Cardiovascular Deaths and Air Pollution in Charleston S.C.

CECIL F. JACOBS, MD, MPH, and BETTYE ANNE LANGDOC, AB

FOR several years, public health officials have suspected that a harmful relationship exists between air pollution and the health of the public. However, documentation that such a relationship exists has been unobtainable except during periods of intense pollution such as occurred in London in 1952 and on several other occasions and in Donora, Pa., in 1948.

Such acute episodes have resulted in excess mortality primarily among aged persons or persons suffering from chronic diseases or conditions which make them highly sensitive to atmospheric conditions which exist during acute pollution episodes. Such excess mortality has been considered unlikely to occur until after several days of exposure.

Little data had been available which would implicate daily exposure to air pollution as a major factor in mortality among the population of a community. One reason such data have been lacking is probably that air pollution levels have been increasing gradually, but steadily, throughout the world for 30 or more years and, consequently, the impact on mortality has been impossible to measure adequately.

Generally, such measurements can only be made when air pollution levels are reduced in a short time period and the population at risk remains relatively stable. Needless to say, such situations have been rare.

A study of the population and patterns of mortality in Charleston County, S.C., indicated that daily exposure to air pollution could result in excessive mortality rates among the general population. Preliminary data are also available which suggest that reduction in levels of air pollution can result in a decline in mortality rates among the exposed population.

Mortality rates before and during a reduction in levels of air pollution are examined in this paper, and mortality of populations is compared with different levels of exposure to air pollution.

Background Information

Charleston County occupies the middle one-third of the coastline of the State and much of its area consists of islands, marshes, tidal creeks, and beaches. According to the 1970 U.S. Census, 247,650 perons live here. Approximately 200,000 of this number reside in and immediately adjacent to the city of Charleston, which is located in the geographic center of the county on a peninsula bounded by the Ashley and Cooper Rivers.

Practically all major sources of industrial air pollution are located on the Charleston Peninsula north of the city. In 1968, there were five fertilizer plants which produced sulfuric acid for fertilizer manufacture; a large Kraft papermill; a large

Dr. Jacobs is district medical director of the South Carolina State Board of Health and director of the Charleston County Health Department. Mrs. Langdoc is director of information and education, Charleston County Health Department. Tests for levels of significance on all data were made by W. W. Dyal, chief, Statistical Activity, Immunization Branch, Center for Disease Control, Atlanta, Ga. Tearsheet requests to Cecil F. Jacobs, MD, 334 Calhoun St., Charleston, S.C. 29401.

ferroalloy plant which had five electric furnaces; a chemical complex which produced organic phosphites and phosphates, phosphoric acid, and, manufactured among other products, a pesticide (cholinesterase inhibitor) and a defoliant; an asphalt shingle plant; an electric generating plant; a military airbase and a civilian airport; a large naval base; three scrap metal dealers burning large numbers of automobiles and scrap electrical wiring; and several smaller industries. The exhaust fumes from approximately 117,645 motor vehicles registered in the county added to the pollution.

As can be seen in the photodiagram, the Charleston Peninsula is flat, almost completely surrounded by the rivers and harbor, and only a few feet above water level. The climate is usually warm and humid and the area is subject to frequent atmospheric temperature inversions, usually at night, which prevent the vertical movement of air pollutants.

In 1968, the U.S. Weather Bureau reported temperature inversions or isothermal layers, or both, extending from the surface to about 1,000 feet for varying periods on 307 days. What has not been recognized heretofore is that the airmass overlying the land area cools at night while the airmass overlying the water remains approximately the temperature of the water, especially at lower levels. When there is limited movement of air in the area, this phenomenon tends to create a thermal barrier to the horizontal movement of air pollutants in the same manner as the atmospheric inversion creates a barrier to vertical movement.

