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Long-Term Mortality Study of Steelworkers

I. Methodology

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This report is the first of a series concerned with the study of chronic disease mortality in relationship to prior occupational history. In the present paper we consider the methodological problems encountered in designing long-term studies of industrial population mortality, biases resulting from limitation of data resources, and cause of death patterns observed within the steel industry in one county among white and nonwhite employees. Later papers will be concerned with methods of follow-up and interoccupational differences in mortality.

The epidemiologic approach to the study of chronic disease of occupational origin follows the traditional pattern established in the study of infectious diseases; i. e., potential occupational hazards are noted through the identification of disease states more common to certain occupational groups than to others. The full potential of this approach, however, has not been realized because of severe limitations in data resources. Consequently, estimates of disease incidence associated with occupation have frequently been based on partial information and the interpretation of such data has been dependent on very broad assumptions regarding missing information. Because many findings of great significance to the understanding of occupational disease have come from such limited analyses, there has been a tendency to overlook some of the selective factors which lead to biased estimates of the presence of disease. This has been especially true in the study of conditions with a long latent period between exposure and the appearance of disease.

A brief review of the several approaches to the study of occupationally related mortality will clarify some of the selective factors leading to biased estimates. The first attempt to relate systematically the pattern of disease to occupation is found in the classical work of Ramazzini.[1] Using this approach one can compare the proportion of each specific disease to all diseases for each of the occupations under study. Unfortunately, Ramazzini could not relate the incidence of disease to the population at risk because, at that point in time, no statistics on occupation had been collected. Therefore, his conclusions regarding the relationship between specific diseases and occupations would only be valid to the extent that the relative frequency of disease reflected the underlying disease rate.

That such an approach may lead to valid and very worthwhile conclusions, especially in the case of rare diseases, is seen in the finding of scrotal cancer in chimney sweeps by Pott,[2] and Berman's finding of

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This research was supported in part by contract number PH43-62-147, National Institutes of Health, Public Health Service.

liver cancer in the Bantu.[3] Following the lead of Pott, Henry[4,5] identified a number of occupations subject to unusually high rates of skin cancer; and Doll,[6] using an age adjusted modification of the relative frequency approach, was able to demonstrate the high risk of cancer of the lung and nasal sinuses in nickel workers. Gilliam[7] has pointed out the dangers inherent in the use of relative frequency as a substitute for incidence rates.

With the development of vital statistics systems and the inclusion of occupation in population censuses, a new source of information became available. The introduction of census returns and death certificates provided estimates of both the numerator and denominator required for estimating the rate of disease. However, two new sources of bias are encountered in the use of such records. *First*, mortality rates based on information obtained from death certificates are dependent on the assumption that mortality reflects disease incidence. *Second*, the use of occupational information noted on death certificates and census returns may lead to a conclusion of "no risk" when in fact a risk exists. Conversely, we may also expect "false-positives." These errors will arise especially when the occupation as stated on the death certificate refers to the last occupation. Significant changes in employment may have occurred during the interval between exposure to a hazardous occupation and death. While the classification of death certificates by "usual occupation" should lead to better estimates of occupationally related mortality, there also are hazards in this approach. Mortality may be consequent to exposure in an occupation other than the usual occupation. More importantly, occupations noted on death certificates frequently cover such broad areas of employment as to be unusable for analysis.

To overcome the limitation inherent in the definition of occupation on vital records, recourse has been to investigate better sources of information, such as employer records, or by-products, as those available to the social security system. While some of the problems encountered in the earlier approaches may still obtain, as would occur with inadequately or poorly defined occupational histories, the greatest source of bias is frequently the design of the study. Two common sources of bias observed in such studies involve (1) the definition of the population at risk; and/or (2) the choice of a control or comparison population. As to the choice of a comparison population, it is not uncommon to see industrial population mortality contrasted with the experience of the general population, and followed by the conclusion that no hazards exist because of the more favorable experience of the industrial population. Since the employed group is generally selected for health by means of pre-employment physical examination, and must maintain a certain level of good health to remain employed, we would expect a more favorable picture of mortality for the employed population. Enterline[8] has illustrated a number of "errors" which result from the indiscriminate choice of comparison or "control" groups.

