

A RETROSPECTIVE COHORT MORTALITY STUDY  
OF A PHOSPHATE FERTILIZER PRODUCTION FACILITY

Leslie T. Stayner  
Theodore Meinhardt  
Richard Lemen  
David Bayliss  
Robert Herrick  
Gordon R. Reeve  
Alexander B. Smith  
William Halperin

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Division of Surveillance, Hazard Evaluations and Field Studies  
Industrywide Studies Branch

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ABSTRACT

A retrospective cohort mortality study of phosphate fertilizer production workers was undertaken to determine whether this group is at increased risk of dying from any cause, and particularly from lung cancer. Altogether 3199 workers, who had ever been employed at this facility were included in this investigation. These workers were followed for vital status ascertainment from their first date of employment up to December 1, 1977, or the date of death, whichever occurred first. Overall, no statistically significant elevations in cause specific mortality were observed for the entire study population. However, when the analysis was stratified by duration of employment, and length of followup, a statistically significant ( $p < .05$ ) excess in lung cancer mortality was observed among workers with greater than 10 years of employment and followup (SMR=411). Because of the small number of deaths involved, and because we had prior knowledge of a lung cancer cluster at this plant, we believe that these findings should be viewed as suggestive, and that other investigations in plants with similiar exposures are needed to clarify whether an occupationally related lung cancer excess truly exists.

## Introduction

Phosphate ore contains uranium and thorium as natural constituents. The mining and processing of this ore may result in human exposures to uranium and thorium, and to radon daughters which are decay products of uranium. Concern has been raised about these exposures due to the well known adverse effects of radiation exposure, and particularly due to the association between radon daughter exposure and the development of respiratory cancer in uranium miners (1).

A 1975 report prepared by the Environmental Protection Agency (EPA) documented elevated background radiation levels in an area of central Florida which has a large phosphate industry (2). In another report, the EPA measured external gamma radiation and airborne radionuclides in mining, milling and processing facilities(3). Direct gamma radiation exposures ranged from 0.06 to 0.3 rem per year, and were below the 5 rem occupational guideline and the 0.5 rem per year guideline for the general population. Estimated lung doses ranged from .05 to 3.0 rem per year and were well below the 15 rem guideline for radiation workers and usually below the 1.5 rem guideline for the general population.

Two epidemiologic studies have investigated the possible relationship between lung cancer mortality, and phosphate ore mining and processing. An unpublished study conducted by the Florida State Health Department compared

the lung cancer mortality rates in Polk County, which has a large phosphate mining and processing industry, to the mortality rates in Orange County, which does not have this industry (4). Lung cancer rates were found to be significantly higher ( $p < .05$ ), about 20 percent, in Polk than in Orange County. The excess was predominantly among white males between the ages of 55 and 64.

The second study (5) compared counties in the U.S. with high rates of lung cancer to those containing phosphate deposits, mines or processing plants. The data used for lung cancer rates came from the Atlas of Cancer Mortality for U.S. Counties (6) and the data for the location of phosphate facilities was taken from the 1970 U.S. Geological Survey map (7). The number of counties that had both statistically significant high lung cancer mortality rates, and phosphate processing facilities or phosphate rock mills, was significantly ( $p < .001$ ) greater than the number expected. However, phosphate mines and processing facilities tend to be in urban areas, which are known to have higher lung cancer mortality rates than rural areas, and when the study results were stratified by county population size, the magnitude of the differences was greatly reduced, and not statistically significant.

In early 1974, researchers at the National Institute for Occupational Safety and Health (NIOSH) received a report of several cases of lung cancer that occurred among workers at a phosphate fertilizer plant. It was learned subsequently that three black men, each fifty years of age or less, who were

reportedly nonsmokers, had developed lung cancer. These men had worked as maintenance men at a fertilizer production plant, and performed the same tasks and thereby experienced similar exposures. To investigate further the relationship between work in the phosphate industry and the risk of developing lung cancer, NIOSH initiated a study to evaluate the mortality experience of workers in the phosphate fertilizers industry.

