EPA-600/1-77-002
January 1977

LUNG FUNCTION IN SCHOOL CHILDREN: 1971-1972 CHATTANOOGA STUDY

By

Victor Hasselblad
Statistics and Data Management Office
Health Effects Research Laboratory
Research Triangle Park, N.C. 27711

U.S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF RESEARCH AND DEVELOPMENT
HEALTH EFFECTS RESEARCH LABORATORY
RESEARCH TRIANGLE PARK, N.C. 27711

DISCLAIMER

FOREWORD

The many benefits of our modern, developing, industrial society are accompanied by certain hazards. Careful assessment of the relative risk of existing and new man-made environmental hazards is necessary for the establishment of sound regulatory policy. These regulations serve to enhance the quality of our environment in order to promote the public health and welfare and the productive capacity of our Nation's population.

The Health Effects Research Laboratory, Research Triangle Park conducts a coordinated environmental health research program in toxicology, epidemiology, and clinical studies using human volunteer subjects. These studies address problems in air pollution, non-ionizing radiation, environmental carcinogenesis and the toxicology of pesticides as well as other chemical pollutants. The Laboratory develops and revises air quality criteria documents on pollutants for which national ambient air quality standards exist or are proposed, provides the data for registration of new pesticides or proposed suspension of those already in use, conducts research on hazardous and toxic materials, and is preparing the health basis for non-ionizing radiation standards. Direct support to the regulatory function of the Agency is provided in the form of expert testimony and preparation of affidavits as well as expert advice to the Administrator to assure the adequacy of health care and surveillance of persons having suffered imminent and substantial endangerment of their health.

This particular epidemiologic study was conducted as part of the Community Health Environmental Surveillance System (CHESS). Lung function was used as the health indicator because previous studies suggested that this measure is sensitive to air pollution. Chattanooga was chosen because of its unique high ambient NO_2 air pollution exposures.

John H. Knelson, M.D.
Director,
Health Effects Research Laboratory

ABSTRACT

Previous studies of lung function in children have indicated that decreases in lung function are associated with higher air pollution exposures. For this reason, three quarter second timed forced expiratory volume was chosen as one of the health indicators in the Environmental Protection Agency's Community Health Environmental Surveillance System (CHESS). The city of Chattanooga, Tennessee was chosen because of its exposure to a large stationary source of nitrogen dioxide. The present study, conducted in 1971-1972, was a follow-up to an earlier study performed by Shy, et al. in 1968-1969. The present study did not confirm the slight differences found in the earlier study. This might be explained by the reduction in NO_2 levels since the 1968-1969 study.

ACKNOWLEDGMENTS

Several people contributed to the preparation of this report with little or no credit. Listed alphabetically, they are, Robert Chapman, Barbara Crabtree, John Creason, Wayne Fulford, Warren Galke, Jerome Gerding, Margarita Morrison, Ken Mullins, William Nelson, Everett Quesnell, Michael Quigley, Carl Shy, and Jose Suné.

INTRODUCTION

Significant decreases in lung function early in life may be a risk factor for later respiratory disorders. Previous studies in Japan, Great Britain, Italy and North America report decreased lung function in children living in areas of high air pollution.[1-6] Based on these findings, lung function in school children measured by three-quarter second forced expiratory volume ($FEV_{0.75}$) was selected as a health indicator in the Environmental Protection Agency's Community Health Environmental Surveillance System (CHESS). Highly significant decreases in lung function have been noted with aging, chronic obstructive lung disease, and cigarette smoking.[7] Ceasing cigarette smoking lessens chronic respiratory disease symptoms.[8] Therefore, reducing ambient air pollution might improve lung function, and decrease risk of chronic respiratory disease from previous elevated air pollution exposures.

The present study primarily investigates the effects on a community exposed to a large stationary source of atmospheric nitrogen dioxide (NO_2). The source, the Volunteer Army Ammunition Plant, is located in Hamilton County, Tennessee, just beyond the northeastern fringes of the city of Chattanooga. A substantial proportion of trinitrotoluene (TNT) produced in the United States was manufactured at this plant, which operated only during World War II and the Korean and Vietnam conflicts. Shy, et al,[9] conducted a similar lung function survey in Chattanooga in 1968-1969. Since that time, however, air quality in the plant vicinity has improved due to pollution control and decreased TNT production. This study, a follow-up of the 1968-69 survey, was designed to test the hypothesis that early childhood exposure to ambient NO_2 air pollution reduces lung function in later childhood. A similar lung function study of New York City children exposed to increased sulfur oxide and particulate air pollution in early childhood suggests that effects are still observed in later childhood, although current pollution levels had been greatly reduced.[10] Rejection of the above hypothesis would indicate that reduction in ambient NO_2 air pollution may lead to improvements in lung function.

METHODS

FEV Measurements and Covariates

Three geographic areas (or communities) each containing three elementary schools were selected from Hamilton County, Tennessee: (1) Red Bank, a control area three to five miles north of downtown Chattanooga, representing low exposure to NO_2; (2) Brainerd, a low to intermediate exposure area east of downtown Chattanooga; and (3) Harrison, the area nearest the plant, with previous high exposure to NO_2. These areas are shown in Figure 1. Within each community, children in the elementary schools were enrolled for the study. Most children resided within one and one-half miles of at least one centrally located air monitoring station. The three communities are geographically close enough to experience similar meteorologic conditions so explicit adjustment for differences in meteorology was not necessary. A total of 5589 children participated in the study. Each child's age, race, and sex were obtained from school records. The analyses however, were restricted to whites, since ethnic differences could have biased the study. In particular, blacks have been shown to have lower measured lung function than whites of comparable age, sex and height.[11-14] Of the 4880 white children, 150 reporting asthma during the study were deleted. Children with insufficient or no age and sex information were also deleted, leaving 4704 children in the basic analysis file. Deletions are detailed in Table 1. Age distributions by sex and community are shown in Table 2 for children in the basic analysis file.

A family health questionnaire distributed in January, 1971 to the parents of the study's children obtained information on smoking habits, educational level of the parents, and length of residence. This questionnaire was the same type described in Health Consequences of Sulfur Oxides: A Report from CHESS 1970-1971.[15] Information is summarized in Tables 3 and 4 for families in the basic analysis file who returned the questionnaire. There was no indication of educational differences by community. The fathers showed slight smoking differences by community, but the differences showed no pattern. The mothers had similar smoking habits across all three communities. Though the smoking habits of elementary school children were not documented, there was no particular reason to suspect that their smoking habits would be very different in the high and low pollution areas. The prevalence of cigarette smoking among children is probably most strongly influenced by parental smoking habits and these were shown to be relatively similar. Table 5 shows the length of residence in Chattanooga for all 3 communities. Although there were differences by community, a majority of the families in each community had lived in the city for 12 or more years. Eighty percent of the families had lived in the city for at least four years, which includes the periods of elevated exposures. Thus the effects of migration should be minimized in this study.

The three-quarter second forced expiratory volume ($FEV_{0.75}$) test was performed in the schools. Two rounds of testing were conducted: in winter (February-March 1972) and in spring (April-May 1972). Just before testing, children received an introduction and test demonstration, which emphasized maximal inspiration first, then expiration, as forceful and complete as possible, into the spirometer. Each child was tested until three valid FEV measurements were obtained. Since the $FEV_{0.75}$ is effort dependent, the maximum of each child's three readings was used in data analysis. At the time of testing, each child also reported the presence or absence of a cough, cold, sore throat, or asthma.

All tests were performed with a 12-liter bellows-type spirometer manufactured by Cardiopulmonary Instruments, Inc. (CPI). In this instrument, expired air displaces a cylinder whose air seal is a pliable rolling diaphragm. The mechanical displacement of a piston over 0.75 second is transduced to a voltage which is displayed, as $FEV_{0.75}$, on a nixie-tube digital readout. The CPI instrument was calibrated before testing against both a Collins water-filled spirometer and 1.5 liter syringe. Several times each testing day, the linearity of the digital readout was checked. All raw $FEV_{0.75}$ readings from the CPI instruments were converted to body temperature and pressure, saturated conditions (BTPS).

The 4704 elementary school children included in the basic analysis file were analyzed separately by age, sex, and season. An age cut was made at 9 years (108 months) because the relative effects of age and height on lung function appear to change near this age.[10] Each analysis required deletions for inadequate information, summarized in Table 1. The FEV's were required to be between 0.4 and 4.0 liters. The heights were restricted to a range from 30 to 72 inches. If any of the variables were missing, or outside the indicated ranges, that observation was deleted from the analysis.

The statistical analyses were made using a general linear model.[16] The particular model which was chosen allowed for a linear effect of standing height and age, as well as for community and machine differences. A dichotomous variable was also included to indicate a cough, cold or sore throat. The tests of significance can be thought of as a test of the effect of a particular variable above and beyond the effect of all other variables. This procedure can be conservative, if the independent variables are highly correlated In this case, the factors of age, height and machine are independent of community and symptom, and so the tests for community differences or symptom effect should not suffer from this problem. The means shown in the analysis tables (Tables 15 and 17) are adjusted for age and height differences.

Pollutant Exposures

Air pollution exposures were constructed with data from five sources: (1) local monitoring done at the 9th street and Georgia Avenue post office, (2) averages from two stations at the Volunteer Army Ammunition Plant (VAAP), (3) Division of Abatement, National Air Pollution Control Administration (NAPCA), data used for an interstate air quality study,[17] (4) Division of Health Effects NAPCA, data used in the study by Shy, et al,[10] and (5) the CHESS network, which was installed for this and other related studies.