In defining the population at risk there are two common forms of selection that may lead to incorrect estimates of disease experience. *First*, there is the case where morbidity or mortality information is limited to that available to the employer. The pattern of disease observed in this approach will, of course, be distorted to the extent that persons leaving employment may have experienced different risks than those remaining. *Second*, mortality due to chronic diseases of occupational origin may be estimated from the experience of working or recently employed populations rather than from the appropriate population defined many years earlier. The immediately obvious study design to overcome the bias due to this form of selection is the prospective study.

However, in the case of diseases with long latent periods (for some diseases possibly 20 to 25 years), prospective studies of industrial populations are not generally feasible. In addition to the considerable cost involved in such studies it is unlikely that professional staffs could be recruited for such an extended effort. An alternative approach, which has proved useful for study of certain selected populations, is the prospective study done in retrospect. That is, we identify an industrial population specified far enough in the past so that latent effects can be observed, and then determine the mortality experience of the study group from the point of observation through the present period. Mancuso,[9,10] by referring to records of the Social Security Administration, has demonstrated the value of this approach in assessing the mortality experience of men exposed to beta-naphthylamine and to asbestos. Unfortunately, Social Security Administration records are classified by such broad areas of employment as to prove generally inadequate for the study of industries with many varied exposures.[11] The prospective study in retrospect has also proved useful in the study of certain selected occupations, where detailed histories of exposure to hazardous agents were known; i.e., uranium miners,[12] and also in the case of religious orders, where there may be little change in occupation over time.[13]

In the present study we attempt to demonstrate

the usefulness of the same approach by reference to detailed occupational histories provided by a single employer. With the trend to greater computerization of employee records, such studies should become more practicable in the future. For the present, however, the study of occupational mortality by reference to current employer records is limited by the availability of occupational histories going back sufficiently far in time to identify long-term factors. Consequently, compromises may have to be made between what would be considered a long enough period for the appearance of latent effects and the period for which records are available. Of course, if the period selected is insufficient to identify these effects, we can extend such studies into the future.

Materials and Methods

Diseases of possible occupational origin have been reported for a number of work areas and specific occupations in the steel industry.[14–16] Findings in some cases have been contradictory as shown by reports of excessive lung cancer in coke-oven workers in one study[17] and negative results in another.[18] Case-control findings of other high risk groups such as crane operators in the "hot-metals" industry remain to be confirmed.[19] In an attempt to clarify these differences, and to identify other potential hazards in the steel making process, a collaborative study was initiated in 1962, by the U. S. Public Health Service and the University of Pittsburgh, Graduate School of Public Health, in cooperation with three large steel firms. It was, thus, possible to obtain employment records for a sufficiently large group of workers so that intra-industry comparisons could be made. All of the men employed by the three firms in 1953, in seven plants located within a single county, constitute the cohort under study. The cohort represents approximately 62% of all men working in basic iron and steel production in the county in 1953.

There were 59,072 steelworkers employed at the seven plants in 1953. Records of these men were collected between July 1962, and December 1964. This work was carried out by teams of four clerks assigned to each of the plants. Record collection proceeded rapidly at those personnel offices which could provide rosters of all men employed in 1953. At others, much time was spent in collating current rosters with weekly or monthly lists of removals and retirements, dating back to 1953. Problems were also encountered in locating individual records in any one of a number of open or closed files kept according to varying alphabetical and numerical schemes. In several instances inactive records were filed numerically under a system which allowed for the assignment of the same number to more than one employee. At one of the plants the inactive file, dating back to 1900, consisted of approximately 100,000 records. The 59,072 records finally included in this study, therefore, are only a small segment of the total number of records reviewed.