During periods of atmospheric inversions, the thermal barriers around the peninsula create, in effect, a large funnel shaped bottle with the industrial complex located in the mouth of the bottle. Emissions from local industry, open burning, and automobile exhausts are trapped in this bottle exposing the population of the peninsula to high concentrations of air pollutants. During 1968 and in preceding years, emission control devices were few and far between in industrial plants and on automobiles. Open burning of dumps and scrap during the day and at night was common, and many of the polluting industries were operated around the clock.

Table 1. Total deaths and deaths from three leading causes, Charleston County, S. C., 1968 and 1970

Cause of death	1968		1970	
	Deaths	Rate per 100,000	Deaths	Rate per 100,000
Total deaths	1,958	790.6	1,718	693.7
Diseases of the heart	628	253.6	466	188.2
Stroke	183	73.9	129	52.1
All forms of cancer	258	104.2	227	91.7

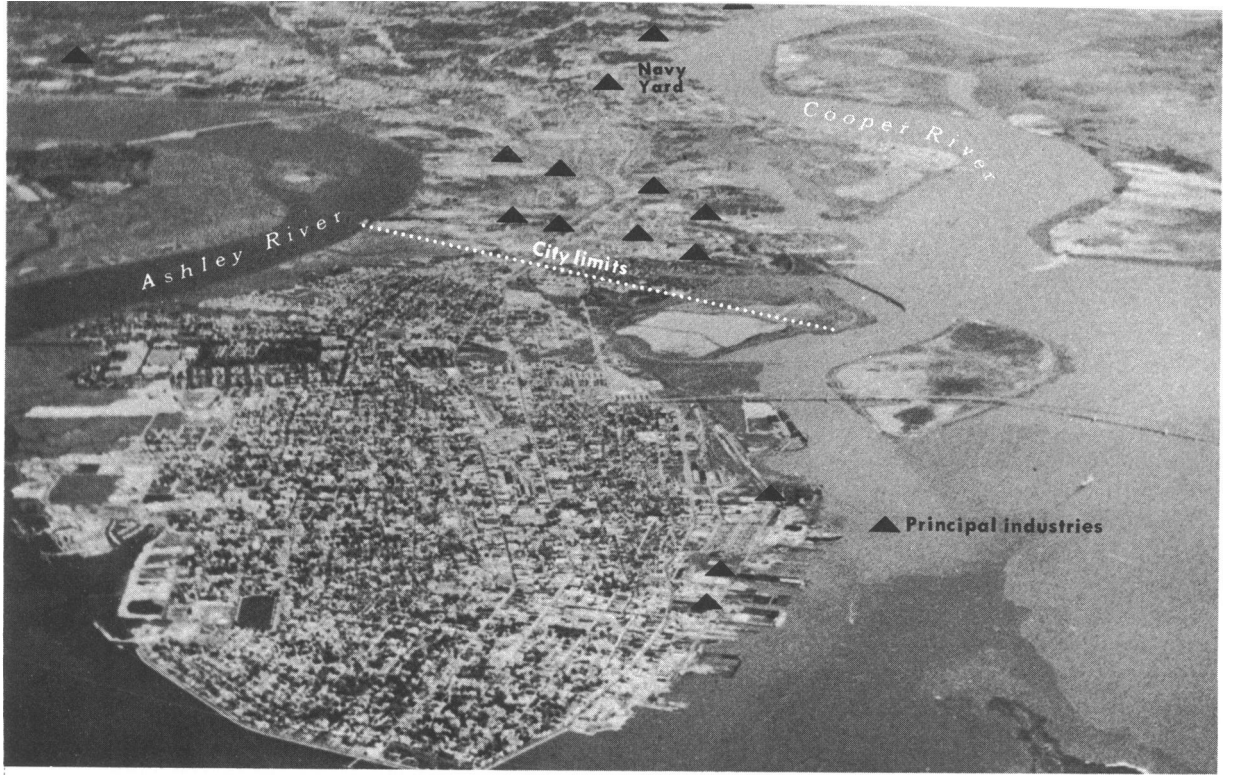
Table 2. Levels of suspended particulate matter in industrial area and approximately 4 miles from industrial area, Charleston Peninsula, 1968–1970

Year	Industrial area		Health department	
	Number samples	Annual average ($\mu g/m^3$)[1]	Number samples	Annual average ($\mu g/m^3$)[1]
1968	117	227.6	20	74.4
1969	268	170.7	73	57.9
1970	514	120.5	58	55.3

[1] $\mu g/m^3$—micrograms per cubic meter of air.