#### Study Background

The plant where the individuals had worked is a phosphate fertilizer production facility. This facility was constructed in 1951 and was purchased by a second company in 1969. The plant has operated continuously since 1951 with very little employment turnover when management changed.

The present and past products of this facility are various ammonium phosphates which are predominantly used for fertilizers and were used in the past for animal feed additives. A pilot project was operated between 1953 and 1958 which recovered uranium from the phosphate ore.

In 1976 NIOSH conducted an industrial hygiene survey at this facility (8) to evaluate in particular occupational exposures in the cleaning of a reaction vessel, a task in which all three of the reported lung cancer cases had been involved. Crushed phosphate ore is mixed in these vessels with sulfuric acid to produce phosphoric acid and gypsum as a byproduct. Workers enter

the vessel once a year to chip away gypsum deposits from the agitator. Environmental samples were taken for uranium, radon daughters, fluoride, sulfuric acid, phosphoric acid, cadmium, chromium, vanadium and arsenic. A summary of the results from this survey is presented in Table I. All samples were found to be below all applicable standards except for two fluoride samples.

A number of other companies were visited by NIOSH in an attempt to identify a suitable location for this study. After completing this survey, NIOSH selected the facility described above. The other companies were rejected because either they had operated for a briefer period of time, employed fewer production workers, or lacked critical personnel information.

#### Data Collection

All available pertinent records were microfilmed at both the company that originally owned the facility (company A) and the company that purchased it in 1969 (company B). Company B's personnel records were available for all salaried and hourly employees who were working in or after 1969, the year the plant was purchased. The personnel folders containing initial application, job transaction sheets, and other supporting personnel forms were microfilmed. From these records we were able to obtain the following information: employee's name, social security number, birth date, race (on almost all personnel), and a detailed occupational history.

At company A, all terminated personnel records were copied. These records were interfiled with all of Company A's personnel records which included eleven different facilities. This data system consisted predominantly of a record for each person which contained the following information: employee's name, social security number, address, date of birth, race, and limited occupational history (containing only beginning and ending job title, and dates).

#### Data Reduction

All necessary information to create a demographic file was coded. This demographic file provided necessary information for the initiation of vital status ascertainment of former employees.

Approximately 3000 workers, out of over 13,500 individuals in company A's file, had ever been employed at the plant. A plant location variable was added to the computer file, to permit selection of the appropriate plant workers for the study cohort.

The personnel files from company A did not contain detailed occupational histories. For the most part, these files did have the date first and last employed at the facility and in the corporation. In addition, they contained the job titles corresponding to the first and last date employed at the facility. The date first and last employed at the facility and the corresponding job titles were coded and entered into the computer file.

### Methods

The vital status of study subjects was ascertained using a number of sources of information. All study subjects were sent to the Social Security Administration (SSA) for linkage with their files. SSA provided us with vital status information that was current as of December 31, 1977.

Inquiries were sent for individuals who were not identified by SSA to the Internal Revenue Service (IRS) and to the Florida Department of Motor Vehicles, Division of Driver Licenses. The IRS only provides addresses, and does not provide a date of last contact. The addresses identified through the IRS search were sent to the local post office for confirmation that the individuals still resided at that address. For the limited number of subjects not successfully traced through these methods, a private locator service was used. Using these methods, subjects were followed for vital status ascertainment from their first date of employment up to December 31, 1977, or the date of death, whichever came first.

Death certificates were obtained from state vital statistics departments. Cause of death was coded by a nosologist using the revision of the International Classification of Diseases in effect at the time of death. Deceased workers for whom no death certificate have yet been located were assumed dead on the date specified by the reporting agency and the cause of death was coded unknown.