A single 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 key punching (Fig. 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 men leaving employment before January 1, 1962, a follow-up procedure was instituted to determine vital status as of that date. (The details of this procedure and a discussion of the problems encountered will be the subject of a separate report.) In broad outline, the follow-up schema consisted of reference to death lists and city directories, as well as inquiries to many local, state, and Federal agencies. When no determination could be made through these sources, mail and telephone contacts were made to the next of kin. The procedure for verifying death information assured that those still living were not classified as deceased. Conversely, some of those employees not located through follow-up may have been dead. All deaths included in this study were confirmed by death certificates. At the end of these operations, information on vital status, as of January 1, 1962, had been obtained on all but 97 of the 59,072 steelworkers. Two of the 97 men classified in vital status as "unknown," however, were reported by a single source to be deceased. Since no death certificate could be located for either of these persons in the jurisdiction where death was reported to have occurred, they were assumed to be alive on January 1, 1962.

When it was determined that a study member had died before January 1, 1962, information concerning the underlying cause of death was obtained from appropriate sources and transferred to the survey sheet in coded form. For persons who died in the "study county," this information was copied from a death listing prepared from punch cards pro-

1 IN COLUMN 1

NAME: _____ SOCIAL SECURITY NO. 2-10

EMPLOYMENT NO.: _____ FIRM AND PLANT 11-12

OTHER IDEN.: _____ EVER(1) NEVER(2) UNK.(9) MARITAL STATUS 13

WHITE(1) NONWHITE(2) UNK.(9) RACE 14

SPECIFY IF FOREIGN BORN: _____ PLACE OF BIRTH

00 20 OTHER U.S.

10 21 U.S. NOS

11 99 UNKNOWN

EMPLOYEE 15-16

FATHER 17-18

MOTHER 19-20

DATE OF BIRTH 21-24

WORKING(1) RETIRED(2) LEFT(3) DEAD(4) RECORD STATUS 25

ALIVE (1) DEAD (2) UNK. (9) STATUS 12-31-61 26

PLACE OF DEATH: _____ DATE OF DEATH 27-30

CAUSE OF DEATH 31-34

FILM NO. _____

ADDRESS, OR ADDRESSES, IN 1953: 70 MM 35-37

14 X 17 38-40

FINAL OX 41-44

RESIDENCE 45-47

JOB TITLE	DEPARTMENT	JOB	BEGINNING DATE
		48-51	52-55
		56-59	60-63
		64-67	68-71
		72-75	76-79
		11-14	15-18
		19-22	23-26
		27-30	31-34
		35-38	39-42
		43-46	47-50
		51-54	55-58
		59-62	63-66
		67-70	71-74

FOLLOW-UP LAST ADDRESS:		P.O.	DIRECTORY	OTHER (SPECIFY)
	CHG. DEAD.			
" "	CHG. DEAD.			
" "	CHG. DEAD.			
" "	CHG. DEAD.			
	CHG. DEAD.			

NEXT OF KIN _____ RELATIONSHIP _____

ADDRESS _____ PHONE _____

VERIFICATION OF DEATH INFORMATION

CO. CERT. NO. _____ SOCIAL SECURITY _____ OTHER (SPECIFY) _____

CERTIFICATE REQUESTED FROM _____ DATE _____ RECEIVED _____

SCHEDULE COMPLETE: CODING VERIFIED: PUNCHING VERIFIED:

Fig. 1. Survey form.