Recognizing the potential threat to the public health and being made aware, by the public, of the nuisance aspect of various odors originating in the industrial area, the Charleston County Health Department, with the reluctant cooperation of various industries, began a program to reduce levels of air pollution. The campaign to reduce air pollution began in 1968 but only limited control devices were installed that year. Because of this, data on mortality during 1968 were selected to provide a baseline for the measurement of the impact of pollution on health. Control of industrial air pollution and open burning has progressed steadily through 1969 and 1970 and is nearing its scheduled completion date of December 1972. A program for control of emissions from moving sources is scheduled to begin as industrial pollution sources are controlled.

Some indication of the scope and success of the pollution control program may be realized by the fact that more than $7 million has been committed to installation of control devices and $15 million to the construction needed to utilize control devices. Two court actions resulted in consent injunctions, and three other court actions are pending, but we hope these need not be completed.



Although special pollution control laws and regulations have been enacted by the State, all legal action instituted has been based on existing public health nuisance and public health hazard laws and regulations. These were considered to be more effective and enforceable.

Sulfuric acid manufacture has been discontinued by four plants, and open burning of dumps, automobiles, and electrical wiring has been discontinued. One plant which was part of a large chemical complex was closed and moved to another State because of the inability to control emissions. Another part of this plant was completely enclosed and operates under negative pressure to insure collection and removal of all emissions.

It was hoped that measurable health effects would be noted as a result of reduced pollution levels; however, we did not anticipate that the effects would be noticeable in a short period.

A community health index study was being conducted in 1971 by the health department with the Center for Disease Control in Atlanta, Ga., to establish mortality and morbidity patterns in all segments of the community. During this study, an unexpected decrease in deaths was noted for 1970 (table 1). There were also decreased death rates in the diseases of the heart, stroke, and cancer, the three major causes of death; however, the greatest reduction occurred in 1970 in deaths attributed to diseases of the heart.

These changes in mortality took place during a period when there were no major population changes. There was no known movement of population of any significance in or out of the county or within the county itself. The only known change taking place which could have any appreciable effect on the health of a large segment of the population was a reduction in levels of air pollution.

Sampling for a wide variety of air pollutants was not carried out routinely in 1968; however, for the purpose of this paper, it was believed that the levels of suspended particulate matter in 1968–70 could be used as an indication of the improvement in the ambient air of the community.

Comparisons given were based on samples collected in health department high air volume samplers in the industrial area on the Charleston Peninsula and on the roof of the health department building located approximately 4 miles away (table 2).

Method

For study purposes, deaths attributed to diseases of the heart for 1968 and 1970 were compared. The baseline year selected was 1968, because industrial pollution control was essentially nonexistent during that period. Some 1967 data were used to demonstrate the validity of the 1968 data. Total deaths in 1969 were only approximately 50 less than 1968 and can be

considered a transition year in the control of industrial air pollution, although there were 240 fewer deaths in 1970 than in 1968.

High mortality rates attributed to diseases of the heart are not new to the Charleston Peninsula. A study by Enterline and co-workers (*1*) was made of heart deaths in white males 45–64 years old in 163 U.S. cities during the period 1949–51. In that study, the city of Charleston ranked second highest with a rate of 825.6 per 100,000.

Health departments in the cities with highest rates in that survey have been contacted to determine if common factors existed at that time and what changes if any have occurred since that period. Any information obtained will be included in future articles.