The 9th street post office and the VAAP data provide the only year to year comparisons of pollution levels prior to 1970. The 9th street post office data were collected using a high-volume sampler. Data from 1958 to 1972 for TSP, Nitrate, and Sulfate are shown in Table 6. The VAAP data consists of NO_2 measurements collected using a Technicon instrument with a Saltzman reagent. Data from two sites for the years 1968-1973 are shown in Table 7.

The NO_2 data collected by the Division of Abatement, NAPCA, were used for an interstate air quality study of Chattanooga, Tennessee and Rossville, Georgia.[17] The data were collected from September, 1967 to November 1968 at 10 sites. The sites are shown in Figure 2, and the data are shown in Table 8. The colorimetric Saltzman technique was used at all stations.

The data collected by the Division of Health Effects, NAPCA, are taken from the study by Shy, et al.[10] The data are shown in Table 9, with the NO_2 data converted to $\mu g/m^3$. The locations of the monitoring sites are shown in Figure 1. The NO_2 data were measured by the Jacobs-Hochheiser method, so the accuracy of the values is very questionable. This method has interference problems summarized in a paper by Hauser and Shy.[18] Both the NO_2 and nitrate values do show much higher levels in the Harrison area, and such differences could not likely be entirely due to the measurement method.

CHESS data were available for four pollutants: total suspended particulates (TSP), sulfate fraction of the TSP (sulfate), nitrate fraction of the TSP (nitrate), and nitrogen dioxide (NO_2). All of the pollutants were measured in micrograms per cubic meter ($\mu g/m^3$). The measurements for TSP, sulfate, and nitrate all came from a hi-volume air sampler. The methods are detailed in Appendix A of Health Consequences of Sulfur Oxides: A Report from CHESS, 1970-1971.[16] The NO_2 data were measured by the Jacobs-Hochheiser procedure. These data are presented only to give a rough estimate of the relative exposures during the years 1970 to 1972. The CHESS aerometric data are presented in Tables 10-13. Table 14 gives a summary by year. There were two sites in Red Bank, two in Brainerd, and five in the Harrison community. The locations of the sites are shown in Figure 1.

Although there is much site-to-site and year-to-year variation, some general conclusions about the areas can be drawn: 1) TSP levels have been quite similar across all areas; the levels in Harrison were slightly lower if there were any differences, 2) Sulfate fractions were very similar across all areas, 3) Nitrate levels have been highest in Harrison, and lowest in Red Bank, 4) NO_2 values were higher primarily at site 31 in Harrison, but sites nearer the Volunteer Army Ammunition Plant showing higher values than those farther away, and 5) both NO_2 and nitrate levels were higher around 1968-1969 in all areas, and have decreased since then.

RESULTS

The adjusted mean FEV's for each community appear in Table 15. These FEV's are adjusted for height, age, machine, and presence of symptoms. They are computed for each age-sex category by season. Where possible, each student's winter and spring readings were averaged and the analyses of these averages also appear in Table 15.

The adjusted means (Table 15) show generally lower values in the Harrison area during the winter season, but higher values in the spring season. There are almost no differences in the adjusted means for the average of the two seasons. None of the differences were significant at the .05 level for the winter season (Table 16). All significant inter-community differences showed Harrison with higher mean values.

One by-product of the analysis is a table of the effect of a cold, cough, or sore throat has on children's FEV. These average effects, adjusted for age, height, machine, and community are shown in Table 17. In all but one analysis (females less than 108 months, spring season), the adjusted mean values for children with symptoms were less than those without symptoms. These differences were significant at the .05 level in only 2 of the 7 analyses, however. The differences averaged about 20 cubic centimeters.

Regression coefficients, mean heights and ages, and mean square errors are given in Tables 18, 19, and 20. These values are presented for comparison with other studies. The regression coefficients verify the finding that the FEV's of younger children are more dependent on age than the FEV's of the older children. The tables can also be used to generate confidence intervals about the adjustment equations. Younger children, who have smaller lung capacities, showed an expected smaller mean square error. The averages of the two seasons also showed a smaller mean square error than either of the separate seasons, which is consistent with the properties of the variance of an average.

CONCLUSIONS

The hypothesis was not supported that previous or current elevated NO_2 or nitrate exposures have an irreversible measureable effect on children's ventilatory performance. The only adjusted mean FEV's for the Harrison community that were lower than the other communities occurred in the winter season, and none of these were statistically significant. The means in the Harrison community for the spring season were generally higher than the other two communities, and the averages for the two seasons were quite similar for all three communities. There is nothing in the aerometric data to suggest that the Harrison community had a unique higher exposure during the winter season only.

The lack of consistent differences attributable to pollution in this study does not contradict the earlier study of Shy, et al.[9] The Shy study found a slight effect attributable to NO_2 pollution, but was done during a period of greatly elevated exposures, as indicated by the aerometric data. The present study was conducted at least two years after these elevated exposures. The effects on lung function may be at least partially reversible. There is always the possibility that machine or technician biases masked an existing effect, or that differences do exist but are too small to detect.

REFERENCES

1. Watanabe, H., F. Kaneko, H. Murayama, S. Yamaoka, and T. Kawaraya. "Effects of Air Pollution on Health. Report No. 1: Peak flow rate and vital capacity of primary school children", Reports of the Osaka City Institute of Hygiene, Vol. 26, pp 32-37, 1964.

2. Toyama, T., "Air Pollution and Its Health Effects in Japan", Arch. Environ. Health, Vol. 8, pp 53-173, 1964.

3. Holland, W. W., T. Halil, A. E. Bennett, and A. Elliott", Factors Influencing the Onset of Chronic Respiratory Disease", Brit. Med. J., Vol. 21, pp 7-16, 1969.

4. Lunn, J. E., J. Knowelden and A. J. Handyside, "Patterns of Respiratory Illness in Sheffield Infant School Children", Brit. J. Prev. Soc. Med., Vol. 21, pp 7-16, 1967.

5. Petrilli, F. and S. Kanitz, "Preliminary Results of the Epidemiological Research in Genoa Dealing with Air Pollution and Its Relation to Respiratory Function", Giorn, Igien. Med. Prev., Vol. 7, pp 205-220, 1966.

6. Anderson, D. O. and C. Kinnis, "An Epidemiologic Assessment of a Pediatric Peak Flowmeter", Amer. Rev. Resp. Dis., Vol. 95, pp 73-80, 1967.

7. Higgins, I. T. T., P. D. Oldham, A. L. Cochrane, and J. C. Gilson, "Ventilatory Function in Miners: A Five Year Follow-up Study", Brit. J. Industr. Med., Vol. 19, pp 65-76, 1962.

8. Higgins, I. T. T., M. W. Higgins, J. C. Bilson, H. Campbell, W. E. Waters, and B. F. Ferris, "Smoking and Chronic Respiratory Disease: Findings in Surveys Carried Out in 1957 and 1966 in Staveley, in Derbyshire, England", Chest, Vol. 59, pp 345-355, 1971.

9. Shy, C. M., et al, "The Chattanooga School Children Study: Effects of Community Exposure to Nitrogen Dioxide". APCA Journal, Vol. 20, pp 539-545, 1970.

10. Shy, C. M., et al, "Ventilatory Function in School Children, 1970-1971 Testing in N. Y. Communities", Health Consequences Sulfur Oxides: A Report from CHESS, 1970-1971, U. S. Environmental Protection Agency, EPA-6501, 1-74-004, 1974.

11. Wilson, M. G. and D. J. Edwards, "Diagnostic Value of Determining Vital Capacity of Lungs of Children", J. Amer. Med. Assoc., Vol. 78 pp 1107-1110, 1922.

12. Smillie, W. G. and D. L. Augustine, "Vital Capacity of Negro Race", J. Amer. Med. Assoc., Vol. 87, pp 2055-2058, 1962.

13. Roberts, F. L. and J. A. Crabtree, "The Vital Capacity of the Negro Child", J. Amer. Med. Assoc., Vol. 88, pp 1950-1954, 1927.

14. Damon, A., "Negro-White Differences in Pulmonary Function (Vital Capacity, Timed Vital Capacity and Expiratory Flow Rate)", Human Biology, Vol. 38, pp 380-393, 1966.

15. Health Consequences of Sulfur Oxides: A Report from CHESS, 1970-1971, U. S. Environmental Protection Agency, EPA-6501, 1-74-004, 1974.

16. Graybill, Franklin A., An Introduction to Linear Statistical Models, Vol. I, McGraw-Hill Book Company, Inc. 106-147, 1961.

17. Chattanooga, Tennessee - Rossville Georgia Interstate Air Quality Study 1967-1968, U. S. Public Health Service, NAPCA Publication No. APTD-0583, Durham, N. C., October, 1970.

18. Hauser, Thomas R., and Shy, Carl M., "Position Paper: NO_x Measurement", Environmental Science and Technology, Vol. 6, pp 890-894, 1972.