The analysis was performed using a modified life table analysis program developed by NIOSH (9). Person-years at risk of dying (PYARs) were calculated from the first date of employment at the plant through the end of study date (12/31/77), the date of death, or the date when the subject was lost to follow-up, whichever occurred first. PYARs were obtained for each sex, race, five-year age and calendar period groups. The expected deaths were calculated by multiplying the appropriate PYARs by the U.S. death rates specific for five year age groups, five year calendar periods, sex, race and cause of death. The results were summed over the specific categories to obtain the total expected deaths for each cause. The findings were also stratified by duration of employment and length of followup. Length of followup was intended to act as a surrogate measure for latency, and duration of employment as a surrogate measure for exposure in this study.

Standardized Mortality Ratios (SMRs) were calculated for each race and sex category by dividing the number of observed deaths by the number expected and multiplying by 100. An exact test based on the Poisson distribution was used for testing statistical significance. Ninety percent confidence limits were calculated using Fisher exact limits. For death categories with less than two observed deaths, no statistical tests, SMRs or confidence limits were computed. A one tailed p value of .05 was used as the minimum criteria for statistical significance. Confidence limits and the statistical tests were computed with the aid of the Hewlett Packard Programs described in Rothman and Boice (10).

## FINDINGS

Altogether 3199 workers were identified as having worked at this plant from 1951 to 1976. Dates of employment were not available for 39 workers (1.2 percent). These subjects could not be included in the life table analysis because person years at risk and duration of employment could not be calculated. None of these individuals had died from respiratory cancer.

The vital status of this cohort at the end of the study date (12-31-77) is presented in Table II. Over 96 percent of the study population were determined to be either alive or deceased. For the known deceased, approximately 93 percent of the death certificates have been obtained. The remaining 7 percent of the death certificates were not obtainable even after exhaustive efforts.

Table III presents a frequency distribution of the cohort for sex, race, age at hire and length of employment. Overall, this population was predominantly white and male. The majority of the workers were in their 20's when hired. Fifty four percent of the workforce had worked less than one year. In fact, 45 percent had worked less than six months.

The cause specific mortality experience for all study subjects is presented in Table IV. None of the cause specific SMRs were significantly ( $p < .05$ ) elevated. There was a significant ( $p < .001$ ) excess of death in the unknown

category. This excess was attributable to the 7 percent of death certificates that were not obtainable (Table II). There was a deficit for all causes of death combined (SMR = 84), which was primarily due to a large deficit for diseases of the circulatory system (SMR = 62).

Sex and race specific mortality is presented in Tables V, VI, and VII.

Again, no cause specific SMRs were significantly ( $p < .05$ ) elevated. White males had a SMR that was greater than one hundred for malignancies of the genitals (SMR = 253), urinary organs (SMR = 247), diabetes mellitus (SMR = 208) and diseases of the respiratory system (SMR = 119). Black males had SMRs that were greater than one hundred for tuberculosis (SMR = 178) and for malignancies of the trachea, bronchus and lung (SMR = 181). White females had an elevated risk for diseases of the circulatory system (SMR = 246). No deaths were observed among black females.

In Tables VIII and IX, the relationship between lung cancer, duration of employment and length of followup is presented. For white males (Table VIII) no trends were evident for either duration of employment or length of follow-up. Extremely small excesses were evident for the 0-10 year and 10-20 year length of follow-up groups which had SMRs of 118 and 105 respectively. For black males (Table IX) the SMRs appeared to increase with both duration of employment and length of followup, although there were only a few deaths in each of these categories. Workers with greater than 20 years of employment had a SMR of 1250 which was statistically significant ( $p < .05$ ). The length of followup categories of 10-20 years and 20+ years had SMRs of 173 and 357

respectively.

Hospital records were obtained for the five black males lung cancer cases and confirmed the death certificate diagnosis of lung cancer. Four of the cases were confirmed histologically to be squamous cell carcinomas, and in one case no histologic information was provided. One of the cases was described as a non-smoker, two of the cases were described as smokers and the records for the other cases did not divulge their smoking habits.