Because of a change in code numbers for diseases of the heart between the seventh and eighth revisions of the International Classification of Diseases (ICD), the following code numbers were used to determine diseases of the heart for this study—in 1967 and 1968, numbers 400–443, seventh revision, ICD, and in 1970, numbers 390–398, 402, 404, and 410–429, eighth revision, ICD.

Source of data was the office of vital records of the Charleston County Health Department. Records of all deaths occurring in the county are filed with the health department. Data for this paper were taken from death certificates on file of residents of Charleston County. Total resident deaths from all causes were obtained from the Bureau of Vital Records of the South Carolina State Board of Health. A number of resident deaths attributed to diseases of the heart occurred outside of Charleston County, presumably in nursing homes, homes of family members, or while traveling. Since these persons had been out of the county for varying periods of time and their certificates were not available for comparison, they were excluded from the study. There were 43 more deaths attributed to diseases of the heart occurring outside Charleston County in 1970 than in 1968. This number would not be enough, however, to nullify the results presented in this paper.

All rates used in this paper were based on 1970 census figures. This results in slightly lower rates for 1967 and 1968 than would have been produced had estimated population figures been used. True differences in rates will be somewhat greater than those reported; however, since most of the differences were already highly significant, this was of no great consequence. We believed that it was more desirable to use reliable figures for the determination of rates for census tract areas than to rely on estimates. Because we believed that air pollution was involved, comparisons were first made between populations residing in six industrial tracts with the total county population (table 3).

From the data reported in table 3, the population in the industrial area was obviously at significantly higher risk to death from diseases of the heart than the total county population in 1968, but not in 1970. The decrease in deaths was significant in both populations, and we inferred that the changes noted were caused by reduced levels of air pollution; however, the number of deaths in the industrial area did not adequately account for the total decrease in deaths noted in table 1.

Examination of the data by individual census tracts revealed that all areas of the Charleston

Table 3. Comparison of deaths attributed to diseases of the heart, Charleston County, S.C., 1968 and 1970

Area	1968		1970		1968 and 1970 significance level (P)[1]
	Deaths	Rate per 100,000	Deaths	Rate per 100,000	
Total county	628	253.6	466	188.2	0.001
Industrial census tracts	68	409.2	39	234.7	.006

[1] County compared with industrial rates: 1968, $P=0.001$; 1970, $P=0.23$.

Table 4. Comparison of population characteristics in county and study areas, Charleston County, S.C.

Characteristics	Total county	Peninsula census tracts	Perimeter census tracts
Total population	247,650	57,478	71,380
White	168,414	20,402	61,839
Nonwhite	79,236	37,076	9,559
Male	126,913	26,757	34,985
Female	120,737	30,721	36,395
Total, 45–64 years	41,443	11,758	13,459
Male	19,705	5,152	6,505
Female	21,738	6,606	6,954

SOURCE: 1970 U.S. Census.

In 1968 smoke from burning automobiles obscures horizon on Charleston Peninsula. Open burning of automobiles on peninsula is now banned

Peninsula were involved, including portions from the industrial area to the tip of the peninsula—a distance of approximately 6 miles. The mortality experience of the population living on the Charleston Peninsula was compared with the total county population. Comparisons were also made with the population of nine census tracts which are adjacent to the Charleston Peninsula but separated from it by water (either rivers or harbor). Table 4 gives demographic data on the population of the entire county and on residents of the peninsula and perimeter census tracts.

The population of the nine-tract perimeter, because of its proximity to the peninsula population, was selected to demonstrate that bodies of water produce thermal barriers to the horizontal movement of air pollutants. As a result of the protection afforded them by these thermal barriers, they were also used as a control population to study the harmful effects of air pollution on human health.

In examining the data on an individual census tract basis, it appeared that some harmful effects from exposure to air pollution were experienced by portions of the perimeter population residing immediately adjacent to the industrial area; however, the degree of these effects was not so great that the size of the population could not mask them to a great extent.