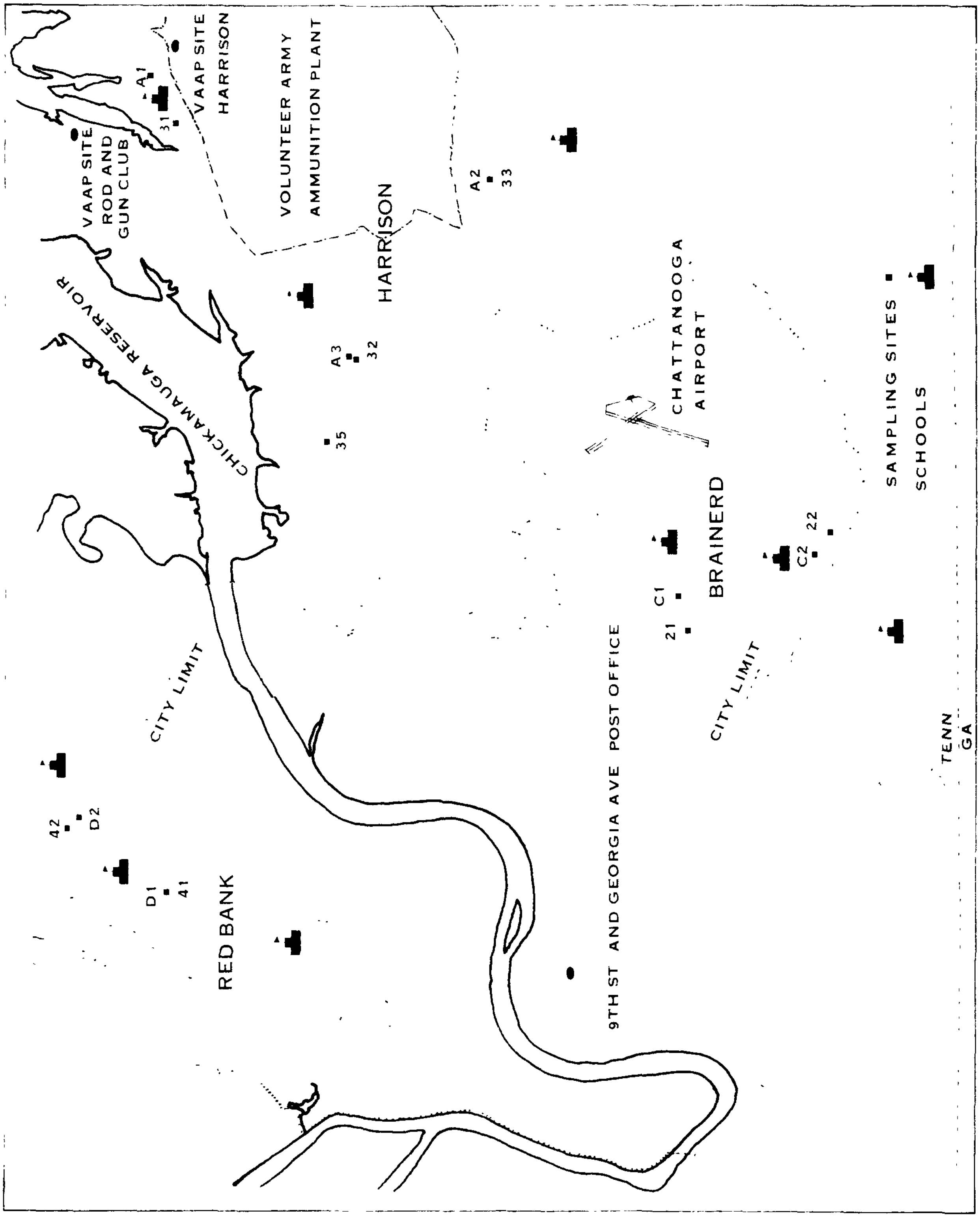

Figure 1. Air Monitoring Sites and School Locations in the Greater Chattanooga Area

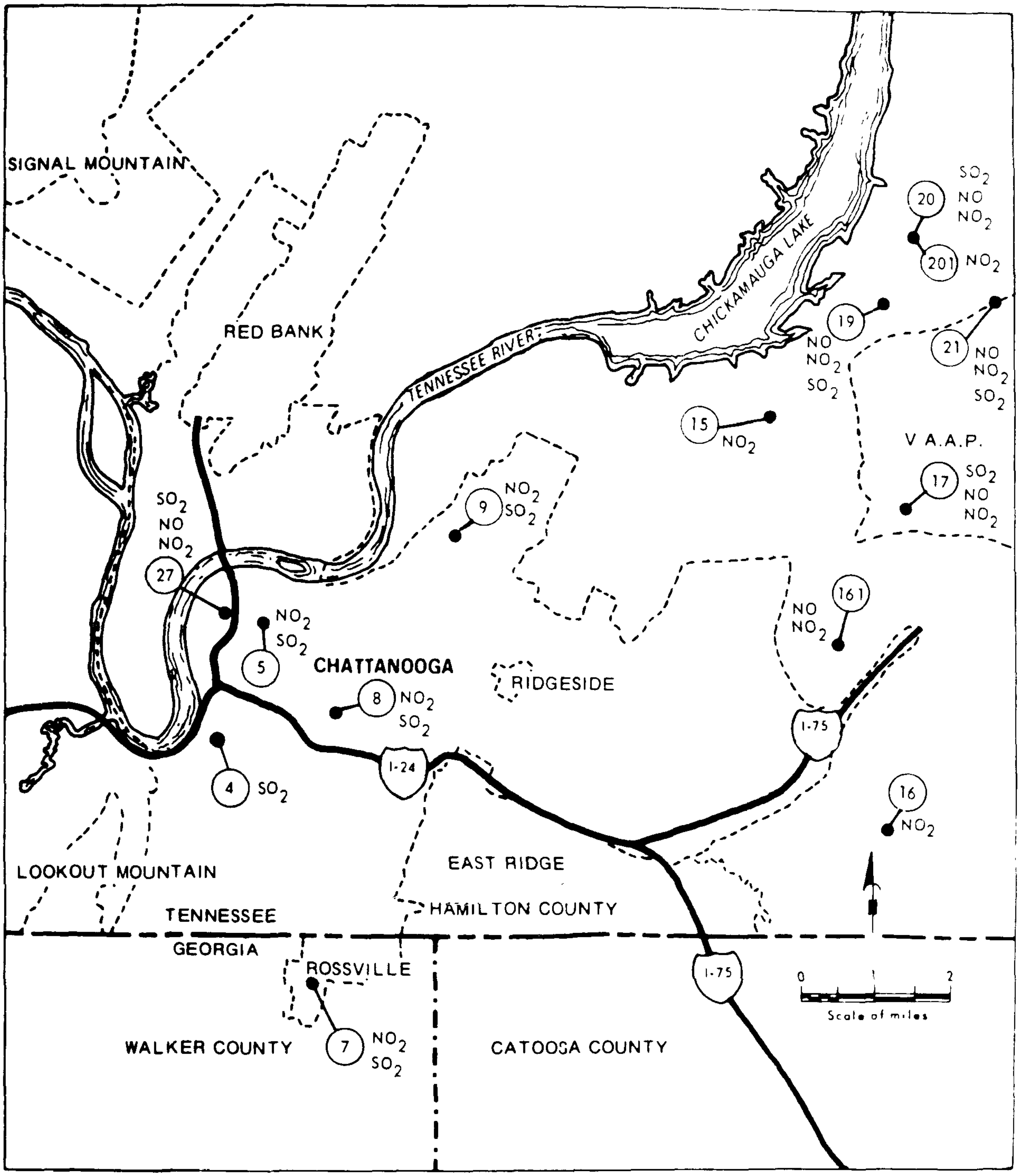

Figure 2. NO_2 Sites for 1967 to 1968 Data Collected by the Division of Abatement, National Air Pollution Control Administration