Finally, in an attempt to determine whether the five black lung cancer cases shared a common exposure, their job titles were reviewed. Three of the five cases held the position of cleanup man when they first started working at the plant. There was no clustering of job titles for the position held on the last day of work. There was also no indication in the employees' personnel records that any of them had worked in the uranium recovery operation. In order to determine whether the observation that 3 of the cases were first employed as cleanup men represented a significant excess, a life table analysis was performed for black males that were first employed as cleanup men. This analysis revealed that 2.36 deaths were expected versus the 3 cases observed, yielding a SMR of 127, which was not statistically significant.

Discussion

Overall, no statistically significant increases in cause specific mortality were observed for the entire study population, or for any of the individual sex-race groups. However, when lung cancer mortality was stratified by duration of employment and length of followup there was an apparent excess among black males with greater than 10 years of employment and followup. This pattern is consistent with the effect of a respiratory carcinogen, which is expected to increase with duration of exposure, and often only appears after a latency period of about 20 years. If the analyses were restricted to black males with at least 10 years of employment and followup, this would yield a SMR of 411 which is statistically significant (p one tail < .05).

Two of the five black male lung cancer victims were among the original 3 cases reported to NIOSH. The third case is still alive. Thus, this study confirms an excess of lung cancer originally identified by a cluster. It would have been valuable to look for an excess of lung cancer at a similiar plant where there was no a priori knowledge that a cluster existed. Inferences in regard to causality must await observations by other investigations in this industry.

A possible explanation for the fact that the excess risk of lung cancer was only apparent in black males is that blacks may have been assigned to less hygienic positions, resulting in higher exposures to respiratory

carcinogens. Other studies have noted that lung cancer excesses in blacks, not seen in whites may be related to certain jobs being assigned preferentially to nonwhites (11).

Sixty percent (3/5) of the lung cancer cases among black males first worked as cleanup men at the plant, which paralleled the fact that of 690 blacks in this study 404 (59 percent) had worked as cleanup men, whereas, of 2498 whites in this study only 26 (1 percent) had held this job. This position involved cleaning the phosphoric acid reaction vessel, a task which (Table 1) may result in exposures to several potential respiratory carcinogens including chromium, arsenic, uranium and radon daughters. There was a slight lung cancer excess for this job (SMR = 127) which was not statistically significant. This excess was based upon a difference of 0.7 between the observed and expected number of deaths and may easily be a result of chance variation.

This plant is located in Polk County, which has significantly higher lung cancer mortality rates than the United States as a whole (4). However lung cancer rates in Polk County are only elevated for white males; nonwhite males during the period of 1950 to 1969 in Polk County had lung cancer rates that were 18% lower than U.S. rates (6). Therefore, the observed excess of lung cancers among black males at this plant is not a result of elevated background rates.

Although only 93 percent of the death certificates were obtained, the net effect of not ascertaining the remaining 7 percent of deaths would be to reduce the probability of detecting an effect. These deaths contributed person-time to the study without contributing disease specific deaths and would thereby inflate the expected number of deaths in the cause specific categories. We believe this effect to be minimal, since the amount of person-time contributed by these 13 subjects was small relative to the entire study population.

The majority of expected deaths in Tables VIII and IX had less than 20 years of followup, since about 93 percent of the person years in this study were in the less than 20 years of followup category, and many of the study subjects are still relatively young. The relatively short length of followup limits the ability of this study to detect an association between employment at this plant, and the risk of dying from diseases with a long latency period (e.g. lung cancer). As this population matures, the number of subjects with adequate length of follow-up (e.g. 10-20 years) will increase. Therefore, this cohort will be followed and reported on in the future.

In summary, a statistically significant excess in lung cancer mortality was observed among black males in the longest duration of employment and followup categories. Although the small number of deaths involved preclude any conclusion, this finding is suggestive of a possible association with occupational exposure. A slight excess was found for black males that first started as cleanup men. However, this excess was not statistically

significant, and may very well have been due to chance variations. The followup of this study population will be continued, since it is still fairly young. Inferences of causality are undermined by our prior knowledge of the lung cancer cluster and the small number of deaths involved. Other investigations in plants with similar exposures are needed to clarify whether an occupationally related lung cancer excess really exists.