The population residing on the Charleston Peninsula was unquestionably at significantly higher risk to death from diseases of the heart than the perimeter population. Only a factor common to the total population on the peninsula would be capable of producing the results noted. Water can be ruled out since the same water system supplies the peninsula and 90 percent of the perimeter population. Food and milk are from common suppliers. No techniques in medical care can be determined which would be available to one population that would not be available to the other.

The only other known common factor that could be involved is the air. Air in and of itself is considered relatively nontoxic; however, it acts as a carrier for almost any waste product. The air in the Charleston industrial area has long been considered highly polluted. In 1968, the health officer publicly stated that he considered breathing the air in Charleston to be equivalent to smoking at least two packs of cigarettes per day. The data indicate that manmade air pollution combined with nature's bottle effect around the peninsula produced a situation that resulted in premature deaths for a significant number of people. The average age at death from diseases of the heart among residents of the Charleston Peninsula in 1968 was 65.2 years. In 1970, this

had increased to 68.8 years, based on calculations by the authors.

To state positively that reduction in air pollution resulted in reduced mortality would be premature. Only several years' experience can verify such an assumption; however, 1970 data do indicate that such a possibility is likely.

In this study, deaths were compared in two populations with exposures to air pollution levels at two extremes. The data show that the population with greater exposure experienced significantly higher mortality rates from diseases of the heart than did the population with lower levels of exposure. This higher mortality was shown to be true for the total population and for women 45–64 years of age (table 5). The decrease in death rates is not as great in men 45–64 years old as one would expect in this population, because men generally have more advanced levels of arteriosclerosis than their female counterparts. It could also be that males are more sensitive to, or have a greater degree of exposure to, air pollution which continued in 1970 even though at reduced levels.

Women on the peninsula bore a disproportionate share of heart deaths; the data show that 55.3 percent of all heart deaths in women 45–64 years old in 1968 occurred in residents of the peninsula. Their numbers constitute only 30.4 percent of all women in this age group.

With decreasing air pollution levels, death rates declined in the population that had previously experienced higher levels of exposure. Although the rates decreased appreciably, in 1970 there were still significantly higher rates among the population residing on the Charleston Peninsula, indicating that the bottle effect, noted earlier, continued to generate levels of pollution detrimental to human health.

The data strongly support the theory that the detrimental effect of air pollution on persons in this community is largely to the cardiovascular system.

When stroke deaths were added to heart deaths, we were able to account for 90 percent of the decrease in total deaths which occurred in the county in 1970 as compared with 1968.

The fact that stroke deaths occurred in the same pattern as did heart deaths tends to support the bottle effect theory of local air pollution exposure and the effect of air pollution on the cardiovascular system (tables 5 and 6).

Table 5. Comparison of all deaths and heart disease and stroke deaths for various age and sex groups, by area, Charleston County, S.C., 1968 and 1970

Area	1968		1970		1968 and 1970		
	Deaths	Rate per 100,000	Deaths	Rate per 100,000	Significance level *P*	*P* values for peninsula compared with perimeter	
Deaths, all causes:							
Total, county	1,958	790.6	1,718	693.7	<0.001		
Charleston Peninsula	749	1,303.1	575	1,000.4	< .001	<0.001	<0.001
Perimeter census tracts	395	553.4	357	500.1	.16		
Deaths, diseases of heart:							
Total, county	628	253.6	466	188.2	.001		
Charleston Peninsula	295	513.2	172	299.2	< .001	< .001	< .001
Perimeter census tracts	136	190.5	128	179.3	.60		
Deaths, diseases of heart, males, 45–64 years:							
Total, county	184	[1] 933.8	149	[1] 756.2	.06		
Charleston Peninsula	56	[1] 1,086.9	41	[1] 795.8	.14	< .02	< .14
Perimeter census tracts	41	[1] 630.3	37	[1] 568.8	.60		
Deaths, diseases of heart, females, 45–64 years:							
Total, county	94	[2] 432.4	67	[2] 308.2	.05		
Charleston Peninsula	52	[2] 787.2	26	[2] 393.6	.01	< .001	< .01
Perimeter census tracts	14	[2] 201.3	9	[2] 129.4	.32		
Deaths, stroke:							
Total, county	183	73.9	129	52.1	9.01		
Charleston Peninsula	94	163.5	58	100.9	.01	< .001	< .001
Perimeter census tracts	39	54.6	28	39.2	.20		