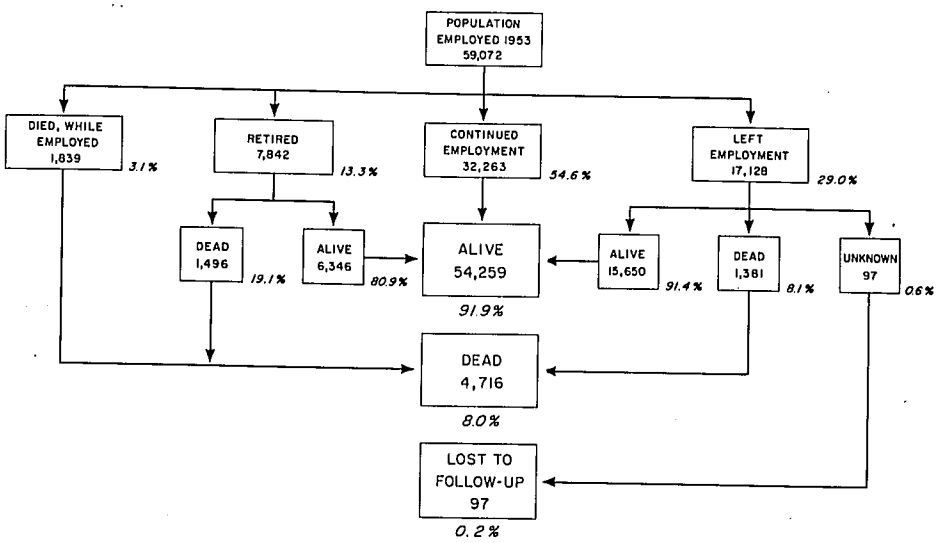

Fig. 2. Steelworkers employed in 1953, classified by employment status and vital status through December 31, 1961.

vided by the State Health Department, while the cause of death for those dying in other counties within the state was transcribed from death certificates on file at the state capital. Death certificates for those expiring outside the state were obtained from the various jurisdictions, and coded by a nosologist trained at the National Vital Statistics Division of the U. S. Public Health Service. All deaths were classified according to the International List.[20] Twelve per cent of the steelworker decedents died outside of the "study county." Of these, 333 died in other counties within the state, 215 in other states, and 18 in other countries.

An analysis of mortality, in terms of occupational history, requires a schema for assigning each member of the study population to the correct occupational group. 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. As a beginning point, an existing classification schedule was renumbered to allow for easy grouping into specific job titles and the several work areas.[21] Early review of work sheets returned from the plants showed that this code would be inadequate for our purpose, as many job titles and work areas had not been included in the original schema. Because of the unique titles used at each of the plants, especially in the earlier years, it was necessary to set up a system for translating diverse titles into common 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 IBM listings of translations and newly assigned numbers were provided for the clerks 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 assignment of job title numbers.

Findings

The distribution of the study population by employment status at the beginning of follow-up, and the determination of vital status are shown in Fig. 2. Of the 59,072 steelworkers employed in 1953, 54.6% were alive and still employed in one of the seven plants at some time subsequent to the cutoff date of December 31, 1961. The proportion continuing employment was somewhat greater for white workers (55.4%) than for nonwhite (49.4%). More than 17,000 steelworkers had left employment between 1953 and 1961. Because the whereabouts of these persons were unknown to the 1953 employer, vital status by the end of 1961 had to be determined through the follow-up schema as described previously.

The rate of turnover in the steel industry appears to be greater for nonwhite workers, as indicated by

TABLE I

OBSERVED AND EXPECTED* DEATHS FOR SELECTED CAUSES BY RACE
STEELWORKERS 1953-1961

Cause of Death	List Number	Total		White		Nonwhite	
		Observed	Expected	Observed	Expected	Observed	Expected
All Causes		4716	5766.8	4083	4773.5	633	993.3
Infective and parasitic diseases	001-138	65	166.9	39	94.7	26	72.2
Malignant neoplasms	140-205	1008	1091.4	861	929.0	147	162.4
Vascular lesions affecting C.N.S.	330-334	365	464.3	310	359.8	55	104.5
Heart disease	400-443	1906	2311.3	1721	2012.5	185	298.8
Arteriosclerotic and deg. heart disease	420-422	1680	2002.9	1537	1773.4	143	229.5
Other heart disease	(400-416) (430-443)	226	308.4	184	239.1	42	69.3
Diseases of respiratory system	470-527	165	237.6	136	178.4	29	59.2
Accidents	800-962	356	311.8	302	252.6	54	59.2
Homicide and suicide	(963-964) (970-985)	118	138.7	94	100.7	24	38.0
All other causes	Residual	733	1044.8	620	845.8	113	199.0

* Expected deaths calculated by applying age, race and calendar year specific rates of the study county to steelworker person years at risk.

the percentage leaving employment. Thirty-six per cent of nonwhite steelworkers had left employment for reasons other than retirement or death by the end of 1961, as compared to 29% of white workers. Retirement for age or disability accounted for 13.3% of the study population, while slightly more than three per cent of steelworkers died while employed between 1953 and December 31, 1961. The proportion of workers retiring, and those dying while employed, was approximately the same for the two races.