TABLE I

Environmental Data - Personal and Area Samples  
mg/m<sup>3</sup>

	Number of Samples	Range	Average
Fluoride	7	0.02 - 13.24	3.39
Sulfuric Acid	8	0.013 - 0.22	0.11
Phosphoric Acid	8	0.03 - 0.52	0.25
Cadmium	11	0.002	0.002
Chromium (total)	11	0.001 - 0.02	0.002
Uranium	2	0.005 - 0.014	0.010
Vanadium	11	0.01	0.01
Arsenic	4	0.001	0.001

Radon Daughter Sample Results

Number of Samples	Counts per minute (range)	Working Level* (range)
7	0 - 25	0.00 - 0.02

\*Working Level is defined as any combination of short-lived radon-222 daughters, polonium-218, lead-214, bismuth-214, and polonium-214, in one liter of air, without regard to the degree of equilibrium, that will result in the ultimate emission of  $1.3 \times 10^5$  MeV of alpha particle energy.

TABLE II  
VITAL STATUS  
(As of 12-31-77)

	NUMBER	PERCENT
Known to be alive	2,910	91.0
Known to be deceased	176	5.5
Death certificates obtained	163	
Death certificates outstanding	13	
Not known to be alive or deceased	113	3.5
	3,199	100

TABLE III  
Sex, Race, Age and Length of Employment  
Distribution of Study

	NUMBER	PERCENT
Sex		
Male	2981	93.2
Female	212	6.6
Unknown	6	.2
Race		
White	2498	78.1
Black	690	21.6
Other	11	.3
Age at Hire*		
18 to 28	1973	61.7
28 to 43	1022	31.9
43 to 58	159	5.0
58+	4	.1
Unknown	41	1.3
Length of Employment		
0 to <1 year	1733	54.2
1 to <10 years	1028	32.1
10 to <20 years	312	9.8
20+ years	87	2.7
Unknown	39	1.2

\*Age when subjects began work at the facility

TABLE IV  
Cause Specific Mortality For All Study Members

CAUSE OF DEATH	OBSERVED	EXPECTED	SMR**	90 PERCENT CONFIDENCE*** INTERVAL
Tuberculosis	2	1.63	123	22,386
All malignant neoplasms	22	28.99	76	51,108
Buccal cavity & pharynx	0	1.08	—	—
Digestive Organs & Peritoneum	3	7.23	41	11,107
Larynx	0	.43	—	—
Trachea, Bronchus & Lung	10	8.85	113	61,192
Other parts of the Respiratory system	0	.15	—	—
Breast	1	.55	—	—
Female Genital Organs	0	.36	—	—
Male Genital Organs	2	1.09	183	33,578
Urinary Organs	2	1.10	182	32,572
Lymphatic & Hematopoietic	2	3.78	53	09,167
Other & Unspecified Sites	2	4.40	98	08,143
Benign & Unspecified Neoplasms of the brain	0	.43	—	—
Diabetes Mellitus	4	2.58	155	53,355
Diseases of the Blood & Blood forming organs	0	.74	—	—
Psychoneurotic, Personality & Mental Disorders	0	2.92	—	—
Diseases of the Nervous System	3	8.73	34	09,89
Diseases of the Circulatory System	36	54.56	66	49,87
Diseases of the Respiratory System	5	7.93	63	25,133
Diseases of the Digestive System	2	9.66	21	04,65
Diseases of the Genito-urinary system	2	2.27	88	16,277
Diseases of the Skin	0	.23	—	—
Diseases of the Bone & Organs of Movement	0	.13	—	—
Accidents & Violence	54	53.94	100	79,126
Unknown	16	4.30	372*	233,565
All others	9	9.66	93	49,163
All deaths	155	189.51	82	71,93

\*p (one tail) < .001

\*\* SMRs were not calculated for death categories with only one death.