[1] Rate per 100,000 males, 45–64 years.
[2] Rate per 100,000 females, 45–64 years.

If heart and stroke deaths were excluded, there would be no significant difference in rates between 1968 and 1970 for all other causes of death in either the peninsula or the perimeter populations, which supports the fact that air pollution affects the cardiovascular system (table 7).

To eliminate the possibility that the results may have occurred by chance and to rule out any likelihood that influenza could have affected 1968 figures, 1967 age-sex specific data were examined. The results presented in table 8 show that 1967 rates were essentially the same as 1968 mortality rates for heart disease.

Probably the most conclusive data presented, which support the theory of the harmful effect of air pollution on human health, were the comparison of deaths in women 45–64 years of age. A number of physicians believe that the hormones generated by women during their childbearing years provide protection against the development of arteriosclerosis and, consequently, to death from diseases of the heart. It should, therefore, be expected that women 45–64 years of age, having recently lost this hormonal protection, would be more susceptible than their male counterparts in this age bracket. Evidence of this may be found in the 50 percent reduction in heart deaths that occurred in females on the peninsula between 1968 and 1970 as air pollution levels declined.

That the death rate among women 45–64 years old on the peninsula in 1970 remained much higher than women of this age group living in the perimeter area indicated the continued presence of harmful levels of air pollution. Although age-color-specific rates are not given, because census tract figures are not yet available from the 1970 census, both whites and nonwhites were affected. A comparison of deaths from diseases of the heart, by color, Charleston Peninsula, 1968 and 1970 follows.

Color	*Deaths*	*Rate per 100,000*
1968:		
White	141	691.1
Nonwhite	154	415.4
1970:		
White	94	460.7
Nonwhite	78	210.4

Some of the differences in rates by color can be attributed to variations in the age of the populations. Further study will be given this

Table 6. Comparison of deaths attributed to stroke, Charleston Peninsula and perimeter census tracts, among population 45–64 years old, Charleston County, S.C., 1968 and 1970

Area	1968		1970		Significance level (*P*)
	Deaths	Rate [1]	Deaths	Rate [1]	
Charleston Peninsula	35	297.7	19	161.6	0.04
Perimeter census tracts	9	66.9	10	74.3	.84

[1] Rates per 100,000 population 45–64 years.
NOTE: Peninsula compared to perimeter: 1968, $P = <0.001$; 1970, $P = 0.05$.

Table 7. Deaths from all causes, excluding heart and stroke, peninsula and perimeter census tracts, Charleston County, S.C., 1968 and 1970

Area	1968		1970		Significance level (*P*)
	Deaths	Rate per 100,000	Deaths	Rate per 100,000	
Charleston Peninsula	326	567.1	302	524.4	0.36
Perimeter census tracts	220	308.2	201	281.6	.36

Table 8. Deaths from diseases of the heart, peninsula and perimeter census tracts, by sex, in population 45–64 years, in Charleston County, S. C., 1967, 1968, and 1970

Sex and year [1]	Peninsula		Perimeter	
	Number	Rate per 100,000 [2]	Number	Rate per 100,000 [2]
Males:				
1967	56	1,086.9	37	568.8
1968	56	1,086.9	41	630.3
1970	41	795.8	37	568.8
Females:				
1967	60	908.3	18	258.8
1968	52	787.2	14	201.3
1970	26	393.6	9	129.4

[1] Rates per 100,000 population, 45–64 years.
[2] All rates based on 1970 population.

