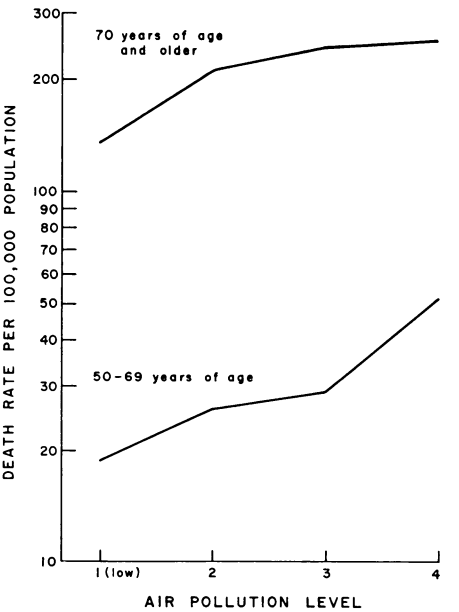
It was interesting to note the interaction of age and economic status revealed in these data. The fact that the association between economic level and prostatic cancer mortality was reversed for those under 70 years of age and for those 70 years and over should caution those who study associations by interpreting age-adjusted rates. If we had

age adjusted these rates, we would have found little or no association between economic status and prostatic cancer in these data. The fact that the younger population (50-69) experienced similar death rates, regardless of economic level, is consistent with the concept that the disease is more fulminating and easily recognizable among them and therefore its detection will not be markedly influenced by economic factors. In the old (70 and over), the disease is more chronic and frequently goes unrecognized; thus, the higher economic elderly will be more apt to receive a diagnosis of prostatic cancer because of better and more available diagnostic and treatment services. The fact that the upper economic elderly group did not show an air pollution mortality gradient may be due to selective factors which reduced the base population living in the highest air pollution area to very low numbers. In a previous paper we have demonstrated an interaction between respiratory symptoms, air pollution, and residential mobility.[11] It is conceivable that among the economically favored elderly with prostatic cancer a similar mechanism may be operative.

In the introduction to this paper we alluded to an association between occupational exposure to cadmium oxide dust and prostatic cancer and to the existence of cadmium in particulate urban air.[7-10] Potts reported that among 70 men chronically exposed to cadmium oxide dust over a period of ten or more years, while working in a factory producing alkaline batteries, eight died between 1960 and 1964 of whom three (38 per cent) were attributed to prostatic cancer. Kipling and Waterhouse surveyed a group of 248 workers who had experienced at least one year of occupational exposure to processes utilizing cadmium oxide and then followed them for varying periods.[8] Based on age-specific death rates derived from the Birmingham Cancer Registry applied to person-years of observation among the 248, he derived an expected over-all cancer mortality of 13. Twelve cancer deaths were observed among the 248. However, of the 12, four deaths were attributed to prostatic cancer which had an expectation of 0.56. The probability of this observation occurring by chance was estimated to be 0.003. The National Air Pollution Study reported cadmium levels between 0.001 and 0.062 mg/cu m in 26 major American cities.[10] We are not aware of any efforts to measure cadmium levels in various parts of a particular community. We hope to be able to do this for Buffalo and its environs since the high volume filters used in the Erie County Air Pollution Study are still available.

With respect to increasing mortality over time, it is apparent that this phe-

Figure 1—Death rates per 100,000 population for prostatic cancer according to suspended particulate air pollution levels, white males 50-69 and 70 years and over living in census tracts of median family income $5,175-$7,347, Buffalo and environs, 1959-1961



nomenon is fully consistent with airborne carcinogenesis. If there is an important chemical carcinogen involved in the genesis of prostatic cancer and if its discharge into air is increasing, then human exposure will, of necessity, also increase over time.

Summary

In this paper, an association has been reported between prostatic cancer and suspended particulate air pollution that appears to be independent of economic status, at least in men under 70. In the middle economic grouping among white males 50-69 years of age, the mortality rate for prostatic cancer was 2.7 times as high in the most polluted zone as in the least polluted, compared with 1.7 for white males 70 or over. These observations replicate findings in the Nashville Air Pollution Study.

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