\*\*\* Fischer exact limits were used.

TABLE V  
Cause Specific Mortality For White Males

CAUSE OF DEATH	OBSERVED	EXPECTED	SMR	90 PERCENT CONFIDENCE* INTERVAL
Tuberculosis	0	.47	—	—
All malignant neoplasms	15	18.72	80	49,123
Buccal cavity & pharynx	0	.61	—	—
Digestive Organs & Peritoneum	3	4.39	68	19,117
Larynx	0	.25	—	—
Trachea, Bronchus & Lung	5	5.90	85	33,178
Other parts of the Respiratory system	0	.10	—	—
Male Genital Organs	2	.79	253	45,797
Urinary Organs	2	.81	247	44,777
Lymphatic & Hematopoietic	2	2.72	74	13,231
Other & Unspecified Sites	1	3.15	—	—
Benign & Unspecified Neoplasms of the brain	0	.28	—	—
Diabetes Mellitus	3	1.44	208	57,538
Diseases of the Blood & Blood forming organs	0	.29	—	—
Psychoneurotic, Personality & Mental Disorders	0	1.09	—	—
Diseases of the Nervous System	1	4.21	—	01,113
Diseases of the Circulatory System	26	36.49	71	50,99
Diseases of the Respiratory System	5	4.21	119	47,250
Diseases of the Digestive System	1	5.22	—	—
Diseases of the Genito-urinary system	1	.98	—	—
Diseases of the Skin	0	.10	—	—
Diseases of the Bone & Organs of Movement	0	.08	—	—
Accidents & Violence	30	30.10	100	72,135
Unknown	6	1.72	349	152,689
All others	6	5.43	110	48,218
All deaths	94	110.84	88	71,101

\*p (one tail) < .01

\*\* SMRs were not calculated for death categories with only one death.

\*\*\* Fischer exact limits were used.

TABLE VI  
Cause Specific Mortality For Black Males

CAUSE OF DEATH	OBSERVED	EXPECTED	SMR	90 PERCENT CONFIDENCE* INTERVAL
Tuberculosis	2	1.12	178	32,562
All malignant neoplasms	6	8.38	72	31,141
Buccal cavity & pharynx	0	.45	—	—
Digestive Organs & Peritoneum	0	2.50	—	—
Larynx	0	.17	—	—
Trachea, Bronchus & Lung	5	2.76	181	71,381
Other parts of the Respiratory system	0	.05	—	—
Male Genital Organs	0	.30	—	—
Urinary Organs	0	.26	—	—
Lymphatic & Hematopoietic	0	.89	—	—
Other & Unspecified Sites	1	1.05	—	—
Benign & Unspecified Neoplasms of the brain	0	.12	—	—
Diabetes Mellitus	1	1.01	—	—
Diseases of the Blood & Blood forming organs	0	.33	—	—
Psychoneurotic, Personality & Mental Disorders	0	1.79	—	—
Diseases of the Nervous System	2	4.11	49	09,153
Diseases of the Circulatory System	7	16.78	42	20,78
Diseases of the Respiratory System	0	3.49	—	—
Diseases of the Digestive System	1	4.15	—	—
Diseases of the Genito-urinary system	1	1.19	—	—
Diseases of the Skin	0	.11	—	—
Diseases of the Bone & Organs of Movement	0	.04	—	—
Accidents & Violence	24	23.00	104	72,147
Unknown	9	2.49	361	189,631
All others	2	4.66	43	08,135
All deaths	55	72.78	76	60,95

\*p (one tail) <.001

\*\* SMRs were not calculated for death categories with only one death.

\*\*\* Fischer exact limits were used.