The success of the follow-up schema is indicated by the fact that less than one per cent of those leaving employment could not be located. The procedure was more productive for locating white employees, with only 0.5% classified as unknown at the cutoff date as compared to 1.1% of nonwhites. While a number of cultural factors may be associated with this difference, some part of the disparity between the races can be more simply explained as the result of extensive demolition of Negro slum areas in the "study county" during the period covered. As a result, many of the initial addresses provided by the employer were nonexistent when the follow-up procedure was instituted. Vital status was eventually determined for all but 97 (0.2%) of the 59,072 men initially selected for study. The lack of definitive information for such a small group will have little effect on the over-all mortality picture for steelworkers. Even if we were to assume that all these individuals had died, the total mortality rate would be increased only one per cent.

In Table I, the distribution of steelworker deaths is contrasted with the number of deaths expected on the basis of race and age specific mortality rates for the study county. While direct comparisons are inappropriate because of the selectivity of the employed population, it is informative to examine the pattern of observed to expected mortality for the two races. Both white and nonwhite steelworkers showed lower mortality over the nine-year period than would have been predicted by the experience of their counterparts in the general population, the deficit being greater for nonwhite (36%) than for white steelworkers (15%). The greater deficit for nonwhite steelworkers was evident for all causes of death except accidents, and was particularly striking for heart disease and vascular lesions affecting the central nervous system.

The effect of selection on the pattern of disease observed in an employed population is seen in the contrasting mortality rates for acute, as compared to chronic, conditions. The rate of steelworker mortality due to infective and parasitic diseases was 61% lower than expected while the deficit for heart disease was only 17%. Although white steelworkers showed striking deficits for most causes of death, the number of deaths due to accidents was 14%

higher than expected. Factors responsible for this difference, and perhaps others which are masked by the use of "study county" rates, will be considered in a later analysis of intra-industry mortality in terms of occupation and area of employment. In this presentation we will concern ourselves with differences in mortality between the races within the steelworker population and "study county," and consider the implications of these findings for further study of industrial population mortality.

The distribution of the steelworker population and mortality from all causes by race and age is shown in Table II. For each 1,000 steelworkers employed in 1953, there were 80 deaths during the nine-year period of follow-up. All-causes mortality for nonwhite steelworkers was almost eight per cent greater than for whites. Examination of the age-specific rates shows that almost all of this difference was accounted for by higher rates for the nonwhites at the young ages, the greatest difference being a 54% excess in the youngest age groups. For each succeeding age group the difference between the two races decreased, so that the excess for nonwhites was only six per cent for ages 45 to 54. The nonwhite steelworker also showed a somewhat lower mortality rate than his white co-worker after age 55. This racial pattern of all-causes mortality by age is not peculiar to the steelworker population. In the "study county," nonwhites showed a higher mortality than whites before age 65, and somewhat lower rates thereafter (Table IV). The same phenomenon can also be seen in published vital statistics for the United States, with more favorable rates for nonwhites apparent after age 75.[22]

Examination of cause-specific mortality shows the

TABLE II

POPULATION, DEATHS DUE TO ALL CAUSES AND RATE PER 1,000 EMPLOYED IN 1953 BY RACE AND AGE
(Steelworkers 1953-1961)

Rate and Age Group	Population	Deaths	Rate per 1,000
Total	59,072	4,716	79.8
< 35	24,439	376	15.4
35-44	15,166	743	49.0
45-54	10,445	1,267	121.3
55-64	7,812	1,880	240.7
≥ 65	1,210	450	371.9
White	51,705	4,083	79.1*
< 35	21,468	310	14.4
35-44	13,499	640	47.4
45-54	8,721	1,048	120.2
55-64	6,925	1,678	242.3
≥ 65	1,092	407	372.7
Nonwhite	7,367	633	85.1*
< 35	2,971	66	22.2
35-44	1,667	103	61.8
45-54	1,724	219	127.0
55-64	887	202	227.7
≥ 65	118	43	364.4

* Adjusted for age to the total steelworker population by the direct method.