Table 1. Deletions and Subsets of the 1971-1972 Chattanooga Analysis File

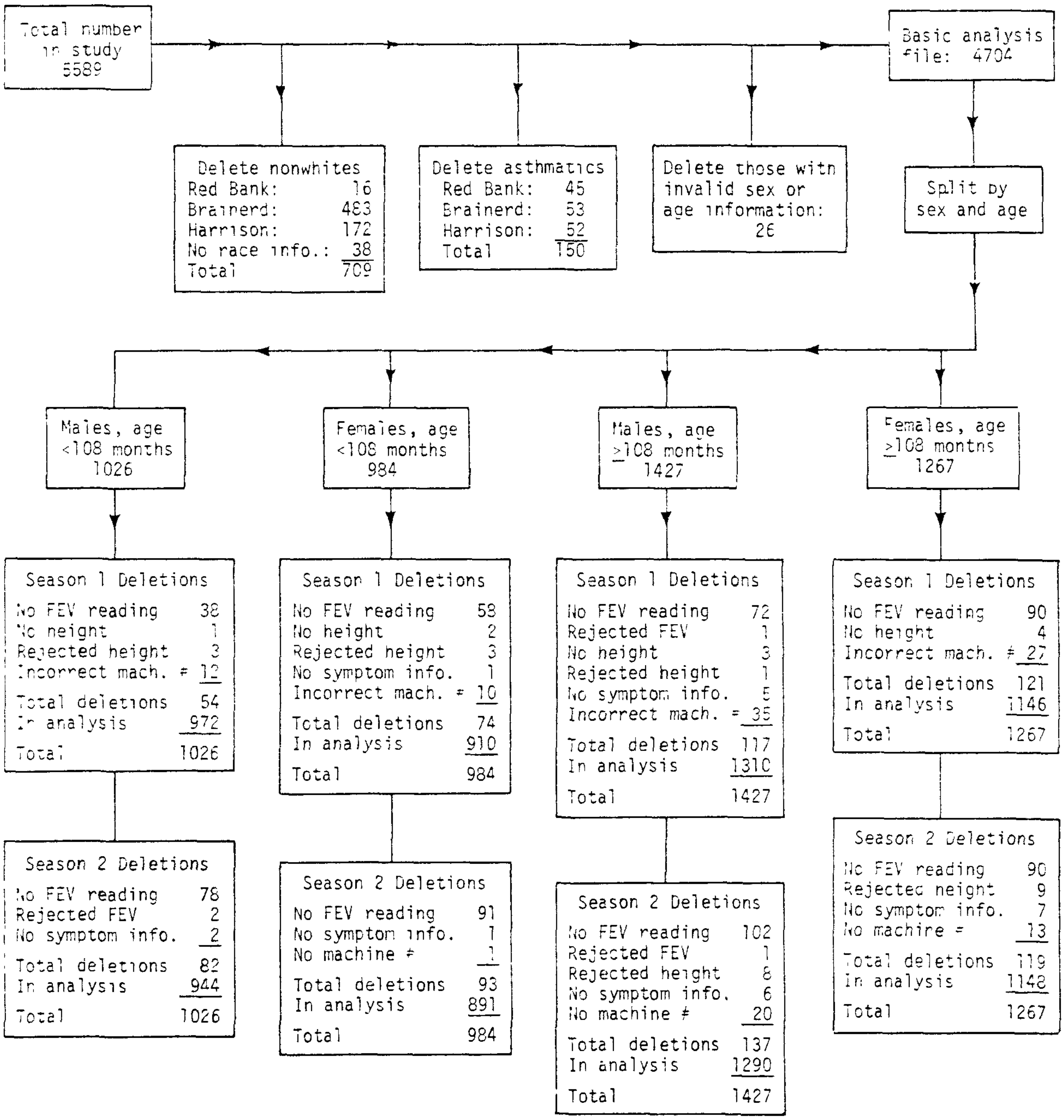

Table 2. Age and Sex Distribution of the Basic Analysis File

Age at First Test Round (Season 1)	Red Bank				Brainerd				Harrison				Total	
	Males		Females		Males		Females		Males		Females			
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
5 years	6	0.7	10	1.2	0	0.0	0	0.0	10	1.2	9	1.2	35	0.7
6 years	71	7.8	68	8.3	68	10.0	63	9.6	84	9.7	84	10.9	438	9.3
7 years	125	13.8	138	16.8	107	15.8	104	15.8	154	17.7	138	17.9	766	16.3
8 years	140	15.5	116	14.1	109	16.1	107	16.2	152	17.5	147	19.1	771	16.4
9 years	172	19.0	158	19.2	102	15.0	113	17.1	177	20.4	148	19.2	870	18.5
10 years	163	18.0	142	17.3	104	15.3	103	15.6	149	17.1	113	14.7	774	16.5
11 years	140	15.5	125	15.2	138	20.4	133	20.2	101	11.6	85	11.0	722	15.3
12 years or more	89	9.8	64	7.8	50	7.4	36	5.5	42	4.8	47	6.1	328	7.0
Total	906		821		678		659		869		771		4704	

Table 3. Education of Head of Household for Basic Analysis File

	Red Bank		Brainerd		Harrison	
	Number	Percent	Number	Percent	Number	Percent
No Information	669	38.7[a]	637	47.6[a]	626	38.2[a]
With Information:						
Less Than High School	161	15.2	91	13.0	164	16.2
High School	306	28.9	212	30.3	295	29.1
More Than High School	324	30.6	238	34.0	333	32.8
College Graduate	267	25.2	159	22.7	222	21.9
Total	1058	61.3[a]	700	52.4[a]	1014	61.8[a]

Chi-square for educational differences by community = 7.416, $p = .2841$.

[a] These percents are of both those with and without educational information. The other percents are just of those with educational information.

Table 4. Smoking Distribution of Parents for Basic Analysis File

Fathers

	Red Bank		Brainerd		Harrison	
	Number	Percent	Number	Percent	Number	Percent
No Information or No Father	738	42.7[a]	718	53.7[a]	676	41.2[a]
With Information:						
Never Smoked	253	25.6	149	24.1	259	26.9
Ex-smoker	280	28.3	161	26.0	241	25.0
Less Than 1 Pack/Day	64	6.5	64	10.3	83	8.6
About 1 Pack/Day	216	21.8	161	26.0	223	23.1
Greater Than 1 Pack/Day	176	17.8	84	13.6	158	16.4
Total	989	57.3[a]	619	46.3[a]	964	58.8[a]

Chi-square for smoking differences by community = 17.570, p = .0247.

Mothers

	Red Bank		Brainerd		Harrison	
	Number	Percent	Number	Percent	Number	Percent
No Information or No Mother	673	39.0[a]	640	47.9[a]	632	38.6[a]
With Information:						
Never Smoked	574	54.5	354	50.8	540	53.6
Ex-smoker	153	14.5	88	12.6	132	13.1
Less Than 1 Pack/Day	105	10.0	96	13.8	109	10.8
About 1 Pack/Day	163	15.5	110	15.8	150	14.9
Greater Than 1 Pack/Day	59	5.6	49	7.0	77	7.6
Total	1054	61.0[a]	697	52.1[a]	1008	61.4[a]

Chi-square for smoking differences by community = 11.685, p = .1658.

[a] These percents are of both those with and without smoking information. The other percents are just of those with smoking information.

Table 5. Parents Length of Residence in Present City for Basic Analysis File

	Red Bank		Brainerd		Harrison	
	Number	Percent	Number	Percent	Number	Percent
No Information	669	38.7[a]	639	47.8[a]	626	38.2[a]
With Information:						
0-1 Years	85	8.0	35	5.0	100	9.9
2-3 Years	122	11.5	61	8.7	109	10.7
4-7 Years	144	13.6	105	15.0	171	16.9
8-11 Years	153	14.5	70	10.0	123	12.1
12 or more Years	554	52.4	427	61.2	511	50.4
Total	1058	61.3[a]	698	52.2[a]	1014	61.8[a]

Chi-square for length of residence differences by community = 35.465, $p < .0001$.

[a] These percents are of both those with and without residence information. The other percents are just of those with residence information.

Table 6. Annual Means of Aerometric Data from the Downtown Post Office. All measurements are in $\mu g/m^3$. TSP means are geometric; nitrate and sulfate means are arithmetic.

	9th St. and Georgia Ave. Post Office		
	TSP	Nitrate	Sulfate
1972	106.	2.27	12.7
1971	-	-	-
1970	113.	3.04	10.0
1969	105.	3.98	13.9
1968	135.	4.12	9.4
1967	139.	2.10	8.5
1966	131.	2.04	9.6
1965	143.	2.44	9.2
1964	179.	2.65	9.4
1963	183.	-	-
1962	146.	1.13	7.0
1961	190.	1.38	10.5
1960	171.	1.64	8.9
1959	181.	1.52	10.5
1958	215.	2.20	13.3

Table 7. Quarterly and Annual NO_2 Means for Two Sites at the Volunteer Army Ammunition Plant. All measurements are in $\mu g/m^3$.

	Harrison School (Gate 20)				
	Jan-Mar	Apr-June	July-Sept	Oct-Dec	Annual
1968	140.	240.	192.	199.	193.
1969	135.	240.	275.	125.	194.
1970	120.	150.	101.	108.	120.
1971	98.	103.	64.	78.	86.
1972	80.	82.	84.	71.	79.

	Chattanooga Red and Gun Club				
	Jan-Mar	Apr-June	July-Sept	Oct-Dec	Annual
1968	174.	382.	273.	314.	286.
1969	125.	361.	370.	165.	255.
1970	236.	218.	170.	157.	195.
1971	122.	186.	122.	133.	140.
1972	102.	113.	155.	114.	121.

Table 8. Division of Abatement, National Air Pollution Control Administration, NO_2 Means for September 1967 to November 1968. All values are arithmetic means given in $\mu g/m^3$

Station Number	Operating Period	Number Observations	Arithmetic Mean
5	12/67 - 3/68	95	78.
7	4/68 - 11/68	233	78.
15	12/67 - 11/68	341	157.
16	12/67 - 3/68	96	59.
17	2/68 - 11/68	295	196.
19	5/68 - 11/68	202	412.
20	9/67 - 11/68	456	294.
21	9/67 - 11/68	457	176.
27	4/68 - 11/68	201	78.
161	4/68 - 11/68	230	157.
201	12/67 - 5/68	128	314.

Table 9. Division of Health Effects, National Air Pollution Control Administration, Pollution Means for October 1968 to April 1969. All values are given in $\mu g/m^3$. TSP means are geometric means; all others are arithmetic means.

Site	Pollutant			
	NO_2	Nitrate	Sulfate	TSP
Red Bank D1	84.9	1.7	10.1	56.7
Red Bank D2	85.8	1.8	9.9	51.4
Brainerd C1	111.1	2.6	10.1	55.7
Brainerd C2	137.1	2.8	9.6	66.8
Harrison A1	216.5	7.3	13.2	74.3
Harrison A2	122.2	3.9	10.0	52.2
Harrison A3	153.8	6.3	11.4	70.5

TABLE 10. CHATTANOOGA TSP FREQUENCY DISTRIBUTIONS BY SITE.
VALUES GIVEN IN MICROGRAMS PER CUBIC METER.

