LONG-TERM MORTALITY EXPERIENCE OF STEELWORKERS

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ABSTRACT

This study continues the study of long-term, cause-specific mortality patterns of employees of 7 Allegheny County, Pennsylvania steel plants, 1953-1975, and of coke oven workers for 10 non-Allegheny County plants, 1951-1975. The study includes analyses of mortality patterns for 57 work areas in the Allegheny County plants and an analyses of coke plant workers, in the non-Allegheny plants, emphasizing malignant neoplasms and nonmalignant respiratory diseases. Major findings for the Allegheny County coke plant workers are: 1) among coke oven workers, kidney cancer mortality remains elevated, primarily for white workers; 2) among all workers mortality from nonmalignant respiratory diseases has increased with observation time; and 3) among nonoven workers in these plants, excesses in pancreatic, large intestine, buccal cavity and pharyngeal cancers are consistent with previous findings. Updated mortality analyses for 10 non-Allegheny County plants indicate: 1) lung cancer mortality remains comparable between white and black coke oven workers; 2) an elevated relative risk for lung cancer was observed in 9 of these 10 plants, and 3) no evidence presently exists in these plants for excess mortality from nonmalignant respiratory diseases.

TABLE OF CONTENTS

I. INTRODUCTION

In 1962 the Department of Biostatistics, University of Pittsburgh, initiated a study under contract with the National Cancer Institute to examine what relationships, if any, existed between occupational exposures in the steel plants and cause specific mortality among workers, with particular reference to respiratory cancers. This first phase was carried out by Dr. J. W. Lloyd, an epidemiologist-biometrician with the National Cancer Institute, and under the direction of Dr. Antonio Ciocco, chairman of the Department of Biostatistics, University of Pittsburgh. Cooperation from the steel plants had been obtained through the considerable assistance of Drs. John D. Lauer and Robert Halen of Jones and Laughlin Steel Corporation, and Drs. Robert O'Connor and Merle Bundy of United States Steel Corporation. The cohort identified and followed for mortality consisted of all men employed in 1953 by three firms at seven steel plants in Allegheny County and represented approximately 62 percent of all men working in basic iron and steel production in the county in 1953. The first phase of this study consisted of collecting and processing detailed work histories for the approximately 59,000 men employed at these plants in 1953. All deaths among the study cohort during the years 1953 to 1961 were ascertained and cause of death verified by a copy of the death certificate. Analysis of the overall and specific mortality for 57 work areas within the industry revealed:

1) As expected, the average annual mortality rates of steelworkers were lower than those of the male population of the county in which the plants are situated; and

2) Several work areas, in particular, the coke plant, exhibited an unusual mortality experience in contrast to that of workers in other areas within the steel plants.

Further comprehensive analyses were carried out which confirmed an excess risk of lung cancers among black men employed at the coke ovens and suggested an excess of cancers of the digestive system among coke plant workers employed in the by-product and coal handling areas.

In 1966 the initial findings for coke oven workers were reported to a joint meeting of the American Iron and Steel Institute Committees on Industrial Health and Industrial Hygiene. After examination of the data, the committees agreed that the study should be expanded in order to evaluate further the extent to which the coke oven population, particularly its non-white segment, is at risk of developing lung cancer. It was also suggested that Mr. Leo Teplow, who was Vice President of the American Iron and Steel Institute and had presided over the meeting, take appropriate action.

At about the same time, Dr. Lloyd was transferred to the newly created National Institute of Environmental Health Sciences, which accepted the steelworkers study as part of its program and undertook to fund an extension of the work. Meanwhile, Mr. Teplow negotiated a grant from the American Iron and

Steel Institute to help defray the cost of extending the project and secured for us the cooperation of the officials of the additional steel plants that satisfied the requirements of the expanded coke oven worker study. Dr. Carol K. Redmond joined the Department of Biostatistics faculty in January, 1967, in order to supervise and evaluate this next phase of the study. In 1967 data collection began at ten selected plants in diverse parts of the United States and Canada.

In order to facilitate comparisons, methods of data collection, processing, and analysis in this study are as compatible as possible with the original investigation. In Allegheny County all men employed in seven plants during 1953 comprised the cohort for study, thus allowing for comparisons of coke oven worker mortality with that of the total steelworkers' population. A study of the same magnitude was not feasible in the expansion of the study to a larger geographic area.

Since primary interest was focused on coke oven workers, we included as study subjects all men at the ten study plants who had worked at the coke ovens at any time in the five year period 1951 through 1955. This group had the advantage of allowing for a period of follow-up comparable in time to the study county cohort, where requirement for inclusion was employment in 1953. A five year time span was selected for defining the cohorts in order to increase the size of the coke oven samples for the plants. Men working only in the coal and coke handling or by-product areas of the coke plant were not included, due to Lloyd's observation that these men were not subject to an excess risk of respiratory cancer. The observation period for vital status was 1951 through 1966. An additional aspect of this investigation was extension of follow-up on the Allegheny County cohort through 1966.

The results of this investigation confirmed an excess mortality from respiratory cancers among coke oven workers in other geographic areas and indicated that both white and nonwhite workers are at risk. The apparent differences between white and nonwhite oven workers in Allegheny County appear to be attributable primarily to a lesser exposure among the whites studied. Further, certain work areas in addition to the coke plant, were indicated for the Allegheny county cohort where further exploration was warranted. Accordingly, the present contract was negotiated in July, 1971, with the National Institute for Occupational Safety and Health. Its primary goal was to attempt to delineate which significant mortality findings for specific work areas might be due to occupational factors and which were likely to reflect other factors, such as selection for health or chance variation. A second goal was the evaluation of the lung cancer risk among crane operators, to clarify earlier reports in the literature of excess lung cancer among crane operators in the "hot metals" industry. A third objective was to carry out methodological studies since this large scale industrial cohort provided a unique opportunity to assess various approaches to the study of occupational hazards. Finally, because of interest in clarifying the role of smoking as a factor influencing steelworkers' mortality, a more recent cohort (1961) was selected with the intention of obtaining data relative to smoking from the plant medical record. Unfortunately, the medical records were found to be too incomplete with respect to smoking

histories to be used; subsequently, collection of data on smoking habits was eliminated from the contract work scope, although employment histories and follow-up through December 31, 1970, was obtained for all men employed at the original plants in 1961. For comparative purposes the 1953 cohort's employment records and vital status was also updated through 1970. Detailed reports of the analyses for this work were completed and submitted in June, 1974, and September, 1975. Findings from this phase will be presented and discussed as appropriate in other sections of this report; hence, they are not summarized here. Previous accomplishments of note under this contract include:

1) The epidemiological studies of coke oven workers through the 1970 update for Allegheny County formed the basis for the development of a standard for exposure to coke oven emissions by the Occupational Safety and Health Administration in 1977.

2) The methods for study design, data collection, processing, and follow-up developed in the various phases of this study have been adopted by many other occupational epidemiologists in carrying out their own studies.

3) The cause specific mortality experience of steelworkers, in conjunction with field surveys of heat stress and physical exertion, provided the only data available for the long-term health effects of heat. From June, 1974, through December, 1976, under a separate contract with NIOSH (Contract Number CDC-99-74-114), an investigation was carried out to determine whether any mortality risk, especially cardiovascular, exists following prolonged heat exposures and to explore possible interactions between heat stress, physical exertion, and disease. Methods employed in this study illustrate the unique opportunity to use and build upon this large scale longitudinal cohort to answer a broad variety of questions related to occupational health.

4) Evaluations of common study designs and analytic procedures, such as retiree cohorts, PMRs versus SMRs, and multiple causes of death, have contributed to the methodology for occupational epidemiology.

These data have been the material for numerous publications, presentations, and student essays and dissertations. A bibliography is provided in Appendix A.

Recognizing the importance of continuing this research, an extension of this contract was funded in September, 1976. The work accomplished during this most recent phase is reported here. The work scope for the period from September, 1976, to present has included updating the mortality for the Allegheny County cohort through 1975 and extending the observation period for the ten non-Allegheny County coke oven plants from 1966 through 1975. Since the amount of monies available from NIOSH were limited, the decision was made, with the concurrence of the project officer, to update vital status only. Work histories during the period 1971-1975 for the Allegheny County

workers and during the period 1967-1975 for the non-Allegheny County workers were not updated. Thus, all assignments to specific work sites have been based on prior employment information on file. This introduces some limitation on the examination of more specific delineations of dose response relationships.

Purpose of Present Work

The primary objective of the current report is to provide additional information to answer questions engendered by the research discussed above. Sepcifically, our aims are:

1) To continue the comprehensive analysis of mortality by work area in order to clarify earlier findings and to draw more definitive inferences where numbers permit. Part II of this report presents the mortality patterns through 1975 for the 57 work areas represented in the Allegheny County cohort.

2) To carry out analyses of the cause specific mortality of coke plant workers with emphasis on the deaths from malignant neoplasms of various sites and nonmalignant respiratory diseases in the major subdivisions of the coke plant. An important issue to be addressed is the inter-plant variability in lung cancer risks among the coke oven workers. For several non-Allegheny plants that began operation in the 1940s, the additional follow-up should assist us in identifying whether excess deaths from lung cancer begin to occur after lapse of a sufficient latent period. Comparison of the cancer risks for more recent time periods to those in the earlier follow-ups provides some assessment of the short term impact of protective devices, work practices and equipment changes introduced by the steel industry subsequent to our first reports on coke oven workers. Part III of this report contains a detailed analysis of the updated results for the two Allegheny County coke plants, while Part IV provides the results for the coke oven cohorts at the ten non-Allegheny County plants.

3) To present additional work on the development and comparison of different methodological techniques to identify and to test hypotheses related to safety and health hazards in the occupational environment. Part V of this report summarizes the time trends in the Standardized Mortality Ratios (SMRs) for all Allegheny County steelworkers and each of the major work areas using the United States male rates as the standard. Of particular concern is the role selection for health plays in such comparisons as the observation time is extended. In addition, copies of several methodological papers published or presented during the course of this contract are given in Appendix B.

Finally, in the Summary and Recommendations, we indicate the directions which we feel would be most relevant for future research pertinent to identifying and/or evaluating health hazards affecting steelworkers.

METHODS AND MATERIALS

Details of the procedures for data collection and follow-up have been given in a number of publications; in particular the first and third papers in the series appearing in the Journal of Occupational Medicine describe fully the original design for the Allegheny County study (see Appendix A). A brief review is presented here to facilitate an understanding of the information presented in this report. Since the same general approach was used for the study of plants outside of Allegheny County, the methods given below will be discussed for Allegheny County. Where differences exist in study design, these will be described in Part IV, where the findings for non-Allegheny plants are presented.

Definition of the Cohort

As indicated earlier, the Allegheny County cohort consists of all male employees working at the seven plants in 1953. Several procedures were used in determining this cohort. At some plants complete rosters were available for all men employed in 1953, while at others such a roster had to be completed by collating current rosters with weekly or monthly lists of terminations and retirements dating back to 1953. The 58,821* records included in this study represent only a small segment of the total records screened. For example, at one of the plants the inactive file, dating back to 1900, consisted of approximately 100,000 records from which records of those meeting the study criteria had to be located.

In addition to employment in 1953, the men selected for the study had to meet certain other eligibility criteria:

1) The workers had to have been employed for at least 30 consecutive days; and

2) Men hired as summer replacements only were not eligible.

Both hourly and salaried workers were included in the cohort.

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*This is seven less than in earlier publications. At the time of the 1970 update, seven records were determined to be ineligible and have now been excluded. Of these, five were females whose first name was not given on the original employment record, one individual was on the file twice under two different social security numbers, and one was a summer replacement only. During the process of screening these same files for individuals employed in 1961 in connection with the 1970 update phase, an additional 593 individuals were identified who also met the criteria for inclusion in the 1953 cohort. This indicates that only 1 percent of the cohort was missing in the initial screening; these records have not been included in the analyses here, primarily to preserve comparability with earlier work.

For the initial data collection phase a multipurpose survey form was designed for transcription of basic information, for use as a follow-up reference form, and as a code sheet for items requiring translation prior to keypunching (Figure 1). Rapid gathering of information was further facilitated by the inclusion of a number of codes on the survey form. This allowed for maximum coding of data at the time of transcription from the personnel file. Information transcribed from the personnel records included a complete work history from time of first employment with the specific firm through 1961, birth place of employee and his parents, race, marital status, and identifying information used for follow-up. For work histories which were too extensive to be recorded on the survey sheet, continuation sheets were attached. In the extension of the study outside Allegheny County, the employment records were microfilmed rather than abstracted.

Reproductions of the microfilmed histories of all men selected for the study were then prepared. Reproductions were inserted in an envelope, with a specially printed coding form printed on the front jacket that was compatible in format to the original Allegheny County survey forms (Figure 2). The back of the envelope was utilized for summarizing pertinent follow-up information for those men who left employment prior to the cut-off date for observation. This second approach to data collection and processing has proven to be exceptionally efficient and time saving for the project.

Another aspect of processing which required considerable thought in design was a method for coding and classification of workers' occupations. In the present study the task was made more difficult by changes in job title terminology over an extended period of time, and by varying usage within the several firms cooperating in the study. Since each man in the study was employed in 1953, the 1953 edition of the Job Description and Classification Manual for the steel industry was used to assist in defining work areas and specific job titles.[1] Early review of work sheets returned from the plants revealed that this code would be inadequate for our purpose, as many job titles and work areas were not in the manual. Because of the unique titles used at each of the plants, especially in prior years, it was necessary to set up a system for translating diverse titles into synonymous terms.

To that end, lists of unique job titles and work areas were sent to each personnel office, with the request that they provide a translation in terms of currently used titles, or indicate that the job could not be included under the current classification. From this information listings of translations and newly assigned numbers were provided for the study staff engaged in job coding. Under the system finally developed, each job title or abbreviation was assigned a specific four digit code, which identified the occupation as belonging to one of ten basic groups or 76 subgroups within the steel industry. Approximately 14,000 distinct titles or abbreviations were noted during the initial assignment of job title numbers. Additional job codes have been added as new jobs were encountered during the various updates. As mentioned earlier, work histories have not been collected during the extension of the mortality through 1975.

Follow-up Methods

Systematic procedures for following workers who terminated employment during the observation period have been devised for this study. The third paper in the Journal of Occupational Medicine gives a detailed description and evaluation of the highly successful follow-up scheme employed for the first phase. Essentially the same scheme has been used for the more recent updates, with some modifications to improve the efficiency of the operation and/or accuracy of the information obtained.

The anticipated sequence of follow-up steps for the current phase are summarized in Figure 3. As Level 1 in Figure 3 shows, the first step in the follow-up operations was to obtain more recent information from the seventeen plants. Excellent cooperation was given by all but two of the plants in the original studies. One firm, which had nine plants in the study, furnished us with computer tapes for matching that contained information for all currently active workers and recent retirees at the nine plants. Of the two plants where permission to return was not readily granted, one eventually agreed to participate, but the second, a non-Allegheny County plant with the fewest records in the study, refused to provide follow-up information. Since the number of workers was small, only 247, we felt it would be feasible to obtain follow-up information from alternate sources and discontinued our efforts to solicit the assistance of plant personnel. Only two non-oven workers have been lost to follow-up at this plant.

The plan was to have federal agencies, within the confines of confidentiality, assist in ascertaining vital status for those men who had left employment. Because of the large number of records involved in the relatively small study staff, the initial follow-up through Internal Revenue Service was important for reducing the number to be followed through later sources. Second, in previous updates of the mortality, Social Security Administration specified the social security numbers of individuals whose vital status was not known to the source. Unfortunately, the current follow-up began just as the various federal and other agencies were concerned with developing new guidelines to comply with the Privacy Act. Internal Revenue Service decided that it could no longer provide record linkage for research purposes. Social Security Administration, while continuing to supply information for deaths, would no longer identify the status unknowns. Although both agencies have recently changed their initial positions to permit access to information needed for health research projects, these modifications came too late to allow us to utilize these resources optimally. Further, other local and federal sources that previously assisted in our efforts, such as Veterans Administration, were unwilling to provide us with follow-up information. Thus, we found ourselves following many more individuals than anticipated by the less efficient and more time consuming, costly methods shown in Level 3 of Figure 3. This prolonged considerably the time required to complete the follow-up and to obtain death certificates. One resource that had not been utilized in earlier phases was the Department of Motor Vehicles for the various states. We were able to resolve many of the "lost to follow-up" within the last few months by establishing a match based on dates of driver's license renewal or traffic violations.

The results of our intensive follow-up efforts are summarized in Figure 1 (Part II) for the Allegheny County steelworkers and in Figure 1 and Table 1 (Part IV) for the non-Allegheny County workers. Although our losses are still relatively small, they are greater than for previous updates, primarily because of the reasons cited above.

When we ascertained that a worker had died prior to January 1, 1976, information on the cause of death was obtained from the appropriate state or local office of vital statistics. For individuals dying in Pennsylvania, the cause of death was transcribed from the death certificates on file at the State Division of Vital Statistics; for individuals dying in other states or Canada, a copy of the death certificate was obtained. The State Department assisted in the verification of deaths occurring outside the United States or Canada.

The underlying cause of death in the most recent update was coded for all decedents according to both the Seventh and the Eighth Revision of the International List, whereas earlier deaths were coded according to the Seventh Revision which was in effect at the time the study was initiated.[2] [3] All deaths in this study have been coded by the same nosologist, Mrs. Marian Heid. Internal comparisons among the steelworkers' job groups are based on the classification of cause of death according to the Seventh Revision. In comparisons to the general United States population involving Standardized Mortality Ratios, the steelworkers have been classified according to the Seventh Revision, but the Eighth Revision codings have been used to derive comparability ratios required for the population rates (See Part IV).

Statistical Methods

Tables have been constructed for each job group by classifying the workers by interest or comparison group, race, age at entry to the study, and calendar years of follow-up: 1953-1957*, 1958-1962, 1963-1967, 1968-1972, 1973-1975, and, when applicable, by plant and length of experience. An expected number of deaths from a selected cause of death was calculated for each stratum specified above, under the assumption that workers in the interest and control groups have the same death rate within each stratum. The total expected number of deaths is the sum of the specific rates for the total workers in the stratum multiplied by the number of workers at risk in the interest group. The estimated relative risk (or weighted odds ratio) is a weighted average of the estimated risks within each stratum, with the weights approximately proportional to the stratum precision. Because the relative risk is a weighted average, it cannot be obtained directly by dividing total observed deaths by the total expected deaths. To test whether the relative risks differ significantly from one, a summary chi-square with one degree of freedom has been calculated.[4] [5]

Whenever a large number of significance tests are performed, some will be significant due to chance variation. Further, the problem of

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*The year 1951 was used for non-Allegheny County plants.

multiple comparisons arises, and the significance levels resulting tend to be too low. Therefore, significance levels should not be overstressed, but rather serve as a guide, with close examination of the consistency of significant findings.

REFERENCES

1. United Steelworkers of America: CIO and United States Steel Corporation. Job Description and Classification Manual, 1953.

2. Manual of the International Statistical Classification of Diseases, Injuries, and Cause of Death. WHO, Geneva, Switzerland. Seventh Revision, 1957.

3. Eighth Revision International Classification of Disease. adopted for use in the United States. D.H.E.W., P.H.S., National Center for Health Statistics, P.H.S. Publication No. 1693, 1968.

4. Mantel, N., and Haenszel, W.: Statistical aspects of the analysis of data from retrospective studies of disease. J. Nat. Cancer Inst., 32:719-748, 1959.

5. Mantel, N.: Evaluation of survival data and two new rank order statistics arising in its consideration. Cancer Chemother Rep., 50:163-170, 1966.

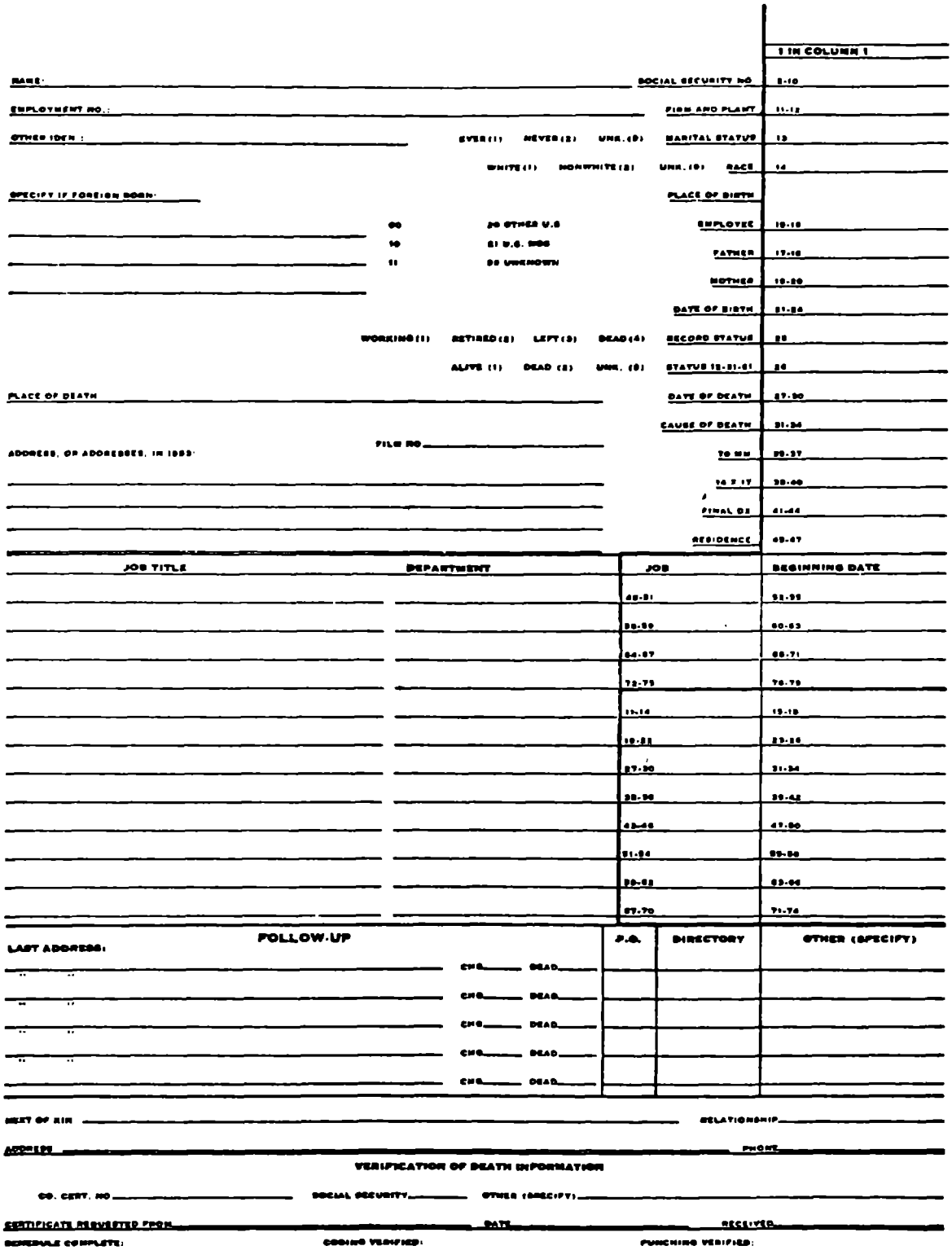


Fig. 1. Survey form.

PITT 1120 (8/67)

STEELWORKERS MORTALITY STUDY

Duplicate record — Example only

NAME						CARD NO 1	SOC. SEC. NO.
FIRM AND PLANT	11-12		16-21		27-30	46-51	52-55
MARITAL STATUS	13		BLANK	DATE OF DEATH			
RACE	14	DATE OF BIRTH	21-24	CAUSE OF DEATH	31-34	56-59	60-63
PLACE OF BIRTH	15-16	RECORD STATUS	25		BLANK	64-67	68-71
STATE OF BIRTH	17-18	STATUS 12-31-64	26	NUMBER OF EVENTS	46-47	72-75	76-79

ADDITIONAL WORK HISTORY

CARD No. 2 (COL. 1)			CARD No. 4 (COL. 1)			CARD No. 6 (COL. 1)		
JOB CODE	BEGINNING DATE		JOB CODE	BEGINNING DATE		JOB CODE	BEGINNING DATE	
11-14	15-18	(5)	11-14	15-18	(21)	11-14	15-18	(37)
19-22	23-26	(6)	19-22	23-26	(22)	19-22	23-26	(38)
27-30	31-34	(7)	27-30	31-34	(23)	27-30	31-34	(39)
35-38	39-42	(8)	35-38	39-42	(24)	35-38	39-42	(40)
43-46	47-50	(9)	43-46	47-50	(25)	43-46	47-50	(41)
51-54	55-58	(10)	51-54	55-58	(26)	51-54	55-58	(42)
59-62	63-66	(11)	59-62	63-66	(27)	59-62	63-66	(43)
67-70	71-74	(12)	67-70	71-74	(28)	67-70	71-74	(44)

CARD No. 3 (COL. 1)			CARD No. 5 (COL. 1)			CARD No. 7 (COL. 1)		
JOB CODE	BEGINNING DATE		JOB CODE	BEGINNING DATE		JOB CODE	BEGINNING DATE	
11-14	15-18	(13)	11-14	15-18	(29)	11-14	15-18	(45)
19-22	23-26	(14)	19-22	23-26	(30)	19-22	23-26	(46)
27-30	31-34	(15)	27-30	31-34	(31)	27-30	31-34	(47)
35-38	39-42	(16)	35-38	39-42	(32)	35-38	39-42	(48)
43-46	47-50	(17)	43-46	47-50	(33)	43-46	47-50	(49)
51-54	55-58	(18)	51-54	55-58	(34)	51-54	55-58	(50)
59-62	63-66	(19)	59-62	63-66	(35)	59-62	63-66	(51)
67-70	71-74	(20)	67-70	71-74	(36)	67-70	71-74	(52)

INITIALLY CODED	VERIFIED	JOBS CODED	VERIFIED	FINAL REVIEW	PUNCHING VERIFIED

STEELWORKERS MORTALITY STUDY — FOLLOW-UP

NAME		SOC. SEC. NO.
LAST KNOWN ADDRESS		PHONE NO.
NEXT OF KIN	RELATIONSHIP	FATHER'S FIRST NAME
ADDRESS		PHONE NO

MILL INFORMATION REGARDING DEATH

PLACE OF DEATH	DATE OF DEATH

SOCIAL SECURITY

SOC. SEC. CARD PUNCHED & VERIFIED	STATUS	1. ALIVE	2. DEATH CLAIM	3. OTHER (SPECIFY)
PLACE OF DEATH				DATE OF DEATH

POST OFFICE FOLLOW-UP

NEW ADDRESS	DEAD
NEW ADDRESS	APPROX. DATE OF DEATH
NEW ADDRESS	UNKNOWN OR NFA
NEW ADDRESS	
NEW ADDRESS	

OTHER FOLLOW-UP

SOURCE	1. ALIVE	2. DEATH CLAIM	3. OTHER (SPECIFY)	
PLACE OF DEATH				DATE OF DEATH
SOURCE	1. ALIVE	2. DEATH CLAIM	3. OTHER (SPECIFY)	
PLACE OF DEATH				DATE OF DEATH
SOURCE	1. ALIVE	2. DEATH CLAIM	3. OTHER (SPECIFY)	
PLACE OF DEATH				DATE OF DEATH

VERIFICATION OF DEATH INFORMATION

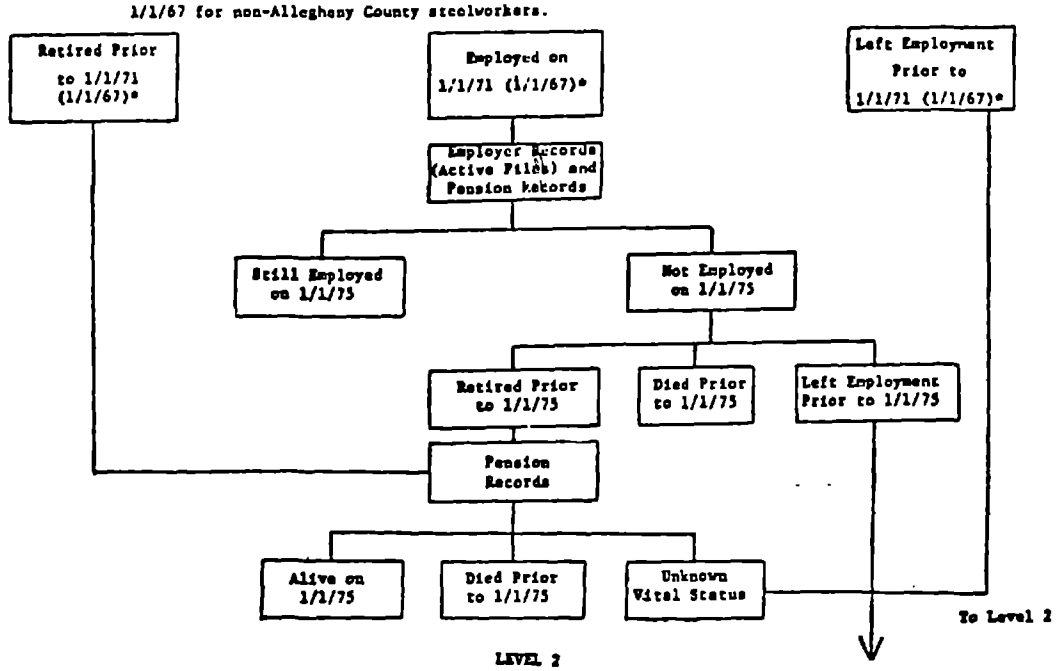
CERTIFICATE REQUESTED FROM	DATE	DATE RECEIVED	CERTIFICATE NO

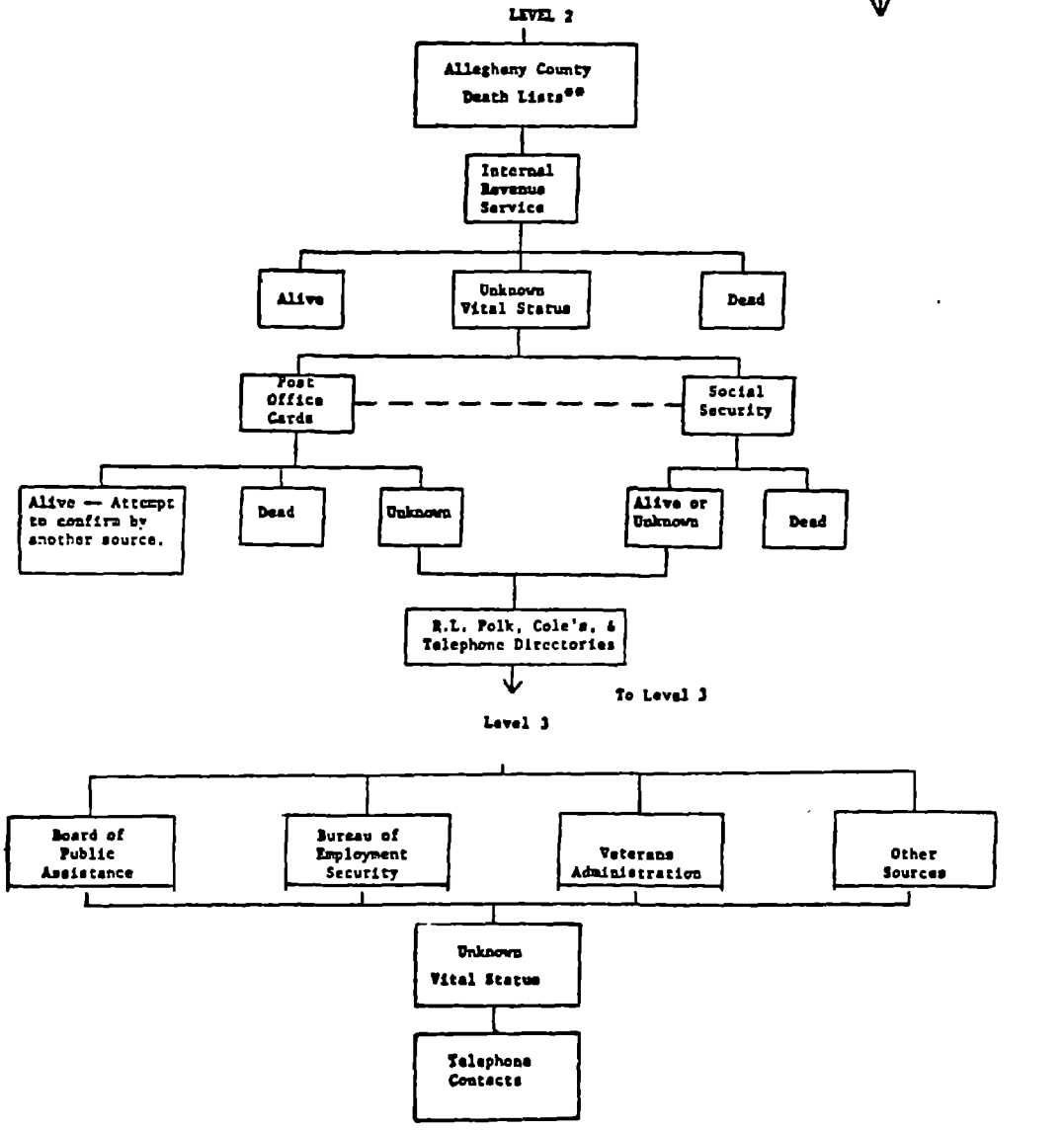
PITT - 1120 (8/67) BACK

Figure 2. SPECIALLY PRINTED ENVELOPES WITH CODING FORMS ON FRONT AND BACK.