TABLE III

MORTALITY FROM SELECTED CAUSES PER 1,000 EMPLOYED IN 1953 BY RACE
(Steelworkers 1953-1961)

Cause of Death	List Number	White		Non-white	
		Deaths	Rate*	Deaths	Rate*
All Causes		4,083	79.1	633	85.1
Infective and parasitic diseases	001-138	39	0.8	26	3.1
Malignant neoplasms	140-205	861	16.8	147	19.6
Vascular lesions affecting C.N.S.	330-334	310	6.0	55	7.6
Heart disease	400-443	1,721	33.3	185	25.3
Arteriosclerotic and deg. heart disease	420-422	1,537	29.7	143	19.6
Other heart disease	(400-416) (430-443)	184	3.6	42	5.7
Diseases of respiratory system	470-527	136	2.6	29	3.7
Accidents	800-962	302	5.8	54	7.3
Homicide and suicide	(963-964) (970-985)	94	1.8	24	3.4
All other causes	Residual	620	12.1	113	15.0

* Rates adjusted by age to total steelworker population by the direct method.

TABLE IV

MORTALITY DUE TO ALL CAUSES BY RACE AND AGE 1953-1961
(Steelworkers and "Study County")

Race and Age[3]	Steelworkers			Study[2] County Rate
	Person Years at Risk	Deaths	Rate[1]	
White	448,196	4,083	911.0	1578.2
< 35	134,400	162	120.5	135.4
35-44	126,598	415	327.8	348.8
45-54	95,173	848	891.0	1022.9
55-64	61,363	1,337	2178.8	2500.0
≥ 65	30,662	1,321	4308.3	6844.3
Nonwhite	63,668	633	994.2	1880.6
< 35	18,297	36	196.8	317.7
35-44	16,304	75	460.0	741.9
45-54	14,663	154	1050.3	1686.4
55-64	11,266	231	2050.4	3440.9
≥ 65	3,138	137	4365.8	6505.8
$\frac{\text{Nonwhite Rate}}{\text{White Rate}} \times 100$				
All Ages			1.09	1.19
< 35			1.63	2.35
35-44			1.40	2.13
45-54			1.18	1.65
55-64			0.94	1.38
≥ 65			1.01	0.95

[1] Rate per 100,000 person years at risk.
[2] Average annual rate per 100,000 population.
[3] For study county: < 35 = 20 - 34; ≥ 65 = 65 - 84.

source of the differences in over-all mortality for the two races (Table III). With the exception of a single cause of death, the nonwhite steelworker mortality was higher than that observed for whites. A striking exception is seen for arteriosclerotic and degenerative heart disease, with the white steelworkers showing mortality more than 50% greater than the nonwhites. The greatest excesses in nonwhite mortality rates are seen for infectious and parasitic diseases, and also diseases of the respiratory system. Examination of the age-specific rates for these causes may give insight to the racial pattern of all-causes mortality by age for steelworkers and the general population.

In order to make age comparisons for the steelworker population and the "study county" population, mortality rates have been determined in a different fashion than those shown in Tables II and III. In Tables IV, V and VI, the mortality rates are expressed in terms of person years at risk at specific ages, whereas the earlier Tables are in terms of age in 1953.

All-causes mortality rates for the steelworkers and the "study county" population are given in Table IV. The age differentials by race for steelworkers are, as expected, somewhat different from those seen in Table II. While the over-all pattern by age remains the same, and the nonwhite to white ratio for all ages is little different, the ratios based on person-year rates have magnified the nonwhite excess at the younger ages. The most striking feature of the nonwhite to white mortality ratios shown in Table IV is the much greater excess of nonwhite mortality in the general population. For each of the age groups included in the usual span of working years the excess in the general population was 40% or more greater than that seen for steelworkers. It is interesting to note that the difference is not seen after age 65. More detailed information would be required to interpret adequately the causes for these differences. To a great extent they are probably a reflection of the known correlation between economic level and health status. In any case, it is apparent that the gainfully employed nonwhite steelworker has experienced less of an increase in mortality in relationship to his white co-worker than did his counterpart in the general population.