	MONTHS	NO. OBS.	MIN	FREQUENCY DISTRIBUTION - PERCENT 10	30	50	70	90	95	99	MAX	ARITH. MEAN	GEO. MEAN	STD. DEV.	S.D. LOGS
RED BANK	7/71- 9/71	92	37.4	45.2	57.8	64.0	73.1	90.2	94.2	104.5	126.1	66.0	64.0	16.7	.25
SITE 41	10/71-12/71	87	27.9	35.9	56.0	69.2	84.2	110.0	127.6	137.5	145.4	72.5	66.8	28.7	.42
	1/72- 3/72	81	16.0	35.4	62.5	84.4	111.9	150.4	168.0	214.9	217.4	90.9	78.8	46.0	.57
	4/72- 6/72	85	26.1	41.8	59.5	75.7	92.1	115.6	136.9	180.4	232.3	78.7	72.4	34.3	.41
	7/71- 6/72	345	16.0	39.1	58.4	69.7	87.4	118.3	137.4	200.6	232.3	76.6	70.0	33.8	.43
RED BANK	7/71- 9/71	92	24.0	38.8	52.2	59.7	69.5	85.7	88.1	95.1	121.1	61.1	58.5	17.5	.31
SITE 42	10/71-12/71	86	16.7	29.9	47.0	61.6	79.0	105.2	118.4	139.8	144.1	65.1	58.5	29.5	.48
	1/72- 3/72	78	25.5	36.6	59.2	84.2	110.0	151.6	171.8	297.3	612.2	94.8	79.8	72.[illegible]	.57
	4/72- 6/72	89	23.7	45.3	61.8	80.6	98.2	134.7	149.4	211.6	261.3	86.0	78.3	39.0	.44
	7/71- 6/72	345	16.7	36.8	54.4	67.0	86.7	120.6	146.4	193.8	612.2	76.1	67.6	45.5	.47
BRAINERD	7/71- 9/71	92	24.2	41.7	55.4	63.6	77.5	90.5	95.3	105.1	107.5	65.9	63.0	18.8	.31
SITE 21	10/71-12/71	87	18.1	37.6	59.1	73.4	88.8	122.4	144.5	203.3	210.1	79.2	71.2	36.9	.47
	1/72- 3/72	83	17.3	33.4	49.4	63.0	84.2	141.1	166.8	235.0	265.9	77.5	66.2	48.6	.56
	4/72- 6/72	88	23.7	41.3	60.2	76.6	89.7	116.5	12[illegible].7	138.7	156.1	77.5	72.0	28.2	.41
	7/71- 6/72	350	17.3	38.1	56.4	68.4	84.7	114.5	136.3	208.1	265.9	74.9	68.0	34.8	.44
BRAINERD	7/71- 9/71	91	23.1	36.2	48.0	56.7	67.2	80.5	84.8	95.2	112.1	57.5	55.0	16.9	.31
SITE 22	10/71-12/71	85	21.2	32.3	44.1	55.9	76.4	98.2	109.9	141.2	195.0	62.7	57.1	28.6	.43
	1/72- 3/72	75	21.3	31.9	50.5	57.6	84.4	135.0	158.2	226.7	234.0	72.5	62.6	43.3	.54
	4/72- 6/72	88	22.3	40.9	56.9	62.9	77.4	101.5	115.7	158.4	231.5	70.0	65.0	29.7	.38
	7/71- 6/72	339	21.2	35.1	49.6	58.8	72.7	99.0	115.8	182.9	234.0	65.4	59.6	30.8	.42
HARRISON	7/71- 9/71	83	17.3	33.8	45.3	58.3	72.5	96.8	113.7	155.3	183.4	63.4	57.9	28.6	.43
SITE 31	10/71-12/71	84	17.8	25.9	39.8	52.7	71.5	112.4	131.6	158.2	164.2	60.8	52.4	34.6	.55
	1/72- 3/72	76	14.7	22.8	36.1	44.7	57.6	94.2	111.9	153.7	179.8	53.2	46.0	31.1	.54
	4/72- 6/72	78	17.0	33.9	51.2	62.9	76.5	117.0	128.5	139.6	148.6	68.4	61.9	30.0	.47
	7/71- 6/72	321	14.7	28.0	42.1	55.7	71.5	105.0	124.6	156.2	183.4	61.5	54.3	31.5	.51
HARRISON	7/71- 9/71	92	22.7	38.2	47.7	55.4	72.5	87.5	97.3	111.5	130.5	60.8	57.2	21.3	.36
SITE 32	10/71-12/71	80	19.4	27.9	39.8	53.4	77.0	105.0	115.7	129.1	133.8	61.3	54.6	29.5	.49
	1/72- 3/72	84	11.5	21.2	34.2	44.4	63.1	86.4	106.5	115.1	118.8	50.8	44.6	25.8	.52
	4/72- 6/72	83	18.8	37.7	52.4	63.0	83.2	106.3	115.7	122.9	130.8	68.2	63.2	25.7	.40
	7/71- 6/72	339	11.5	29.2	43.4	55.3	72.3	98.8	110.1	125.3	133.8	60.2	54.5	26.2	.46
HARRISON	7/71- 9/71	91	18.2	34.1	44.3	53.6	61.4	78.1	87.4	128.3	162.7	56.4	52.7	22.0	.36
SITE 33	10/71-12/71	84	17.4	27.6	36.4	47.1	68.3	92.7	102.2	114.9	124.5	54.4	48.9	25.4	.47
	1/72- 3/72	78	11.7	23.7	34.9	45.8	54.9	75.4	83.9	136.2	155.0	48.7	43.5	24.6	.49
	4/72- 6/72	84	16.6	38.1	53.2	62.7	72.1	91.1	100.1	106.1	107.0	63.6	60.1	20.1	.36
	7/71- 6/72	337	11.7	29.7	41.6	53.1	65.2	85.7	99.6	124.5	162.7	55.9	51.1	23.6	.43
HARRISON	7/71- 9/71	92	17.1	26.4	38.0	48.9	61.8	83.2	86.1	123.9	128.7	52.3	47.8	22.2	.43
SITE 34	10/71-12/71	85	12.9	17.4	27.7	39.6	55.1	75.6	94.7	109.1	119.2	43.9	38.1	24.0	.54
	1/72- 3/72	70	11.1	18.5	30.9	36.3	45.1	66.5	88.6	102.9	109.6	41.0	36.5	20.7	.49
	4/72- 6/72	85	15.6	31.3	43.2	58.7	69.0	97.3	111.9	149.9	210.3	61.3	54.6	30.8	.49
	7/71- 6/72	332	11.1	22.2	34.8	44.5	60.4	83.9	98.7	123.0	210.3	50.1	44.1	25.9	.51
HARRISON	7/71- 9/71	92	22.7	37.7	46.5	53.1	68.9	89.0	94.2	114.6	119.0	5[illegible].5	56.1	20.6	.34
SITE 35	10/71-12/71	84	16.1	27.9	57.1	70.6	83.9	115.5	139.9	181.8	207.2	73.5	64.7	36.4	.53
	1/72- 3/72	83	15.0	29.2	38.6	49.9	65.5	102.8	126.2	140.8	143.6	58.6	51.6	30.9	.50
	4/72- 6/72	84	16.2	37.0	46.4	59.0	74.8	118.2	140.0	165.8	180.1	68.1	60.6	34.7	.48
	7/71- 6/72	343	15.0	32.5	44.6	59.4	74.7	105.2	129.1	164.9	207.2	64.8	58.0	31.5	.47

TABLE 11. CHATTANOOGA SULFATE FRACTION FREQUENCY DISTRIBUTIONS BY SITE. VALUES GIVEN IN MICROGRAMS PER CUBIC METER.