FIGURE 3
Follow-up Flow Chart

Level 1: Follow-up involves maximum utilization of employer records and pension records to determine vital status of men known to be alive on 1/1/71 for Allegheny County steelworkers and on 1/1/67 for non-Allegheny County steelworkers.





* 1/1/71 for County workers, 1/1/67 for non-County workers

** Lists of all deaths within Allegheny County for all years, 1/1/71-12/75

SECTION II.

LONG TERM MORTALITY OF STEELWORKERS:

MORTALITY BY WORK AREA, 1953-1975

II. LONG TERM MORTALITY OF STEELWORKERS: MORTALITY BY WORK AREA, 1953-1975

INTRODUCTION

This report is a continuation of the study of long-term mortality for a large cohort of men employed in seven Allegheny County, Pennsylvania, steel plants in 1953.[1] The relationship between employment within specified areas of the steel industry and mortality from all causes is examined, based on a twenty-two year observation period, 1953-1975. Previous analyses have considered the cause-specific mortality patterns for fifty-seven work areas.[2] By comparing the number of workers from each work area whose deaths have been recorded with the number of deaths that can be predicted based on the experience of the total steelworker population, work areas with significantly higher or lower mortality are identified. Earlier studies have identified excess mortality in the following work groups:[3 4 5 6 7]

Work Area or Occupational Group	Excess Mortality Due To
Open hearth workers	Diseases of the digestive system
Coke oven workers	Respiratory cancers, kidney cancer
Sheet and tin mill workers:	
Batch pickling and sheet drying	Arteriosclerotic heart disease
Coating	Hypertensive heart disease
Heat treating and forging	Cancer of lymphatic and hematopoietic tissues
Tin finishing and shipping	Cancer of lymphatic and hematopoietic tissues
Masons:	
White workers	Non-malignant respiratory diseases, respiratory cancers
Nonwhites	Hypertensive heart disease

The purpose of the present report is to summarize the updated cause-specific mortality patterns by work area, highlighting those areas and those causes of death for which workers show significant deviations from expectation. A major aspect will be to check for consistency of the findings of this report with previous reports and publications using the data from the original cohort of steelworkers employed during 1953, and based on mortality to 1961, 1966, and 1970 respectively.[2 8 9]

METHODS AND MATERIALS

Details of the study design and data collection procedures have been described previously.[1,10] Information obtained from personnel records of the seven Allegheny County plants for each of 58,821 steelworkers employed in 1953 was used to evaluate the risks of dying from specific causes of death by each of 57 work areas. The workers were classified into work areas using three employment cohorts, which were defined as follows:

1) Employment in a particular work area based on the first job held in 1953. Men so employed are compared to all other steelworkers.

2) Employment in a particular work area based on having worked in that area for at least one month prior to or during 1953. Men so employed in a given work area are compared to steelworkers never employed in this work area through 1953.

3) Employment in a particular work area based on having worked in that area for at least five years prior to or during 1953. Men so employed in a given work area are compared to all other steelworkers having accumulated five or more years experience in the steel industry prior to or during 1953.

The total group of steelworkers in the cohort is used for comparison with the men employed in each work area because it eliminates possible bias related to employability. It has already been shown in an earlier report that the total steelworker population experienced lower mortality than the general population.[1] However, it should be recognized that selection for health may be expected to occur within specific work areas in the steel industry as well. As a result, differences in mortality by work area may not always be related to exposure from the occupational environment, and the results must be interpreted with caution.

As indicated earlier, because of the limited funding available, the contract work scope provided for updating vital status only, and information relative to job changes between 1970 and 1975 has not been obtained.

Population

A total of 58,821 steelworkers were in the 1953 cohort, defined as male workers employed at one of the seven Allegheny County steel plants sometime during 1953, and having worked a continuous period of at least one month. By the end of 1970, 36 percent of the workers were alive and still employed at one of the seven plants. Only five percent of the cohort had died while still employed by the end of 1970, and 28 percent had retired. The remaining 30 percent had otherwise left employment by the end of 1970.

Figure 1 shows the breakdown of the cohort of steelworkers at risk in 1953, classified by employment status through December 1970, with vital status updated through 1975. By the end of 1975, the number of steelworkers

confirmed to have died from the original cohort was 18,152 (31%); for 24 of these a date of death was obtained but no death certificate was received, and the cause of death had to be classed as unknown. The number of steelworkers still alive was 40,236 (68%), and the number of steelworkers whose vital status remained unknown as of the end of 1975 was 433 (0.7%). Of these 433, there is some evidence that 21 have died, but lacking confirmation from a death certificate, no date or cause of death can be coded. There is no information for the remaining 412; they must be considered lost to follow-up for the present.

FINDINGS

In Table 1 the distribution of mortality rates for the steelworkers is summarized by race and by age in 1953. The ratios for these mortality rates to those for the 1953-1966 study, and to those for the 1953-1970 study, are relatively constant for each age-race group and decline with increasing age. The mortality rates for nonwhites are consistently higher than those for white workers.

Table 2 shows the distribution of the 1953 steelworker population by employment cohort, work area, and race. It should be noted that only in the first employment cohort (first job in 1953) will there be exactly one entry per steelworker, totalling 58,821. In the second employment cohort (ever worked through 1953) there will be at least one work area classification per worker, but there may be more than one if a man worked in more than one work area prior to and including 1953. In the third employment cohort (worked 5+ years through 1953), many of the 58,821 steelworkers will not be represented as having worked in any work area for five or more years; nevertheless it is possible that a man may be represented in more than one work area if he worked at least five years in both areas prior to and including 1953.

The distribution of causes of death by race is presented in Table 3. These figures are similar to those obtained in the two previous updates. The percentages of death attributable to cancers and to cardiovascular-renal diseases by race for the two previous studies, and for the present study, are given in Table 4.

Table 4

PERCENTAGES OF DEATHS ATTRIBUTABLE TO CANCERS AND CARDIOVASCULAR-RENAL DISEASE, BY RACE

	Race					
	White			Nonwhite		
Cause of Death	1953-1966	1953-1970	1953-1975	1953-1966	1953-1970	1953-1975
All cancers	20.9%	20.8%	21.1%	22.3%	23.4%	23.3%
Cardiovascular-renal disease	55.1%	56.6%	57.0%	45.2%	46.2%	48.0%

Cause-Specific Mortality by Work Area

The mortality experience of the steelworkers is summarized by race, cause of death, and work area for relative risks which reached significance in any of the three employment cohorts.

Summary by cause of death. A summary by cause of death, employment cohort, race, and work area is given in Appendix C, Tables 01-25. Relative risks are listed for each work area which shows a statistically significant excess or deficit in one or more employment cohort. The tables in Appendix C may be used to identify work areas for which an excess or deficit mortality was observed for a particular cause of death. Table 04, for example, lists work areas which showed excess or deficit mortality from respiratory cancer.

Summary by work area. A summary by work area, employment cohort, race, and cause of death is given in Appendix D, Tables 01-48. Of the fifty-seven work areas identified, forty-eight showed statistically significant excess or deficit relative risks in one or more employment cohort, for one or more cause of death. The tables in Appendix D may be used to identify which causes of death were responsible for the excess or deficit mortality observed for a particular work area. Table 03, for example, lists those causes of death which showed excess or deficit mortality for coke plant workers.

Summary relative risk tables. Summary tables of relative risks for all the work areas, cause of death, and employment cohorts for which Appendices C and D were abstracted are presented in Appendix E. On each page the relative risks for each work area by race are given. There is a separate page for each cause of death and employment cohort combination.

In general, the mortality data provided by the update period 1970-1975 reinforce most of the findings of earlier reports with regard to cause-specific mortality patterns within individual work areas.

Coke Plant

Nonwhite coke plant workers still show significant excesses in mortality from all cancers, and most particularly from cancers of the respiratory organs. An additional fourteen respiratory cancer deaths (all from cancer of the lungs, bronchus, or trachea) were identified among the nonwhite coke plant workers ever employed through 1953. The excess respiratory cancer deaths reported are significant at the 0.01 level for all three employment cohorts.

Cancer of the kidney continues to represent a significant source of excess mortality for white coke plant workers. Based on seven deaths, one of which occurred in this update period, excess risks significant at the 0.01 level for white workers in all three employment cohorts were recorded.

The mortality data through 1975 are consistent with the trend toward an excess of deaths for white workers from nonmalignant respiratory diseases that was observed previously. The relative risks from this cause of death for both white and nonwhite workers were consistently greater than 1.0, and in fact higher for the nonwhite workers than for the white workers in each group.

However, except for all workers whose first job in 1953 was in the coke plant (RR: 1.49; $p < .05$), all of the other values fail to reach significance. The relative risks discussed above are summarized in Table 5.

Table 5

RELATIVE RISKS FOR COKE PLANT WORKERS

Cause of death (race)	Employment cohort		
	First job	Ever work	5+ years
All cancers (nonwhite)	1.65**	1.52*	1.88**
Cancer of lungs, bronchus, and trachea (nonwhite)	2.92**	2.75**	3.98**
Cancer of kidney (white)	7.60**	5.16**	11.99**
Nonmalignant respiratory diseases			
(white)	1.44	1.11	1.19
(nonwhite)	1.57	1.42	1.49
(all)	1.49*	1.19	1.28

*$p < .05$ **$p < .01$

A detailed report on coke plant workers mortality has been prepared concurrent to this one, and focuses on other variables such as age, place and time of employment within the coke plant, and length of exposure.

Iron and Steel Production

This area includes the blast furnace, open hearth, Bessemer Convertor, electric furnace, and foundry.

Open hearth. A previous report on the mortality experience of open hearth steelworkers noted a deficit in mortality from cardiovascular-renal diseases and an excess in nonmalignant diseases of the digestive system.[5] Although relative risks for these two causes of death are in the same direction as reported previously, both appear to be within the range expected by chance. It therefore appears that the findings of the previous study on open hearth workers must be qualified somewhat by the additional data from the present update.

An excess of deaths from cancer of the kidney for nonwhite workers who had ever worked in the area through 1953 was noted (RR: 5.54, $p < .05$) based on seven deaths, two of which occurred during the update period. These relative risks for open hearth workers are summarized in Table 6.

Table 6

RELATIVE RISK FOR OPEN HEARTH WORKERS

Cause of death (all races)	Employment Cohort		
	First job	Ever work	5+ years
Cardiovascular-renal disease	0.97	0.96	0.96
Nonmalignant digestive disease	1.08	1.08	1.16
Cancer of kidney (nonwhite)	--	5.54*	--

*p < .05 ** p < .01

Foundry. A previous report indicated a deficit of deaths from arteriosclerotic heart disease for white workers whose first job in 1953 was in the foundry.[9] Excess risks had been reported for white workers for cancer of genito-urinary organs, and especially for cancer of the prostate. The results of the update are consistent with the previous findings. In addition, an excess of deaths from cancer of the kidney among white workers has become significant, with two additional deaths among those who had worked there five or more years. No deaths from genito-urinary cancers have been reported among nonwhite workers. Earlier findings of excess mortality for white workers due to cancers of the lung, bronchus, and trachea failed to reach significance. The relative risks for foundry workers are summarized in Table 7.

Table 7

RELATIVE RISKS FOR FOUNDRY WORKERS

Cause of death (white)	Employment cohort		
	First job	Ever Work	5+ years
All cancers	1.27*	1.12	1.27*
Cancer of the lungs, bronchus, and trachea	1.39	0.99	1.30
Genito-urinary cancer	1.99*	1.81**	2.40**
Cancer of prostate	2.16*	1.91*	2.20*
Cancer of kidney	--	2.55*	3.68**
Arteriosclerotic heart disease	0.76*	0.92	0.83

*p < .05 **p < .01

Other areas. White blast furnace workers showed an excess risk of dying from other nonmalignant digestive diseases, and white workers whose first job in 1953 was on the electric furnace showed an excess in mortality due to cancer of the bladder and other urinary organs. The relative risks for these workers are summarized in Table 8.

Table 8

RELATIVE RISKS FOR BLAST FURNACE AND ELECTRIC FURNACE WORKERS

Cause of death (white)	Employment cohort		
	First job	Ever work	5+ years
Blast furnace			
Other non-malignant digestive disease	1.62*	1.40*	1.60*
Electric furnace			
Cancer of bladder and other urinary organs	5.42**	2.56*	--

*p < .05 **p < .01

Primary Mills

This area includes billet, bloom and slab mills, and the soaking pits. White workers in the billet, bloom and slab mills have been reported earlier to show excess mortality due to tuberculosis of the respiratory system, and "ill-defined" causes. In addition, an excess of deaths for all workers from hypertensive heart disease has been reported.[9]

Data from the most recent update period are consistent with the previous reports, with relative risks of about the same magnitude. In addition, there is a significant excess of deaths for nonwhite workers who ever worked in the billet, bloom and slab mills from vascular lesions of the central nervous system. The relative risks for workers in the billet, bloom and slab mills are summarized in Table 9.

Table 9

RELATIVE RISKS FOR BILLET,
BLOOM AND SLAB MILL WORKERS

Cause of death	Employment cohort		
	First job	Ever work	5+ years
Vascular lesions of the central nervous system (nonwhite)	1.77	1.80*	1.53
Hypertensive heart disease			
(white)	1.48	0.97	1.22
(nonwhite)	1.78	2.17*	2.31
Tuberculosis of the respiratory system (white)	2.84**	1.47	2.18
Ill-defined causes (white)	1.78*	1.45	1.96**

*p < .05 **p < .01

Secondary Mills

This area includes merchant mills, plate mill, general finishing and shipping, hot strip mill, rail mill rolling, rail mill finishing, steel yards, and structural mill.

Structural mill. In findings of earlier reports it was noted that white structural mill workers showed significant excess mortality from all causes; from cancer of the kidney; from cardiovascular-renal disease, primarily arteriosclerotic heart disease; and from accidents.[9]

Results from the present update are consistent with the earlier findings with the exception of cancer of the kidney: there were no new deaths reported from this cause since the last update, so the excess, based on five cases, failed to reach significance. In addition, earlier findings of excess mortality from cirrhosis of the liver, and homicides and suicides, although greater than one, failed to reach significance.

There was, however, a significant excess mortality among white workers whose first job in 1953 was in the structural mill from cancer of lymphatic and hematopoietic tissues, with two additional deaths from this cause. The relative risks are summarized in Table 10.

Table 10

RELATIVE RISKS FOR STRUCTURAL MILL WORKERS

Cause of death (white)	Employment Cohort		
	First job	Ever work	5+ years
All causes	1.23**	1.19**	1.22**
Cancer of kidney	--	3.19	--
Cancer of lymph and hematopoietic tissues	2.22*	1.63	2.16
Cardiovascular-renal disease	1.15	1.18**	1.17*
Arteriosclerotic heart disease	1.20*	1.24*	1.24*
Cirrhosis of liver	1.66	1.44	1.37
Accidents	1.76*	1.63*	2.03*
Homicides and suicides	1.83	1.67	1.09

*p < .05 **p < .01

Other areas. Other areas in the secondary mills where excess risks were noted were in the plate mill, where white workers showed excess mortality from cancer of the kidney (5 deaths, RR: 4.11, $p < .05$). White workers who ever worked in the axle mills had excess deaths from cancer of the lungs, bronchus, and trachea (18 deaths, RR: 2.04, $p < .01$). Nonwhite workers who ever worked in general finishing and shipping had excess deaths from digestive and peritoneal cancer (17 deaths, RR: 2.28, $p < .01$). White workers whose first job in 1953 was in the hot strip mill had excess deaths from diabetes mellitus (5 deaths, RR: 5.94, $p < .01$). White workers who ever worked in rail mill finishing had excess deaths from nonmalignant digestive disease (19 deaths, RR: 1.76, $p < .05$).

Sheet and Tin Mill

The sheet and tin mill consists of that portion of the steel plant where the unfinished slabs of steel are processed for industrial use. The work areas are classified according to the operations which take place there:

1) Annealing - Normalizing
2) Batch Pickling and Sheet Dryers
3) Coating
4) Cold Reducing Mills
5) Continuous Pickling and Electric Cleaning
6) Flying Shears and Slitters
7) Heat Treating and Forging

8) Hot Pack Mills
9) Hot Strip Rolling
10) Sheet Finishing and Shipping
11) Stainless Annealing, Pickling, and Processing
12) Temper Passing and Cold Rolling
13) Tin Finishing and Shipping

Workers in sheet and tin mill operations have been reported in earlier updates to have shown excess mortality in various work areas.[9]

Batch pickling and sheet dryer workers had shown an excess in all causes, and specifically from arteriosclerotic heart disease. Coating area workers had shown increased risks of dying from hypertensive heart disease. Workers in the tin finishing and shipping area had shown excess mortality from cancer of lymphatic and hematopoietic tissues and cancers not otherwise listed. The results of the present update confirmed all of these observations.

White workers employed in the sheet finishing and shipping area no longer showed a significant excess risk of dying from arteriosclerotic heart disease, as was reported in earlier analyses. The excesses reported earlier in lymphatic and hematopoietic cancers for workers in heat treating and forging continued to be nonsignificant as they were in the last update, although still greater than one. There was no evidence of excessive non-malignant respiratory disease in the annealing - normalizing area, consistent with the last update; and no significant excess risk of dying from accidents in this area. In the stainless annealing pickling and processing area, the excess risk of dying from accidents was also nonsignificant in this update; the only area still showing a significant risk of dying from accidents was in the hot pack mills. However, white workers who worked five or more years in the stainless annealing, pickling, and processing area show excess mortality from digestive and peritoneal cancer, and those whose first job in 1953 was in this area showed excess mortality for all cancers. These findings are summarized in th list of selected relative risks in Table 11. All values are for white workers.

Table 11

RELATIVE RISKS FOR SHEET AND TIN MILL WORKERS

Cause of death (white)	Employment cohort		
	First job	Ever work	5+ years
Batch pickling and sheet dryers			
All causes	1.77*	1.41*	1.63*
Arteriosclerotic heart disease	1.88	1.57*	2.03*
Coating			
Hypertensive heart disease	6.36**	4.28**	7.47**
Heat treating and forging			
Lymphatic and hematopoietic cancer	2.03	1.69	1.87
Hot pack mills			
Accidents	0.73	1.68*	0.93
Tin finishing and shipping			
Lymphatic and hematopoietic	3.30*	3.95*	3.14*
All other cancers	2.06	2.48*	2.79
Stainless annealing, pickling, processing			
All cancers	3.08**	1.19	1.65*
Digestive and peritoneal cancer	--	2.04*	2.52*

*p < .05 **p < .01

Other areas. Other areas in the sheet and tin mill where excess risks occurred were in annealing and normalizing, where nonwhite workers for five or more years showed nine deaths from arteriosclerotic heart disease (RR: 2.79, p < .05). White workers whose first job in 1953 was in the cold reducing mills showed 36 deaths from respiratory cancer (RR: 1.52, p < .05) White workers with five or more years in continuous pickling and electric cleaning showed five deaths from causes not otherwise listed (RR: 3.80, p < .01). White workers whose first job in 1953 was in sheet finishing and shipping showed 35 deaths from accidents (RR: 1.59, p < .01).

Tube Mills.

The updated mortality figures showed a significant excess of deaths fro nonmalignant respiratory disease among white workers whose first job in 1953 was in the tube mills. This finding, based on eight deaths, has not shown u in earlier studies. Although the other two employment cohorts did not show

significant risks, the values are greater than one. The update period yielded seven additional deaths from this cause for white workers who had ever worked in the tube mills through 1953. The relative risks are summarized in Table 12.

Table 12

RELATIVE RISKS FOR TUBE MILL WORKERS

Cause of death (white)	Employment cohort		
	First job	Ever work	5+ years
Nonmalignant respiratory disease	2.64*	1.59	1.78

*$p < .05$

Maintenance

Men working in maintenance departments may perform assignments in various parts of the plant, so their exposure to occupational hazards may be intermittent and related more to where they are performing their job rather than the nature of the job itself. Work areas considered as maintenance include the mason department, carpenter shop, blacksmith shop, electric maintenance assigned, electric shop, garage, locomotive and car repair, machine shop, maintenance NOS, mechanical maintenance assigned, paint shop, pattern shop, pipe shop, riggers and structural, roll shop, and weld shop.

Mason department. In previous reports, white workers in the mason department showed excess mortality from non-malignant respiratory diseases, thought to be from working with abrasive and dusty materials.[7] The present data confirmed this finding, continuing to show highly significant excess mortality from this cause. Sixteen additional deaths were identified among white workers ever having worked in the department through 1953.

A previous report indicated excess mortality among white workers from respiratory cancer deaths, but a subsequent follow-up found the excess to be nonsignificant.[7 9] The present data showed levels of risk among white workers from respiratory cancer deaths which, although greater than one, continue to be nonsignificant.

Differential mortality patterns by race had been noted in previous reports for cancers of the digestive organs and peritoneum, with white workers showing deficit mortality and nonwhite workers showing excess mortality. This trend is still apparent when the present data are added, but none of the risks now reach significance.

Earlier reports had noted increased risk from cancers of the lymphatic and hematopoietic tissues, particularly among nonwhite workers in this area. The risks are still significant for nonwhite workers whose first job in 1953 was in the mason department, but the mortality experience of the past five years has reduced the risks somewhat.

Significantly higher risks of dying from cardiovascular-renal diseases had been reported for nonwhite workers. The present follow-up confirmed this risk for nonwhite workers who ever worked in the mason department through 1953. Nonsignificant excesses in mortality occurred for nonwhite workers from vascular lesions of the central nervous system, arteriosclerotic heart disease, and hypertensive heart disease.

Nonwhite workers continued to have significantly greater mortality than one would expect from all causes. The excess in mortality which had been reported from homicides and suicides among nonwhite workers remained highly significant on the basis of eleven deaths reported for those who had ever worked in the mason department. No new deaths from this cause were recorded during the period of the present update, however.

The above findings are summarized in Table 13.

Table 13

RELATIVE RISKS FOR MASON DEPARTMENT WORKERS

Cause of death	Employment cohort		
	First job	Ever work	5+ years
Respiratory cancer (white)	1.42	1.04	1.44
Digestive and peritoneal cancer			
(white)	0.56	0.98	0.53
(nonwhite)	1.36	1.29	1.87
Cancer of lymphatic and hematopoietic tissues			
(white)	--	0.98	1.29
(nonwhite)	2.97*	1.60	--
Nonmalignant respiratory disease (white)	2.44**	1.74**	2.69**
All causes (nonwhite)	1.22*	1.24**	1.34*
Cardiovascular-renal disease (nonwhite)	1.26	1.25*	1.18
Vascular lesions of the central nervous system (nonwhite)	1.22	1.05	1.44
Arteriosclerotic heart disease (nonwhite)	1.35	1.26	1.10
Hypertensive heart disease (nonwhite)	1.67	1.59	2.06
Homicides and suicides (nonwhite)	2.19	2.27*	8.60**

*p < .05 **p < 0.1

Blacksmith shop. Updated mortality figures showed a significant excess mortality from respiratory cancer, specifically cancer of the lung, bronchus and trachea, among white workers in the blacksmith shop. Seven additional deaths from this cause occurred during the update period among white workers who had ever worked in this area through 1953. The relative risks for blacksmith shop workers are summarized in Table 14.

Table 14

RELATIVE RISKS FOR BLACKSMITH SHOP WORKERS

Cause of death (white)	Employment cohort		
	First job	Ever work	5+ years
Respiratory cancer	1.89*	1.68*	2.19**
Cancer of the lungs, bronchus, and trachea	1.84	1.64*	2.01*

*p < .05 **p < .01

Other areas. Other areas in the maintenance department where excess risks were noted were in electric maintenance assigned, where white workers showed excess mortality from cancer of the kidney (first job; 6 deaths, RR: 3.51, p < .01). White workers who worked five or more years in the machine shop showed excess deaths from digestive and peritoneal cancer (56 deaths, RR: 1.49, p < .01). In all other maintenancy areas, white workers showed a significant excess of respiratory cancer deaths; however, it must be considered tentative being based on only seven deaths (first job; RR: 2.50, p < .05).

Miscellaneous

Among the miscellaneous work areas are included general labor, janitors, general receiving and stores, plant protection, power and fuel, transportation and yard, and river or marine ways. Two work areas which were found previously to have highly significant excess deaths from all causes were the janitor and plant protection departments.[8] This observation was borne out by the present update. In addition, white janitors were seen to display an excess mortality from cardiovascular-renal disease, especially arteriosclerotic heart disease, and from nonmalignant digestive disease. Nonwhite janitors showed excessive mortality from genito-urinary cancer, and particularly cancer of the prostate, which was highly significant for nonwhites who had worked five or more years.

Plant protection workers had previously shown excess mortality from arteriosclerotic heart disease. This finding was strongly reinforced by the present update, where white workers in the plant protection department showed highly significant excess mortality from all causes, all cardiovascular-renal disease, and especially arteriosclerotic heart disease across all three employment cohorts. In addition, white workers in this area showed significant

excess mortality from diabetes mellitus and those who had worked five or more years showed excess mortality from cirrhosis of the liver. The relative risks for these two areas are summarized in Table 15.

Table 15

RELATIVE RISKS FOR JANITORS AND PLANT PROTECTION WORKERS

Cause of death	Employment cohort		
	First job	Ever work	5+ years
Janitors (white)			
All causes	1.36**	1.31**	1.31*
Cardiovascular-renal disease	1.32*	1.23*	1.31
Arteriosclerotic heart disease	1.32*	1.19	1.34
Nonmalignant digestive disease	2.26**	1.88**	--
Janitors (nonwhite)			
Genito-urinary cancer	1.91	2.23**	2.05
Cancer of the prostate	2.32*	2.90**	2.79**
Plant protection (white)			
All causes	1.28**	1.20**	1.23**
Cardiovascular-renal disease	1.47**	1.37**	1.46**
Arteriosclerotic heart disease	1.46**	1.35**	1.40**
Diabetes mellitus	2.74**	2.05*	2.23*
Cirrhosis of liver	1.69	1.67	2.33

*$p < .05$ **$p < .01$

From what we have learned about the steel industry operation and work area assignment practices, we believe that this finding may very well be related to pre-employment or subsequent selective assignment due to reasons of health.

The deficit mortality for workers in the power and fuel department which was identified in an earlier report failed to show up in the present update; in fact, the relative risk for all workers who ever worked in the area through 1953 was exactly one. Excess mortality was observed for white workers with five or more years in the work area from all other cancers (15 deaths, RR: 1.73, $p < .05$), from hypertensive heart disease (22 deaths, RR: 1.82, $p < .05$), and from all other causes of death (22 deaths, RR: 1.74, $p < .05$).

Workers in the transportation and yard areas had excess deaths from digestive and peritoneal cancer for both races. Nonwhite workers who had ever worked in the area had 25 deaths (RR: 1.61, $p < .05$), while white workers whose first job in 1953 was in the area had 43 deaths (RR: 1.72, $p < .01$) from this cause. Cirrhosis of the liver was insignificant for white workers of five or more years employment (14 deaths, RR: 1.85, $p < .05$), while respiratory cancer mortality showed a significant deficit among white workers of five or more years (13 deaths, RR: 0.50, $p < .05$), and a significant excess among nonwhite workers who have ever worked in the area (29 deaths, RR: 1.66, $p < .05$).