Mortality rates and white/nonwhite mortality

TABLE V

MORTALITY DUE TO SELECTED CAUSES BY RACE AND AGE 1953-1961
(Steelworkers and "Study County")

	Arteriosclerotic and Degenerative Heart Disease			Diseases of Respiratory System			Infective and Parasitic Diseases		
	Steelworkers		Study County	Steelworkers		Study County	Steelworkers		Study County
Race and Age[4]	Deaths	Rates[1]	Rate[2]	Deaths	Rates[1]	Rate[2]	Deaths	Rates[1]	Rate[2]
White	1,537	342.9	614.4	136	30.3	60.3	39	8.7	26.3
< 35	17	12.6	10.6	5	3.7	3.9	2	1.5	3.2
35-44	133	105.1	106.1	12	9.5	11.9	2	1.6	10.0
45-54	343	360.4	390.6	25	26.3	33.7	8	8.4	26.4
55-64	511	832.7	974.9	49	79.9	92.5	14	22.8	47.0
≥ 65	533	1738.3	2823.5	45	146.8	278.9	13	42.4	83.9
Nonwhite	143	224.6	486.9	29	45.5	108.2	26	40.8	116.4
< 35	1	5.5	23.8	1	5.5	18.1	1	5.5	25.7
35-44	11	67.5	120.5	4	24.5	60.3	4	24.5	76.3
45-54	33	225.1	374.1	5	34.1	95.7	3	20.5	132.8
55-64	59	523.7	894.6	13	115.4	191.1	16	142.0	241.1
≥ 65	39	1242.8	2097.4	6	191.2	353.1	2	63.7	231.9
White Rate / Nonwhite Rate X 100									
All Ages		152.7	126.2		66.6	55.7		21.3	22.6
< 35		(3)	44.5		(3)	21.5		27.3	12.5
35-44		155.7	88.0		38.8	19.7		6.5	13.1
45-54		160.1	104.4		77.1	35.2		41.0	19.9
55-64		159.0	109.0		69.2	48.4		16.1	19.5
≥ 65		139.9	134.6		76.8	79.0		66.6	36.2

[1] Rate per 100,000 person years at risk.
[2] Average annual rate per 100,000 population.
[3] Number too small for comparison.
[4] For study county: < 35 = 20 - 34; ≥ 65 = 65 - 84.

TABLE VI

MORTATLITY DUE TO DISEASES OF THE RESPIRATORY SYSTEM
(Steelworkers and "Study County," 1953-1961)

Group and Cause of Death	List Number	White		Nonwhite		Nonwhite Rate / White Rate X 100
		Deaths	Rate[1]	Deaths	Rate[1]	
Steelworkers[1]						
Influenza and pneumonia	(480-483) (490-493)	77	17.2	20	31.4	182.6
Bronchitis	500-502	5	1.1	0	0.0	0.0
Other respiratory diseases	(470-475) (510-527)	54	12.0	9	14.1	117.5
Study County[2]						
Influenza and pneumonia	(480-483) (490-493)		40.2		78.8	196.0
Bronchitis	500-502		2.1		2.6	123.8
Other respiratory diseases	(470-475) (510-527)		17.9		27.1	151.4

[1] Rate per 100,000 person years at risk. [2] Average annual rate per 100,000 population.

ratios for the most divergent causes of death are shown in Table V. Examination of the ratios for arteriosclerotic and degenerative heart disease shows that whites experienced greater mortality than nonwhites in both the steelworker and "study county" populations. The excess in white mortality from these diseases was more marked in the steelworker population and was apparent for each age group. In the "study county" the higher rates for whites were not seen until ages 45 to 54. These differences explain in large part the more favorable mortality due to all causes for nonwhite steelworkers at the