	MONTHS	NO. OBS.	MIN	FREQUENCY DISTRIBUTION - PERCENT 10	30	50	70	90	95	99	MAX	ARITH. MEAN	GEO. MEAN	STD. DEV.	S.D. LOGS
RED BANK SITE 41	7/71- 9/71	92	2.5	5.6	7.7	10.4	13.3	17.3	21.6	25.4	28.2	11.2	10.1	5.1	.47
	10/71-12/71	86	2.3	5.3	7.2	9.5	12.4	18.1	23.8	34.4	40.8	11.2	9.7	6.6	.51
	1/72- 3/72	82	2.2	5.3	7.1	8.2	10.7	13.5	17.9	33.3	41.2	9.7	8.8	5.5	.44
	4/72- 6/72	85	1.1	5.5	7.4	8.5	11.1	17.7	21.7	28.0	34.6	10.3	9.1	5.6	.51
	7/71- 6/72	345	1.1	5.5	7.4	9.1	11.9	17.2	22.2	32.5	41.2	10.6	9.4	5.7	.48
RED BANK SITE 42	7/71- 9/71	92	.8	5.3	7.5	9.8	13.4	17.2	20.0	24.1	27.5	10.9	9.7	5.1	.52
	10/71-12/71	86	4.5	5.4	7.0	8.5	10.8	14.4	19.0	21.9	22.0	9.6	8.8	4.1	.39
	1/72- 3/72	80	3.7	5.3	7.4	8.3	10.7	15.0	17.9	26.2	28.4	9.8	8.9	4.7	.42
	4/72- 6/72	89	3.4	5.8	7.6	9.2	12.1	18.1	20.0	25.2	29.6	10.8	9.8	5.1	.44
	7/71- 6/72	347	.8	5.4	7.4	8.9	11.8	17.0	19.7	25.1	29.6	10.3	9.3	4.8	.45
BRAINERD SITE 21	7/71- 9/71	92	3.3	5.5	7.3	10.7	13.8	18.2	21.8	28.5	30.4	11.5	10.3	5.5	.49
	10/71-12/71	87	4.2	5.8	7.1	9.0	11.2	17.1	19.3	21.4	23.7	10.1	9.3	4.3	.40
	1/72- 3/72	84	3.7	5.4	7.8	8.9	11.1	14.9	18.1	21.8	23.1	9.9	9.2	4.0	.38
	4/72- 6/72	89	2.1	5.9	7.6	9.3	11.5	17.6	19.1	35.6	50.1	10.9	9.6	6.6	.48
	7/71- 6/72	352	2.1	5.6	7.4	9.4	12.0	17.5	19.4	27.9	50.1	10.6	9.6	5.2	.44
BRAINERD SITE 22	7/71- 9/71	91	2.2	5.6	7.8	9.8	13.1	16.8	19.8	22.9	32.0	11.0	9.9	5.0	.47
	10/71-12/71	86	3.4	4.8	6.5	7.7	10.4	16.2	18.1	21.6	21.9	9.2	8.3	4.4	.45
	1/72- 3/72	78	4.4	6.0	7.6	8.6	10.5	14.6	18.7	45.7	52.4	10.3	9.2	7.1	.43
	4/72- 6/72	87	4.0	5.8	7.6	9.3	11.3	16.5	17.6	28.4	56.5	10.7	9.6	6.5	.44
	7/71- 6/72	342	2.2	5.4	7.2	8.8	11.3	16.4	18.8	28.6	56.5	10.3	9.2	5.8	.45
HARRISON SITE 31	7/71- 9/71	83	3.9	6.0	7.4	11.4	14.1	18.5	22.0	30.6	40.6	12.0	10.7	6.1	.48
	10/71-12/71	83	1.2	5.0	6.2	8.1	10.5	16.1	18.1	21.8	22.2	9.3	8.3	4.5	.50
	1/72- 3/72	78	3.1	4.6	6.1	7.3	9.4	14.4	16.9	30.5	36.9	9.7	7.7	5.2	.46
	4/72- 6/72	78	2.9	6.3	7.6	9.3	11.4	15.6	19.0	36.9	54.3	10.8	9.6	6.7	.45
	7/71- 6/72	322	1.2	5.3	6.9	8.7	11.6	17.2	19.0	31.1	54.3	10.2	9.0	5.8	.49
HARRISON SITE 32	7/71- 9/71	92	1.5	6.1	8.1	11.2	14.8	19.5	22.2	26.8	40.8	12.2	10.8	6.0	.51
	10/71-12/71	80	1.1	5.1	6.1	8.3	11.2	14.5	18.4	22.5	25.7	9.2	8.3	4.4	.48
	1/72- 3/72	84	3.1	4.7	6.2	7.6	9.3	12.2	13.6	18.9	19.9	8.1	7.6	3.3	.38
	4/72- 6/72	84	.9	6.2	7.8	9.2	11.1	16.2	18.3	20.7	26.7	10.1	9.3	4.3	.46
	7/71- 6/72	340	.9	5.2	6.9	8.7	11.5	16.4	19.2	24.6	40.8	10.0	8.9	4.9	.48
HARRISON SITE 33	7/71- 9.71	91	2.0	5.8	8.1	11.6	14.9	18.9	21.0	27.2	43.8	12.1	10.8	6.1	.49
	10/71-12/71	82	.6	5.2	6.8	8.2	11.2	16.4	19.2	22.5	24.3	9.8	8.7	4.7	.52
	1/72- 3/72	81	4.6	5.7	7.4	8.7	10.7	13.2	14.0	21.5	25.8	9.4	8.8	3.5	.34
	4/72- 6/72	85	4.0	6.2	8.3	10.4	12.0	16.7	19.4	25.0	31.3	10.9	10.0	4.7	.40
	7/71- 6/72	339	.6	5.7	7.6	9.3	12.3	16.8	19.5	24.9	43.8	10.6	9.6	5.0	.45
HARRISON SITE 34	7/71- 9/71	92	2.7	5.6	7.6	10.1	14.2	18.6	20.4	24.6	25.1	11.2	10.0	5.2	.49
	10/71-12/71	82	1.7	4.7	7.1	9.3	11.7	17.8	19.5	22.5	23.5	10.2	9.0	5.0	.52
	1/72- 3/72	76	3.4	5.6	7.0	8.1	9.7	13.7	16.6	27.6	38.9	9.3	8.5	5.0	.40
	4/72- 6/72	85	2.7	5.6	8.0	9.6	11.9	15.7	18.0	29.9	46.4	10.8	9.8	5.7	.43
	7/71- 6/72	335	1.7	5 3	7.4	9.4	11.7	16.7	19.6	25.9	46.4	10.4	9.3	5.3	.47
HARRISON SITE 35	7/71- 9/71	91	3.6	6.0	8.2	11.2	13.8	19.0	21.2	26.2	30.5	11.9	10.8	5.3	.44
	10/71-12/71	82	.7	5.4	6.9	9.3	12.6	17.2	20.7	24.7	27.1	10.4	9.1	5.2	.56
	1/72- 3/72	85	3.2	4.8	6.3	7.9	9.7	13.7	18.2	30.1	36.6	9.1	8.1	5.2	.46
	4/72- 6/72	84	2.5	5.5	7.5	8.9	11.3	14.7	17.4	26.0	30.3	10.0	9.1	4.6	.42
	7/71- 6/72	342	.7	5.4	7.3	9.1	11.7	17.2	20.6	28.1	36.6	10.4	9.3	5.2	.48

TABLE 12. CHATTANOOGA NITRATE FRACTION FREQUENCY DISTRIBUTIONS BY SITE. VALUES GIVEN IN MICROGRAMS PER CUBIC METER.

	MONTHS	NO. OBS.	MIN	FREQUENCY DISTRIBUTION - PERCENT 10	30	50	70	90	95	99	MAX	ARITH. MEAN	GEO. MEAN	STD. DEV.	S.D. LOGS
RED BANK SITE 41	7/71- 9/71	91	BMDL	.5	1.4	1.7	2.4	3.1	3.6	4.5	4.6	1.9	1.4	1.0	.96
	10/71-12/71	85	.6	1.1	1.6	2.2	3.0	5.7	6.4	7.3	8.5	2.8	2.3	1.8	.62
	1/72- 3/72	82	.1	.7	1.2	1.6	2.0	3.2	5.2	6.5	7.2	1.9	1.5	1.3	.74
	4/72- 6/72	85	.2	.4	.7	.9	1.3	2.1	2.7	4.0	4.0	1.1	.9	.8	.66
	7/71- 6/72	343	BMDL	.5	1.1	1.6	2.2	3.7	4.8	6.9	8.5	1.9	1.5	1.4	.82
RED BANK SITE 42	7/71- 9/71	90	BMDL	.4	1.2	1.6	1.9	2.8	3.5	4.5	4.5	1.6	1.2	1.0	1.08
	10/71-12/71	86	.5	1.0	1.5	2.0	2.6	4.4	5.8	6.3	7.0	2.4	2.0	1.5	.58
	1/72- 3/72	80	.1	.8	1.2	1.6	2.1	3.0	4.9	6.8	7.6	1.9	1.5	1.4	.76
	4/72- 6/72	89	.1	.4	.6	.9	1.5	2.0	2.7	4.1	4.2	1.2	.9	.8	.72
	7/71- 6/72	345	BMDL	.5	1.1	1.6	2.0	3.3	4.3	6.1	7.6	1.8	1.3	1.3	.86
BRAINERD SITE 21	7/71- 9/71	91	BMDL	.8	1.6	2.4	3.0	4.3	4.7	9.2	10.9	2.5	2.0	1.7	.84
	10/71-12/71	87	.4	1.4	2.3	2.8	4.1	6.7	7.9	14.1	27.2	3.9	3.1	3.4	.67
	1/72- 3/72	84	.3	.9	1.6	2.1	3.2	6.7	8.5	11.8	14.3	3.0	2.3	2.5	.73
	4/72- 6/72	89	.3	.5	.8	1.2	1.7	3.1	3.5	4.4	5.5	1.5	1.2	1.0	.67
	7/71- 6/72	351	BMDL	.7	1.4	2.2	3.0	5.0	6.9	11.1	27.2	2.7	2.0	2.5	.80
BRAINERD SITE 22	7/71- 9/71	90	BMDL	.8	1.3	2.0	2.9	4.2	4.8	8.4	10.1	2.4	1.8	1.7	.91
	10/71-12/71	86	.4	1.5	2.2	3.0	4.5	9.2	11.3	13.9	17.1	4.2	3.3	3.3	.71
	1/72- 3/72	78	.3	1.0	1.5	2.1	3.7	6.3	9.2	15.2	22.0	3.2	2.3	3.3	.80
	4/72- 6/72	88	.2	.5	.6	1.0	1.4	2.5	3.3	4.7	5.2	1.3	1.0	1.0	.69
	7/71- 6/72	342	BMDL	.6	1.2	2.0	3.0	5.2	8.2	13.3	22.0	2.8	1.9	2.7	.89
HARRISON SITE 31	7/71- 9/71	81	BMDL	1.4	2.7	4.5	7.9	16.6	21.7	29.6	38.1	7.3	4.3	7.2	1.25
	10/71-12/71	82	.8	2.4	4.6	7.4	14.5	22.2	28.7	61.6	81.6	11.9	7.9	12.3	.92
	1/72- 3/72	78	.2	1.6	3.4	6.9	9.6	17.8	21.6	45.3	53.9	8.8	5.6	8.9	1.06
	4/72- 6/72	78	.2	.5	1.3	4.5	8.4	12.9	17.8	20.6	21.2	5.8	3.1	5.5	1.28
	7/71- 6/72	319	BMDL	1.0	2.9	5.9	9.8	18.2	22.3	41.9	81.6	8.5	4.9	9.1	1.18
HARRISON SITE 32	7/71- 9/71	91	BMDL	1.1	1.9	2.8	4.3	7.0	8.6	12.3	13.5	3.5	2.6	2.7	.95
	10/71-12/71	79	.4	1.7	2.6	3.5	4.6	8.0	10.4	17.0	30.2	4.6	3.6	3.9	.68
	1/72- 3/72	84	.3	.8	1.6	2.5	3.7	6.7	9.5	16.4	16.5	3.4	2.5	3.2	.82
	4/72- 6/72	84	.2	.5	1.0	1.6	2.5	5.9	7.2	12.2	13.6	2.5	1.7	2.5	.90
	7/71- 6/72	338	BMDL	.7	1.6	2.6	3.9	7.0	9.0	14.0	30.2	3.5	2.5	3.2	.89
HARRISON SITE 33	7/71- 9/71	90	BMDL	.7	1.6	2.7	3.5	5.4	6.5	9.3	10.1	2.9	2.1	2.0	1.01
	10/71-12/71	84	.9	2.0	3.0	4.2	5.8	12.0	14.0	18.4	18.8	5.7	4.5	4.2	.67
	1/72- 3/72	81	.1	1.0	2.0	3.5	4.9	9.6	11.3	15.8	16.8	4.5	3.0	3.6	1.08
	4/72- 6/72	85	.2	.5	1.1	1.6	3.2	5.3	6.6	9.2	11.7	2.5	1.7	2.1	.90
	7/71- 6/72	340	BMDL	.8	1.8	3.2	4.3	8.5	11.3	16.3	18.8	3.9	2.6	3.4	.99
HARRISON SITE 34	7/71- 9/71	90	BMDL	.9	1.8	2.3	4.1	8.3	10.4	13.5	16.3	3.7	2.4	3.3	1.02
	10/71-12/71	84	.4	1.6	2.9	4.6	7.7	12.8	14.8	34.3	39.1	6.6	4.6	6.5	.88
	1/72- 3/72	76	.1	.8	1.9	2.5	3.7	7.8	8.8	11.4	13.7	3.4	2.4	2.7	.92
	4/72- 6/72	85	.3	.4	.7	1.3	2.6	4.2	6.7	15.1	16.1	2.3	1.4	2.9	.97
	7/71- 6/72	335	BMDL	.6	1.6	2.5	4.2	9.2	12.6	16.2	39.1	4.0	2.5	4.5	1.04
HARRISON SITE 35	7/71- 9/71	92	BMDL	.7	1.7	2.5	3.6	5.3	6.3	8.7	9.4	2.9	2.1	1.9	1.01
	10/71-12/71	83	.4	1.3	2.1	3.0	4.3	7.4	9.1	13.4	16.8	3.8	3.0	2.8	.71
	1/72- 3/72	85	BMDL	.7	1.3	2.0	2.9	4.9	7.3	13.4	15.6	2.7	1.8	2.6	1.05
	4/72- 6/72	84	.1	.3	.8	1.3	2.2	3.6	5.4	6.9	8.1	1.8	1.2	1.6	.98
	7/71- 6/72	344	BMDL	.6	1.4	2.2	3.1	5.3	7.5	12.2	16.8	2.8	1.9	2.4	1.00