A 1968 view of the peninsula across the Cooper River shows heavy pollution—area above atmospheric inversion and across river is clear. Below, the peninsula in 1972 after pollution controls were instituted

difference when age-color figures are available from the 1970 census.

Economic level provided no protection, as indicated by data for five census tracts on the tip of the peninsula. This area has a population of 10,136 and is predominantly a white, high-socioeconomic population. The death rates per 100,000 from diseases of the heart were 1967, 710.3; 1968, 749.8; and 1970, 513.0.

The higher rates for the population in these census tracts, when compared with the total peninsula, may be explained by the fact that the population 45 years of age or older is approximately 15 percent greater than is found in the population of the total peninsula.

That the changes noted in this paper are not simply a reflection of any events affecting this State or region can be seen in an examination of deaths in two similar-sized counties in this area (table 9).

Greenville County, S.C. (population 240,546) is situated in the northwestern part of the State and most nearly approximates the population of Charleston County. Chatham County (Savannah, Ga., population 187,767) is a heavily polluted port city approximately 100 miles south of Charleston. No major change in death patterns in either community was noted (table 9).

Discussion

Validity of data from death certificates is frequently questioned because the actual cause of death as it appears on death certificates is sometimes inaccurate. Although some individual certificates might be questioned, it must be assumed that the same yardstick was used to determine heart deaths in 1968 and 1970.

Although no attempt is made to identify the causative agent or agents, it does not appear that the effects noted are directly related to levels

In 1968, emissions from ferroalloy plant completely obscured background on Charleston Peninsula. Below, March 1972, same area as above after new $17 million plant had been built

of suspended particulate matter. Death rates did not decline with distance from the industrial area as do readings for particulate matter as recorded at the sampling station on the health department building. This discrepancy should not be taken to mean that smaller airborne particles of inert or chemically active materials alone or in combination with other compounds or gases may not be involved. It must be remembered that particulate matter and sulfur dioxide have been implicated in large-scale pollution disasters, such as those in London and Donora, Pa.

Table 9. Death rates for all causes and heart disease, Greenville County, S.C., and Chatham County, Ga., 1968 and 1970

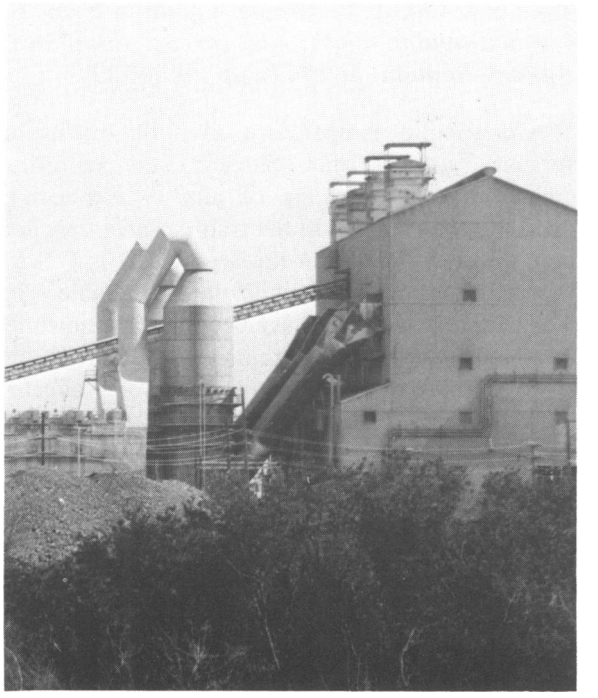
Area	1968		1970	
	Deaths	Rate per 100,000[1]	Deaths	Rate per 100,000[1]
Chatham County, Ga.:				
Total deaths.....	2,015	1,073.1	1,917	1,020.9
Heart deaths.....	701	373.3	682	363.2
Greenville County, S.C.:				
Total deaths.....	2,197	913.3	2,158	897.1
Heart deaths.....	793	329.7	782	325.1

[1] 1970 U.S. Census.