White river or marine ways workers showed excess mortality from all causes; and in particular, excess deaths from nonmalignant digestive disease (8 deaths, RR: 2.46, $p < .05$), especially cirrhosis of the liver (5 deaths, RR: 3.51, $p < .05$) among workers of five or more years.

DISCUSSION

The findings presented here indicate that there are 48 of the 57 work areas examined in the steel plants which are associated, either positively or negatively, with mortality from certain causes. The problem is then to evaluate which, if any, of these observed associations are likely to be due to occupational exposures, and which of the associations are spurious, and can be explained as direct selection for health, selection for other characteristics associated with health and mortality or as unlikely chance occurrences. Since the etiology of the chronic diseases and the mechanisms by which the work area exposures can affect the development of disease processes are not known at the present time, we must rely upon the analysis of observations resulting from epidemiological investigations, such as the present study, to identify areas where hazards may exist. Certainly, the results point out the importance of carrying out further analyses and studies of appropriate epidemiological data, and at the same time, initiating experimental studies which will identify and measure the amount of any elements present in the occupational environment that could produce the types of mortality patterns which have been observed.

The method of analysis used in this report is designed to be more sensitive to identifying those work areas which consistently show an excess or deficit in mortality over time. In other words, statistical significance for the mortality pattern, 1953-1975, is most likely to be found whenever the differences observed in the five time periods are all in the same direction. Thus, it is possible in the summary to miss an important excess if all the susceptible men die early in follow-up, since later time periods may show less than the expected mortality from the cause of interest. The same rationale is applicable when considering the differences among various age groups in the work areas. For this reason, although the report has concentrated on the total mortality from 1953 to 1975, we have also compared these findings to the mortality during the preceding phases of this study.

Several general considerations are important in assessing the results for particular work areas. As indicated under statistical methods, whenever a large number of statistical tests are performed, some will be significant by chance alone. Further, a problem arises in connection with the multiple comparisons which are carried out, so that the significance level started is an underestimate of the true significance level. Since these analyses are primarily for the purpose of hypothesis generation, rather than testing, the specific significance levels serve as a guide, but are not the only criterion for selecting work areas which merit further review.

Lloyd et al discuss some of the criteria which are helpful in differentiating between excess mortality, which is likely to be a consequence of

occupational or environmental exposures, and excess mortality related to selection biases.[2] Two important criteria are: 1) the specificity of the response to a particular cause of death category or organ system; and 2) the consistency of the findings within a particular work area across various subgroups of the population, such as age, race, nativity, etc.

Cause-specific mortality patterns according to duration and nature of various job exposures provide further clues as to the potential etiologic significance of these findings. We have attempted to show in this report the important mortality findings only as they relate to the workers' area of employment prior to and during 1953, considering time spent in specific job exposures. In addition, changes in jobs during the period of follow-up may well have some relationship with subsequent mortality. Our interest is to consider this aspect more fully in future analyses for only those work areas where our current data indicate such in-depth review is warranted.

One general limitation of this long-term study of the effects of occupational exposures should be kept in mind. While we have been successful in obtaining and analyzing a complete job exposure history at the selected plants for all study subjects, this exposure represents only a part of the workers' total environment. It is evident that, at this time, we do not possess information to evaluate the contribution to mortality findings of factors outside the work environment and the possible interaction of these factors with occupational exposures.

The strength of the association, as estimated by the relative risk, is also important in evaluating these data. For example, a 25 percent increase in lung cancer might reasonably occur due to some unmeasured risk factor, such as a difference in smoking habits between those in the work area of interest and those in the comparison group. However, a 100 percent increase is much less likely to be due to lack of comparability of risk factors between the interest and comparison group. Finally, one can use the temporal relationships between suspect exposures and mortality, and what is known to date about the etiology of the disease in question to determine which work areas should be studied further.

Since the coke plant is the subject of Part II of this report, findings for that area will not be discussed in this section.

Applying the basic epidemiological principles described above to interpret the findings for the other work areas leads us to recommend strongly further observation for mortality and analysis of this cohort. Mortality risks among three work areas scrutinized in previous reports are either more pronounced or substantiated by increased numbers of deaths. These include: 1) Foundry, 2) Mason Department, and 3) Billet, Bloom, and Slab Mills. Several of the sheet and tin mill areas have elevated cancer risks which should also be investigated further. While there are a variety of exposures that could be suspect, of particular interest are those exposures, especially nickel, involved in the making of stainless steel at one of the study plants. Men involved in pickling operations should be evaluated as a separate group due to

present concerns related to this occupation. Since our cohort provides the only longitudinal study of workers involved in a number of occupations of current interest, we feel that continued maintenance and periodic updates of this unique database are indicated.

REFERENCES

1. Lloyd, J.W., and Ciocco, A.: Long-term mortality study of steelworkers. I. Methodology. J. Occup. Med., 11:299-310, 1969.

2. Lloyd, J.W.; Lundin, F.E., Jr.; Redmond, C.K.; and Geiser, P.B.: Long-term mortality study of steelworkers. IV. Mortality by work area. J. Occup. Med., 12:151-157, 1970.

3. Redmond, C.K.; Ciocco, A.; Lloyd, J.W.; and Rush, H.W.: Long-term mortality study of steelworkers. VI. Mortality from malignant neoplasms among coke oven workers. J. Occup. Med., 14:621-629, 1972.

4. Lerer, T.J.; Redmond, C.K.; Breslin, P.P.; Salvin, L.; and Rush, H.W.: Long-term mortality study of steelworkers. VII. Mortality patterns among crane operators. J. Occup. Med., 16:608-614, 1974.

5. Redmond, C.K.; Gustin, J.; and Kamon, E.: Long-term mortality study of steelworkers. VIII. Mortality patterns of open hearth steelworkers (a preliminary report). J. Occup. Med., 17:40-43, 1975.

6. Mazumdar, S.; Lerer, T.; and Redmond, C.K.: Long-term mortality study of steelworkers. IX. Mortality patterns among sheet and tin mill workers. J. Occup. Med., 17:751-755, 1975.

7. Rockette, H.E.; and Redmond, C.K.: Long-term mortality study of steelworkers. X. Mortality patterns among masons. J. Occup. Med., 18:541-545, 1976.

8. Ciocco, A.; and Redmond, C.K.: Mortality experience of steelworkers. Part I: Mortality experience of Allegheny County Steelworkers, 1953-1966. Report on Analyses 1970-71, Contract No. PH 43-62-147.

9. Redmond, C.K.: Long-term mortality study of steelworkers. Section I: Work area analyses. Report on Analyses 1975-76, Contract No. HSM 099-71-32.

10. Redmond, C.K.; Smith, E.M.; Lloyd, J.W.; and Rush, H.W.: Long-term mortality study of steelworkers. III. Follow-up. J. Occup. Med., 11:513-521, 1969.

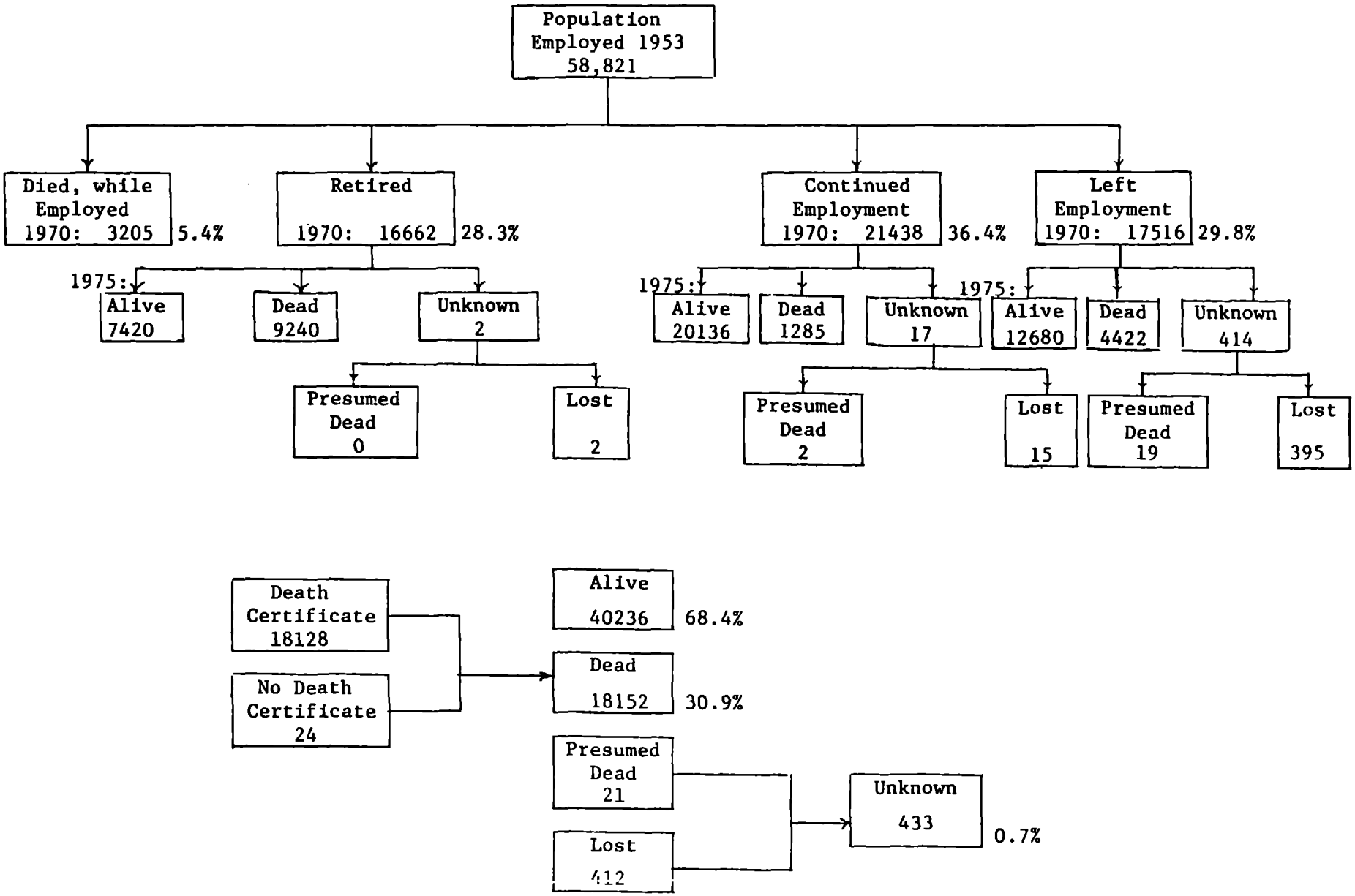


Figure 1: STEELWORKERS EMPLOYED IN 1953, CLASSIFIED BY EMPLOYMENT STATUS TO 31 DECEMBER 1970, AND BY VITAL STATUS TO 31 DECEMBER 1975.

Table 1

MORTALITY RATE FROM ALL CAUSES, 1953-1975, OF 58821
ALLEGHENY COUNTY STEELWORKERS BY RACE AND AGE IN 1953

RACE: All Races

Age	Number At Risk In 1953	Total Deaths 1953-1975	Mortality Rate/1000 At Risk In 1953
TOTAL	58821	18152	308.6
<35	24218	2170	89.6
35-44	15149	3811	251.6
45-54	10447	5113	489.4
55-64	7801	5955	763.4
65+	1206	1103	914.6

RACE: White

Age	Number At Risk In 1953	Total Deaths 1953-1975	Mortality Rate/1000 At Risk In 1953
TOTAL	51472	15626	303.6
<35	21271	1819	85.5
35-44	13483	3324	246.5
45-54	8717	4205	482.4
55-64	6914	5281	763.8
65+	1087	997	917.2

RACE: Nonwhite

Age	Number At Risk In 1953	Total Deaths 1953-1975	Mortality Rate/ 1000 At Risk In 1953
TOTAL	7349	2526	343.7
<35	2947	351	119.1
35-44	1666	487	292.3
45-54	1730	908	524.9
55-64	887	674	759.9
65+	119	106	890.8

Table 2

DISTRIBUTION OF 1953 STEELWORKER POPULATION FOLLOWED THROUGH 1975 BY EMPLOYMENT COHORT, WORK AREA, AND RACE

WORK AREA	FIRST JOB IN 1953		EVER WORKED THROUGH 1953		5 OR MORE YEARS EXPERIENCE	
	WHITE	FREQUENCY NONWHITE	WHITE	FREQUENCY NONWHITE	WHITE	FREQUENCY NONWHITE
1) GEN ADMINISTRATIVE AND CLERICAL	3270	18	5110	34	2361	11
2) GEN TECHNICAL	2367	14	3683	16	1578	7
3) COKE PLANT	1635	908	2382	1176	1180	664
4) BLAST FURNACE	2355	1101	4218	1416	1731	590
5) OPEN HEARTH	5457	1699	9634	2336	3974	1275
6) BESSEMER CONVERTER	24	0	240	88	118	35
7) ELECTRIC FURNACE	1074	143	1871	270	776	38
8) FOUNDRY	890	253	1780	346	764	169
9) HEAT TREAT AND FORGING	1003	16	1685	46	708	20
10) BILLET BLOOM AND SLAB MILLS	2911	224	5785	421	2613	203
11) SOAKING PITS	94	14	148	28	19	0
12) MERCHANT MILLS	2129	395	3886	682	1985	302
13) PLATE MILL	1547	239	3005	436	1442	246
14) AXLE MILLS	6	0	293	6	45	0
15) GENERAL FINISHING AND SHIPPING	399	82	1309	213	511	113
16) HOT STRIP MILL	164	1	567	1	174	0
17) RAIL MILL ROLLING	339	46	852	97	288	32
18) RAIL MILL FINISHING	347	98	726	145	245	42
19) STEEL YARDS	88	32	299	77	68	11
20) STRUCTURAL MILL	1196	164	1972	252	980	128
21) ANNEALING NORMALIZING	1344	16	2604	53	1203	24
22) BATCH PICKLING AND SHEET DRYERS	55	21	137	50	45	19
23) COATING	328	0	545	0	269	0
24) COLD REDUCING MILLS	1396	97	1933	113	849	65
25) CONTINUOUS PICKLING AND ELEC CLEANING	205	0	254	0	147	0
26) FLYING SHEARS AND SLITTERS	8	0	28	0	5	0
27) HOT PACK MILLS	566	5	1229	19	737	5
28) HOT STRIP ROLLING	1008	0	1623	2	864	1
29) SHEET FINISHING AND SHIPPING	1733	36	3304	109	1334	48
30) STAINLESS ANNEAL PICKLG AND PROCESSING	46	1	384	2	148	0
31) TEMPER PASSING AND COLD ROLLING	369	0	783	0	335	0
32) TIN FINISHING AND SHIPPING	396	1	668	1	348	0
33) GENERAL LABOR	546	449	3153	1215	565	375
34) JANITORS	205	321	512	421	112	190
35) MASON DEPARTMENT	1304	439	2511	697	757	243
36) BLACKSMITH SHOP	266	4	555	6	231	5
37) CARPENTER SHOP	406	0	665	1	277	0
38) ELECTRIC MAINTENANCE ASSIGNED	1605	5	3201	8	1581	2
39) ELECTRIC SHOP	551	1	1620	2	760	2
40) GARAGE	147	0	242	2	98	1
41) LOCOMOTIVE AND CAR REPAIR	121	9	261	22	104	7
42) MACHINE SHOP	1442	2	2406	11	1271	1
43) MAINTENANCE NOS	70	2	558	5	246	0
44) MECHANICAL MAINTENANCE ASSIGNED	2687	60	6134	201	2289	73
45) PAINT SHOP	263	2	777	10	197	2
46) PATTERN SHOP	68	0	95	0	64	0
47) PIPE SHOP	738	5	1412	14	657	6
48) RIGGERS AND STRUCTURAL	1189	8	2525	21	1034	6
49) ROLL SHOP	374	0	502	3	314	0
50) WELD SHOP	644	2	758	2	460	2
51) ALL OTHER	138	6	1085	75	302	9
52) GENERAL RECEIVING AND STORES	192	4	382	9	168	2
53) PLANT PROTECTION	674	1	656	4	469	1
54) POWER AND FUEL	1343	62	2336	213	976	89
55) TRANSPORTATION AND YARD	1293	341	2842	633	671	194
56) TUBE MILLS INCLUDES TUBE FINISHING	239	1	659	10	294	2
57) RIVER OR MARINE WAYS	218	1	293	1	177	1
58) TOTAL	51472	7349	51472	7349	36367	4912

Table 3

DISTRIBUTION OF CAUSES OF DEATH, 1953-1975, FOR STEELWORKERS EMPLOYED IN 1953 BY RACE

CAUSE OF DEATH	WHITE N = 51472		NONWHITE N = 7349		TOTAL N = 58821	
	N	%	N	%	N	%
ALL CAUSES	15626	100.0	2526	100.0	18152	100.0
ALL CANCERS	3300	21.1	589	23.3	3889	21.4
BUCCAL AND PHARYNGEAL CANCER	114	0.7	13	0.5	127	0.7
DIGESTIVE AND PERITONEAL CANCER	1099	7.0	175	6.9	1274	7.0
RESPIRATORY CANCER	1073	6.9	205	8.1	1278	7.0
CANCER OF LUNGS, BRONCHUS, TRACHEA	1013	6.5	194	7.7	1207	6.6
OTHER RESPIRATORY CANCER	60	0.4	11	0.4	71	0.4
GENITO-URINARY CANCER	370	2.4	91	3.6	461	2.5
CANCER OF PROSTATE	209	1.3	69	2.7	278	1.5
CANCER OF TESTIS AND OTHER GENITAL ORGANS	16	0.1	0	0.0	16	0.1
CANCER OF KIDNEY	62	0.4	10	0.4	72	0.4
CANCER OF BLADDER AND OTHER URINARY ORGANS	83	0.5	12	0.5	95	0.5
CANCER OF LYMPH AND HEMATOPOIETIC TISSUES	260	1.7	41	1.6	301	1.7
SKIN CANCER	27	0.2	2	0.1	29	0.2
ALL OTHER CANCERS	357	2.3	62	0.1	419	2.3
CARDIOVASCULAR-RENAL DISEASE	8908	57.0	1213	48.0	10122	55.8
VASCULAR LESIONS OF THE CENTRAL NERVOUS SYSTEM	1214	7.8	221	8.7	1435	7.9
ARTERIOSCLEROTIC HEART DISEASE	6531	41.8	713	28.2	7244	39.9
HYPERTENSIVE HEART DISEASE	358	2.3	126	5.0	484	2.7
OTHER CARDIOVASCULAR-RENAL DISEASE	806	5.2	153	6.1	959	5.3
NONMALIGNANT RESPIRATORY DISEASE	683	4.4	150	5.9	833	4.6
NONMALIGNANT DIGESTIVE DISEASE	861	5.5	104	4.1	965	5.3
CIRRHOSIS OF LIVER	446	2.9	45	1.8	491	2.7
OTHER NONMALIGNANT DIGESTIVE DISEASE	415	2.7	59	2.3	474	2.6
TUBERCULOSIS OF RESPIRATORY SYSTEM	56	0.4	28	1.1	84	0.5
DIABETES MELLITUS	242	1.5	54	2.1	296	1.6
ACCIDENTS	681	4.4	137	5.4	818	4.5
HOMICIDES AND SUICIDES	236	1.5	59	2.3	295	1.6
ILL-DEFINED CAUSES	183	1.2	76	3.0	259	1.4
ALL OTHER CAUSES	475	3.0	116	4.6	591	3.3

SECTION III.

LONG TERM MORTALITY OF STEELWORKERS:

MORTALITY AMONG ALLEGHENY COUNTY COKE PLANT WORKERS, 1953-1975

III. LONG TERM MORTALITY OF STEELWORKERS: MORALITY AMONG ALLEGHENY COUNTY COKE PLANT WORKERS, 1953-1975

This section of the report presents the updated findings for men employed in two coke plants in Allegheny County, Pennsylvania. The major purpose of our current analyses are:

1) To summarize for several subdivisions of the coke plant the relationships between the work environment and cause-specific mortality, particularly site specific cancer mortality, and;

2) To examine these findings in comparison with earlier reports[1-8] on the same cohort of Allegheny County coke plant workers, considering the extent to which the deaths added in the most recent five years strengthen or fail to confirm earlier patterns in the data.

Classification of Workers in the By-product Coke Plant

The primary purpose of the by-product coke plant is the transformation of coal into metallurgical coke, with a secondary function being the recovery of chemical by-products resulting from carbonization. The by-product coke plant consists of three major areas:

1) coal-handling
2) coke ovens
3) by-products plant

Classifying coke plant workers into various work and exposure areas is complicated, even with the detailed job histories available in the study. Terminology from plant to plant and over time is not standardized and certain job titles are too ambiguous to precisely classify. Workers at the coke plants have been classified into the categories "oven" and "non-oven" (Figure 1) according to groups of jobs using the same definitions as in previous updates of this cohort.[2-8] The coke oven group included all jobs which required that some part of the working day be spent at the top or side of the ovens. These have further been described as full-time or part-time. All other jobs have been classified as nonoven. When a worker held jobs in both oven and nonoven areas, priority was given to coke oven experience when assigning a worker to a specific work area group. For workers at the ovens, topside experience was given precedence over side oven experience. Those workers not assigned to oven work areas were classified into one of three nonoven work sites. These are the coal handling area, the by-products area, and other coke plant. The by-products area functions to recover the chemical by-products resulting from the carbonization of bituminous coal. When classifying workers, the by-products areas have been given priority over coal handling areas in terms of chemical exposures for determining carcinogenic risk. A certain number of nonoven jobs remained unclassified into any specific area; these are designated as "other coke plant" in the report. This method of classification clearly delineates the specificity of the lung cancer excess deaths to the jobs at the coke ovens.

Review of Background of Coal Tar Cancers

It has been known for over 200 years, beginning with Percivall Pott's (1775) observation of scrotal cancers in London chimney sweeps, that some agent produced during combustion of bituminous coal is carcinogenic for the skin of man,[9-12] while studies beginning in the 1930's demonstrate the carcinogenicity of coal tars for other internal organ systems.[13-16] An excellent review of the historical studies has been given by Lloyd and will only be summarized briefly here.[1]

Following Pott's observation of chimney sweeps, the next occupational group noted in 1873 to have a risk of scrotal cancer was men involved in the carbonization of lignite. This was followed by a report of Manouvriez in 1876 that French briquette workers who were exposed to coke oven tar and pitch suffered from scrotal cancer and facial epithelioma.[17] Further reports of occupational skin cancers in related occupations followed, leading Great Britain in 1907 to include scrotal epithelioma and epitheliomatous cancer of the skin related to exposure to coal tar compounds under the Workman's Compensation Act.

In 1907 the first report[18] of skin cancers among carbon workers in the United States was published. Animal studies beginning in the early 1900's eventually resulted in the isolation of 3, 4 benzpyrene, a potent skin carcinogen.

Observations dealing with cancers of other organ sites in association with coal tar or distillate exposures began to appear in the 1930's.[13-16] Both Japanese and British producer gas workers were reported to show excesses in lung cancer in 1936. The earliest study of coke oven workers published by Reid and Buck[19] described a negative finding for lung cancer in retirees, a result which may be partly attributable to study design and partly to our subsequent observation that the extremely high risk is limited to a small proportion of all coke oven workers. An unpublished report in 1960 by Phair and Stirling dealing with competing causes of death among coal tar workers cites a negative finding for white workers (22 observed deaths versus 22 expected), but a three fold excess for nonwhite workers (17 observed deaths versus 5.8 expected).[20] This rather puzzling excess was found on further subdivision of the workers to be confined to Allegheny County, Pennsylvania, workers in coke production and handling. The lack of consistency in the results, coupled with certain methodological limitations of the study, led the authors to question the reliability of this observation.

Review of Previous Findings from Present Cohort Investigations

Lloyd presented the first analysis of coke plant workers in Allegheny County based on the follow-up period 1953-1961.[1,2] His major observations were:

1) An excess mortality risk from lung cancer among coke plant workers, which was confined to men employed at the coke ovens. The greatest risk occurred among topside workers, where the estimated relative

risk was ten-fold among men with five or more years at the top of the ovens. The risk was apparently limited to nonwhite workers, but an examination by length of exposure at the top of the ovens showed that topside oven workers at that time in the Allegheny County plants were primarily black. This observation suggested that lack of sufficient exposure to produce lung cancer might explain the negative finding for whites.

2) An excess risk of certain digestive cancers occurred in nonoven coke plant workers, but the number of deaths were too small to attempt to delineate the risk further.

Because of the need to define more fully the lung cancer risk among coke oven workers, particularly as related to racial and geographic differences, the study was expanded in the late 1960's to 10 additional plants. For these plants the study population was limited to all coke oven workers, and a sample of other workers in the plants matched by race and starting date of employment to the coke oven workers. In addition, the mortality observation period for the original Allegheny County steelworkers population was extended through 1966.

Examination of the mortality for 4,661 coke oven workers revealed that:[5]

1) The excess lung cancer risks among white and nonwhite workers were the same when length and area of employment at the ovens were taken into account.

2) The excess risk noted for Allegheny County workers occurred in other geographic areas as well.

3) A finding of a significant excess in kidney cancer deaths became apparent with the larger cohort available for study.

With the updated findings for the Allegheny County steelworkers it was possible to investigate in greater detail the cause specific cancer mortality among nonoven coke plant workers. Conclusions of note from these analyses are:[8]

1) Cancers of the digestive system were significantly elevated in nonoven workers. Cancers of the colon and pancreas accounted for the entire excess. The excess risk did not appear to cluster in any specific job group included in nonoven jobs.

2) Cancers of the buccal cavity and pharynx appeared high in nonoven workers, although the number of deaths was small.

In the extension of the work histories and observation period through 1970 for the Allegheny County workers only, the additional deaths observed strengthened several trends noted previously which were nonsignificant. The two most important of these results were the statistically significant lung cancer excess among side oven workers who were never topside, and the 47 percent

excess in nonmalignant respiratory diseases ($p < .05$) for men with five or more years in the coke plant. For men with fifteen or more years, the excess risk of other respiratory diseases was 101 percent ($p < .01$) with both oven and non-oven workers exhibiting a similar pattern.

Population At Risk

Tables 1 and 2 show the distribution of coke plant workers by work area subdivision, race, and length of employment at the start of follow-up. Of the 58,821 steelworkers employed through 1953, 3,558 worked at some time in the coke plant. The number employed five years or more through 1953 was almost half (1,844). Differing distributions by race within the two work areas of the coke plant are seen for these two periods of employment. For nonwhite workers ever employed through 1953, 90.1 percent were employed at the coke ovens compared to only 41.2 percent for white workers.

It is interesting to note that 19.2 percent (226) nonwhites worked full-time topside at the ovens compared to only 3.3 percent of whites (79 workers), whereas only 8 nonwhites had part-time topside positions compared to 312 white workers.

For men employed for five years or more through 1953, the proportionate distribution by race and work area remained the same. The number of whites at risk in the high exposure jobs was small, as was the number of nonwhites at risk in by-products and coal-handling jobs.

Results of Present Update

The observed and expected deaths and relative risks by area of employment are shown in Tables 3 through 8 for the 3,588 men employed in the coke plants through 1953. In Table 3 the All Causes mortality was only 4 percent greater for the total coke plant workers compared to the total steelworkers population. However, the All Cancers category was over 20 percent greater ($p < .01$). The 45 excess in All Cancer deaths was due primarily to malignant neoplasms of the respiratory system and genito-urinary system (Table 4). There was a 55 percent increased risk of lung cancer mortality with 114 observed compared to 78.7 expected deaths ($p < .01$). Excess mortality, though not statistically significant, was also seen for malignant neoplasms of the pancreas (RR: 1.54), for malignant neoplasms of the prostate (RR: 1.45), and for malignant neoplasms of the kidney (RR: 1.89).

In examining other leading causes of death (Table 3) there was some evidence, though not statistically significant, of excess mortality from nonmalignant respiratory disease and from pulmonary tuberculosis (RR: 1.22 and 1.14, respectively). The relative risks from cardiovascular-renal diseases were all close to one. Mortality from nonmalignant digestive disease was statistically less than expected (37 deaths observed compared to 56.7 expected) with the most pronounced deficit in this category for cirrhosis of the liver. When oven and nonoven work categories were examined, differences in cancer risk for these areas became apparent (Table 4). The overall excess mortality for all cancer sites was only slightly greater for the oven workers compared

to the total coke plant workers. However, the oven workers experienced over a two-fold excess lung cancer mortality ($p < .01$). Relative risks of 1.67 and 2.88 were also seen for cancer of the prostate and kidney, respectively ($p < .05$). It is interesting to note, however, that a lower than expected mortality was observed for malignant neoplasms of the digestive and peritoneal organs among oven workers. The nonoven workers experienced lung cancer risks over 100 percent lower than the oven workers (relative risks of 0.91 compared to 2.05, respectively). Meanwhile, nonoven workers experienced a statistically significant ($p < .01$) excess of deaths from cancer of the digestive organs and peritoneum (RR: 1.48).

Tables 5 through 8 show cancer mortality for coke plant workers who ever worked through 1953 and for workers with 5 years or more experience in specific oven and nonoven areas. In the coke oven areas, highly significant excesses in mortality were seen for malignant neoplasms of the respiratory system and kidney. A greater excess risk for those who have worked at least 5 years compared to those who ever worked through 1953 at the same sites, supported the idea of a dose-response relationship.

For those who ever worked through 1953 in nonoven areas (Table 7), less than expected mortality was seen for respiratory cancer, while an excess of mortality was seen for cancer of the digestive organs and peritoneum. Among by-products workers, lung cancer mortality was 54 percent lower than expected, while cancer of the pancreas was 3 times greater ($p < .05$). For workers in the same nonoven areas with 5 years or more work experience the relationships were stronger (Table 8). Deaths from malignant neoplasms of the respiratory system were 78 percent lower than expected (2 deaths observed compared to 8.8 expected, $p < .05$).

One of the most important aspects in epidemiological investigations of occupational carcinogenesis is the evidence for a dose-response relationship. The volatile effluents escaping into the atmosphere at specific work sites are considered to involve greater exposures to polycyclic hydrocarbons compared to other work sites. The gradient of exposure and risk, in decreasing order, are presumed to be: 1) oven topside, 2) oven side, and 3) nonoven, with full-time topside workers having greater exposures than part-time topside workers. Previously reported from this study has been evidence for a dose-response relationship between these exposure levels and lung cancer mortality.[1-8] Table 9 presents mortality findings for work experience in the coke plant for malignant neoplasms of the trachea, bronchus, and lung. It can be observed that a dose-response relationship was satisfied based upon the work area and length of employment at the site. The risk for those who have ever worked at least 5 years at any of the plant areas was greater than those who have ever worked at the same area. A gradient of risk existed for workers at different areas along the ovens. The relative risk for full-time topside oven workers was at least 3 times greater than side oven workers and at least 5 times greater than nonoven workers.