TABLE 13. CHATTANOOGA NO2 FREQUENCY DISTRIBUTIONS BY SITE.
VALUES GIVEN IN MICROGRAMS PER CUBIC METER.

	MONTHS	NO. OBS.	MIN	FREQUENCY DISTRIBUTION - PERCENT 10	30	50	70	90	95	99	MAX	ARITH. MEAN	GEO. MEAN	STD. DEV.	S.D. LOGS
RED BANK SITE 41	7/71- 9/71	90	17.1	24.1	32.9	39.5	44.6	51.7	61.6	68.1	81.0	39.6	37.9	11.7	.30
	10/71-12/71	78	10.1	22.6	33.1	40.2	51.8	67.2	72.5	96.2	137.3	43.8	39.5	20.0	.48
	1/72- 3/72	78	7.8	18.7	34.5	46.1	55.1	76.2	81.6	118.5	125.4	47.7	42.2	22.9	.53
	4/72- 6/72	64	5.9	23.9	34.5	41.6	58.5	70.2	82.1	151.1	157.0	47.9	41.5	26.5	.57
	7/71- 6/72	310	5.9	23.3	33.8	41.5	50.9	68.3	77.0	124.6	157.0	44.4	40.1	20.6	.47
RED BANK SITE 42	7/71- 9/71	89	20.2	27.5	35.8	39.9	48.2	61.4	77.5	111.7	127.2	44.3	41.6	17.7	.35
	10/71-12/71	75	BMDL	20.5	36.7	45.7	55.8	71.5	75.9	94.9	102.2	46.6	41.3	19.8	.57
	1/72- 3/72	68	10.3	24.0	37.4	48.4	61.6	71.9	81.1	84.3	84.4	48.7	44.5	19.1	.46
	4/72- 6/72	79	BMDL	22.5	37.0	47.1	58.8	77.9	104.4	152.7	183.9	51.6	44.2	28.9	.61
	7/71- 6/72	311	BMDL	23.2	36.5	44.5	55.8	72.8	82.1	117.9	183.9	47.7	42.8	21.9	.50
BRAINERD SITE 21	7/71- 9/71	89	8.1	21.8	32.4	38.7	46.1	58.3	69.3	82.5	108.4	40.1	36.6	16.5	.45
	10/71-12/71	81	BMDL	19.0	31.5	43.7	57.8	73.8	75.2	88.0	121.4	44.1	38.0	21.8	.61
	1/72- 3/72	79	11.1	21.1	28.6	39.5	49.7	74.1	80.0	116.0	127.0	43.5	38.1	23.2	.52
	4/72- 6/72	74	13.3	20.7	35.4	42.5	55.5	75.1	86.9	102.7	109.6	46.3	41.9	20.5	.47
	7/71- 6/72	323	BMDL	20.2	32.2	40.9	49.2	71.6	76.3	111.8	127.0	43.4	38.5	20.6	.51
BRAINERD SITE 22	7/71- 9/71	89	16.2	36.5	46.8	54.5	64.1	81.2	90.6	108.2	117.2	57.2	54.1	18.7	.35
	10/71-12/71	82	BMDL	25.6	39.7	51.5	63.7	80.8	87.4	106.9	123.7	52.6	46.3	22.9	.59
	1/72- 3/72	84	10.0	25.6	40.8	48.2	64.3	85.9	98.5	139.7	152.5	54.2	48.1	26.5	.51
	4/72- 6/72	75	19.7	27.6	38.8	49.4	60.1	81.1	86.6	93.1	97.1	50.7	47.0	19.5	.40
	7/71- 6/72	330	BMDL	27.3	41.2	51.6	63.6	82.7	89.1	118.8	152.5	53.8	48.9	22.2	.47
HARRISON SITE 31	7/71- 9/71	87	10.2	21.3	34.4	55.0	78.7	116.1	139.5	180.0	275.7	64.4	52.3	43.2	.66
	10/71-12/71	84	BMDL	13.1	37.3	56.6	78.9	127.2	146.0	179.3	187.3	64.5	47.5	44.2	.91
	1/72- 3/72	85	11.2	15.8	38.0	51.9	68.0	111.3	136.5	147.7	154.5	58.4	48.0	35.3	.67
	4/72- 6/72	70	14.9	22.6	37.2	52.9	72.2	110.2	132.6	198.5	282.3	62.1	51.1	43.0	.62
	7/71- 6/72	326	BMDL	18.7	36.8	53.3	77.2	118.4	139.2	176.8	282.3	62.4	49.7	41.4	.72
HARRISON SITE 32	7/71- 9/71	91	7.8	19.6	29.1	41.3	47.9	67.0	71.5	84.5	86.1	41.2	37.0	17.9	.50
	10/71-12/71	82	BMDL	19.0	34.3	51.0	68.7	91.6	99.2	136.2	145.4	53.2	44.0	29.3	.69
	1/72- 3/72	82	13.0	20.5	30.3	47.4	61.7	77.8	86.4	103.0	112.0	48.8	42.8	23.8	.54
	4/72- 6/72	77	12.7	23.1	32.3	40.4	49.1	70.9	82.2	96.1	110.9	44.1	40.3	19.3	.43
	7/71- 6/72	332	BMDL	20.3	32.1	43.3	56.8	77.0	86.9	111.6	145.4	46.7	40.8	23.3	.55
HARRISON SITE 33	7/71- 9/71	91	14.3	19.2	24.5	31.9	38.6	47.8	60.6	87.5	94.4	33.6	31.1	14.2	.39
	10/71-12/71	81	7.8	23.8	38.8	47.0	59.6	81.2	97.6	115.8	120.6	51.1	45.4	23.5	.53
	1/72- 3/72	86	9.8	26.9	34.7	49.1	64.4	88.6	101.1	135.0	171.5	53.3	46.9	27.8	.52
	4/72- 6/72	77	9.4	20.6	30.9	37.9	52.2	73.7	93.0	101.2	117.3	43.4	38.3	22.2	.52
	7/71- 6/72	335	7.8	20.8	31.5	39.5	50.8	77.4	94.1	118.3	171.5	45.2	39.7	23.6	.51
HARRISON SITE 34	7/71- 9/71	87	6.2	15.3	20.8	26.1	37.5	52.6	61.3	73.2	123.9	31.8	27.5	18.1	.56
	10/71-12/71	83	BMDL	9.1	17.9	26.3	36.0	53.9	63.9	112.4	116.4	30.2	23.8	21.0	.74
	1/72- 3/72	61	5.9	12.8	20.1	26.5	34.4	46.2	57.3	69.9	71.6	28.7	24.9	14.9	.56
	4/72- 6/72	77	6.8	13.9	18.3	27.6	37.0	47.8	56.1	72.4	83.5	29.2	25.7	15.0	.52
	7/71- 6/72	308	BMDL	11.7	19.2	26.4	36.2	52.0	60.9	83.1	123.9	30.1	25.5	17.6	.60
HARRISON SITE 35	7/71- 9/71	82	7.3	21.0	31.0	45.2	57.0	73.9	83.6	102.2	133.1	46.5	40.9	22.5	.55
	10/71-12/71	83	BMDL	11.1	27.3	37.0	49.2	71.2	78.6	96.3	121.0	39.4	31.9	23.0	.73
	1/72- 3/72	86	9.8	15.4	25.2	36.3	48.6	61.2	71.5	92.8	98.2	38.0	33.1	19.2	.55
	4/72- 6/72	79	10.7	17.3	25.1	34.3	47.3	56.8	70.0	99.7	128.1	38.1	33.6	20.1	.51
	7/71- 6/72	330	BMDL	16.0	26.6	38.2	49.8	69.0	78.2	97.3	133.1	40.5	34.7	21.4	.60