TABLE VII  
Cause Specific Mortality For White Females

CAUSE OF DEATH	OBSERVED	EXPECTED	SMR**	90 PERCENT CONFIDENCE*** INTERVAL
Tuberculosis	0	.03	—	—
All malignant neoplasms	1	1.84	—	—
Buccal cavity and pharynx	0	.02	—	—
Digestive Organs & Peritoneum	0	.33	—	—
Larynx	0	.01	—	—
Trachea, Bronchus & Lung	0	.19	—	—
Other parts of the Respiratory system	0	0	—	—
Breast	1	.50	—	—
Female Genital Organs	0	.34	—	—
Urinary Organs	0	.03	—	—
Lymphatic & Hematopoietic	0	.17	—	—
Other & Unsuspected Sites	0	.23	—	—
Benign & Unspecified Neoplasms of the brain	0	.03	—	—
Diabetes Mellitus	0	.12	—	—
Diseases of the Blood & Blood forming organs	0	.03	—	—
Psychoneurotic, Personality & Mental Disorders				
Diseases of the Nervous System	0	.38	—	—
Diseases of the Circulatory System	3	1.22	246	67,636
Diseases of the Respiratory System	0	.22	—	—
Diseases of the Digestive System	0	.27	—	—
Diseases of the Genito-urinary system	0	.09	—	—
Diseases of the Skin	0	.02	—	—
Diseases of the Bone & Organs of Movement	0	.01	—	—
Accidents & Violence	0	.79	—	—
Unknown	1	.08	—	—
All others	1	.42	—	—
All deaths	6	5.57	108	47,213

\*\* SMRs were not calculated for death categories with only one death.

\*\*\* Fischer exact limits were used.

TABLE VIII I  
 Length of Followup & Duration of Employment at the Plant for  
 Malignancies of the Trachea, Bronchus & Lung Among White Males

Duration of Employment (Years)				
Length of Followup (Years)	0 - 10	10 - 20	20 +	Total
0 - 10				
Observed	2	0	0	2
Expected	1.69	0	0	1.69
SMR*	118	-	-	118
10 - 20				
Observed	2	1	0	3
Expected	1.91	.95	0	2.86
SMR*	105	-	-	105
20 +				
Observed	0	0	0	0
Expected	.97	.17	.22	1.36
SMR*	-	-	-	-
<hr/>				
Total				
Observed	4	1	0	5
Expected	4.57	1.12	.22	5.91
SMR*	88	-	-	85

\*SMRs were not computed for categories with only one death.

TABLE IX  
 Length of Followup & Duration of Employment at the Plant  
 for Malignancies of the Trachea, Bronchus & Lung Among Black Males