The mortality patterns by race for coke oven and nonoven workers is of particular interest (Appendix F). When the All Causes category was examined in Tables 10 and 11, there was a gradient of risk for nonwhites only. The

relative risk for whites, however, was less than one for all oven and nonoven jobs. The relative risks for cardiovascular-renal diseases and for malignant neoplasms both were very close to one, with no statistically significant differences between observed and expected deaths.

The picture for nonwhites was very different. Among the 81 observed deaths for full-time topside oven workers, 70 were nonwhites. The relative risk for all cardiovascular-renal disease was less than one (0.76). This was primarily due to the small number of observed deaths from arteriosclerotic heart disease (RR: 0.34, $p < .05$). Most of the excess mortality from All Causes in nonwhites was due to the large excess mortality from malignant neoplasms of the respiratory system. Of the 70 observed deaths from All Causes, 24 were due to respiratory cancer. Thus, a large relative risk of 6.96 reported for all full-time topside oven workers was due to the large number of excess deaths among nonwhites (RR: 8.19, $p < .01$).

Table 12 and 13 summarize the changes over time in the mortality experience of the coke plant workers who worked five years or more through 1953. The observed and expected deaths and the relative risks are shown at 10 years, 20 years, and for the most recent update through 1975.

DISCUSSION

The greatest excess mortality in the Allegheny County coke plants occurred among coke oven workers. Examination of the cause-specific mortality revealed certain consistent and significant differences between coke oven workers and other employees. Some of the differences can be summarized as follows:

1) Excess mortality occurring among coke oven workers was primarily due to mortality from malignant neoplasms.

2) Highly significant excess risks of lung cancer were seen in coke oven jobs only.

3) Among coke oven workers, significant excess mortality from cancers of the genito-urinary organs was seen; specifically large relative risks were noted for malignant neoplasms of the kidney.

4) Among nonoven workers, significant excess risks of cancer of the large intestine and pancreas were unique to the nonoven work sites.

5) Observed excess risks tended to be highly specific by race (Appendix F).

Among oven workers, the greatest excess lung cancer deaths were in nonwhites. The gradient in risk by work area and time spent at the ovens was remarkably clear (Table 11). The relative risk for those employed five years or more almost doubled from oven side to part-time topside workers and doubled again for full-time topside workers. However, this

was not seen at all for the white population. If a dose-response relationship is presumed to exist between the concentration of volatile hydrocarbons at the oven sites and lung cancer risk, then the large gradient of risk observed for nonwhites would be expected for whites also. Certainly part of the problem of evaluating the risk for whites was the small size of the study population at the oven sites. Only 28 white workmen were employed five years or more in the full-time topside jobs and only 2 deaths from cancer of the lung occurred in the population. While only 0.8 deaths were expected, certainly the study population was too small to estimate the risk reliably (Table 10). Among part-time topside workers this was not the situation. Of 208 white employees, 5 deaths were from lung cancer, while 5.2 were expected. The relative risk was only 0.96. Similarly, at the side of the ovens where the proportion of white workers was not small (164/549), the excess mortality was not great, 26 percent compared to 124 percent for nonwhites.

Two factors may at least partially account for the discrepancy in lung cancer risk between nonwhites and whites. First, within the respective subsites at the coke ovens, whites and nonwhites may have had different jobs and consequently, different exposures to volatile hydrocarbon effluents. Such a noncomparability in type of work within the work areas could have come about even though the criteria for assignment were uniform throughout the study. The definitions used to establish the job groups may not have been sensitive enough to reflect workers' exposure levels, despite the fact that they spent the same relative time at the oven sites. When one examines the total population who ever worked at the ovens (Table 5), the relative risk for part-time topside workers was lower than side oven workers. This appears contradictory to the gradient of risk indicated for nonwhites.

The second factor is associated with socioeconomic differences by race. From other studies, it is known that mortality rates for a number of causes, including lung cancer, are inversely correlated with educational qualification and occupational category.[21 22] However, evidence from the expanded coke oven workers' study, discussed in Part III of this report, showed that when a sufficient number of white topside oven workers are observed, the excess risk from cancers of the trachea, bronchus and lung is similar to that of the black population.

This discussion of lung cancer mortality must be considered along with the observed difference in excess mortality from cancers of the genito-urinary system. Unlike the lung cancer risk where the excess mortality was more pronounced for the nonwhites, the findings for cancer of the kidney indicated that the white coke oven workers might have been at greater risk. White oven workers who worked five years or more had a relative risk of 8.5 ($p < .01$) for cancer of the kidney. Less than expected mortality was observed for nonwhite oven workers. No significant excesses in mortality were seen for topside workers. However, it is worth noting that for white part-time topside workers a relative risk of 9.92 was seen for cancer of the kidney, although only 3 deaths were observed compared to 0.3 expected. At the side of the ovens white workers experienced 2 deaths compared to 0.2 expected. Certainly these numbers are small, but in contrast to the lung cancer experience of nonwhites, the excess relative risk for cancer of the kidney did not appear to differ in magnitude between part-time top oven

and side oven workers. For whites who ever worked at the ovens through 1953, the relative risk for prostatic cancer was 1.99 (8 deaths observed compared to 4.1 expected), though this difference was not statistically significant. Interestingly, as indicated in previous reports, no significant excesses in mortality were observed for cancer of the bladder. Cancer of the kidney is less common than bladder cancer, and the risk factors are less clear. Urban incidence rates are higher than rural incidence rates in males. However, few industrial carcinogens have been linked to kidney cancer in man.[23] [24]

In the nonoven areas, excesses in large intestine and pancreatic cancer deaths were seen in the white population only. The relative risks for malignant neoplasms of the large intestine and pancreas were 2.11 ($p < .05$) and 2.44 ($p < .05$) respectively. The small number of nonwhites made evaluating the race-specific risks difficult. Of a total of 1,517 nonoven jobs for workers ever employed through 1953, only 117 were nonwhites.

The significant excess in cancers of the colon and pancreas among workers in the coke plant merits attention. To date, descriptive epidemiological data have provided little information regarding the relationship between cancer of the intestines or pancreas and occupational exposures. However, other aspects of the descriptive epidemiology of these diseases are known. The age-adjusted death rates, 1966-1967, for cancer of the intestines in the United States were 13.7/100,000 white males and 12.0/100,000 nonwhite males, suggesting that there is no difference by race.[25] Cancer of the large intestine is relatively rare in developing countries; higher mortality is usually found in economically advanced regions of the western world. It has been suggested that this is due to changes in the consumption of animal fats, which accompanies advancement in economic status.[26] [27] The age-adjusted death rates, 1966-1967 for cancer of the pancreas in the United States were 8.4/100,000 for whites and 9.9/100,000 for nonwhites.[25]

The results of the Third National Cancer Survey provide estimates of the average annual age-adjusted cancer incidence rates, 1969-1971, for United States males, based upon a survey of approximately 10 percent of the total population. For cancer of the colon, these figures were 33.4 and 28.2/100,000 for white and nonwhite males, respectively, and the corresponding rates for pancreatic cancer were 12.2 and 17.2/100,000.[28] Allegheny County, which was included in one of the nine areas covered by the survey, showed incidence rates generally consistent with the national figures: colon cancer rates of 39.2 and 27.1 for whites and nonwhites, and pancreatic cancer rates of 12.4 and 18.1.[29] The slightly higher colon cancer rate within Allegheny County may reflect the higher percentage of foreign-born residents, as compared with the other survey areas. It is interesting that for most countries there is a positive correlation between the incidence of colon and pancreatic cancers.[26]

Although pancreatic cancers have been related to cigarette smoking, and colon cancers are believed to be largely influenced by diet, there have been some studies that indicate that chemical carcinogens may play some role. A high mortality ratio for cancers of the large bowel has been reported in the following occupational groups: footwear workers, machinists, and job-setters.[30]

In a proportionate mortality study of chemists, a significant excess was found for cancers of the pancreas.[31] Cancer of the pancreas has been reported to occur excessively among workers exposed to benzidine and/or bethanaphthylamine.[32] The British Registrar-General's Report indicates a higher mortality from cancer of the pancreas in employees of the coke and gas plants.[30]

Cancers of the large intestine have been induced in animals with various compounds. Most of the major intestinal carcinogens are not found in the coke plant environment; however, several of the aromatic animes such as 2' 3-dimethyl-4-aminobiphenyl, 3-methyl-2-naphthylamines, 2- 3-acetylaminophenanthrene, and 4-aminostilbene produce colonic tumors in rodents.[33 34] Benzidine, 4-aminobiphenyl, and N-2-fluoreny-lacetamide have also been shown to produce colon cancer in animals.[33] Various chemicals present in the by-products are of the coke plant, such as benzpyrene, anthracene, benzol, coal tar and pitch, creosote, and 8-hydroxyquinoline, have been shown to produce cancers of sites other than the intestines.[35]

Our analyses indicate that the increased risk from cancer of the large intestines is primarily in white workers in coal handling and in "all other nonoven" jobs. Previously, excesses were indicated in white by-products workers as well.[8] The lack of specificity to one work area combined with an apparent difference in the races creates some question regarding the occupation as a factor in the etiology of the colon cancer excess.

Although some ethnic groups appear to have an inherently greater risk of digestive tract cancers than the general American-born population, birthplace-specific comparisons show that the excess in cancers of the digestive tract in whites is not due to a greater proportion of foreign-born in the nonoven area than in the rest of the steelworkers' population.[8] Secondly, the general trend in the literature is that, with respect to intestinal cancer, immigrants tend to have risks similar to the population to which they migrate.[36 37]

Of interest is the very low mortality from cancer of the lung in the by-products area. The low rates for both races combined is due to the less than expected mortality for the whites in this work area. The relative risk for whites was 0.14 ($p < .05$), while the relative risk of nonwhites was not significantly less than one (0.83), based on only one observed death. The low mortality of the whites in the by-products area compared to the rest of the steelworkers population is unexplained, but this may be attributable to differences in socioeconomic factors relating to whites in nonoven jobs compared to the rest of the steelworkers.

Comparing the current results with findings from previous reports shows an overall downward trend in excess mortality with time, with several cause of death categories showing changes in statistical significance as the deaths from the most recent update were added.

Among noncancer deaths, lower than expected mortality for cirrhosis of the liver was seen for coke oven workers. The relative risk changed from 0.58 through 1970 to .044 through 1975 ($p < .05$). The biggest changes over time were seen for malignant neoplasms, both for men who ever worked through

1953 and for those who worked five years or more through 1953. Comparing these results with the last update, there was a decrease in the relative risk for full-time topside oven workers for malignant neoplasms of respiratory system, from 6.45 ($p < .01$) to 4.79($p < .01$). This was reflected in a change in the relative risk for all oven workers from 2.33 ($p < .01$) to 2.03 ($p < .01$). For malignant neoplasms of the genito-urinary system, the reduction in the relative risk from 1.97 to 1.56 also resulted in a change in the over all statistical significance from the 1 percent to the 5 percent level.

Among nonoven workers who ever worked through 1953, the relative risks for malignant neoplasms of the respiratory system increased toward one. The largest relative risk among nonoven workers occurred for cancers of the digestive organs and peritoneum. This excess risk also diminished over time. In 1970 the relative risk for cancer of the large intestine was 2.22 ($p < .01$) and for pancreas 3.72 ($p < .01$). Through 1975 the relative risk for large intestine was 1.90 ($p < .04$) and pancreas 2.71 ($p < .01$). For cancer of the digestive system, the statistically significant excess risk disappeared for coal handling workers between the 1970 and 1975 updates.

Among oven workers who were employed five years or more through 1953, similar reductions in excess mortality were observed for malignant neoplasms of the respiratory system and genito-urinary system. The exception in a downward trend was observed in side oven workers, where the relative risk increased from 1.79 ($p < .04$) to 1.89 ($p < .01$), from 1970 to 1975.

Among nonoven workers employed for five years or more through 1953, there were large downward changes in the relative risk for cancers of the large intestine and pancreas; from 2.31 ($p < .04$) and 3.67 ($p < .01$) to 2.17 ($p < .01$) and 2.78 ($p < .01$), respectively. Significance in excess mortality from malignant neoplasms of the pancreas disappeared over time for all other coke plant workers. Changes in significance of the relative risk were also seen among nonoven workers dying from malignant neoplasms of the buccal cavity and pharynx. In the nonoven by-products area the low relative risk changed from 0.16 to 0.22 ($p < .05$) for malignant neoplasms of the trachea, bronchus and lung.

Although the alteration in cancer risks may be related to a decrease in exposures over time, the closed nature of the cohort may also lead to fewer susceptibles or long term exposed workers present with longer follow-up time. Thus, there is insufficient data at the present time to draw any firm inference as to a reduction in risk in recent times.

REFERENCES

1. Lloyd, J.W.: Lung cancer mortality in Allegheny County coke plant workers. Doctoral dissertation, 1966.

2. Lloyd, J.W. and Ciocco, A.: Long-term mortality study of steelworkers: I. Methodology. J. Occup. Med., 11:299-310, 1969.

3. Robinson, H.: Long-term mortality study of steelworkers: II. Mortality by level of income in whites and nonwhites, J. Occup. Med., 11:411-416, 1969.

4. Redmond, C.K.; Smith, E.M.; Lloyd, J.W.; and Rush, H.W.: Long-term mortality study of steelworkers: III. Follow-up. J. Occup. Med., 11:513-521, 1969.

5. Lloyd, J.W.; Lundin, F.E., Jr.; Redmond, C.K.; et al: Long-term mortality study of steelworkers. IV. Mortality by work area. J. Occup. Med., 12:151-157, 1970.

6. Lloyd, J.W., Long-term mortality study of steelworkers. V. Respiratory cancer in coke plant workers, J. Occup. Med., 13:53-68, 1971.

7. Redmond, C.K.; Ciocco, A.; Lloyd, J.W.; and Rush, H.W.: Long-term mortality study of steelworkers. VI. Mortality from malignant neoplasms among coke oven workers, J. Occup. Med., 14:621-629, 1972.

8. Redmond, C.K.; Strobino, B.; and Cypess, R.: Cancer experience among coke by-product workers, Annals of the New York Academy of Sciences, 271:102-115, 1976.

9. Pott, P.: Cancer Scroti, In Chirurgical Observations, London, Hawes, Clark and Collings, 1975.

10. Volkmann, R.: Beitrage zur Chirurgie, Leipzig, Druck and Vertag von Breitkept and Hartel, 1875.

11. Butlin, H.T.: Cancer of the scrotum in chimney-sweeps and others. Brit. Med. J., I 1341-1346, 2:1-6, 66-71, 1892.

12. Henry, S.A.: Cancer of the Scrotum in Relation to Occupation. London, Oxford University Press, 1946.

13. Heller, I.: Occupational cancers, J. Industr. Hyg., 12:169-197, 1930.

14. Brockbank, W.: The occupational incidence of primary lung cancer. Quart. J. Med., 1:31-40, 1932.

15. Kennaway, N.M.; Kennaway, E.L.: A study of the incidence of cancer of the lungs and larynx. J. Hyg. (Camb), 36:236-267, 1936.

16. Teleky, L.: Occupational cancer of the lung. J. Industr. Hyg. Toxicol, 19:73-85, 1937.

17. Manouvriez, A.: Maladies et hygiene des ouvriers travaillant a la fabrication des agglomeres de houille et de brai, Ann. Hyg. Publ. Med. Leg., 45:459-482, 1876.

18. Leuke, A.W.: Epithelioma in carbon workers, Cleveland Med. J., 6:199-202, 1907.

19. Reid, D.D., and Buck, C.: Cancer in coking plant workers, Brit. J. Indust. Med., 13:265-269, 1956.

20. Phair, J.J. and Sterling, T.: Competing Causes of Death in Coal Tar Workers, (unpublished report), 1960.

21. U.S. Department of Health, Education, and Welfare. Mortality trends for leading causes of death, United States, 1950-69. DHEW Publ. No. (HRA) 74-1853, Rockville, Maryland, 1974.

22. Redmond, C.K.; Weinberg, G.B.; et al: Mortality In Allegheny County, Pennsylvania, 1960-1971. Department of Biostatistics and Epidemiology, University of Pittsburgh, Pittsburgh, PA 1978.

23. Pavone - Macaluso, M.: Etiology of kidney tumors. In: King, J.S., Jr., ed., Renal Neoplasia. Boston, Little, Brown and Company, 1967.

24. U.S. Department of Health, Education, and Welfare. Smoking and Health A Report of the Surgeon General. DHEW Publ. No. (PHS) 79-50066, Washington, D.C., 1979.

25. Segi, M. and Kurihara, M.: 1972. Cancer mortality for selected sites in 24 countries. No. 6. Japan Cancer Society. Tokyo, Japan, 1966-1967.

26. Wynder, E.L., Hyams, L., and Shigematsu, T.: Correlations of international cancer death rates, an epidemiological exercise. Cancer, 20:113-126, 1967.

27. Stewart, H.L.: Geographic pathology of cancer of the colon and rectum. Cancer, 28:25-28, 1971.

28. Biometry Branch, National Cancer Institute. The Third National Cancer Survey Advanced Three Year Report, 1969-1971 Incidence. DHEW Publication No. (NIH) 74-637, 1974.

29. Department of Biostatistics, University of Pittsburgh. The Third National Cancer Survey, Cancer Incidence in the Pittsburgh Metropolitan Area--Trends over Time, 1947-1971, and Intra-Area Variation, 1969-1971. Co-operative Health Survey, 1974.

30. The Registrar-General's Decennial Supplement, England and Wales. 1951. Part II. Occupational Mortality. H.M.S.O. London, England, 1958.

31. Li, F.P., Fraumeni, J.F., Jr., Mantel, N. and Miller, R.: Cancer mortality among chemists. J. Natl. Cancer Inst., 43:1159-1164, 1969.

32. Mancuso, T.F. and El-Attar, A.A.: Cohort study of workers exposed to betanaphthylamine and benzidine. J. Occup. Med., 9:277-285, 1967.

33. Weisburger, J.H.: Colon carcinogens: their metabolism and mode of action. Cancer, 28:60-70, 1971.

34. Schoental, R. and Bensted, J.P.M.: Tumours of the intestines induced in rats by intraperitoneal injections of N-methyl- and N-ethyl-N-nitrosourethanes. Brit. J. Cancer, 22:316-323, 1968.

35. Hueper, W.C. and Conway, W.D.: Chemical Carcinogenesis and Cancers. Charles C. Thomas, Springfield, Ill., 1964.

36. Wynder, E., Graham, S. and Eisenberg, H.: Report of the Research Committee, World Health Organization on Gastroenterology: Conference on the etiology of cancer of the gastro-intestinal tract. Cancer, 19:1561-1566, 1966.

37. Haenszel, W. and Correa, P.: Cancer of the colon and recutm and adamatous polyps, a review of epidemiological findings. Cancer, 28:14-24, 1971.

Figure 1

STEELWORKERS POPULATION, ALLEGHENY COUNTY, PENNSYLVANIA

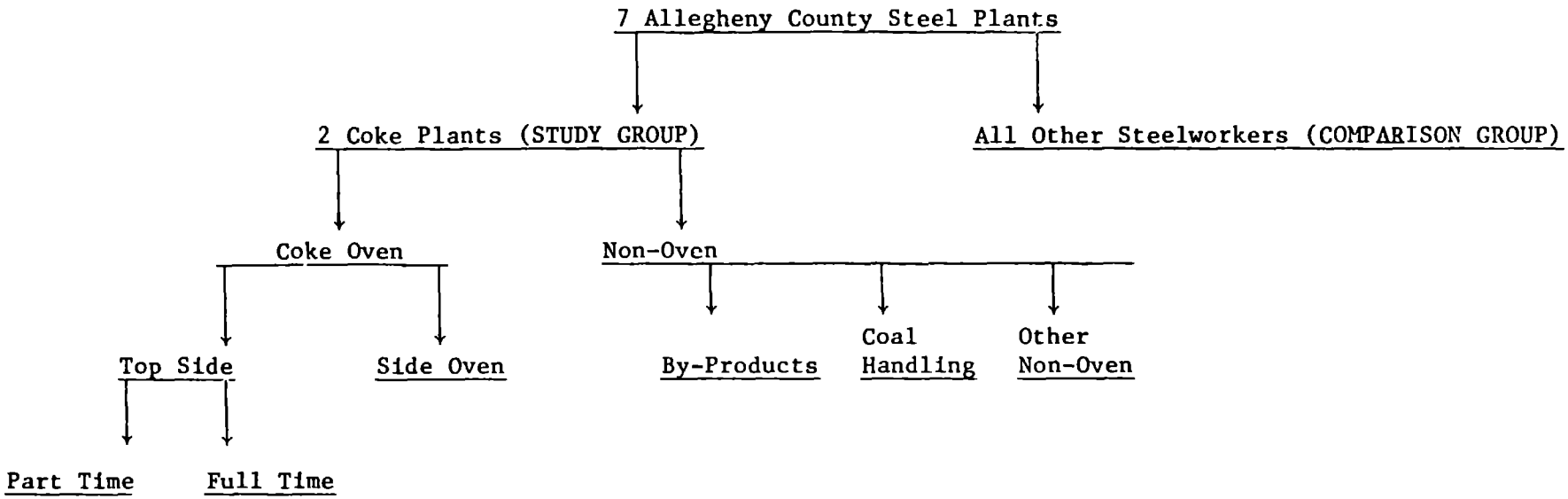


Table 1

DISTRIBUTION OF COKE PLANT WORKERS BY WORK AREA,
RACE AND PERIOD OF EMPLOYMENT

Ever Employed Through 1953

Coke Plant		Coke Oven (2,041 workers)						Nonoven (1,517 workers)					
		Topside Full-time		Topside Part-time		Side Oven		By-Products		Coal Handling		All Other Nonoven	
		Number	%	Number	%	Number	%	Number	%	Number	%	Number	%
Total	3,558	305	8.5	320	8.9	1,416	39.4	501	14.8	210	5.9	806	22.5
White	2,382	79	3.3	312	13.1	591	24.8	459	19.3	205	8.6	736	30.9
Nonwhite	1,176	226	19.2	8	0.7	825	70.2	42	3.6	5	0.4	70	5.9

Table 2

DISTRIBUTION OF COKE PLANT WORKERS BY WORK AREA,
RACE AND PERIOD OF EMPLOYMENT

Worked 5 Years or More Through 1953

Coke Plant		Coke Oven (987 workers)						Nonoven (826 workers)					
		Topside Full-time		Topside Part-time		Side Oven		By-Products		Coal Handling		All Other Nonoven	
		Number	%	Number	%	Number	%	Number	%	Number	%	Number	%
Total	1,844	148	8.0	290	15.7	549	29.8	344	18.7	111	6.0	371	20.1
White*	1,180	28	2.4	208	17.6	164	13.9	303	25.7	107	9.1	341	28.9
Nonwhite**	664	120	18.1	82	12.3	385	58.0	41	6.2	4	0.6	30	4.5

*Includes 29 white employees not assigned to any one coke plant area.
**Includes 2 nonwhite employees not assigned to any one coke plant area.

TABLE 3

Observed and Expected Mortality, 1953-1975, and Relative Risks[1] for Allegheny County Steelworkers Ever Employed in the Coke Plant in 1953 by Cause of Death and Place of Employment

Cause of Death	Coke Plant N= 3,558			Coke Oven N= 2,041			Nonoven N= 1,517		
	Obs.	Exp.	Rel. Risk*	Obs.	Exp.	Rel. Risk	Obs.	Exp.	Rel. Risk
All Causes	1173	1136.5	1.04	690	650.4	1.08	483	484.2	1.00
All Cancers	294	249.2	1.21**	179	144.4	1.29**	115	102.8	1.13
Cardiovascular-Renal Disease	601	611.8	0.98	329	338.3	0.97	272	274.2	0.99
Vascular Lesions of CNS	92	93.1	0.99	57	54.1	1.06	35	39.0	0.89
Arteriosclerotic Heart Disease	414	419.3	0.99	214	222.8	0.95	200	197.1	1.02
Hypertensive Disease	34	37.3	0.90	22	24.8	0.87	12	12.8	0.94
Other Cardiovascular-Renal Disease	61	62.1	0.98	36	36.6	0.98	25	25.3	0.99
Nonmalignant Respiratory Disease	67	56.1	1.22	42	33.6	1.29	25	22.2	1.13
Nonmalignant Digestive Disease	37	56.7	0.63**	21	31.8	0.64	16	25.3	0.62
Cirrhosis of Liver	16	27.5	0.56*	7	15.2	0.44*	9	12.7	0.70
Other Digestive Disease	21	29.2	0.70	14	16.6	0.83	7	12.7	0.55
Tuberculosis of Respiratory System	8	7.1	1.14	6	5.0	1.23	2	2.1	--
Diabetes Mellitus	18	19.8	0.90	10	11.8	0.83	8	8.1	0.99
Accidents	61	53.4	1.16	38	32.1	1.20	23	20.6	1.12
Homicides and Suicides	22	20.0	1.11	18	13.0	1.44	4	7.0	0.57
Ill-Defined Causes	28	21.0	1.40	23	14.2	1.76*	5	6.7	0.74
All Other Causes	37	41.1	0.89	24	26.1	0.91	13	15.3	0.84

[1]Significance of Relative Risk (Rel. Risk) based on Summary Chi-Square with one degree of freedom.
*Significance at 5% level; ** Significance at 1% level; -- less than 5 deaths.

TABLE 4

Observed and Expected Mortality, 1953-1975, and Relative Risks[1] for Allegheny County Steelworkers Ever Employed in the Coke Plant in 1953 by Cause of Death and Place of Employment

Cause of Death	Coke Plant N= 3,558			Coke Oven N= 2,041			Nonoven N= 1,517		
	Obs.	Exp.	Rel. Risk*	Obs.	Exp.	Rel. Risk	Obs.	Exp.	Rel. Risk
All Sites-Malignant Neoplasms	294	249.2	1.21**	179	144.4	1.29**	115	102.8	1.13
Respiratory Organs	121	83.4	1.55**	90	50.1	2.03**	31	32.4	0.95
Lungs, Trachea, Bronchus	114	78.7	1.55**	86	47.4	2.05**	28	30.6	0.91
Other Respiratory Organs	7	4.6	1.63	4	2.6	--	3	1.8	--
Digestive Organs and Peritoneum	84	79.6	1.06	34	44.4	0.74	50	34.6	1.48**
Large Intestine	24	21.1	1.15	6	11.1	0.51	18	9.8	1.90*
Pancreas	18	12.3	1.54	5	6.8	0.71	13	5.1	2.71**
Other Digestive Organs	42	46.2	0.90	23	26.5	0.86	19	19.7	0.96
Genito-Urinary Organs	41	32.2	1.32	28	18.9	1.56*	13	12.8	1.02
Prostate	29	21.1	1.45	20	12.7	1.67*	9	7.8	1.16
Kidney	8	4.5	1.89	7	2.6	2.88*	1	1.8	--
Bladder	3	5.8	0.50	1	3.2	--	2	2.7	--
Buccal Cavity and Pharyngeal Organs	8	7.4	1.09	2	3.9	--	6	3.4	1.81
Lymph and Hematopoietic Tissues	18	18.6	0.97	10	10.7	0.92	8	7.8	1.02
Skin Cancer	0	1.6	--	0	0.8	--	0	0.8	--
All Other Cancers	22	26.5	0.81	15	15.7	0.95	7	10.9	0.63

[1]Significance of Relative Risk (Rel. Risk) based on Summary Chi-Square with one degree of freedom.
*Significance at 5% level; ** Significance at 1% level; -- less than 5 deaths.

TABLE 5

Observed and Expected Mortality, 1953-1975, And Relative Risks[1] For Malignant Neoplasms By Site For Allegheny County Steelworkers Ever Employed At The Coke Ovens Through 1953

Cause of Death	Ever Worked Through 1953 Coke-Oven Experience N= 2,041			Ever Worked Through 1953 Oven Topside Full-Time N= 305			Ever Worked Through 1953 Oven Topside Part-Time N= 320			Ever Worked Through 1953 Oven Side N= 1,416		
	Obs.	Exp.	Rel. Risk	Obs.	Exp.	Rel. Risk	Obs.	Exp.	Rel. Risk	Obs.	Exp.	Rel. Risk
All Sites-Malignant Neoplasms	179	144.4	1.29**	56	25.9	2.37**	25	21.9	1.15	98	92.9	1.06
Respiratory Organs	90	50.1	2.03**	36	9.0	4.79**	9	7.2	1.25	45	30.4	1.56**
Lungs, Trachea, Bronchus	86	47.4	2.05**	35	8.6	4.87**	8	6.8	1.17	43	28.7	1.58**
Other Respiratory Organs	4	2.6	--	1	0.4	--	1	0.4	--	2	1.7	--
Digestive Organs and Peritoneum	34	44.4	0.75	4	7.8	0.50	5	7.2	0.70	25	29.8	0.83
Large Intestine	6	11.1	0.51	0	1.9	--	1	2.0	--	5	7.4	0.65
Pancreas	5	6.8	0.71	1	1.2	--	0	1.0	--	4	4.6	--
Other Digestive Organs	23	26.5	0.86	3	4.6	--	4	4.2	--	16	17.8	0.89
Genito-Urinary Organs	28	18.9	1.56*	6	3.7	1.70	6	2.5	2.50	16	12.4	1.32
Prostate	20	12.7	1.67*	4	2.5	--	3	1.4	--	13	8.5	1.60
Kidney	7	2.6	2.88*	2	0.5	--	3	0.4	--	2	1.6	--
Bladder	1	3.2	--	0	0.6	--	0	0.6	--	1	2.2	--
Buccal Cavity and Pharyngeal Organs	2	3.9	--	0	0.6	--	1	0.7	--	1	2.7	--
Lymph and Hematopoietic Tissues	10	10.7	0.92	3	1.8	--	1	1.7	--	6	7.0	0.84
Skin Cancer	0	0.8	--	0	0.1	--	0	0.2	--	0	0.6	--
All Other Cancers	15	15.6	0.95	7	3.0	2.50*	3	2.4	--	5	10.0	0.49

[1]Significance of Relative Risk (Rel. Risk) based on Summary Chi-Square with One Degree of Freedom.
*Significance at 5% level; **Significance at 1% level; -- less than 5 deaths.