Table 14. Annual Pollutant Means (μg/m³) from CHESS for 1970 to 1973

	Red Bank		Brainerd		Harrison				
Site	41	42	21	22	31	32	33	34	35
TSP geometric mean									
1970[a]	70.0	58.8	64.9	61.9	55.0	55.2	51.0	40.6	51.5
1971	68.5	59.1	66.4	57.5	55.9	55.6	50.8	42.2	55.1
1972	70.0	66.6	65.1	59.0	53.7	53.2	49.6	43.5	54.3
Sulfate Fraction arithmetic mean									
1970[a]	13.4	12.0	12.7	12.3	13.0	12.2	12.4	12.6	12.9
1971	10.3	9.3	9.7	9.4	9.6	10.1	9.8	9.7	10.3
1972	11.1	11.1	11.3	10.6	11.1	9.8	11.1	11.7	10.7
Nitrate Fraction arithmetic mean									
1970[a]	1.2	1.0	2.0	1.4	8.4	1.8	2.1	2.0	1.7
1971	2.4	2.0	3.1	3.0	12.9	4.1	4.8	4.6	3.2
1972	1.1	1.1	1.6	1.5	7.1	2.3	2.5	2.0	1.7
NO_2 arithmetic mean									
1970[a]	57.9	58.9	62.3	80.5	142.7	65.1	67.7	53.8	55.3
1971	41.9	47.2	44.5	56.9	73.8	47.9	46.5	33.1	42.2
1972	40.8	43.9	40.9	47.7	61.6	42.0	43.0	30.2	35.8

[a] June through December values only.

Table 15. Height, Age, Machine, and Symptom Adjusted Mean $FEV_{0.75}$ Distributed by Community and by Season

Age < 108 Months

Community	Males			Females		
	Winter	Spring	Average	Winter	Spring	Average
Red Bank	1.313 (329)[a]	1.340 (308)	1.334 (298)	1.187 (315)	1.211 (298)	1.204 (288)
Brainerd	1.300 (267)	1.308 (268)	1.311 (260)	1.173 (248)	1.193 (251)	1.185 (234)
Harrison	1.286 (376)	1.368 (368)	1.331 (351)	1.202 (347)	1.261 (342)	1.237 (315)

Age ≥ 108 Months

Community	Males			Females		
	Winter	Spring	Average	Winter	Spring	Average
Red Bank	1.824 (513)	1.848 (507)	1.835 (494)	1.745 (446)	1.764 (443)	1.755 (424)
Brainerd	1.810 (358)	1.807 (351)	1.806 (336)	1.734 (345)	1.761 (345)	1.747 (325)
Harrison	1.797 (439)	1.861 (432)	1.826 (413)	1.706 (355)	1.781 (360)	1.751 (331)

[a] ( ) indicates sample size for that mean.

Table 16. F Values for Analysis of Variance, Distributed by Season and by Sex

Factor	D.F.[a]	Winter	Spring	Average
Males < 108 Months				
Height	1	353.39***	391.57***	457.30***
Age	1	23.76***	15.50***	19.02***
Machines	1	1.34	11.30***	
Symptom	1	7.61**	.05	
Community	2	1.69	7.41**	1.49
Females < 108 Months				
Height	1	343.89***	352.58***	409.30***
Age	1	12.47***	16.55***	13.56***
Machines	1	.20	1.11	
Symptom	1	1.40	2.58	
Community	2	1.93	12.63***	8.11***
Males ≥ 108 Months				
Height	1	730.75***	853.27***	905.44***
Age	1	38.31***	7.89**	12.82***
Machines	1	16.47***	3.84	
Symptom	1	3.54	.67	
Community	2	1.69	5.97**	1.94
Females ≥ 108 Months				
Height	1	757.39***	867.61***	979.28***
Age	1	36.98***	2.18	10.08**
Machines	1	3.00	11.16***	
Symptom	1	2.91	12.71***	
Community	2	2.80	0.76	0.14

[a] Degrees of freedom of the numerator. The degrees of freedom for the denominator are given in Table 17.

* $p < 0.05$

** $p < 0.01$

*** $p < 0.001$

Table 17. Height, Age, Machine, and Community Adjusted Mean $FEV_{0.75}$ Distributed by Symptoms and Season

Age < 108 Months

	Males		Females	
	Winter	Spring	Winter	Spring
No Symptoms	1.310 (694)	1.343 (776)	1.196 (576)	1.220 (676)
Symptoms	1.272 (278)	1.339 (168)	1.180 (334)	1.242 (215)

Age ≥ 108 Months

	Males		Females	
	Winter	Spring	Winter	Spring
No Symptoms	1.817 (1061)	1.843 (1143)	1.737 (815)	1.781 (914)
Symptoms	1.787 (249)	1.827 (147)	1.711 (331)	1.719 (234)

Table 18. Regression Coefficients for Height and Age Distributed by Sex and Age

	Regression Coefficients		
	Winter	Spring	Average
Males < 108 months			
Height (liters/inch)	.0538	.0614	.0603
Age (liters/month)	.0040	.0034	.0034
Females < 108 months			
Height (liters/inch)	.0522	.0539	.0542
Age (liters/month)	.0028	.0033	.0028
Males ≥ 108 months			
Height (liters/inch)	.0619	.0725	.0707
Age (liters/month)	.0038	.0018	.0021
Females ≥ 108 months			
Height (liters/inch)	.0661	.0740	.0724
Age (liters/month)	.0045	.0011	.0022

Table 19. Mean Heights and Ages of Those in the Analysis, by Sex and Age

	Winter	Spring	Average
Males < 108 months			
Height (inches)	50.297	50.623	50.501
Age (months)	91.702	93.975	92.970
Females < 108 months			
Height	49.968	50.191	50.110
Age	91.467	93.629	92.658
Males ≥ 108 months			
Height	56.609	56.750	56.659
Age	127.743	129.689	128.628
Females ≥ 108 months			
Height	56.906	57.072	57.027
Age	127.482	129.287	128.331

Table 20. Mean Square Error of FEV Analyses By Season

Age-Sex Group	Winter	Spring	Average
Males < 108 Months	.0361 (965)[a]	.0378 (937)	.0300 (904)
Females < 108 Months	.0309 (903)	.0300 (884)	.0243 (832)
Males ≥ 108 Months	.0483 (1303)	.0501 (1283)	.0425 (1238)
Females ≥108 Months	.0538 (1139)	.0543 (1141)	.0433 (1075)

[a] ( ) indicates degrees of freedom.

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO. EPA-600/1-77-002	2.	3. RECIPIENT'S ACCESSION NO.
4. TITLE AND SUBTITLE LUNG FUNCTION IN SCHOOL CHILDREN: 1971-1972 CHATTANOOGA STUDY		5. REPORT DATE January 1977
		6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) Victor Hasselblad		8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS Statistics and Data Management Office, Health Effects Research Laboratory, Research Triangle Park, N.C. 27711		10. PROGRAM ELEMENT NO. 1AA601
		11. CONTRACT/GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS Health Effects Research Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, Research Triangle Park, N.C. 27711		13. TYPE OF REPORT AND PERIOD COVERED In House
		14. SPONSORING AGENCY CODE EPA-ORD
15. SUPPLEMENTARY NOTES		

16. ABSTRACT

Previous studies of lung function in children have indicated that decreases in lung function are associated with higher air pollution exposures. For this reason, three quarter second timed forced expiratory volume was chosen as one of the health indicators in the Environmental Protection Agency's Community Health Environmental Surveillance System (CHESS). The city of Chattanooga, Tennessee was chosen because of its exposure to a large stationary source of nitrogen dioxide. The present study, conducted in 1971-1972, was a follow-up to an earlier study performed by Shy, et al. in 1968-1969. The present study did not confirm the slight differences found in the earlier study. This might be explained by the reduction in NO_2 levels since the 1968-1969 study.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Lung Respiratory system Children Air Pollution	Chattanooga	06 F

18. DISTRIBUTION STATEMENT RELEASE TO PUBLIC	19. SECURITY CLASS (This Report) UNCLASSIFIED	21. NO. OF PAGES 35
	20. SECURITY CLASS (This page) UNCLASSIFIED	22. PRICE

EPA Form 2220-1 (9-73)