SOURCE: Office of vital statistics, Georgia Department of Health, and office of vital records, South Carolina State Board of Health.

Direct application of these data cannot be made to every community in the country. There are many variables yet to be determined. It can be inferred, however, that environmental factors, especially air pollution, are of major importance in the varying mortality patterns from community to community and within individual communities.

Although, as previously mentioned, the causa-



tive agent or combination of agents is yet to be determined, it should be mentioned that in the general community, levels of oxides of nitrogen and sulfur oxides, and particulates did not approach the permissible levels already established. Combinations of several agents may well prove fatal to susceptible persons at concentrations far below permissable levels for any single agent.

The marked drop in total deaths is of primary importance, and the fact that 90 percent of that drop is reflected in a decrease in cardiovascular deaths is important, but of more importance is the pattern in which these deaths occurred in 1967 and 1968. Based on the significant difference in death rates from cardiovascular diseases which exists between the peninsula and perimeter populations, and based on the absence of any other logical or reasonable explanation for this difference, it has been assumed that the difference is caused by exposure to unacceptable concentrations of one or more air pollutants.

It is further reasonable to conclude that although the air pollutants are from manmade sources, they reach dangerous concentrations on the peninsula because of frequent atmospheric temperature inversions combined with thermal barriers created around the peninsula by the action of the warmer temperatures of the water on the overlying airmasses.

Although the absolute drop in death rates in 1970 tends to indicate that partial control of pollution resulted in fewer deaths, no final conclusion can be reached at present. We believe there is little doubt that pollution is responsible for increased death rates and that adequate control of air pollution will ultimately result in fewer deaths. There are several possible explanations for the 1970 decline which must be explored; however, the two most reasonable possibilities are (*a*) the number and duration of atmospheric temperature inversions were significantly lower in 1970, resulting in lower levels of exposure for the population; and (*b*) a specific agent was removed from the air which, either alone or in combination with other agents, was responsible for the excess mortality.

All such possibilities will be examined closely in further studies.

REFERENCE

(*1*) Enterline, P. E., Rikli, A. E., Sauer, H. I., and Hyman, M.: Death rates for coronary heart disease in metropolitan and other areas. Public Health Rep 75: 759–766, August 1960.

JACOBS, CECIL F. (South Carolina State Board of Health), and LANGDOC, BETTYE ANNE: ***Cardiovascular deaths and air pollution in Charleston, S.C. Health Services Reports, Vol. 87, August–September 1972, pp. 623–632.***

Atmospheric temperature inversions and thermal barriers created by the warming of air overlying water result in the trapping of air pollutants in the area of the Charleston, S.C., peninsula. The people living there have been frequently exposed to excessive levels of air pollution.

Death rates in this population were compared to those in an adjacent population with lower levels of exposure to air pollution. Cardiovascular death rates were significantly higher among the exposed population, and death rates decreased as air pollution controls were invoked and the quality of the ambient air on the peninsula improved.

Although age-color-specific rates can not be compared until 1970 U.S. Census figures are available, State data on white and nonwhite death rates in 1968 and 1970 indicated both groups were affected. Examination of cardiovascular death rates of persons of high-socioeconomic status living in five census tracts indicate that this population suffered excessively high death rates, therefore, economic status does not appear to provide any appreciable protection.

Only a factor common to the inhabitants of the peninsula would be capable of producing the differences observed in cardiovascular death rates. Practically all such factors are readily eliminated except pollution of the ambient air.

A specific emission or combination of emissions was not identified as the causative factor. In continuing studies, to be reported later, we hope the identity of the agent or agents responsible for the excessive mortality rates reported will be more clearly identified.