TABLE 6

Observed and Expected Mortality, 1953-1975, And Relative Risks[1] for Malignant Neoplasms By Site For Allegheny County Steelworkers Employed At the Coke Ovens For Five or More Years Through 1953

Cause of Death	≥ Five Years Through 1953 Coke Oven Experience N= 987			≥ Five Years Through 1953 Oven Topside Full-Time N= 148			≥ Five Years Through 1953 Oven Topside Part-Time N= 290			≥ Five Years Through 1953 Oven Side N= 549		
	Obs.	Exp.	Rel. Risk	Obs.	Exp.	Rel. Risk	Obs.	Exp.	Rel. Risk	Obs.	Exp.	Rel. Risk
All Sites-Malignant Neoplasms	123	89.0	1.46**	37	14.2	2.90**	34	24.1	1.44*	52	47.4	1.11
Respiratory Organs	66	29.6	2.63**	26	4.6	6.96**	15	7.9	1.96*	25	14.1	1.89**
Lungs, Trachea, Bronchus	63	28.3	2.63**	25	4.4	6.94**	14	7.5	1.91*	24	13.5	1.91**
Other Respiratory Organs	3	1.3	--	1	0.2	--	1	0.4	--	1	0.7	--
Digestive Organs and Peritoneum	20	27.0	0.72	1	4.5	--	6	7.6	0.79	13	15.3	0.84
Large Intestine	4	6.9	0.57	0	1.2	--	1	2.0	--	3	3.9	--
Pancreas	3	4.0	--	0	0.6	--	1	1.1	--	2	2.3	--
Other Digestive Organs	13	16.2	0.79	1	2.7	--	4	4.5	--	8	9.1	0.87
Genito-Urinary Organs	19	12.9	1.54	3	2.2	--	7	3.0	2.38*	9	7.4	1.23
Prostate	12	8.7	1.43	3	1.6	--	3	1.8	--	6	5.1	1.88
Kidney	6	1.8	3.55**	0	0.3	--	4	0.5	--	2	1.0	--
Bladder	1	2.1	--	0	0.4	--	0	0.6	--	1	1.3	--
Buccal Cavity and Pharyngeal Organs	1	2.3	--	0	0.3	--	1	0.7	--	0	1.3	--
Lymph and Hematopoietic Tissues	6	6.8	0.86	1	1.0	--	2	2.0	--	3	3.7	--
Skin Cancer	0	0.3	--	0	0.1	--	0	0.1	--	0	0.2	--
All Other Cancers	11	10.0	1.10	6	1.7	3.96**	3	2.8	--	2	5.3	0.36

[1]Significance of Relative Risk (Rel. Risk) based on Summary Chi-Square with one degree of freedom.
*Significance at 5% level; **Significance at 1% level; -- less than 5 deaths.

TABLE 7

Observed and Expected Mortality, 1953-1975, And Relative Risks[1] For Malignant Neoplasms By Site For Allegheny County Steelworkers Ever Employed In Nonoven Areas Of the Coke Plant Through 1953

Cause of Death	Ever Worked Through 1953 Nonoven Experience N= 1,517			Ever Worked Through 1953 By-Products N= 501			Ever Worked Through 1953 Coal Handling N= 210			Ever Worked Through 1953 All Other Coke Plant Nonoven N= 806		
	Obs.	Exp.	Rel. Risk	Obs.	Exp.	Rel. Risk	Obs.	Exp.	Rel. Risk	Obs.	Exp.	Rel. Risk
All Sites-Malignant Neoplasms	115	102.8	1.13	34	36.1	0.94	25	14.7	1.74**	56	51.7	1.09
Respiratory Organs	31	32.4	0.95	5	11.4	0.43	9	4.7	1.93	17	16.3	1.05
Lungs, Trachea, Bronchus	28	30.6	0.91	5	10.8	0.46	8	4.5	1.81	15	15.3	0.98
Other Respiratory Organs	3	1.8	--	0	0.6	--	1	0.3	--	2	1.0	--
Digestive Organs and Peritoneum	50	34.6	1.48**	16	11.9	1.36	9	5.0	1.82	25	17.4	1.46
Large Intestine	18	9.8	1.90*	5	3.3	1.54	4	1.4	--	9	5.0	1.85
Pancreas	13	5.1	2.71**	5	1.7	3.01*	2	0.7	--	6	2.5	2.47
Other Digestive Organs	19	19.7	0.96	6	6.9	0.87	3	2.9	--	10	9.9	1.01
Genito-Urinary Organs	13	12.8	1.02	5	4.6	1.09	4	1.7	--	4	6.5	0.61
Prostate	9	7.8	1.16	4	2.8	--	2	1.0	--	3	4.0	--
Kidney	1	1.8	--	0	0.7	--	1	0.3	--	0	0.9	--
Bladder	2	2.7	--	1	1.0	--	0	0.4	--	1	1.4	--
Buccal Cavity and Pharyngeal Organs	6	3.4	1.81	2	1.2	--	1	0.5	--	3	1.6	--
Lymph and Hematopoietic Tissues	8	7.8	1.02	4	2.8	--	0	1.1	--	4	4.0	--
Skin Cancer	0	0.8	--	0	0.3	--	0	0.1	--	0	0.4	--
All Other Cancers	7	10.9	0.63	2	4.0	--	2	1.6	--	3	5.5	0.54

[1]Significance of Relative Risk (Rel. Risk) based on Summary Chi-Square with One Degree of Freedom.
*Significance at 5% level; **Significance at 1% level; -- less than 5 deaths.

TABLE 8

Observed And Expected Mortality, 1953-1975, And Relative Risks[1] For Malignant Neoplasms By Site For Allegheny County Steelworkers Employed in Nonoven Areas Of The Coke Plant For Five or More Years Through 1953

Cause of Death	≥ Five Years Through 1953 Nonoven Experience N= 826			≥ Five Years Through 1953 By-Products N= 344			≥ Five Years Through 1953 Coal Handling N= 111			≥ Five Years Through 1953 All Other Coke Plant Nonoven N= 371		
	Obs.	Exp.	Rel. Risk	Obs.	Exp.	Rel. Risk	Obs.	Exp.	Rel. Risk	Obs.	Exp.	Rel. Risk
All Sites-Malignant Neoplasms	88	71.5	1.25	23	28.8	0.79	20	11.3	1.82*	45	31.2	1.48*
Respiratory Organs	25	22.0	1.14	2	8.8	0.22*	8	3.5	2.32*	15	9.6	1.58
Lungs, Trachea, Bronchus	23	20.8	1.11	2	8.4	0.23*	8	3.3	2.45*	13	9.1	1.44
Other Respiratory Organs	2	1.2	--	0	0.5	--	0	0.2	--	2	0.5	--
Digestive Organs and Peritoneum	34	24.3	1.42	10	9.6	1.05	8	4.0	2.04	16	10.6	1.53
Large Intestine	14	6.6	2.17**	3	2.6	--	4	1.1	--	7	2.9	2.49
Pancreas	9	3.4	2.78**	3	1.3	--	1	0.5	--	5	1.5	3.50
Other Digestive Organs	11	14.2	1.16	4	5.7	0.70	3	2.4	--	4	6.2	0.64
Genito-Urinary Organs	11	9.5	1.19	5	4.0	1.26	3	1.5	--	3	4.0	--
Prostate	7	5.9	1.58	4	2.5	--	2	0.9	--	1	2.5	--
Kidney	2	1.3	--	0	0.6	--	1	0.2	--	1	0.5	--
Bladder	2	2.1	--	1	0.8	--	0	0.3	--	1	0.9	--
Buccal Cavity and Pharyngeal Organs	6	2.4	2.58*	1	0.9	--	1	0.4	--	4	1.1	--
Lymph and Hematopoietic Tissues	9	5.4	1.70	4	2.2	--	0	0.8	--	5	2.4	2.14
Skin Cancer	0	0.4	--	0	0.2	--	0	0.1	--	0	0.2	--
All Other Cancers	3	7.5	0.40	1	3.2	--	0	1.1	--	2	3.3	--

[1]Significance of Relative Risk (Rel. Risk) based on Summary Chi-Square with One Degree of Freedom.
*Significance at 5% level; **Significance at 1% level; -- less than 5 deaths.

Table 9

OBSERVED AND EXPECTED MORTALITY, 1953-1975 AND RELATIVE RISKS[1] FOR MALIGNANT NEOPLASMS OF THE TRACHEA, BRONCHUS AND LUNG BY LENGTH OF EMPLOYMENT AND PLACE OF EMPLOYMENT FOR ALLEGHENY COUNTY STEELWORKERS EMPLOYED IN THE COKE-PLANT THROUGH 1953

Length of Employment	Place of Employment											
	Oven Topside Full-Time			Oven Topside Part-Time			Oven Side Only			Nonoven		
	Obs.	Exp.	Rel. Risk	Obs.	Exp.	Rel. Risk	Obs.	Exp.	Rel. Risk	Obs.	Exp.	Rel. Risk
Ever worked through 1953	35	8.6	4.87**	8	6.8	1.17	43	28.7	1.58**	28	30.6	0.91
≥ Five years through 1953	25	4.4	6.94**	14	7.5	1.91*	24	13.4	1.91**	23	20.8	1.11

[1]Significance of Relative Risk (Rel. Risk) based on Summary Chi-Square with one degree of freedom.
*Significance at 5% level; **Significance at 1% level.

TABLE 10

Observed and Expected Mortality, 1953-1975, and Relative Risks[1] For White Allegheny County Steelworkers Employed in the Coke Plant For Five Years or More Through 1953 by Cause of Death and Place of Employment

Cause of Death	≥ Five Years Through 1953 Oven Topside Full-Time N= 28			≥ Five Years Through 1953 Oven Topside Part-time N= 208			≥ Five Years Through 1953 Oven Side N= 164			≥ Five Years Through 1953 Nonoven N= 751		
	Obs.	Exp.	Rel. Risk	Obs.	Exp.	Rel. Risk	Obs.	Exp.	Rel. Risk	Obs.	Exp.	Rel. Risk
All Causes	11	12.2	0.88	71	76.0	0.92	62	67.5	0.90	290	295.3	0.98
Cardiovascular-Renal Disease	6	7.3	0.80	40	44.0	0.90	35	40.4	0.85	166	173.5	0.95
Arteriosclerotic Heart Disease	6	5.3	1.14	32	32.6	0.98	21	29.1	0.70	119	126.1	0.94
Vascular Lesions of CNS	0	1.0	--	4	5.8	0.68	7	6.0	1.17	25	24.8	1.01
Malignant Neoplasms-All Sites	2	2.5	--	18	16.3	1.11	12	13.9	0.86	73	62.7	1.18
Respiratory Organs	2	0.8	--	6	5.5	1.09	5	4.2	1.19	21	19.9	1.06
Trachea, Bronchus, Lung	2	0.8	--	5	5.2	0.96	5	4.0	1.26	20	18.8	1.06
Other Respiratory Organs	0	0.0	--	1	0.3	--	0	0.2	--	1	1.07	--

[1]Significance of Relative Risk (Rel. Risk) based on Summary Chi-Square with one degree of freedom.
*Significance at 5% level; **Significance at 1% level; -- less than 5 deaths.

TABLE 11

Observed and Expected Mortality, 1953-1975, and Relative Risks[1] For Non-white Allegheny County Steelworkers Employed in the Coke Plant For Five Years or More Through 1953 by Cause of Death and Place of Employment

Cause of Death	≥ Five Years Through 1953 Oven Topside Full-Time N= 120			≥ Five Years Through 1953 Oven Topside Part-Time N= 82			≥ Five Years Through 1953 Oven Side N= 385			≥ Five Years Through 1953 Nonoven N= 75		
	Obs.	Exp.	Rel. Risk	Obs.	Exp.	Rel. Risk	Obs.	Exp.	Rel. Risk	Obs.	Exp.	Rel. Risk
All Causes	70	47.8	1.62**	39	32.4	1.25	163	146.3	1.15	38	39.14	0.96
Cardiovascular-Renal Disease	19	24.4	0.76	8	16.4	0.46*	76	74.2	1.03	18	21.0	0.84
Arteriosclerotic Heart Disease	5	14.0	0.34*	6	9.3	0.63	47	43.5	1.09	9	12.6	0.70
Vascular Lesions of CNS	6	4.6	1.31	0	3.1	--	14	13.5	1.04	3	3.9	--
Malignant Neoplasms-All Sites	35	11.7	3.45**	16	7.7	2.18**	40	33.5	1.22	15	8.8	1.81*
Respiratory Organs	24	3.8	8.19**	9	2.3	4.24**	20	9.9	2.26**	4	2.1	--
Trachea, Bronchus, Lung	23	3.6	8.10**	9	2.3	4.38**	19	9.5	2.24**	3	2.0	--
Other Respiratory Organs	1	0.1	--	0	0.1	--	1	0.4	--	1	0.1	--

[1]Significance of Relative Risk (Rel. Risk) based on Summary Chi-Square with one degree of freedom.
*Significance at 5% level; **Significance at 1% level; -- less than 5 deaths.

Table 12

OBSERVED AND EXPECTED MORTALITY, 1953-1975, AND RELATIVE RISKS AT TEN, TWENTY, AND TWENTY-THREE YEARS OF FOLLOW-UP FOR MALIGNANT NEOPLASMS BY SITE FOR ALLEGHENY COUNTY STEELWORKERS EMPLOYED AT THE COKE OVENS FOR FIVE YEARS OR MORE THROUGH 1953.

	> Five Years Through 1953 Coke Oven Experience N= 987			> Five Years Through 1953 Oven Topside Full-Time N= 148			> Five Years Through 1953 Oven Topside Part-Time N= 290			> Five Years Through 1953 Oven Side N= 549		
	Obs.	Exp.	Rel. Risk	Obs.	Exp.	Rel. Risk	Obs.	Exp.	Rel. Risk	Obs.	Exp.	Rel. Risk
All Sites - Malignant Neoplasms												
10 Years	55	29.6	2.11**	24	5.4	5.63**	17	7.2	2.50**	14	14.53	0.96
20 Years	105	75.4	1.48**	35	12.5	3.18**	27	19.7	1.39	43	40.3	1.08
23 Years	123	89.0	1.46**	37	14.2	2.90**	34	24.0	1.44*	53	47.4	1.11
Lungs, Trachea, Bronchus												
10 Years	33	9.7	4.90**	17	1.7	15.68**	8	2.1	4.00**	8	3.8	2.30
20 Years	55	23.6	2.80**	24	3.8	8.00**	13	6.0	2.23**	16	10.9	1.74
23 Years	63	28.3	2.63**	25	4.4	6.94**	14	7.5	1.91*	24	13.4	1.91**
Large Intestine												
10 Years	3	2.1	--	0	0.4	--	1	0.6	--	2	1.2	--
20 Years	4	6.0	0.66	0	1.0	--	1	1.7	--	3	3.3	--
23 Years	4	6.8	0.57	0	1.2	--	1	2.0	--	3	3.9	--
Pancreas												
10 Years	1	1.1	--	0	0.2	--	1	.2	--	0	0.5	--
20 Years	3	3.3	--	0	0.5	--	1	.9	--	2	1.9	--
23 Years	3	4.0	--	0	0.5	--	1	1.1	--	2	2.3	--

[1]Significance of Relative Risk (Rel. Risk) based on Summary Chi-Square with one degree of freedom.
*Significance at 5% level; **Significance at 1% level; -- less than 5 deaths.

Table 12 (cont.)

OBSERVED AND EXPECTED MORTALITY, 1953-1975, AND RELATIVE RISKS AT TEN, TWENTY, AND TWENTY-THREE YEARS OF FOLLOW-UP FOR MALIGNANT NEOPLASMS BY SITE FOR ALLEGHENY COUNTY STEELWORKERS EMPLOYED AT THE COKE OVENS FOR FIVE YEARS OR MORE THROUGH 1953.

	> Five Years Through 1953 Coke Oven Experience N= 987			> Five Years Through 1953 Oven Topside Full-Time N= 148			> Five Years Through 1953 Oven Topside Part-Time N= 290			> Five Years Through 1953 Oven Side N= 549		
	Obs.	Exp.	Rel. Risk	Obs.	Exp.	Rel. Risk	Obs.	Exp.	Rel. Risk	Obs.	Exp.	Rel. Risk
Prostate												
10 Years	3	2.5	--	1	0.5	--	0	0.2	--	2	1.5	--
20 Years	10	7.3	1.44	3	1.3	--	1	0.7	--	5	4.3	1.18
23 Years	12	8.7	1.43	3	1.6	--	1	0.9	--	6	5.1	1.19
Kidney												
10 Years	2	0.7	--	0	0.1	--	2	0.2	--	0	0.3	--
20 Years	6	1.7	3.73**	0	0.3	--	4	0.5	--	2	0.9	--
23 Years	6	1.8	3.55**	0	0.3	--	4	0.5	--	2	1.0	--
Buccal Cavity and Pharyngeal Organs												
10 Years	1	0.8	--	0	0.1	--	1	0.2	--	0	0.4	--
20 Years	1	1.9	--	0	0.3	--	1	0.6	--	0	1.1	--
23 Years	1	2.3	--	0	0.3	--	1	0.7	--	0	1.3	--
Lymph and Hematopoietic Tissues												
10 Years	2	2.1	--	0	0.2	--	2	0.6	--	0	1.0	--
20 Years	5	5.9	1.44	1	0.9	--	2	1.7	--	2	3.2	--
23 Years	6	6.8	0.86	1	1.0	--	2	1.9	--	3	3.7	--

[1]Significance of Relative Risk (Rel. Risk) based on Summary Chi-Square with one degree of freedom.
*Significance at 5% level; **Significance at 1% level; -- less than 5 deaths.

Table 13

OBSERVED AND EXPECTED MORTALITY, 1953-1975, AND RELATIVE RISKS AT TEN, TWENTY, AND TWENTY-THREE YEARS OF FOLLOW-UP FOR MALIGNANT NEOPLASMS BY SITE FOR ALLEGHENY COUNTY STEELWORKERS EMPLOYED IN NONOVEN AREAS OF THE COKE PLANT FOR FIVE OR MORE YEARS THROUGH 1953.

	≥ Five Years Through 1953 Nonoven Experience N= 826			≥ Five Years Through 1953 By-Products N= 344			≥ Five Years Through 1953 Coal Handling N= 111			≥ Five Years Through 1953 All Other Coke Plant Nonoven N= 371		
	Obs.	Exp.	Rel. Risk	Obs.	Exp.	Rel. Risk	Obs.	Exp.	Rel. Risk	Obs.	Exp.	Rel. Risk
All Sites - Malignant Neoplasms												
10 Years	24	22.7	1.06	5	8.5	0.58	6	4.1	1.51	13	10.1	1.30
20 Years	64	59.5	1.24	18	23.8	0.83	16	9.5	1.72	32	20.6	1.45**
23 Years	88	71.5	1.25	23	28.8	0.79	20	11.3	1.82*	45	31.1	1.48*
Lungs, Trachea, Bronchus												
10 Years	1	6.1	0.16	0	2.3	--	0	1.1	--	1	2.7	--
20 Years	16	16.9	0.95	2	6.6	0.30	6	2.8	2.18	8	7.4	1.08
23 Years	23	20.8	1.11	2	8.4	0.23*	8	3.3	2.45*	13	9.1	1.44
Large Intestine												
10 Years	6	2.0	3.20*	1	0.7	--	2	0.7	--	3	0.9	--
20 Years	11	5.8	1.94	3	2.2	--	3	1.0	--	5	2.5	2.02
23 Years	14	6.7	2.17**	3	2.6	--	4	1.1	--	7	2.9	2.49*
Pancreas												
10 Years	4	1.1	--	1	0.4	--	0	0.2	--	3	0.5	6.47**
20 Years	9	2.1	3.56**	3	1.0	--	1	0.5	--	5	1.2	4.44**
23 Years	9	3.4	2.78**	3	1.3	--	1	0.5	--	5	1.5	3.51*

[1]Significance of Relative Risk (Rel. Risk) based on Summary Chi-Square with one degree of freedom.
*Significance at 5% level; **Significance at 1% level; -- less than 5 deaths.

Table 13 (cont.)

OBSERVED AND EXPECTED MORTALITY, 1953-1975, AND RELATIVE RISKS AT TEN, TWENTY, AND TWENTY-THREE YEARS OF FOLLOW-UP FOR MALIGNANT NEOPLASMS BY SITE FOR ALLEGHENY COUNTY STEELWORKERS EMPLOYED IN NONOVEN AREAS OF THE COKE PLANT FOR FIVE OR MORE YEARS THROUGH 1953.

	≥ Five Years Through 1953 Nonoven Experience N= 826			≥ Five Years Through 1953 By-Products N= 344			≥ Five Years Through 1953 Coal Handling N= 111			≥ Five Years Through 1953 All Other Coke Plant Nonoven N= 371		
	Obs.	Exp.	Rel. Risk	Obs.	Exp.	Rel. Risk	Obs.	Exp.	Rel. Risk	Obs.	Exp.	Rel. Risk
Prostate												
10 Years	3	1.6	--	1	0.6	--	1	0.3	--	1	0.7	--
20 Years	4	4.6	--	1	2.0	--	1	0.7	--	1	1.9	--
23 Years	7	5.9	1.19	4	2.5	--	2	0.9	--	1	2.5	--
Kidney												
10 Years	1	0.5	--	0	0.2	--	1	0.1	--	1	0.7	--
20 Years	2	1.1	--	0	0.5	--	1	0.2	--	1	1.9	--
23 Years	2	1.3	--	0	0.6	--	1	0.2	--	1	2.5	--
Buccal Cavity and Pharyngeal Organs												
10 Years	1	0.9	--	0	0.3	--	0	0.2	--	1	0.4	--
20 Years	5	2.1	2.49	0	0.8	--	1	0.3	--	4	0.9	--
23 Years	6	2.4	2.58*	1	0.9	--	1	0.4	--	4	1.1	--
Lymph and Hematopoietic Tissues												
10 Years	2	1.7	--	2	0.7	--	0	0.3	--	0	0.8	--
20 Years	8	4.7	1.73	4	1.9	--	0	0.7	--	4	2.1	1.96
23 Years	9	5.4	1.70	4	2.2	--	0	0.8	--	5	2.4	2.14

†Significance of Relative Risk (Rel. Risk) based on Summary Chi-Square with one degree of freedom.
*Significance at 5% level; **Significance at 1% level; -- less than 5 deaths.

SECTION IV

LONG TERM MORTALITY OF STEELWORKERS: MORTALITY AMONG NON-ALLEGHENY COUNTY COKE OVEN WORKERS, 1951-1975

IV. LONG TERM MORTALITY OF STEELWORKERS
MORTALITY AMONG NON-ALLEGHENY COUNTY COKE OVEN WORKERS, 1951-1975

In this section, the ten non-Allegheny County coke ovens are considered. The results of an earlier study of these plants are summarized in Part III of this report. These results were based on follow-up for mortality through 1966. In some instances there were too few deaths to make strong conclusions even when trends were indicated. Follow-up has been carried out so that data is now available for observed and expected deaths through 1975. The purpose of this section is to see if the conclusions reported in the earlier non-Allegheny County study are substantiated with more complete data and to examine any new mortality patterns that may have developed.[1] Some additional specific goals are:

1) To explore inter-plant variability in risks for coke oven workers. For several plants which were started in the 1940's the additional follow-up allows us to better determine whether excess deaths from lung cancer occur after the lapse of a sufficient latent period;

2) The study some other causes of concern among coke oven workers, such as nonmalignant respiraotry diseases, with the augmented number of deaths occurring from these causes; and

3) To assess the trends over time in the lung cancer risks among coke oven workers.

Design and Methods

Originally twelve plants were chosen for the non-Allegheny County coke oven worker cohort, but two were eliminated early in the study because they could not provide sufficient data for men who left employment or died prior to the study closing date. The ten selected plants are in widely scattered parts of the United States and Canada and, hence, provided the opportunity to consider geographic variation in diseases among coke oven workers.

In order to be sure of adequate numbers in the study cohorts, it was decided to consider as study subjects all men in these ten plants who worked at the coke ovens at any time in the period 1951-1955. (This group would be comparable with the Allegheny County coke oven workers, where the criteria for inclusion was employment in 1953.) There were several other criteria which determined a man's eligibility for inclusion as a coke oven employee. These were: 1) the man must have had a total of at least thirty days consecutive employment at the coke ovens; and 2) individuals hired strictly as vacation replacements were not eligible. These two criteria are the same in the Allegheny County steelworkers study.

Once the coke oven workers' records were identified, generally through seniority rosters furnished by the employer, a comparison group from among other men employed at the same plant during the period 1951-1955 was selected.

For each coke oven worker in the study an attempt was made to select two non-oven workers who were of the same race and had the closest starting date of employment to the coke oven worker. The actual method of identifying the nonoven group was not the same for all plants because the record keeping system is not identical at each of the steel plants involved in the study.

Although varying a little in details, the sampling schemes were always one of two basic types which are summarized below. It should be noted that the differences in the sampling schemes discussed below may not produce differences of consequence in results.

1) Sampling Scheme I -- Plants where a number was assigned a man on the date of first employment and this number was never reassigned to another individual.

   In this case, it was possible to select the nonoven workers by simply examining the records of the men closest in number to the coke oven workers. The first two who met other study criteria (see below for criteria) were then selected for the study.

2) Sampling Scheme II -- No sequential number was assigned on the basis of starting date.

   A systematic sample of one out of five of all records in the plant files was microfilmed and returned to the central office where lists were prepared in starting date order of the men in the systematic sample. From these lists, two nonoven workers were selected for each oven worker on the basis of closest starting date, race, and eligibility according to other study criteria.

Criteria for selection of the comparison group, in addition to having the same race and starting date as the coke oven workers, were:

1) The man must have been actively employed sometine in the period 1951-1955.

2) The man must never have held a job at the coke ovens, but could have worked at some other area of the coke plant.

3) The man must have had at least thirty days consecutive employment.

4) Vacation replacements were also excluded from the comparison group.

Table 1 shows the distribution by race and plant of the study workers in the non-Allegheny County plants. For some plants there are not exactly twice as many nonoven workers as oven workers since it was not always possible to obtain two men meeting all study criteria. This was particularly true for the nonwhite coke oven workers in plants where there were few nonwhites in the working force.

As indicated earlier, the employment histories of all men selected for the study were microfilmed at the plants. The reproductions were then inserted in envelope forms. Demographic data and the employment histories were coded on the envelope front according to a format suitable for punching

the data on cards. Specific jobs held by the men from date of first employment through 1966 were coded using the four digit classification code developed by Dr. Lloyd in the original steelworkers' study. It was necessary to expand the code in order to allow for jobs and work areas not encountered in the earlier research. It should be pointed out at this time that the terminology and the physical configuration of the work areas varies from plant to plant, so that it was not always possible to define arbitrarily the jobs which would entail coke oven exposure at all plants. In cases where there was ambiguity in the job titles used, personnel at the plant were consulted to clarify whether the job was at the coke ovens. Many of the coke oven workers had worked in other areas during various periods and/or had interruptions in their employment at the plant, and this information was also coded.

In this contract, follow-up for mortality through December 31, 1975, has been performed according to the follow-up scheme described previously, with some modifications for Canadian employees.

The results of the follow-up are presented in Table 1 which gives the number and percentage of individuals in each plant whose status is still not known. The greatest losses to follow-up occurred at two midwest plants which have a highly mobile population of nonwhites and Spanish Americans.

By the end of 1966, 44 percent of the 9778 coke plant workers in the cohort were alive and still employed at one of the ten plants. Only 4 percent of the cohort had died while still employed by the end of 1966, and 11 percent had retired. The remaining 41 percent had left employment by the end of 1966.

Figure 1 shows the breakdown of the cohort of steelworkers at risk in the ten plants, classified by employment status through December 1966, with vital status updated through 1975. By the end of 1975, the number of steelworkers confirmed to have died from the original cohort was 2406 (25%). No death certificate was received for 43 of these workers, but a date of death was obtained and the cause of death was classified as unknown. The number of steelworkers still alive through 1975 was 6994 (71.5%), and the number whose vital status was unknown as of the end of 1975 was 378 (4%). Of these 378, there is some evidence that 6 have died, but both date of death and cause of death are unknown. There is no information for the remaining 372; they must be considered lost to follow-up for the present.

Results

In each individual plant, relative risks were computed in the same fashion as for the Allegheny County cohort. For the total non-Allegheny County computations, observed and expected deaths across particular age groups, work areas, and calendar year periods were summed to obtain a chi-square and relative risk adjusted for plant differences.

The observed and expected deaths and relative risks by area of employment in 1951-1955 for the non-Allegheny County oven workers are given in

Tables 2-9. A work area for jobs held by a man in 1951-1955 has been assigned using the priority scheme discussed in Section II. Table 2 shows that the relative risk for All Causes for oven workers versus nonoven workers is only 1.06, which is in close agreement with the findings in Allegheny County. There is a fairly high variability in the ten plants which were combined to form this table as the risks for All Causes range form .79 to 1.51. In fact, at one plant (Plant A) the risk is significantly high ($p < .01$). Some of the reasons for this will be addressed later in this section.

Examination of cause specific mortality reveals All Cancers had a high relative risk of 1.36. Statistically significant at the .01 level, the 194 observed deaths exceed the expected number of deaths (162.6) by more than 31. Table 6 shows that cancers of the lungs, trachea, and bronchus are of particular concern, with a relative risk of 2.20 ($p < .01$). There were 82 observed deaths versus 53.7 expected. Prostate cancer (17 deaths versus 12.2 expected) and cancers of the buccal cavity and pharyngeal organs (7 deaths versus 4.5 expected) are also somewhat high among oven workers, although not statistically significant.

Among the other causes of death, tuberculosis has the highest relative risk, but this is based on an incidence of only 8 deaths versus 6.2 expected. The cardiovascular-renal diseases (other than vascular lesions of the central nervous system) showed 366 deaths versus 346.2 expected. Neither of these diseases had a statistically significant relative risk. For the remaining causes of death, the relative risks were all close to or less than 1.