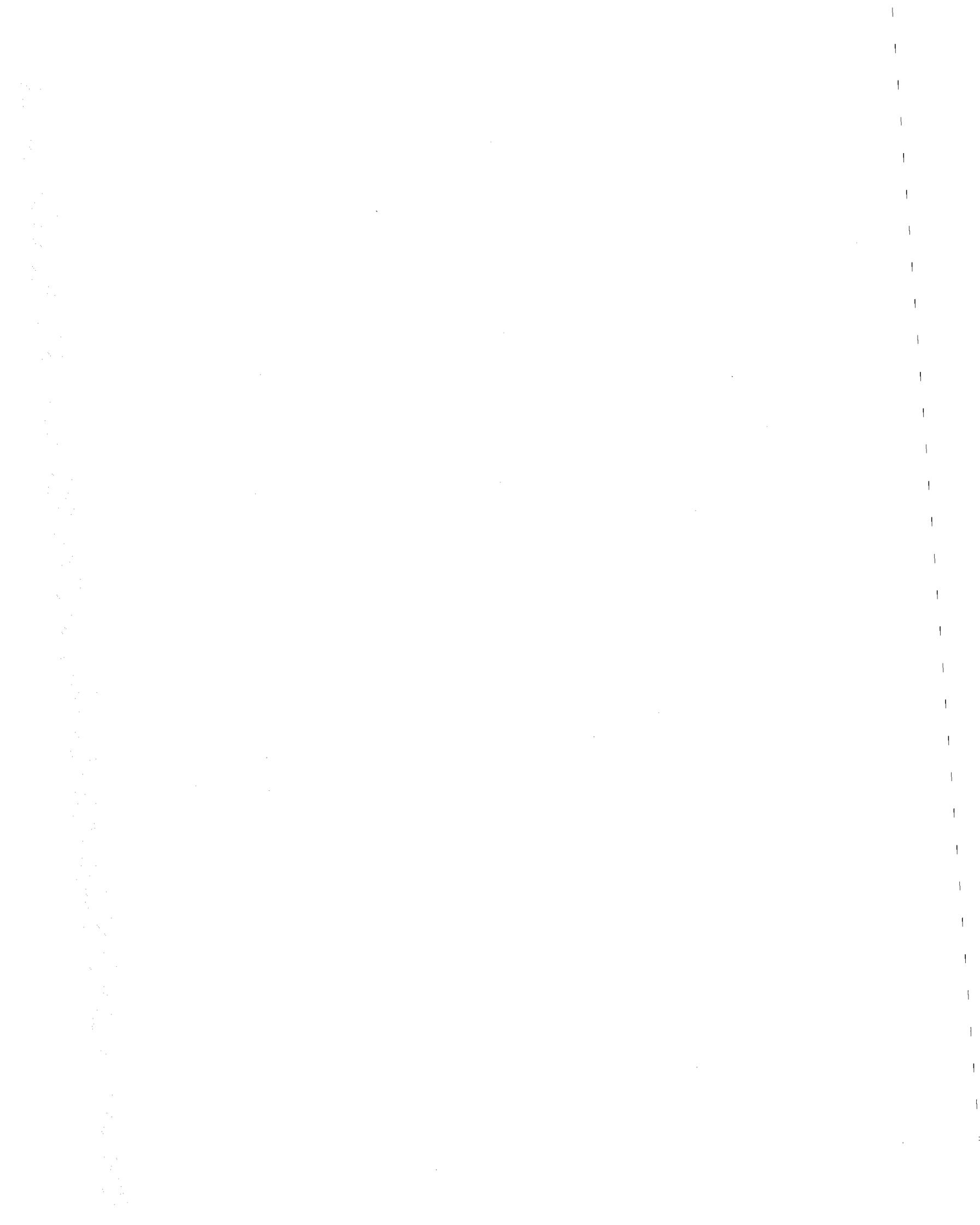
Length of Followup (Years)	Duration of Employment (Years)			Total
	0 - 10	10 - 20	20 +	
0 - 10				
Observed	0	0	0	0
Expected	0.45	0	0	.45
SMR*	-	-	-	-
10 - 20				
Observed	2	1	0	3
Expected	1.21	0.52	0	1.73
SMR*	165	-	-	173
20 +				
Observed	0	0	2	2
Expected	0.35	0.05	0.16	0.56
SMR*	-	-	1250 **	357
<hr/>				
Total				
Observed	2	1	2	5
Expected	2.01	0.57	0.16	2.74
SMR*	100	-	1250 **	182

\*SMRs were not calculated for categories with only one death.

\*\*p (one tail) < .05

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<b>16. Abstract (Limit: 200 words)</b> <p>The mortality experience of workers in the phosphate fertilizer industry (SIC-5191) was evaluated. A retrospective cohort study was conducted to determine if workers had an increased risk of lung cancer. A total of 3160 workers were investigated. The vital status of study subjects was determined from data provided by the Social Security Administration, the Internal Revenue Service, and the Florida Department of Motor Vehicles, and death certificates. Company records were examined in order to obtain a demographic file. Life table analysis was performed and standard mortality ratios (SMRs) were calculated. None of the cause specific SMRs were significantly elevated. For white males no trends associated with lung cancer were evident for either duration of employment or length of followup. For black males, the SMRs appeared to increase with both duration of employment and length of followup, although there were only a few deaths in each of these categories. The authors conclude that there was a statistically significant excess in lung cancer mortality among black males in the longest duration of employment and followup categories. Although the small number of deaths involved preclude generalizing from this result, the finding is suggestive of a possible association with occupational exposure.</p>			
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