Since one of the purposes of this study was to determine the effect of exposure, it is useful to examine relative risk patterns across work areas. The workers who were oven topside full-time have the highest relative risk (1.13) for All Causes (Table 3). In this work area the relative risk for cancers is 1.79 with 71 deaths versus 45.6 expected ($p < .01$). The risk for arteriosclerotic heart disease is also rather high (1.18) with 78 observed deaths versus 69.2 expected. A closer look at the cancers (Table 7) shows that the relative risk for cancers of the lungs, trachea, and bronchus is quite high (RR: 3.52) with 39 deaths versus 16.2 expected ($p < .01$). The incidence of prostate cancer is also greater than expected (5 deaths versus 2.9 expected).

The oven topside part-time workers (Table 4) have a relative risk for All Causes which is slightly less than one (RR: .92). The relative risk for All Cancers (.69) is surprisingly low in this group. Three causes of death which are higher than expected (although not statistically significant) are arteriosclerotic heart disease (34 deaths versus 28.0 expected), non-malignant respiratory diseases (5 deaths versus 1.4 expected), and "other cardiovascular diseases" (7 deaths versus 4.0 expected).

Workers at the side of the ovens only have an overall relative risk of 1.05 (Table 5). Cancers have a high relative risk of 1.28 ($p < .05$) with 109 deaths versus 92.3 expected. The risk for cancer of the lungs, trachea, and bronchus is 1.55 (35 deaths versus 26.0 expected). Other cancers with high risks include prostate cancer (12 deaths versus 7.8 expected), cancers

of the buccal cavity and pharyngeal organs (5 deaths versus 2.4 expected), and cancers of the digestive organs and peritoneum (35 deaths versus 30.9 expected), although none of these specific causes is statistically significant.

A comparison between races shows that for most causes of death the whites have lower relative risks than the nonwhites. For All Causes the white non-Allegheny County workers have a relative risk of .97, while the nonwhites have a risk of 1.12. This is particularly true for topside full-time workers. The relative risk for white workers in this area is .82 while that of nonwhites is 1.25. This is due almost entirely to the different contribution from cancer of the lungs, trachea, and bronchus between the races. For nonwhite topside full-time workers, this relative risk is 3.98 ($p < .01$) with 33 observed deaths versus only 12.8 expected. For the whites the risk is 2.15 with 6 observed deaths versus 3.4 expected. Somewhat surprisingly, the situation is reversed for men who worked only at the side of the ovens. Here the whites have a relative risk of 2.07 with 15 deaths versus 9.37 expected for cancers of the lungs, trachea, and bronchus while the nonwhites had a relative risk of 1.30 (20 deaths versus 16.6 expected). Among all oven workers, the nonwhites have 15 observed deaths from prostate cancer versus 9.4. The relative risk is 2.45 ($p < .05$). The whites have only 2 observed deaths versus 2.8 expected. Among the noncancers, the most noticeable difference between whites and nonwhites seems to occur for arteriosclerotic heart disease. Here the relative risk for nonwhite oven workers is 1.19 (156 observed deaths versus 141.5 expected) while for whites the risk is .97 (107 versus 109.3 expected).

An analysis of the tables for steelworkers ever employed in 1951-1955 across plants seems to show some differences (Appendices G1-H40). The plants with the highest relative risks for All Causes are A and I, each having relative risk 1.51. The high risk in Plant I is probably attributable to chance since there were only 83 oven workers considered and the number of observed deaths is only 3 more than expected (14 versus 11.0). However, in Plant A there were 322 workers considered and the number of observed deaths exceeds the number of expected deaths by nearly 22 (108 versus 86.2). In this instance the relative risk is statistically significant at the .01 level. The risk for All Cancers, cardiovascular-renal diseases, non-malignant respiraotry diseases, and accidents are 2.16 ($p < .05$), 1.31, 2.17, and 2.42 respectively. The oven topside full-time workers have particularly high relative risks. For topside workers, the risk for All Causes is 2.34 ($p < .01$) and cardiovascular diseases is 3.38 ($p < .01$). This is attributable primarily to the nonwhite workers since 96 of the 103 oven topside full-time workers are nonwhite.

Plants C and D provide marked contrasts to Plants A and I. The relative risk for All Causes in Plant C is .84 and in Plant D it is .79. The oven topside full-time workers in Plant D have a relative risk of only .73 (17 deaths versus 21.3 expected) and in Plant C it is only .74 (11 deaths versus 14.2 expected). Further plant by plant analysis, however, does not seem to show any major differences within diseases.

Since cancers of the lungs, trachea, and bronchus are of particular concern. Table 18 shows a breakdown of these cancers by plants and race. It can be seen that there is only one plant (Plant C) where the number of observed deaths is less than the number of expected deaths and this is based on an incidence of only 1 death versus 1.6 expected. The same trend occurs among whites and nonwhites. Hence, it appears that the incidence of excess cancers of the lungs, trachea, and bronchus is a phenomenon that affects oven workers regardless of their race or geographic location.

Tables 19 and 20 give the number of observed and expected deaths by plant and race from All Cancers and All Causes, respectively. The number of observed deaths for All Cancers generally exceeds the number of expected deaths, primarily because of the effect of cancers of the lung, trachea, and bronchus. There is considerable more variability in the relationship between observed and expected deaths for All Causes, as discussed previously.

Tables 10-17 give the observed and expected deaths and relative risks by area of employment for workers with experience at the ovens for more than 5 years. There are no major changes in the All Causes tables, however, the relative risks for lung cancers are of interest and are discussed later.

Analysis of relative risk for workers with five or more years at the ovens by year of death (Table 21) for All Causes shows a slight increase over time, particularly for the nonwhite workers. This does not seem to be the case for cancers, in general, or lung cancers, in particular. In fact, for lung cancers, the period 1963-1967 (about ten years after entry to the study) seemed to be when the relative risk was highest.

An analysis of relative risks for workers with five or more years experience at the ovens by age of entry (Table 22) indicates that workers who were less than 35 at the time of entry to the study have the highest relative risk (RR: 1.64) for All Causes during the study period. The risk is significant at the .05 level. This is true for both white and nonwhite workers. The same phenomenon occurs for All Cancers and lung cancers.

A further breakdown shows that the less than 35 age group has the highest risk for all three work areas when all causes of death are considered. Looking at specific causes of death and specific work areas for this division by age group is not very informative because the number of deaths in a particular group is small.

Discussion

The observation that mortality is excessively high for cancers of the lungs, trachea, and bronchus is again substantiated although the risks are lower here than those previously reported.[1] In this analysis, the mortality from this cause is about 1½ times the expected mortality overall, which is in close agreement with the current findings in Allegheny County.

When both worksite and duration of exposure are taken into account, the relative risks are 3.47 ($p < .01$) for men with five or more years experience

full topside, 2.31 ($p < .05$) for men with five or more years of mixed topside and side oven experience, 2.06 ($p < .05$) for men with five or more years side oven experience only, and 1.83 ($p < .05$) for men with less than 5 years total coke oven experience (Tables 10-17). These are smaller than the figures previously reported for topside workers, but similar for workers at other oven sites.

The fact that these values are lower is a result of the phenomenon, mentioned earlier, that the highest relative risk was during the time period 1963-1967, which is when the previous study was completed.[1] However, the relative risks for 1968-1972 and 1973-1975 are still well above 1, further substantiating the fact that oven workers in general and full-time topside workers in particular have a much higher risk of dying from lung cancer than do other coke plant workers. The relative risk for white oven workers (RR: 2.15) was slightly lower than for nonwhite oven workers (RR: 2.66), but a difference of this magnitude may well be attributable to chance.

The excess of kidney cancer reported previously is not apparent in the update for the non-Allegheny County plants. There are 5 observed deaths versus 4.1 expected. This raises the possibility that the excess was a coincidence, particularly since the number of deaths was small. It appears that further observation will be needed before definitive conclusion can be reached.

The relative risk for nonmalignant respiratory diseases among men who worked at the ovens in 1951-1955 is low (RR: 1.04). The risk for the period 1968-1975 is 1.13 (17 deaths versus 15.8 expected). This is unlike the pattern for Allegheny County where the risks have become more pronounced with time. For topside full-time workers, the relative risk is 1.11. For the period 1968-1975 the risk is 1.77 (7 deaths versus 4.43 expected). Among the men who worked 4 or more years at the ovens, the relative risk is 1.07 in contrast to Allegheny County where the corresponding risk is 1.50. The number of deaths is too small for meaningful analysis when the period 1968-1975 is considered. Since the number of deaths expected after 1967 is still too small for meaningful analysis, further follow-up is suggested prior to drawing any firm conclusions relative to this cause of death.

The inter-plant variability in risks for coke oven workers is considerable. However, it is difficult to determine the reason. For example, both Plants D and J have all white workers, yet the relative risks for All Causes of death are 0.79 and 1.25, respectively. Thus, race does not appear to play a major role. The two plants with the highest risk, Plants A and I, have considerably different racial structures and are from totally different geographic regions, Alabama and Pennsylvania, respectively. Furthermore, Plant I only had 8 workers (< 10%) who had 5 or more years experience while in Plant A nearly half of the workers (47%) had 5 or more years experience at the ovens (at time of entry to the study).

Among the noncancers, it does appear that arteriosclerotic heart disease may have an increased risk in the latter time periods. The relative risk for arteriosclerotic heart disease is less than 1.0 for 1951-1967, but

for 1968-1972 it is 1.18, and for 1973-1975 it is 1.32 with 59 deaths versus 50 expected.

When the workers were classified, it was expected that the "topside full-time" workers would have the most exposure to volatile effluents, hence would have the highest risk for lung cancer followed by the "topside part-time" workers and "oven side only" workers. This is indeed what has occurred. For men employed in 1951-1955, the relative risks for lung cancers in these work areas were 3.52, 1.96, and 1.55, respectively. For men with five or more years experience at the ovens, the risks for lung cancers were 3.47, 2.31, and 2.06, respectively. These figures also indicate that men with longer expsoure at the ovens have more risk of dying from lung cancer.

In summary, the major findings are:

1) Men who work at the coke ovens continue to have an appreciable excess risk of dying from lung cancer. The amount of risk varies between plants, but there is a consistent pattern of the number of observed deaths exceeding the number of expected deaths. Furthermore, increased exposure to the volatile effluents, either because of the work area or length of employment, seems to increase the risk. There is not an appreciable difference in risk between races.

2) The high risk previously reported for kidney cancers is not apparent in this study as there were 5 observed deaths versus 4.1 expected. In fact, prostate cancers (17 deaths versus 12.2 expected) and cancers of the buccal cavity and pharyngeal organs (7 deaths versus 4.5 expected) have higher risks, although they are not statistically significant at the .05 level.

3) There was considerable variation from plant to plant in the relative risks for All Causes and one plant (Plant A) had excessive risks for nearly every major cause of death.

REFERENCE

1. Redmond, C.K.; Ciocco, A.; Lloyd, J.W.; and Rush, H.W.: Long-term Mortality Study of Steelworkers. VI. Mortality from malignant neoplasms among coke oven workers. J.O.M., 14:621-629, 1972.

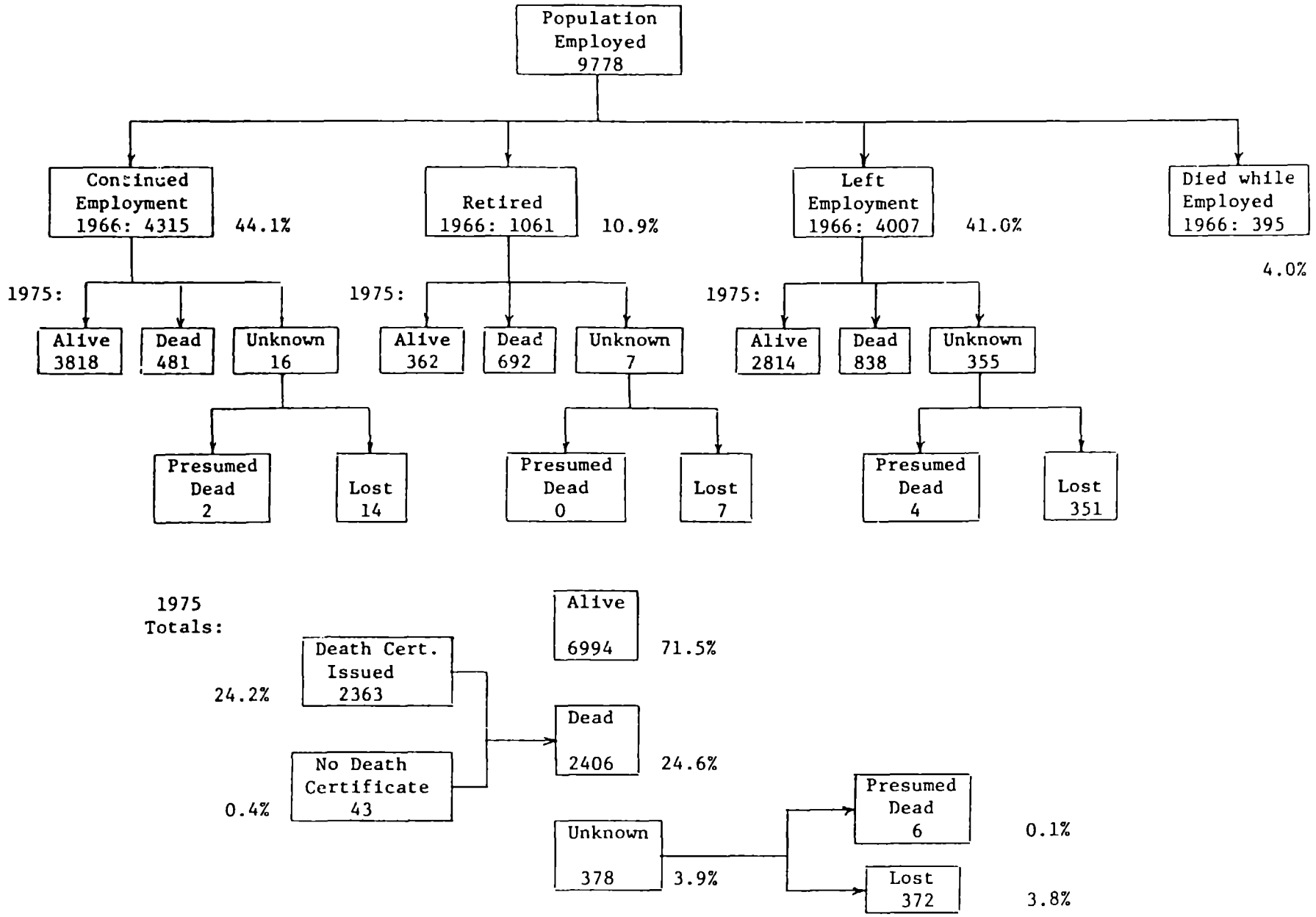


Figure 1: STEELWORKERS EMPLOYED OUTSIDE ALLEGHENY COUNTY, CLASSIFIED BY EMPLOYMENT STATUS ON 31 DECEMBER 1966, AND BY VITAL STATUS ON 31 DECEMBER 1975.

Table 1

DISTRIBUTION BY PLANT, RACE, AND COKE OVEN STATUS OF STUDY GROUP OF MEN EMPLOYED DURING 1951-1955 AT TEN NON-ALLEGHENY COUNTY STEEL PLANTS, FOLLOWED THROUGH 31 DECEMBER 1975

	White Employees				Nonwhite Employees			
Plant	No. in Study	Dead-- no Cert*	Unknown	% Unknown	No. in Study	Dead-- no Cert*	Unknown	% Unknown
A: Coke Oven	78	1	6	7.7	244	0	0	-
Non Oven	156	1	17	10.9	485	3	6	1.2
B: Coke Oven	66	0	1	1.5	90	1	8	8.9
Non Oven	130	0	1	0.8	178	4	7	3.9
C: Coke Oven	242	0	1	0.4	52	0	6	11.5
Non Oven	484	1	3	0.6	87	0	18	20.7
D: Coke Oven	237	0	15	6.3	-	-	-	-
Non Oven	474	0	22(1)+	4.6	-	-	-	-
E: Coke Oven	120	0	11	9.2	366	1	23	6.3
Non Oven	240	1	10	4.2	684	6	47	6.9
F: Coke Oven	90	2	1	1.1	815	5	25(1)	3.1
Non Oven	180	3	3	1.7	1630	9	90(3)	5.5
G: Coke Oven	222	0	4	1.8	18	0	0	-
Non Oven	444	2	8	1.8	5	0	0	-
H: Coke Oven	87	0	1	1.1	274	0	15	5.5
Non Oven	174	1	2	1.1	516	1	22(1)	4.3
I: Coke Oven	82	0	0	-	1	0	0	-
Non Oven	164	0	2	1.2	0	0	0	-
J: Coke Oven	221	1	0	-	-	-	-	-
Non Oven	442	0	3	0.7	-	-	-	-
Total:								
Coke Oven	1445	4	40	2.8	1860	7	77(1)	4.1
Non Oven	2888	9	71(1)	2.5	3585	23	190(4)	5.3

* Numbers in this category refer to workers whose dates of death are known, but for whom death certificates have not yet been received.

\+ Numbers in parentheses refer to workers who are presumed dead, but for whom dates of death and causes of death are unknown.

TABLE 2

OBSERVED AND EXPECTED MORTALITY, 1951-1975, AND RELATIVE RISKS FOR NON-ALLEGHENY COUNTY STEELWORKERS EVER EMPLOYED IN 1951-1955 BY PLANT, CAUSE OF DEATH, RACE, AND PLACE OF EMPLOYMENT

ALL PLANTS

OVEN

Cause of Death	White			Nonwhite			Total		
	Obs Deaths	Exp Deaths	Rel Risk@	Obs Deaths	Exp Deaths	Rel Risk@	Obs Deaths	Exp Deaths	Rel Risk@
All Causes	294	299.34	0.97	577	542.49	1.12*	871	841.83	1.06
All Cancers	63	56.92	1.18	131	105.64	1.47**	194	162.56	1.36**
Cardiovascular-Renal Disease	145	149.50	0.95	283	270.12	1.09	428	419.62	1.03
Vascular Lesions of CNS	15	17.75	0.78	47	55.63	0.77	62	73.38	0.77
Arteriosclerotic Heart Disease	107	109.28	0.97	156	141.49	1.19	263	250.77	1.08
Hypertensive Disease	5	6.03	0.77	48	43.08	1.19	53	49.11	1.13
Other Cardiovascular-Renal Disease	18	16.44	1.17	32	29.92	1.12	50	46.36	1.14
Nonmalignant Respiratory Disease	13	12.80	1.03	26	25.34	1.04	39	38.14	1.04
Nonmalignant Digestive Disease	11	14.27	0.67	15	16.55	0.87	26	30.83	0.78
Cirrhosis of Liver	3	5.94	0.39	8	7.85	1.03	11	13.79	0.72
Other Digestive Disease	8	8.33	0.94	7	8.71	0.73	15	17.03	0.82
Tuberculosis of Respiratory System	2	1.82	--	6	4.40	1.67	8	6.23	1.54
Diabetes Mellitus	3	3.04	--	4	6.02	0.54	7	9.06	0.68
Accidents	31	31.62	0.97	36	38.12	0.92	67	69.73	0.94
Homicides and Suicides	8	9.40	0.79	28	28.46	0.98	36	37.86	0.93
Ill-Defined Causes	12	9.44	1.51	20	21.27	0.91	32	30.71	1.07
All Other Causes	6	10.53	0.45	28	26.57	1.09	34	37.09	0.87
NUMBER OF WORKERS		1445			1860			3305	

@Relative risks are computed using other steelworkers for the comparison group

*Significant at 5% level.

**Significant at 1% level.

--Less than 5 deaths (observed and expected)

TABLE 3

OBSERVED AND EXPECTED MORTALITY, 1951-1975, AND RELATIVE RISKS FOR NON-ALLEGHENY COUNTY STEELWORKERS EVER EMPLOYED IN 1951-1955 BY PLANT, CAUSE OF DEATH, RACE, AND PLACE OF EMPLOYMENT

ALL PLANTS

OVER TOPSIDE FULL-TIME

Cause of Death	White			Nonwhite			Total		
	Obs Deaths	Exp Deaths	Rel Risk@	Obs Deaths	Exp Deaths	Rel Risk@	Obs Deaths	Exp Deaths	Rel Risk@
All Causes	50	57.98	0.82	208	178.26	1.25**	258	236.24	1.13
All Cancers	12	10.82	1.13	59	34.75	2.04**	71	45.56	1.79**
Cardiovascular-Renal Disease	26	28.60	0.88	99	90.52	1.13	125	119.12	1.07
Vascular Lesions of CNS	1	3.69	--	17	19.41	0.85	18	23.11	0.74
Arteriosclerotic Heart Disease	21	20.66	1.02	57	48.53	1.25	78	69.19	1.18
Hypertensive Disease	1	1.44	--	15	13.26	1.17	16	14.70	1.11
Other Cardiovascular-Renal Disease	3	2.81	--	10	9.31	1.09	13	12.13	1.09
Nonmalignant Respiratory Disease	2	2.49	--	10	8.48	1.22	12	10.96	1.11
Nonmalignant Digestive Disease	0	1.94	--	2	5.30	0.35	2	7.24	0.25
Cirrhosis of Liver	0	0.92	--	2	2.45	--	2	3.37	--
Other Digestive Disease	0	1.03	--	0	2.85	--	0	3.87	--
Tuberculosis of Respiratory System	2	0.86	--	2	1.32	--	4	2.19	--
Diabetes Mellitus	0	0.50	--	2	2.15	--	2	2.65	--
Accidents	2	6.13	0.29	14	12.43	1.15	16	18.56	0.84
Homicides and Suicides	2	2.18	--	6	7.92	0.73	8	10.10	0.76
Ill-Defined Causes	2	1.33	--	6	7.00	0.83	8	8.33	0.95
All Other Causes	2	3.13	--	8	8.39	0.94	10	11.52	0.83
NUMBER OF WORKERS		293			595			888	

@Relative risks are computed using other steelworkers for the comparison group

*Significant at 5% level.

**Significant at 1% level.

--Less than 5 deaths (observed and expected)

TABLE 4

OBSERVED AND EXPECTED MORTALITY, 1951-1975, AND RELATIVE RISKS FOR NON-ALLEGHENY COUNTY STEELWORKERS EVER EMPLOYED IN 1951-1955 BY PLANT, CAUSE OF DEATH, RACE, AND PLACE OF EMPLOYMENT
ALL PLANTS
OVEN TOPSIDE PART-TIME

Cause of Death	White			Nonwhite			Total		
	Obs Deaths	Exp Deaths	Rel Risk@	Obs Deaths	Exp Deaths	Rel Risk@	Obs Deaths	Exp Deaths	Rel Risk@
All Causes	67	65.23	1.04	13	19.51	0.60	80	84.74	0.92
All Cancers	12	13.76	0.83	2	4.58	--	14	18.34	0.69
Cardiovascular-Renal Disease	36	31.31	1.20	9	9.83	0.90	45	41.14	1.12
Vascular Lesions of CNS	2	3.85	--	1	2.49	--	3	6.34	0.45
Arteriosclerotic Heart Disease	28	23.28	1.27	6	4.74	1.31	34	28.02	1.28
Hypertensive Disease	1	1.08	--	0	1.66	--	1	2.75	--
Other Cardiovascular-Renal Disease	5	3.10	1.79	2	0.93	--	7	4.03	1.92
Nonmalignant Respiratory Disease	4	2.93	--	1	0.89	--	5	3.82	1.39
Nonmalignant Digestive Disease	3	3.21	--	0	0.58	--	3	3.79	--
Cirrhosis of Liver	1	1.37	--	0	0.30	--	1	1.67	--
Other Digestive Disease	2	1.84	--	0	0.28	--	2	2.13	--
Tuberculosis of Respiratory System	0	0.11	--	0	0.10	--	0	0.21	--
Diabetes Mellitus	1	0.72	--	0	0.31	--	1	1.03	--
Accidents	6	6.51	0.91	0	1.07	--	6	7.58	0.77
Homicides and Suicides	2	2.11	--	0	0.86	--	2	2.97	--
Ill-Defined Causes	1	2.34	--	1	0.45	--	2	2.80	--
All Other Causes	2	2.25	--	0	0.84	--	2	3.09	--
NUMBER OF WORKERS		325			53			378	

@Relative risks are computed using other steelworkers for the comparison group
*Significant at 5% level.
**Significant at 1% level.
--Less than 5 deaths (observed and expected)

TABLE 5

OBSERVED AND EXPECTED MORTALITY, 1951-1975, AND RELATIVE RISKS FOR NON-ALLEGHENY COUNTY STEELWORKERS EVER EMPLOYED IN 1951-1955 BY PLANT, CAUSE OF DEATH, RACE, AND PLACE OF EMPLOYMENT
ALL PLANTS
OVEN SIDE ONLY

Cause of Death	White			Nonwhite			Total		
	Obs Deaths	Exp Deaths	Rel Risk@	Obs Deaths	Exp Deaths	Rel Risk@	Obs Deaths	Exp Deaths	Rel Risk@
All Causes	177	178.78	0.98	356	339.08	1.08	533	517.86	1.05
All Cancers	39	31.70	1.35	70	60.60	1.24	109	92.30	1.28*
Cardiovascular-Renal Disease	83	90.57	0.88	175	168.27	1.06	258	258.83	0.99
Vascular Lesions of CNS	12	11.67	1.04	29	36.47	0.73	41	48.14	0.80
Arteriosclerotic Heart Disease	58	65.39	0.84	93	85.05	1.14	151	150.44	1.00
Hypertensive Disease	3	3.78	--	33	27.69	1.29	36	31.48	1.21
Other Cardiovascular-Renal Disease	10	9.73	1.04	20	19.06	1.07	30	28.78	1.06
Nonmalignant Respiratory Disease	7	7.52	0.91	15	15.95	0.92	22	23.46	0.92
Nonmalignant Digestive Disease	8	9.05	0.85	13	11.95	1.13	21	20.99	1.00
Cirrhosis of Liver	2	4.08	--	6	5.38	1.16	8	9.47	0.80
Other Digestive Disease	6	4.96	1.28	7	6.56	1.10	13	11.52	1.18
Tuberculosis of Respiratory System	0	0.63	--	4	2.74	--	4	3.37	--
Diabetes Mellitus	2	2.09	--	2	3.68	--	4	5.77	0.61
Accidents	23	19.89	1.23	22	24.88	0.84	45	44.77	1.01
Homicides and Suicides	4	5.55	0.64	22	20.14	1.13	26	25.69	1.02
Ill-Defined Causes	9	5.51	2.20	13	13.70	0.93	22	19.21	1.21
All Other Causes	2	6.27	0.25	20	17.19	1.23	22	23.46	0.92
NUMBER OF WORKERS		827			1212			2039	

@Relative risks are computed using other steelworkers for the comparison group
*Significant at 5% level.
**Significant at 1% level.
--Less than 5 deaths (observed and expected)

TABLE 6

OBSERVED AND EXPECTED MORTALITY, 1951-1975, AND RELATIVE RISKS FOR NON-ALLEGHENY COUNTY STEELWORKERS EVER EMPLOYED IN 1951-1955 BY PLANT, CAUSE OF DEATH, RACE, AND PLACE OF EMPLOYMENT
ALL PLANTS
OVEN

Cause of Death	White			Nonwhite			Total		
	Obs Deaths	Exp Deaths	Rel Risk@	Obs Deaths	Exp Deaths	Rel Risk@	Obs Deaths	Exp Deaths	Rel Risk@
Malignant Neoplasms - All Sites	63	56.92	1.18	131	105.64	1.47**	194	162.56	1.36**
Respiratory Organs	28	18.95	2.07*	55	36.82	2.08**	83	55.77	2.08**
Lungs,Trachea,Bronchus	28	18.64	2.16**	54	35.02	2.23**	82	53.66	2.20**
Other Respiratory Organs	0	0.31	--	1	1.80	--	1	2.11	--
Digestive Organs and Peritoneum	17	16.06	1.09	32	34.07	0.90	49	50.13	0.96
Large Intestine	0	1.56	--	7	6.38	1.21	7	7.94	0.79
Pancreas	3	4.25	--	7	6.49	1.13	10	10.73	0.90
Other Digestive Organs	14	10.26	1.72	18	21.20	0.78	32	31.46	1.03
Genito-Urinary Organs	6	6.53	0.88	20	14.72	1.72	26	21.25	1.41
Prostate	2	2.79	--	15	9.44	2.45*	17	12.23	1.81
Kidney	2	1.40	--	3	2.73	--	5	4.13	1.36
Bladder	2	2.34	--	2	1.82	--	4	4.16	--
Buccal Cavity and Pharyngeal Organs	4	2.50	--	3	2.03	--	7	4.53	2.66
Lymph and Hematopoietic Tissues	4	5.89	0.60	11	9.49	1.28	15	15.38	0.96
Skin Cancer	1	1.89	--	2	0.71	--	3	2.59	--
All Other Cancers	3	5.10	0.48	8	7.82	1.04	11	12.91	0.77
NUMBER OF WORKERS		1445			1860			3305	

@Relative risks are computed using other steelworkers for the comparison group
*Significant at 5% level.
**Significant at 1% level.
--Less than 5 deaths (observed and expected)

TABLE 7

OBSERVED AND EXPECTED MORTALITY, 1951-1975, AND RELATIVE RISKS FOR NON-ALLEGHENY COUNTY STEELWORKERS EVER EMPLOYED IN 1951-1955 BY PLANT, CAUSE OF DEATH, RACE, AND PLACE OF EMPLOYMENT
ALL PLANTS
OVEN TOPSIDE FULL-TIME

Cause of Death	White			Nonwhite			Total		
	Obs Deaths	Exp Deaths	Rel Risk@	Obs Deaths	Exp Deaths	Rel Risk@	Obs Deaths	Exp Deaths	Rel Risk@
Malignant Neoplasms - All Sites	12	10.82	1.13	59	34.75	2.04**	71	45.56	1.79**
Respiratory Organs	6	3.43	2.12	34	13.55	3.80**	40	16.98	3.40**
Lungs,Trachea,Bronchus	6	3.41	2.15	33	12.82	3.98**	39	16.23	3.52**
Other Respiratory Organs	0	0.03	--	1	0.73	--	1	0.75	--
Digestive Organs and Peritoneum	3	3.04	--	8	10.50	0.72	11	13.54	0.78
Large Intestine	0	0.19	--	2	1.73	--	2	1.92	--
Pancreas	1	1.03	--	1	1.75	--	2	2.78	--
Other Digestive Organs	2	1.82	--	5	7.02	0.67	7	8.84	0.76
Genito-Urinary Organs	0	1.11	--	8	4.56	2.05	8	5.67	1.53
Prostate	0	0.44	--	5	2.50	2.43	5	2.94	1.94
Kidney	0	0.14	--	1	0.81	--	1	0.95	--
Bladder	0	0.53	--	2	0.95	--	2	1.48	--
Buccal Cavity and Pharyngeal Organs	0	0.20	--	1	0.51	--	1	0.71	--
Lymph and Hematopoietic Tissues	1	1.19	--	4	3.06	--	5	4.25	1.21
Skin Cancer	0	0.59	--	0	0.00	--	0	0.59	--
All Other Cancers	2	1.25	--	4	2.57	--	6	3.82	1.75
NUMBER OF WORKERS		293			595			888	

@Relative risks are computed using other steelworkers for the comparison group
*Significant at 5% level.
**Significant at 1% level.
--Less than 5 deaths (observed and expected)

TABLE 8

OBSERVED AND EXPECTED MORTALITY, 1951-1975, AND RELATIVE RISKS FOR NON-ALLEGHENY COUNTY STEELWORKERS EVER EMPLOYED IN 1951-1955 BY PLANT, CAUSE OF DEATH, RACE, AND PLACE OF EMPLOYMENT
ALL PLANTS
OVEN TOPSIDE PART-TIME

Cause of Death	White			Nonwhite			Total		
	Obs Deaths	Exp Deaths	Rel Risk@	Obs Deaths	Exp Deaths	Rel Risk@	Obs Deaths	Exp Deaths	Rel Risk@
Malignant Neoplasms - All Sites	12	13.76	0.83	2	4.58	--	14	18.34	0.69
Respiratory Organs	7	4.06	2.08	1	0.98	--	8	5.04	1.81
Lungs, Trachea, Bronchus	7	3.90	2.22	1	0.86	--	8	4.76	1.96
Other Respiratory Organs	0	0.17	--	0	0.12	--	0	0.29	--
Digestive Organs and Peritoneum	2	4.10	--	1	2.44	--	3	6.54	0.30
Large Intestine	0	0.46	--	1	1.24	--	1	1.70	--
Pancreas	0	1.22	--	0	0.14	--	0	1.36	--
Other Digestive Organs	2	2.42	--	0	1.06	--	2	3.48	--
Genito-Urinary Organs	1	1.50	--	0	0.44	--	1	1.94	--
Prostate	0	0.59	--	0	0.18	--	0	0.76	--
Kidney	1	0.32	--	0	0.15	--	1	0.47	--
Bladder	0	0.59	--	0	0.08	--	0	0.68	--
Buccal Cavity and Pharyngeal Organs	1	0.88	--	0	0.03	--	1	0.91	--
Lymph and Hematopoietic Tissues	1	1.73	--	0	0.42	--	1	2.15	--
Skin Cancer	0	0.39	--	0	0.00	--	0	0.39	--
All Other Cancers	0	1.09	--	0	0.28	--	0	1.38	--
NUMBER OF WORKERS		325			53			378	

@Relative risks are computed using other steelworkers for the comparison group
*Significant at 5% level.
**Significant at 1% level.
--Less than 5 deaths (observed and expected)

TABLE 9

OBSERVED AND EXPECTED MORTALITY, 1951-1975, AND RELATIVE RISKS FOR NON-ALLEGHENY COUNTY STEELWORKERS EVER EMPLOYED IN 1951-1955 BY PLANT, CAUSE OF DEATH, RACE, AND PLACE OF EMPLOYMENT
ALL PLANTS
OVEN SIDE ONLY

Cause of Death	White			Nonwhite			Total		
	Obs Deaths	Exp Deaths	Rel Risk@	Obs Deaths	Exp Deaths	Rel Risk@	Obs Deaths	Exp Deaths	Rel Risk@
Malignant Neoplasms - All Sites	39	31.70	1.35	70	60.60	1.24	109	92.30	1.28*
Respiratory Organs	15	9.55	2.00	20	17.63	1.19	35	27.18	1.44
Lungs,Trachea,Bronchus	15	9.37	2.07	20	16.62	1.30	35	25.99	1.55
Other Respiratory Organs	0	0.19	--	0	1.00	--	0	1.19	--
Digestive Organs and Peritoneum	12	9.12	1.49	23	21.75	1.08	35	30.87	1.19
Large Intestine	0	1.12	--	4	3.27	--	4	4.39	--
Pancreas	2	2.52	--	6	4.58	1.48	8	7.10	1.19
Other Digestive Organs	10	5.48	2.54*	13	13.90	0.91	23	19.32	1.27
Genito-Urinary Organs	5	4.29	1.23	12	8.68	1.64	17	12.97	1.49
Prostate	2	2.19	--	10	5.56	2.65*	12	7.75	2.03
Kidney	1	0.71	--	2	1.80	--	3	2.51	--
Bladder	2	1.39	--	0	0.77	--	2	2.15	--
Buccal Cavity and Pharyngeal Organs	3	1.18	--	2	1.25	--	5	2.43	3.32
Lymph and Hematopoietic Tissues	2	3.34	--	7	5.86	1.29	9	9.20	0.97
Skin Cancer	1	1.1[illegible]	--	2	0.55	--	3	1.74	--
All Other Cancers	1	3.02	--	4	4.89	--	5	7.91	0.51
NUMBER OF WORKERS		827			1212			2039	

@Relative risks are computed using other steelworkers for the comparison group
*Significant at 5% level.
**Significant at 1% level.
--Less than 5 deaths (observed and expected)

TABLE 10

OBSERVED AND EXPECTED MORTALITY, 1951-1975, AND RELATIVE RISKS FOR NON-ALLEGHENY COUNTY STEELWORKERS EMPLOYED 5 OR MORE YEARS AT TIME OF ENTRY TO STUDY BY PLANT, CAUSE OF DEATH, RACE, AND PLACE OF EMPLOYMENT

ALL PLANTS

OVEN

Cause of Death	White			Nonwhite			Total		
	Obs Deaths	Exp Deaths	Rel Risk@	Obs Deaths	Exp Deaths	Rel Risk@	Obs Deaths	Exp Deaths	Rel Risk@
All Causes	145	138.24	1.10	311	300.00	1.07	456	438.24	1.08
All Cancers	33	29.25	1.23	85	66.79	1.57	118	96.04	1.45
Cardiovascular-Renal Disease	79	77.14	1.04	162	168.87	0.93	241	246.01	0.96
Vascular Lesions of CNS	10	10.28	0.96	26	35.73	0.63	36	46.01	0.70
Arteriosclerotic Heart Disease	55	54.20	1.03	89	87.98	1.02	144	142.18	1.02
Hypertensive Disease	3	4.62	--	29	29.20	0.99	32	33.82	0.91
Other Cardiovascular-Renal Disease	11	8.05	1.90	18	15.95	1.22	29	24.00	1.40
Nonmalignant Respiratory Disease	7	6.28	1.20	14	13.89	1.01	21	20.17	1.07
Nonmalignant Digestive Disease	7	5.64	1.46	4	5.93	0.57	11	11.58	0.92
Cirrhosis of Liver	1	1.61	--	2	2.51	--	3	4.12	--
Other Digestive Disease	6	4.04	2.13	2	3.42	--	8	7.45	1.12
Tuberculosis of Respiratory System	1	1.50	--	2	1.73	--	3	3.23	--
Diabetes Mellitus	2	1.52	--	2	3.99	--	4	5.51	0.62
Accidents	4	5.79	0.62	13	12.21	1.11	17	18.00	0.91
Homicides and Suicides	1	1.35	--	7	4.44	2.27	8	5.79	1.70
Ill-Defined Causes	7	4.97	1.97	9	7.12	1.53	16	12.09	1.70
All Other Causes	4	4.80	--	13	15.02	0.80	17	19.82	0.79
NUMBER OF WORKERS		330			674			1004	

@Relative risks are computed using other steelworkers for the comparison group

*Significant at 5% level.

**Significant at 1% level.

--Less than 5 deaths (observed and expected)

TABLE 11

OBSERVED AND EXPECTED MORTALITY, 1951-1975, AND RELATIVE RISKS FOR NON-ALLEGHENY COUNTY STEELWORKERS EMPLOYED 5 OR MORE YEARS AT TIME OF ENTRY TO STUDY BY PLANT, CAUSE OF DEATH, RACE, AND PLACE OF EMPLOYMENT
ALL PLANTS
OVEN TOPSIDE FULL-TIME

Cause of Death	White			Nonwhite			Total		
	Obs Deaths	Exp Deaths	Rel Risk@	Obs Deaths	Exp Deaths	Rel Risk@	Obs Deaths	Exp Deaths	Rel Risk@
All Causes	10	11.28	0.86	131	109.42	1.34	141	120.70	1.28
All Cancers	1	1.78	--	41	24.25	2.16	42	26.03	1.99
Cardiovascular-Renal Disease	7	6.29	1.14	66	63.44	1.06	73	69.74	1.07
Vascular Lesions of CNS	1	1.13	--	8	14.17	0.51	9	15.30	0.54
Arteriosclerotic Heart Disease	4	4.45	--	40	34.63	1.25	44	39.08	1.19
Hypertensive Disease	0	0.18	--	11	9.49	1.21	11	9.66	1.18
Other Cardiovascular-Renal Disease	2	0.54	--	7	5.16	1.46	9	5.70	1.79
Nonmalignant Respiratory Disease	0	0.67	--	6	5.22	1.19	6	5.89	1.02
Nonmalignant Digestive Disease	0	0.30	--	1	2.11	--	1	2.40	--
Cirrhosis of Liver	0	0.11	--	1	0.86	--	1	0.96	--
Other Digestive Disease	0	0.19	--	0	1.25	--	0	1.44	--
Tuberculosis of Respiratory System	1	0.41	--	1	0.66	--	2	1.07	--
Diabetes Mellitus	0	0.09	--	0	1.17	--	0	1.26	--
Accidents	0	0.48	--	5	4.20	1.25	5	4.69	1.08
Homicides and Suicides	0	0.23	--	2	0.93	--	2	1.16	--
Ill-Defined Causes	1	0.63	--	2	2.14	--	3	2.77	--
All Other Causes	0	0.40	--	7	5.30	1.42	7	5.70	1.29
NUMBER OF WORKERS		21			223			244	

@Relative risks are computed using other steelworkers for the comparison group
*Significant at 5% level.
**Significant at 1% level.
--Less than 5 deaths (observed and expected)

TABLE 12

OBSERVED AND EXPECTED MORTALITY, 1951-1975, AND RELATIVE RISKS FOR NON-ALLEGHENY COUNTY STEELWORKERS EMPLOYED 5 OR MORE YEARS IN TIME OF ENTRY TO STUDY BY PLANT, CAUSE OF DEATH, RACE, AND PLACE OF EMPLOYMENT
ALL PLANTS
OVEN TOPSIDE PART-TIME

Cause of Death	White			Nonwhite			Total		
	Obs Deaths	Exp Deaths	Rel Risk@	Obs Deaths	Exp Deaths	Rel Risk@	Obs Deaths	Exp Deaths	Rel Risk@
All Causes	73	65.22	1.21	49	54.92	0.86	122	120.13	1.02
All Cancers	14	13.74	1.03	13	11.18	1.20	27	24.92	1.11
Cardiovascular-Renal Disease	40	35.06	1.22	26	31.53	0.78	66	66.59	0.99
Vascular Lesions of CNS	4	4.10	--	4	7.88	0.46	8	11.98	0.62
Arteriosclerotic Heart Disease	28	25.04	1.18	14	14.88	0.93	42	39.91	1.07
Hypertensive Disease	1	2.48	--	4	5.90	0.62	5	8.39	0.53
Other Cardiovascular-Renal Disease	7	3.44	3.13	4	2.88	--	11	6.32	2.16
Nonmalignant Respiratory Disease	5	3.39	1.75	2	2.64	--	7	6.02	1.22
Nonmalignant Digestive Disease	4	2.79	--	0	1.65	--	4	4.45	--
Cirrhosis of Liver	0	0.63	--	0	0.76	--	0	1.38	--
Other Digestive Disease	4	2.17	--	0	0.90	--	4	3.06	--
Tuberculosis of Respiratory System	0	0.39	--	0	0.20	--	0	0.59	--
Diabetes Mellitus	2	1.05	--	1	0.80	--	3	1.85	--
Accidents	3	3.41	--	2	2.00	--	5	5.41	0.91
Homicides and Suicides	1	1.08	--	0	0.80	--	1	1.88	--
Ill-Defined Causes	2	2.13	--	2	1.26	--	4	3.39	--
All Other Causes	2	2.18	--	3	2.85	--	5	5.03	0.99
NUMBER OF WORKERS		189			134			323	

@Relative risks are computed using other steelworkers for the comparison group
*Significant at 5% level.
**Significant at 1% level.
--Less than 5 deaths (observed and expected)

TABLE 13

OBSERVED AND EXPECTED MORTALITY, 1951-1975, AND RELATIVE RISKS FOR NON-ALLEGHENY COUNTY STEELWORKERS EMPLOYED 5 OR MORE YEARS AT TIME OF ENTRY TO STUDY BY PLANT, CAUSE OF DEATH, RACE, AND PLACE OF EMPLOYMENT
ALL PLANTS
OVEN SIDE ONLY

Cause of Death	White			Nonwhite			Total		
	Obs Deaths	Exp Deaths	Rel Risk@	Obs Deaths	Exp Deaths	Rel Risk@	Obs Deaths	Exp Deaths	Rel Risk@
All Causes	62	61.19	1.02	131	135.21	0.95	193	196.40	0.97
All Cancers	16	13.50	1.54	31	26.11	1.27	49	39.61	1.35
Cardiovascular-Renal Disease	32	34.91	0.88	70	77.53	0.86	102	112.44	0.87
Vascular Lesions of CNS	5	5.55	0.87	14	17.87	0.73	19	23.42	0.76
Arteriosclerotic Heart Disease	23	24.75	0.90	35	38.72	0.87	58	63.47	0.88
Hypertensive Disease	2	2.20	--	14	13.92	1.01	16	16.12	0.99
Other Cardiovascular-Renal Disease	2	2.40	--	7	7.02	0.99	9	9.43	0.94
Nonmalignant Respiratory Disease	2	2.73	--	6	6.37	0.92	8	9.09	0.84
Nonmalignant Digestive Disease	3	2.01	--	3	3.29	--	6	5.30	1.18
Cirrhosis of Liver	1	0.99	--	1	1.29	--	2	2.28	--
Other Digestive Disease	2	1.02	--	2	2.00	--	4	3.02	--
Tuberculosis of Respiratory System	0	0.57	--	1	0.75	--	1	1.33	--
Diabetes Mellitus	0	0.44	--	1	2.47	--	1	2.90	--
Accidents	1	2.23	--	6	6.15	0.96	7	8.38	0.77
Homicides and Suicides	0	0.19	--	5	2.45	3.06	5	2.64	2.65
Ill-Defined Causes	4	2.02	--	5	3.03	1.97	9	5.05	2.31
All Other Causes	2	2.60	--	3	7.06	0.36	5	9.66	0.44
NUMBER OF WORKERS		120			317			437	

@Relative risks are computed using other steelworkers for the comparison group
*Significant at 5% level.
**Significant at 1% level.
--Less than 5 deaths (observed and expected)

TABLE 14

OBSERVED AND EXPECTED MORTALITY, 1951-1975, AND RELATIVE RISKS FOR NON-ALLEGHENY COUNTY STEELWORKERS EMPLOYED 5 OR MORE YEARS AT TIME OF ENTRY TO STUDY BY PLANT, CAUSE OF DEATH, RACE, AND PLACE OF EMPLOYMENT

ALL PLANTS

OVEN

Cause of Death	White			Nonwhite			Total		
	Obs Deaths	Exp Deaths	Rel Risk@	Obs Deaths	Exp Deaths	Rel Risk@	Obs Deaths	Exp Deaths	Rel Risk@
Malignant Neoplasms - All Sites	33	29.25	1.23	85	66.79	1.57	118	96.04	1.45
Respiratory Organs	14	9.65	2.03	36	23.18	2.41	50	32.83	2.29
Lungs,Trachea,Bronchus	14	9.42	2.15	36	22.33	2.66	50	31.75	2.49
Other Respiratory Organs	0	0.23	--	0	0.85	--	0	1.08	--
Digestive Organs and Peritoneum	11	9.63	1.23	25	24.49	1.04	36	34.13	1.09
Large Intestine	0	0.56	--	6	5.14	1.42	6	5.70	1.11
Pancreas	2	2.74	--	4	4.74	--	6	7.48	0.72
Other Digestive Organs	9	6.33	1.81	15	14.61	1.04	24	20.94	1.25
Genito-Urinary Organs	4	3.86	--	15	9.67	2.27	19	13.52	1.82
Prostate	1	1.38	--	12	6.54	3.59	13	7.92	2.63
Kidney	2	0.98	--	1	1.74	--	3	2.73	--
Bladder	1	1.49	--	2	1.07	--	3	2.56	--
Buccal Cavity and Pharyngeal Organs	1	1.35	--	1	1.27	--	2	2.62	--
Lymph and Hematopoietic Tissues	2	2.56	--	3	3.55	--	5	6.12	0.74
Skin Cancer	1	0.84	--	1	0.30	--	2	1.14	--
All Other Cancers	0	1.36	--	4	4.33	--	4	5.69	0.59
NUMBER OF WORKERS		330			674			1004	

@Relative risks are computed using other steelworkers for the comparison group

*Significant at 5% level.

**Significant at 1% level.

--Less than 5 deaths (observed and expected)

TABLE 15

OBSERVED AND EXPECTED MORTALITY, 1951-1975, AND RELATIVE RISKS FOR NON-ALLEGHENY COUNTY STEELWORKERS EMPLOYED 5 OR MORE YEARS AT TIME OF ENTRY TO STUDY BY PLANT, CAUSE OF DEATH, RACE, AND PLACE OF EMPLOYMENT
ALL PLANTS
OVEN TOPSIDE FULL-TIME

Cause of Death	White			Nonwhite			Total		
	Obs Deaths	Exp Deaths	Rel Risk@	Obs Deaths	Exp Deaths	Rel Risk@	Obs Deaths	Exp Deaths	Rel Risk@
Malignant Neoplasms - All Sites	1	1.78	--	41	24.25	2.16	42	26.03	1.99
Respiratory Organs	0	0.60	--	19	8.20	3.74	19	8.80	3.24
Lungs,Trachea,Bronchus	0	0.57	--	19	7.94	4.00	19	8.51	3.47
Other Respiratory Organs	0	0.04	--	0	0.26	--	0	0.29	--
Digestive Organs and Peritoneum	1	0.71	--	8	8.66	0.89	9	9.37	0.95
Large Intestine	0	0.00	--	3	2.20	--	3	2.20	--
Pancreas	0	0.16	--	1	1.55	--	1	1.70	--
Other Digestive Organs	1	0.56	--	4	4.92	--	5	5.47	0.90
Genito-Urinary Organs	0	0.25	--	8	3.47	3.13	8	3.72	2.80
Prostate	0	0.16	--	6	2.23	4.21	6	2.39	3.71
Kidney	0	0.00	--	0	0.63	--	0	0.63	--
Bladder	0	0.09	--	2	0.44	--	2	0.54	--
Buccal Cavity and Pharyngeal Organs	0	0.00	--	1	0.55	--	1	0.55	--
Lymph and Hematopoietic Tissues	0	0.03	--	2	1.51	--	2	1.54	--
Skin Cancer	0	0.14	--	0	0.00	--	0	0.14	--
All Other Cancers	0	0.04	--	3	1.86	--	3	1.90	--
NUMBER OF WORKERS		21			223			244	

@Relative risks are computed using other steelworkers for the comparison group
*Significant at 5% level.
**Significant at 1% level.
--Less than 5 deaths (observed and expected)

TABLE 16

OBSERVED AND EXPECTED MORTALITY, 1951-1975, AND RELATIVE RISKS FOR NON-ALLEGHENY COUNTY STEELWORKERS EMPLOYED 5 OR MORE YEARS AT TIME OF ENTRY TO STUDY BY PLANT, CAUSE OF DEATH, RACE, AND PLACE OF EMPLOYMENT
ALL PLANTS
OVEN TOPSIDE PART-TIME

Cause of Death	White			Nonwhite			Total		
	Obs Deaths	Exp Deaths	Rel Risk@	Obs Deaths	Exp Deaths	Rel Risk@	Obs Deaths	Exp Deaths	Rel Risk@
Malignant Neoplasms - All Sites	14	13.74	1.03	13	11.18	1.20	27	24.92	1.11
Respiratory Organs	6	3.96	1.76	7	3.36	2.49	13	7.32	2.11
Lungs,Trachea,Bronchus	6	3.86	1.83	7	3.01	2.90	13	6.87	2.31
Other Respiratory Organs	0	0.10	--	0	0.35	--	0	0.45	--
Digestive Organs and Peritoneum	4	4.21	--	3	4.30	--	7	8.52	0.78
Large Intestine	0	0.51	--	1	0.79	--	1	1.30	--
Pancreas	0	1.06	--	1	0.86	--	1	1.92	--
Other Digestive Organs	4	2.65	--	1	2.65	--	5	5.30	0.92
Genito-Urinary Organs	1	1.77	--	2	1.42	--	3	3.19	--
Prostate	0	0.65	--	2	0.76	--	2	1.41	--
Kidney	1	0.38	--	0	0.42	--	1	0.79	--
Bladder	0	0.75	--	0	0.21	--	0	0.95	--
Buccal Cavity and Pharyngeal Organs	1	1.07	--	0	0.30	--	1	1.37	--
Lymph and Hematopoietic Tissues	2	1.80	--	1	0.93	--	3	2.73	--
Skin Cancer	0	0.23	--	0	0.00	--	0	0.23	--
All Other Cancers	0	0.68	--	0	0.88	--	0	1.56	--
NUMBER OF WORKERS		189			134			323	

@Relative risks are computed using other steelworkers for the comparison group
*Significant at 5% level.
**Significant at 1% level.
--Less than 5 deaths (observed and expected)

TABLE 17

OBSERVED AND EXPECTED MORTALITY, 1951-1975, AND RELATIVE RISKS FOR NON-ALLEGHENY COUNTY STEELWORKERS EMPLOYED 5 OR MORE YEARS AT TIME OF ENTRY TO STUDY BY PLANT, CAUSE OF DEATH, RACE, AND PLACE OF EMPLOYMENT
ALL PLANTS
OVEN SIDE ONLY

Cause of Death	White			Nonwhite			Total		
	Obs Deaths	Exp Deaths	Rel Risk@	Obs Deaths	Exp Deaths	Rel Risk@	Obs Deaths	Exp Deaths	Rel Risk@
Malignant Neoplasms - All Sites	18	13.50	1.54	31	26.11	1.27	49	39.61	1.35
Respiratory Organs	8	4.19	3.22	10	7.71	1.43	18	11.91	1.86
Lungs,Trachea,Bronchus	8	4.06	3.48	10	7.16	1.59	18	11.23	2.06
Other Respiratory Organs	0	0.13	--	0	0.55	--	0	0.68	--
Digestive Organs and Peritoneum	6	4.73	1.38	14	11.36	1.33	20	16.09	1.35
Large Intestine	0	0.09	--	2	1.80	--	2	1.89	--
Pancreas	2	1.91	--	2	2.43	--	4	4.33	--
Other Digestive Organs	4	2.73	--	10	7.14	1.60	14	9.87	1.63
Genito-Urinary Organs	3	2.01	--	5	3.36	1.72	8	5.37	1.75
Prostate	1	0.79	--	4	1.96	--	5	2.75	2.40
Kidney	1	0.39	--	1	0.94	--	2	1.33	--
Bladder	1	0.83	--	0	0.28	--	1	1.10	--
Buccal Cavity and Pharyngeal Organs	0	0.32	--	0	0.52	--	0	0.84	--
Lymph and Hematopoietic Tissues	0	0.98	--	0	1.25	--	0	2.23	--
Skin Cancer	1	0.47	--	1	0.16	--	2	0.63	--
All Other Cancers	0	0.81	--	1	1.74	--	1	2.54	--
NUMBER OF WORKERS		120			317			437	

@Relative risks are computed using other steelworkers for the comparison group
*Significant at 5% level.
**Significant at 1% level.
--Less than 5 deaths (observed and expected)

Table 18

OBSERVED AND EXPECTED NUMBER OF DEATHS FROM LUNG CANCER (I.C.D. 162-163, SEVENTH REVISION) BY PLANT AND RACE AMONG MEN EMPLOYED AT THE COKE OVENS DURING 1951-1955 AT TEN NON-ALLEGHENY COUNTY STEEL PLANTS AND FOLLOWED THROUGH DECEMBER 31, 1975.

Plant	White Coke Oven Workers			Nonwhite Coke Oven Workers			All Coke Oven Workers		
	Number at Risk	Observed Deaths	Expected Deaths*	Number at Risk	Observed Deaths	Expected Deaths	Number at Risk	Observed Deaths	Expected Deaths
Plant A	78	1	.69	244	15	6.80	322	16	7.49
Plant B	66	2	.74	90	1	.98	156	3	1.72
Plant C	242	1	.90	52	0	.69	294	1	1.59
Plant D	237	8	4.64	0	0	.00	237	8	4.64
Plant E	120	4	1.96	366	6	5.34	486	10	7.30
Plant F	90	3	2.79	815	22	14.28	905	25	17.07
Plant G	222	3	2.68	18	0	.00	240	3	2.68
Plant H	87	1	.79	274	10	6.93	361	11	7.72
Plant I	82	2	1.82	1	0	.00	83	2	1.82
Plant J	221	3	1.62	0	0	.00	221	3	1.62
Total All Plants	1445	28	18.64	1860	54	35.02	3305	82	53.66

* Expected deaths based on the plant-age-race specific rates for the non-oven group.

Table 19

OBSERVED AND EXPECTED NUMBER OF DEATHS FROM ALL CANCERS BY PLANT AND RACE AMONG MEN EMPLOYED AT THE COKE OVENS DURING 1951-1955 AT TEN NON-ALLEGHENY COUNTY STEEL PLANTS AND FOLLOWED THROUGH DECEMBER 31, 1975.

	White Coke Oven Workers			Nonwhite Coke Oven Workers			All Coke Oven Workers		
Plant	Number at Risk	Observed Deaths	Expected Deaths*	Number at Risk	Observed Deaths	Expected Deaths	Number at Risk	Observed Deaths	Expected Deaths
Plant A	78	2	1.77	244	22	13.76	322	24	15.53
Plant B	66	4	2.49	90	3	4.01	156	7	6.49
Plant C	242	7	8.27	52	3	2.61	294	10	10.88
Plant D	237	15	13.80	0	0	.00	237	15	13.80
Plant E	120	9	5.48	366	17	15.26	486	26	20.74
Plant F	90	6	7.61	815	58	50.97	905	64	58.58
Plant G	222	9	6.86	18	1	1.00	240	10	7.86
Plant H	87	3	3.33	274	27	18.03	361	30	21.36
Plant I	82	2	2.76	1	0	.00	83	2	2.76
Plant J	221	6	4.55	0	0	.00	221	6	4.55
Total All Plants	1445	63	56.92	1860	131	105.64	3305	194	162.56

* Expected deaths based on the plant-age-race specific rates for the non-oven group.

Table 20

OBSERVED AND EXPECTED NUMBER OF DEATHS FROM ALL CAUSES BY PLANT AND RACE AMONG MEN EMPLOYED AT THE COKE OVENS DURING 1951-1955 AT TEN NON-ALLEGHENY COUNTY STEEL PLANTS AND FOLLOWED THROUGH DECEMBER 31, 1975.

	White Coke Oven Workers			Nonwhite Coke Oven Workers			All Coke Oven Workers		
Plant	Number at Risk	Observed Deaths	Expected Deaths*	Number at Risk	Observed Deaths	Expected Deaths	Number at Risk	Observed Deaths	Expected Deaths
Plant A	78	12	11.77	244	96	74.38	322	108	86.15
Plant B	66	18	17.18	90	34	27.23	156	52	44.41
Plant C	242	33	39.09	52	12	11.16	294	45	50.25
Plant D	237	57	64.72	0	0	.00	237	57	64.72
Plant E	120	29	26.22	366	87	82.32	486	116	108.54
Plant F	90	27	35.51	815	245	248.07	905	272	283.58
Plant G	222	48	45.12	18	10	9.47	240	58	54.59
Plant H	87	16	13.77	274	93	89.86	361	109	103.64
Plant I	82	14	10.97	1	0	.00	83	14	10.97
Plant J	221	40	34.99	0	0	.00	221	40	34.99
Total All Plants	1445	294	299.34	1860	577	542.49	3305	871	841.83

*Expected deaths based on the plant-age-race specific rates for the non-oven group.

Table 21

OBSERVED AND EXPECTED NUMBER OF DEATHS AND RELATIVE RISKS FOR ALL CAUSES, ALL CANCERS, AND LUNG CANCERS BY YEAR OF DEATH AND RACE FOR NON-ALLEGHENY COUNTY WORKERS WITH FIVE OR MORE YEARS AT THE OVENS

		White Coke Oven Workers				Nonwhite Coke Oven Workers				All Coke Oven Workers			
		Number at Risk	Observed Deaths	Expected Deaths	Relative Risk	Number at Risk	Observed Deaths	Expected Deaths	Relative Risk	Number at Risk	Observed Deaths	Expected Deaths	Relative Risk
All Causes	1951-1957	330	16	15.62	1.05	674	45	45.17	0.99	1004	61	60.79	1.01
	1958-1962	314	22	27.43	0.68	629	57	58.12	0.96	943	79	85.55	0.86
	1963-1967	292	41	36.85	1.24	572	77	74.40	1.07	864	118	111.25	1.12
	1968-1972	251	42	35.43	1.43	495	78	74.65	1.10	746	120	110.08	1.20
	1973-1975	209	24	22.92	1.09	417	54	47.65	1.29	626	78	70.57	1.22
	All	330	145	138.24	1.10	674	311	300.00	1.07	1004	456	438.24	1.08
All Cancers	1951-1957	330	1	2.54	--	674	8	5.58	1.95	1004	9	8.13	1.21
	1958-1962	314	8	6.69	1.38	629	16	14.80	1.13	943	24	21.48	1.20
	1963-1967	292	9	6.77	1.67	572	26	17.47	2.26*	864	35	24.23	2.07**
	1968-1972	251	10	7.01	1.90	495	18	15.73	1.27	746	28	22.74	1.45
	1973-1975	209	5	6.24	0.74	417	17	13.21	1.69	626	22	19.45	1.25
	All	330	33	29.25	1.23	674	85	66.79	1.57**	1004	118	96.04	1.45**
Lung Cancers	1951-1957	330	0	0.00	--	674	3	0.98	--	1004	3	0.98	--
	1958-1962	314	2	1.49	1.74	629	6	4.05	2.00	943	8	5.54	1.93
	1963-1967	292	8	3.13	++	572	13	7.67	3.39*	864	21	10.80	5.58**
	1968-1972	251	2	2.66	0.63	495	6	4.38	1.81	746	8	7.04	1.26
	1973-1975	209	2	2.15	0.90	417	8	5.24	2.33	626	10	7.39	1.73
	All	330	14	9.42	2.15	674	36	22.32	2.66**	1004	50	31.75	2.49**

* Significant at 5% level
** Significant at 1% level
-- Less than 5 deaths (observed and expected)
++ All deaths occurred in the interest group

Table 22

OBSERVED AND EXPECTED NUMBER OF DEATHS AND RELATIVE RISKS FOR ALL CAUSES, ALL CANCERS, AND LUNG CANCERS BY AGE AT ENTRY AND RACE FOR NON-ALLEGHENY COUNTY WORKERS WITH FIVE OR MORE YEARS AT THE OVENS

		White Coke Oven Workers				Nonwhite Coke Oven Workers				All Coke Oven Workers			
		Number at Risk	Observed Deaths	Expected Deaths	Relative Risk	Number at Risk	Observed Deaths	Expected Deaths	Relative Risk	Number at Risk	Observed Deaths	Expected Deaths	Relative Risk
All Causes	<35	61	12	7.99	1.85	122	23	17.95	1.54	183	35	25.94	1.64*
	35-44	95	22	21.34	1.05	261	92	84.97	1.17	356	114	106.30	1.14
	45-54	96	47	50.87	.87	196	114	120.13	.90	292	161	171.00	.89
	55-64	71	58	51.65	1.33	88	75	70.42	1.15	159	133	122.06	1.22
	65+	7	6	6.40	.83	7	7	6.54	1.24	14	13	12.94	1.01
	All	330	145	138.24	1.10	674	311	300.00	1.07	1004	456	438.24	1.08
All Cancers	<35	61	1	1.33	--	122	6	3.30	3.26	183	7	4.63	2.11
	35-44	95	5	5.43	.90	261	27	20.80	1.66	356	32	26.23	1.43
	45-54	96	14	11.80	1.35	196	35	30.61	1.27	292	49	42.41	1.29
	55-64	71	12	9.83	1.47	88	15	10.46	1.92	159	27	20.29	1.70
	65+	7	1	.87	--	7	2	1.62	--	14	3	2.48	--
	All	330	33	29.25	1.23	674	85	66.79	1.57**	1004	118	96.04	1.45**
Lung Cancers	<35	61	1	.73	--	122	5	1.72	++	183	6	2.45	11.05*
	35-44	95	4	2.04	--	261	14	7.44	4.76**	356	18	9.48	4.05**
	45-54	96	5	4.30	1.34	196	10	9.16	1.16	292	15	13.45	1.21
	55-64	71	4	2.36	--	88	6	3.01	3.56	159	10	5.37	3.80*
	65+	7	0	.00	--	7	1	1.00	--	14	1	1.00	--
	All	330	14	9.42	2.15	674	36	22.33	2.66**	1004	50	31.75	2.49**

* Significant at 5% level
** Significant at 1% level
-- Less than 5 deaths (observed and expected)
++ All deaths occurred in the interest group

SECTION V.

LONG TERM MORTALITY OF STEELWORKERS:

STANDARDIZED MORTALITY RATIOS FOR

ALLEGHENY COUNTY STEELWORKERS, 1953-1975

V. LONG TERM MORTALITY OF STEELWORKERS

STANDARDIZED MORTALITY RATIOS FOR ALLEGHENY COUNTY STEELWORKERS, 1953-1975

Attempts to identify diseases of occupational origin and to clarify dose-response relationships involve a consideration of numerous methodological problems in design and analysis of such studies. One specific problem in this regard is to determine an appropriate control group. A common approach is to contrast the industrial population mortality with the experience of the general population. Since the employed population is selected to some extent for health, one might expect a more favorable mortality experience in the employed group. The extent of this selection has been described for employees whose deaths are known to the employer.[1-3] However, even when all deaths are known to the employer, the problem of selection still remains. Furthermore, this selection may not be the same for various race and age groups, nor is it the same for different causes of death. One method of minimizing these differences between the control and study population is to compare a particular work area to other work areas within the same industry. Such an internal comparison will hopefully reduce this selection bias in the study group. A comparison of the results obtained using relative risk, as estimated by the relative odds ratio and an internal control group versus the SMR with an external control group, has been previously presented.[4] Although internal and external each have advantages and disadvantages, for a population the size of the steelworkers cohort, internal controls would appear to be the more appropriate analysis. Nevertheless, comparison to the total U.S. population provides a different perspective as to the amount of any suggested excess.

Statistical Methods

The SMRs are race specific and are adjusted for age by the indirect method, utilizing the total U.S. male white and nonwhite populations as standard. Age and cause-specific mortality rates in the standard population for the years 1955, 1960, 1965, and 1970 were applied to age-specific subgroups of steelworkers' person years at risk in each 5 year calendar period of follow-up from 1953-1975 to obtain the number of deaths expected in each subgroup. The 1970 U.S. rates were used as the comparison for the entire interval from 1968 through 1975. The SMR is then computed as the ratio of the sum of observed deaths to the sum of expected deaths, summation being taken over calendar year and age group. Significant deviations from one, indicating excess or deficits in a particular work area relative to the control group are identified by examining confidence intervals placed on the SMR parameter. Under the assumption of a Poisson distribution of deaths, these bounds are readily obtained.[5] SMRs are considered to be significantly different from 100, at the 5 percent level, if the 95 percent confidence intervals do not contain 100.

Since the observation period for the study spans the time period for part of the Seventh Revision ICD[6] and part of the Eighth Revision ICDA[7], when using total rates for the years 1953-1975, an adjustment was made so that causes of death coded by the two different revisions would be as

comparable as possible. This adjustment was based on a comparability ratio[8] which was computed by using the results of all deaths occurring in 1966 coded according to the Seventh Revision ICD, and a random sample of these same 1966 deaths stratified by cause and coded according to the Eighth Revision ICDA. The ratios were computed by dividing the numbers of deaths estimated from the stratified random sample (coded by the Eighth Revision) by the numbers of deaths assigned to the most comparable causes when coded by the Seventh Revision. A more detailed description of this procedure can be found in the literature.[8-10]

For some causes of death, comparability ratios were not readily available. In those cases we obtained estimates of the comparability ratios using the steelworker data. This was possible since all deaths were coded according to both the Seventh ICDA and the Eighth ICD for the years 1971 through 1975. Although these estimates have the disadvantage of being based on a smaller population than those done by the National Center for Health Statistics, they have the advantage of being specific to the population of interest. Such factors as race, sex, and age may all affect the comparability ratio and may make the use of the ratios estimated from the steelworkers' population more appropriate. The comparability ratios used for the thirteen selected causes of death for which SMRs were computed are shown in Appendix K.

Findings

The race specific SMRs for these selected causes of death for the Allegheny County steelworker population are shown in Table 1. The SMR for all causes is 91.9 for the whites and 80.7 for the nonwhites. As expected, many of the causes of death have an SMR less than 100. Lung cancer is one exception, having an SMR of 135.2 for whites and 169.2 for nonwhites. Cirrhosis is the only other cause of death with an SMR greater than 130 (133.7 in the whites).

In regard to specific work areas, the SMRs continue to show values less than 100 for most causes. Table 2 shows the observed and expected deaths and standardized mortality ratios by race for those work areas showing a significantly higher SMR for these thirteen causes of death. SMRs based on less than 5 observed deaths were not included in the table.

The only work area showing an excess for "all causes" is the pipe shop. The nonwhite workers in this area have 5 observed deaths, an expected of 1.38 and a resultant SMR of 361.7. This work area was also identified as significantly high for all causes when relative risk was used as a measurement (RR: 7.03). Since the number of observed deaths was small, a meaningful analysis of this work area by specific cause of death was not possible. For the disease categories tuberculosis, other malignant respiratory disease, accidents and homicides and suicides, there were no work areas for which the SMRs were significantly high. For these causes of death, the use of the relative risk can be used to determine work areas with a possible excess of deaths.

For the disease classifications, genito-urinary cancer, cardiovascular disease, nonmalignant respiratory disease and ill-defined causes there were

some work areas with significantly high SMRs. For genito-urinary cancer, the excess was for nonwhite janitors. This group in general showed an excess mortality from several causes of death. Excesses in this job group are difficult to interpret since there is a probable selection factor operating which results in the less fit workers acquiring or being assigned to these jobs. A similar phenomenon may account for the high cardiovascular disease among whites in plant protection (SMR: 121.8).

The excess of nonmalignant respiratory disease in masons was discussed in a previous publication.[11] While the reason for the excess deaths from ill-defined causes in the billet, bloom and slab were not clear, a detailed analysis of the work histories of the decedents from ill-defined causes conveyed a picture of men dying rather suddenly at relatively young ages from "undetermined causes" after an extended period of employment in this work area. Furthermore, the job held by these workers appeared to involve two major operations: scarfing and chipping. Although the ill-defined causes in the foundry showed an excess in previous reports, this is the first update in which it was significant.

The high SMRs for the category "remaining cancers" cannot be directly compared to the remainder category for cancers when analysis was done with relative risk due to the more detailed subclassification used in the latter. However, three of the four work areas showing an excess SMR in this remainder category did show at least one significantly high relative risk in one of the remaining malignant disease categories (Plate Mill - kidney cancer; Stainless Annealing and Pickling - digestive cancer; and Transportation and Yard - digestive cancer).

The final two disease categories are unusual in that they represent diseases for which the SMR for the entire steel population was high. Lung cancer showed an SMR of 135.2 for whites and 169.2 for nonwhites. Furthermore, 17 work areas (Table 2) showed a significantly high SMR in one of the two races. Of these 17 work areas, only the coke plant, cold reducing mills, and blacksmith shop showed a significantly high relative risk based on internal comparisons. It is difficult to determine whether these high SMRs in lung cancer are indicative of a broader exposure than might be reflected in only one work area or represent differences in nonoccupational factors between the steelworkers and the general population. Although less pronounced, the pattern with cirrhosis is similar. Ten of the work areas have significantly high SMRs and only the merchant mills, plant protection, transportation and yard and the river or marine ways showed significantly high relative risks.

As a final consideration, it is interesting to observe the selection phenomenon as measured by a low SMR as a function of time. The selection is greatest in the earliest years of the cohort and shows a definite decrease with time. This pattern is consistent for both the white and nonwhite populations.

In summary we note the following:

1) When some SMRs were computed for comparison purposes for selected causes of death, they showed relatively few significantly high values and in general were consistent with the elevated relative risks.

2) Two exceptions were: lung cancer in both races, and cirrhosis in whites, both of which showed an excess in a large number of work areas. These two diseases showed significantly high SMRs for the total steelworkers population. Such high values in many work areas are difficult to interpret since we cannot distinguish the effect of differences in nonoccupational factors in the steelworkers and general population from occupationally related problems specific to an industry.

3) By observing the SMR over time, one notes the decreasing effect of selection when comparing to the general population. For the whites, there appears to be little selection effect after 23 years of follow-up.

REFERENCES

1. Enterline, P.E.: The estimation of expected rates in occupational disease epidemiology. Public Health Rep., 79:973-978, 1964.

2. Pell, S., and Fleming, A.J.: Cancer of the lung in an industrial population. Arch. Environ. Hlth., 4:135-138, 1962.

3. Pell, S.: The effect of selection factors on epidemiologic research in employed populations. The Nature of Biostatistics, University of Pittsburgh, Pittsburgh, Pa., pp. 175-194, 1969.

4. Redmond, C.K., and Breslin, P.P.: Comparison of methods for assessing occupational hazards. J. Occup. Med., 17:313-318, 1975.

5. Haenszel, W.J., Loveland, D.B., and Sirken, M.G.: Lung-cancer mortality as related to residence and smoking histories. Part 1, White males. J. Natl. Cancer Inst., 28:947-1001, 1962.

6. Manual of the International Statistical Classification of Disease: Injuries and Cause of Death. WHO, Seventh Revision, Geneva, Switzerland, 1957.

7. Eighth Revision International Classification of Disease: Adapted for use in the United States. D.H.E.W., P.H.S., National Center for Health Statistics. P.H.S. Publication No. 1693, 1968.

8. Provisional Estimates of Selected Comparability Ratios Based on Dual Coding of 1966 Death Certificates by the Seventh and Eighth Revisions of the International Classification of Diseases: Monthly Vital Statistics Reprot -- Provisional Statistics from the National Center for Health Statistics, Vol. 17, No. 8, Supplement, 1968.

9. Israel, R.A., and Klebba, A.J.: A preliminary report of the effect of Eighth Revision ICDA on cause of death statistics. AJPH, 59:1651-1660, 1969.

10. Percy, C., Garfinkel, L., Krueger, D., and Dolman, A.B.: Apparent Changes in Cancer Mortality, 1968, Pub. Hlth. Reps., Vol. 89, No. 5, pp. 418-428, 1974.

11. Rockette, H.E., and Redmond, C.K.: Long-term mortality experience of steelworkers. X. Mortality patterns of masons. J. Occup. Med., 18:541-545, 1976.

Table 1

OBSERVED AND EXPECTED DEATHS AND STANDARDIZED MORTALITY RATIOS FOR THE STEELWORKER POPULATION BY RACE FOR SELECTED CAUSES OF DEATH USING THE TOTAL U.S. POPULATION AS CONTROL

Cause of Death	White			Nonwhite		
	Observed	Expected	SMR	Observed	Expected	SMR
All Causes	15626	17001.7	91.9*	2526	3131.8	80.7*
Tuberculosis of the Respiratory System	56	117.3	47.8*	28	54.2	51.62*
Cancer of Lung, Bronchus and Trachea	1013	749.4	135.2*	194	114.7	169.2*
Other Respiratory Cancer	60	69.9	85.9	11	9.7	113.8
Bladder and Kidney Cancer	370	446.9	82.8*	91	86.5	105.2
All Other Cancers	1857	1694.0	109.6*	293	282.4	103.8
Cardiovascular-Renal Disease	8909	9877.4	90.2*	1213	1631.4	74.4*
Nonmalignant Respiratory Disease	683	906.5	75.3*	150	173.5	86.5
Cirrhosis of Liver	446	333.6	133.6*	45	53.3	84.5
Ill-Defined Causes	183	169.7	107.8	76	98.3	77.3*
Accidents	681	926.4	73.5*	137	197.9	69.2*
Homicides and Suicides	236	361.4	65.3*	59	109.4	53.9*
All Other Causes	1132	1353.1	83.7*	229	317.6	72.1*

* $p < .05$

Table 2

OBSERVED AND EXPECTED DEATHS AND STANDARDIZED MORTALITY RATIOS BY RACE FOR THOSE WORK AREAS SHOWING A SIGNIFICANTLY HIGH SMR FOR SELECTED CAUSES OF DEATH

Cause of Death	Work Area	Race	Obs.	Exp.	SMR
All Causes	Pipe Shop	Nonwhite	5	1.38	361.7
Cancer of Bladder and Kidney	Janitors	Nonwhite	11	5.12	215.0
Cancers, excl. Lung, Bladder and Kidney	Open Hearth	White	217	170.07	127.6
	Plate Mill	White	68	52.71	129.0
	Stainless Anneal. Pickl. & Proc.	White	6	2.03	288.1
	Transportation and Yard	White	62	40.58	152.8
Cardiovascular-Renal Disease	Plant Protection	White	210	172.41	121.8
Nonmalignant Respiratory Disease	Mason Dept.	White	28	14.56	192.3
Ill-Defined Causes	Foundry	White	9	3.25	276.5
	Billet, Bloom and Slab Mills	White	21	10.36	202.6

Table 2 (continued)

OBSERVED AND EXPECTED DEATHS AND STANDARDIZED MORTALITY RATIOS BY RACE FOR THOSE WORK AREAS SHOWING A SIGNIFICANTLY HIGH SMR FOR CIRRHOSIS OF THE LIVER

Cause of Death	Work Area	Race	Obs.	Exp.	S
Cirrhosis of Liver	Open Hearth	White	56	34.02	1
	Billet, Bloom and Slab Mills	White	30	19.98	1
	Merchant Mills	White	28	14.46	1
	Structural Mill	White	19	7.88	2
	Cold Reducing Mills	White	18	8.43	2
	Mechanical Maintenance Assigned	White	27	17.44	1
	Riggers and Structural	White	16	7.93	2
	Plant Protection	White	11	4.88	2
	Transportation and Yard	White	15	7.85	1
	River or Marine Ways	White	5	1.52	3

Table 2 (continued)

OBSERVED AND EXPECTED DEATHS AND STANDARDIZED MORTALITY RATIOS BY RACE FOR THOSE WORK AREAS SHOWING A SIGNIFICANTLY HIGH SMR FOR CANCER OF LUNGS, BRONCHUS, AND TRACHEA

Cause of Death	Work Area	Race	Obs.	Exp.	SMR
Cancer of Lung, Bronchus and Trachea	Coke Plant	Nonwhite	56	13.64	410.4
	Open Hearth	White	110	75.45	145.8
	Open Hearth	Nonwhite	44	27.22	161.6
	Foundry	White	28	13.96	200.6
	Billet, Bloom and Slab Mills	White	67	46.58	143.8
	Structural Mill	White	27	17.57	153.7
	Cold Reducing Mills	White	33	16.42	201.0
	Hot Pack Mills	White	20	11.33	176.5
	Hot Strip Rolling	White	28	15.50	180.7
	General Labor	Nonwhite	14	6.47	216.3
	Mason Dept.	White	23	12.65	181.8
	Blacksmith Shop	White	11	4.30	255.6
	Elec. Maintenance Assigned	White	40	24.81	161.2
	Machine Shop	White	34	20.87	162.9
	Paint Shop	White	9	4.05	222.1
	Riggers and Structural	White	35	18.59	188.3
	All Other Maintenance	White	6	1.88	319.6

Table 3

ALL CAUSES SMR'S BY CALENDAR YEAR PERIOD
FOR WHITES AND NONWHITES

	SMR	
Calendar Year	Whites	Nonwhites
1953-1957	77.0	59.7
1958-1962	86.2	73.6
1963-1967	91.7	89.2
1968-1975	99.6	87.3

SECTION VI.

LONG TERM MORTALITY OF STEELWORKERS

SUMMARY AND RECOMMENDATIONS

VI. SUMMARY AND RECOMMENDATIONS

This report has presented a comprehensive overview of the cause specific mortality patterns, 1953-1975, for a cohort of almost 59,000 Allegheny County steelworkers. The mortality among coke oven workers during 1951 through 1975 for ten non-Allegheny County plants has also been analyzed.

Based upon the review of the mortality experience among 57 work areas within the steel industry, several areas have been selected which merit confirmatory studies. Selection of these areas has been done taking into account the consistency of mortality findings for subgroups by race, age and calendar time relative to potential exposures, in addition to the magnitude of the relative risk and statistical significance. Among the areas which merit further work are: 1) Mason Department; 2) Foundry; and 3) several Secondary Mills. Although these worksites have been examined to some extent previously, the additional deaths have in many instances make clearer delineation of patterns possible.

Major findings for the Allegheny County coke plant workers relative to this update are as follows: 1) The excess in lung cancer mortality has continued over time among coke oven workers, with an average relative risk for workers with five or more years at the ovens of 2.63 ($p < .01$) from 1953 through 1975; 2) Kidney cancer mortality among coke oven workers remains elevated and occurs primarily for white workers; 3) Findings of excesses in cancers of the pancreas, large intestine, and buccal cavity and pharynx among nonoven workers are similar to those reported previously, although no specific exposure can be inferred based upon the current patterns in the data; and 4) Mortality from nonmalignant respiratory diseases appears to have increased with longer observation time. The risks occur in both oven and nonoven workers; among oven workers, those with five or more years, part of which was spent topside, have the highest level of risk, while the risk in the nonoven workers appears largely confined to men with five or more years in coal handling; 5) A significant increase in deaths attributed to ill-defined causes among coke oven workers is also present. Thus, the findings are generally consistent with previous reports with the noncancer deaths, such as nonmalignant respiratory diseases, assuming greater importance with continued observation time.

Analysis of the updated mortality for the ten plants outside of Allegheny County has indicated that: 1) The lung cancer mortality among white and black coke oven workers remains comparable; 2) With respect to malignancies of other sites, oven workers exhibit observed mortality only slightly greater than expected from cancers of the kidney, with cancers of the prostate and buccal cavity also elevated. The latter two sites are high for Allegheny County coke plant workers, although cancers of the buccal cavity and pharynx occur principally among nonoven, rather than oven workers; 3) There is no evidence at this time for an overall excess in deaths for respiratory diesases other than cancer; and 4) While intra-plant variability in risks is expected due to the small number of oven workers at risk in most of the plants, it is interesting that nine of the ten plants now have relative risks for lung cancer greater than one. One plant, in particular, seems noteworthy in that

the all causes mortality is significantly high (RR: 1.51). Not only does the overall risk for cancers of the lung approach 5, but also the risks for several other causes, viz., cardiovascular diseases, nonmalignant respiratory diseases, and accidents are considerably greater than one. The interplant differences should be evaluated further over time in order to add to the understanding of various factors, in addition to chance, that may be contributing to the variability among plants.

Examination of the Standardized Mortality Ratios in each of the four observation periods shows that the all causes risks among Allegheny County steelworkers are similar to that of the general population during the period from 1968 to present. This indicates the necessity of considering length of follow-up in assessing the role of selection for health in an industrial cohort. Patterns by cause of death and work area illustrate the difficulties in drawing inferences solely from general population comparisons.

Finally, the need for continued updating of this database as a valuable asset in the assessment of the many work exposures associated with the steel industry is apparent. New leads and confirmation of earlier suggestions have emerged form the updated mortality by work area. For example, the mortality from other respiratory diseases in the coke plant has become important only in the last two updates. While the risks for lung cancer have declined slightly since the latter sixties, it is reasonable to continue monitoring over time to determine whether the risks attain a level similar to other steelworkers. The non-Allegheny County coke oven workers provide an opportunity to consider geographic variability in greater detail as the mortality is extended. The advantages of using an existing large cohort as the basis for future intraindustry exploratory studies is obvious. Hence, our major recommendation is that the follow-up continue to be updated at periodic intervals for all Allegheny and non-Allegheny County workers. Recent updates have confirmed the need for extensive follow-up even with large numbers of workers in assessing reliably the risks for rare diseases. Further, the cohort provides an excellent resource for a population base to carry out more extensive studies of cancer and other disease morbidity and to evaluate the worth of control and screening procedures within various worksites of the steel industry. We are currently planning for an evaluation of the use of sputum and urine cytology among coke oven workers, which involves linking the cytology and medical results with the occupational histories. In addition, we receive numerous requests for recent data on the cohort since the overall cause specific mortality rates for steelworker can serve as a comparison population for other investigators, while the work area analyses provide leads for other studies. In summary, there appear to be considerable advantages to maintaining this large scale cohort and to utilizing the existing database for future studies.

APPENDIX A

Publications, Presentations, and Dissertations using the Steelworkers Data.

Publications

1. Lloyd, J.W. and Ciocco, A.: Long-term mortality study of steelworkers. I. Methodology. J. Occup. Med., 11:299-310, 1969.

2. Robinson, H.: Long-term mortality study of steelworkers. II. Mortality by level of income in whites and nonwhites. J. Occup. Med., 11:411-416, 1969.

3. Redmond, C.K.; Smith, E.M.; Lloyd, J.W.; and Rush, H.W.: Long-term mortality study of steelworkers. III. Follow-up. J. Occup. Med., 11:513-521, 1969.

4. Lloyd, J.W.; Lundin, F.E., Jr.; Redmond, C.K.; and Geiser, P.B.: Long-term mortality study of steelworkers. IV. Mortality by work area. J. Occup. Med., 12:151-157, 1970.

5. Lloyd, J.W.: Long-term mortality of steelworkers. V. Respiratory cancer in coke plant workers. J. Occup. Med., 13:53-68, 1971.

6. Redmond, S.K.; Ciocco, A.; Lloyd, J.W.; and Rush, H.W.: Long-term mortality of steelworkers. VI. Mortality from malignant neoplasms among coke oven workers. J. Occup. Med., 14:621-629, 1972.

7. Lerer, T.J.; Redmond, C.K.; Breslin, P.P.; Salvin, L.; and Rush, H.W.: Long-term mortality study of steelworkers. VII. Mortality patterns among crane operators. J. Occup. Med., 16:608-614, 1974.

8. Lloyd, J.W.: Study of long-latent disease in industrial populations. Biometrics, National Institute for Occupational Safety and Health, 5600 Fishers Lane, Room 3-32, Rockville, MD 20852. J. Wash. Acad. Sci., 64:135-144, 1974.

9. Redmond, C.K.; Gustin, J.; and Kamon, E.: Long-term mortality experience of steelworkers. VIII. Mortality patterns of open hearth steelworkers. (A preliminary report.), J. Occup. Med., 17:40-43, 1975.

10. Mazumdar, S.; Redmond, C.K.; Sollecito, W.; and Sussman, N.: An epidemiological study of exposure to coal tar pitch volatiles among coke oven workers. J. Air Pollut. Control Assoc., 25:382-389, 1975.

11. Redmond, C.K.; and Braslin, P.P.: Comparison of methods for assessing occupational hazards. J. Occup. Med., 17:313-318, 1975.

12. Mancuso, T.F. and Redmond, C.K.: Heart disease mortality among black migrants: A study of Ohio residents (1960-1967). Amer. Heart J., 90:380-388, 1975.

13. Mazumdar, S.; Lerer, T.J.; and Redmond, C.K.: Long-term mortality study of steelworkers. IX. Mortality patterns among sheet and tin mill workers. J. Occup. Med., 17:751-755, 1975.

14. Redmond, C.K.: Comparative cause-specific mortality patterns by work area within the steel industry. HEW Publication No. (NIOSH) 75-157, 1975.

15. Redmond, C.K.; Strobino, B; and Cypess, R.: Cancer experience among coke by-product workers. An. N.Y. Acad. Sci., 271:102-115, 1976.

16. Rockette, H.E. and Redmond, C.K.: Long-term mortality experience of steelworkers. X. Mortality patterns among masons. J. Occup. Med., 18:541-545, 1976.

17. Collins, J.F. and Redmond, C.K.: The use of retirees to evaluate occupational hazards. J. Occup. Med., 18:595-602, 1976.

18. Redmond, C.K.: Epidemiological studies of cancer mortality in coke plant workers. Proceedings of the 7th Annual Conference on Environmental Toxicology, pp. 93-107, 1977.

19. Redmond, C.K.; Emes, J.J.; Mazumdar, S.; Magee, P.C.; and Kamon, E.: Mortality of steelworkers employed in hot jobs. HEW Publication No. (NIOSH) 77-219, 1977.

20. Wong, O.: A competing-risk model based on the life table procedure in epidemiological studies. International Journal of Epidemiology, 6:153-159, 1977.

21. Collins, J.F. and Redmond, C.K.: The use of retirees to evaluate occupational hazards. II. Comparison of cause specific mortality by work area. J. Occup. Med., 20:260-266, 1978.

22. Emes, J.; Mazumdar, S.; Redmond, C.K.; Magee, P.C.; and Kamon, E.: Models for estimating worksite WBGT. Am. Ind. Hyg. Assoc. J., 39:592-597, 1978.

23. Wong, O.; Rockette, H.E.; Redmond, C.K.; and Heid, M.: Evaluation of multiple causes of death in occupational mortality studies. J. Chron. Dis., 31:183-193, 1978.

24. Mazumdar, S. and Redmond, C.K.: Evaluating dose-response relationships using epidemiological data on occupational subgroups. Energy and Health, pp. 265-282, 1978.

Presentations

1. Redmond, C.K.: Assessment of effects of industrial exposures on mortality among steelworkers. Invited paper at Biometrics Society Meeting ENAR, Ithaca, New York, May 30, 1973.

2. Redmond, C.K.: The coke oven study. Invited paper at Symposium on Particulate Polycyclic Organic Matter, sponsored by Industrial Health Foundation, Pittsburgh, Pa., April 20-30, 1975.

3. Breslin, P.P.: Mortality among foundrymen in steel plants. Presented at Society for Occupational and Environmental Health Conference, Washington, D.C., December 4-7, 1977. (Proceedings in press).

4. Redmond, C.K., and Rockette, H.E.: Use of case control studies to evaluate occupational health hazards. Presented at the 19th Annual American Industrial Hygiene Conference, May, 1979.

Doctoral Dissertations and Master's Essays
University of Pittsburgh

1. Lloyd, J.W.: Lung cancer mortality in Allegheny County coke plant workers. Doctoral dissertation, 1966.

2. Robinson, H.: The mortality of a cohort of steelworkers in terms of a job classification scheme and changes in occupational status. Doctoral dissertation, 1968.

3. Ko, H.: The usefulness of plant medical records for supplementary mortality data on steelworkers. Master's essay, 1970.

4. Sollecito, W.A.: Coke oven workers exposure to coal tar pitch volatiles. Master's essay, 1970.

5. Gustin, J.: Disease-specific mortality patterns for open hearth workers. Master's essay, 1971.

6. Schieren, G.: Measuring association in prospective and retrospective studies. Master's essay, 1971.

7. Rodenburg, E.: Employed cohorts: Assessing risk by correcting for health. Master's essay, 1972.

8. Strobino, B.A.: A mortality study of cancer of the digestive system among coke plant workers. Master's essay, 1972.

9. Sussman, N.B.: A study of the relationship between exposure to coal tar pitch volatiles and mortality among coke oven workers. Master's essay, 1973.

10. Collins, J.F.: Use of retiree populations to evaluate occupational hazards. Doctoral dissertation, 1974.

11. Mellinger, W.: A response model for cancer in coke oven workers. Master's essay, 1975.

12. Wong, O.: Adjustment of mortality rates in the presence of confounding factors in occupational health studies. Doctoral dissertation, 1975.

13. Arenas, O.: Mortality rates and multiple causes of death among coal miners, a comparative study with steelworkers. Master's essay, 1977.

14. Arena, V.C., Jr.: The reliability of death certificate data as an indication of cancer morbidity. Master's essay, 1978.

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