TABLE VII
MORTALITY DUE TO INFECTIVE AND PARASITIC DISEASES
(Steelworkers and "Study County," 1953-1961)

Group and Cause of Death	List Number	White		Nonwhite		Nonwhite Rate / White Rate X 100
		Deaths	Rate[1]	Deaths	Rate[1]	
Steelworkers[1]						
Respiratory tuberculosis	001-008	23	5.1	8	12.6	247.1
Tuberculosis, other forms	010-019	2	0.4	6	9.4	2350.0
Syphilis and sequelae	020-029	4	0.9	10	15.7	1744.4
Other infective and parasitic diseases	030-138	10	2.2	2	3.1	140.9
Study County[2]						
Respiratory tuberculosis	001-008		18.2		75.3	413.7
Tuberculosis, other forms	010-019		0.8		10.8	1350.0
Syphilis and sequelae	020-029		4.5		26.8	595.6
Other infective and parasitic diseases	030-138		2.7		3.5	129.6

[1] Rate per 100,000 person years at risk. [2] Average annual rate per 100,000 population.

older ages, since one-third of all steelworker deaths (and a greater percentage at older ages) were allocated to these diseases. The extent to which all-causes mortality is a reflection of arteriosclerotic and degenerative heart disease is also seen in a comparison of steelworker and "study county" ratios. The excess nonwhite mortality for all causes in the general population was nine per cent greater than that seen for steelworkers, while the ASHD deficit for non-white steelworkers was 21% greater than that observed in the general population.

Nonwhites in the steelworker and "study county" population exhibited greater mortality due to diseases of the respiratory system than whites, but the same pattern of greater relative mortality for nonwhites in the "study county" was again observed. On the other hand, while nonwhite mortality due to infective and parasitic diseases was much higher than for whites in both populations, the racial differential between steelworkers and the "study county" population was not apparent. A more detailed breakdown of these causes is given in Tables VI and VII. The greatest part of the nonwhite excess in mortality due to diseases of the respiratory system was attributed to deaths from influenza and pneumonia (Table VI). The almost two-fold difference is consistent with patterns seen in the United States for a number of years.[22] The infective and parasitic diseases present a mixed picture (Table VII). While nonwhite steelworker mortality due to respiratory tuberculosis was more than double that observed for white steelworkers, the nonwhite excess was considerably below that observed for the general population. On the other hand, the single disease of any consequence for which the nonwhite to white ratio was higher for steelworkers than for the study county was syphilis and its sequelae. The significance of this finding remains to be determined because of the small number of deaths due to this cause.

Summary and Discussion

In this, the first of a series of papers dealing with the mortality experience from 1953 to January 1, 1962, of 59,072 males employed in 1953, in seven iron and steel producing plants, we have:

(a) discussed some of the sources of errors and biases related to efforts to estimate relationship of occupation to mortality;

(b) described in general the method of collecting information on death and survivorship of these men from 1953 to 1962; and

(c) presented findings on mortality rates and frequency of causes of death among the white and nonwhite steelworkers and population of the county in which the plants are situated.

Among the major findings, the following are worthy of note:

1. Of the 59,072 men alive in 1953 who constitute the cohort under study, information was obtained regarding vital status, as of January 1, 1962, for all but 97. During the approximately nine-year period, eight per cent of the cohort died.

2. Total mortality for the period was higher among nonwhites than whites. This difference was observed only for the age groups below 54 years of age in 1953. For the age groups 55 years and above, the mortality of the whites was higher than that of the nonwhites.

3. The lower mortality of the whites occurred for all causes of death except for deaths

attributed to arteriosclerotic and degenerative heart disease.

4. As expected, the average annual mortality rates for the steelworkers was lower than that of the male population of the county in which the plants are situated. However, white steelworkers showed an excess of deaths due to accidents.

5. While the pattern of white-nonwhite mortality ratios by age and by cause of death was similar for steelworkers and the general population, the nonwhite deficit for ASHD was more marked for steelworkers, and the nonwhite excess for other causes was greater for the "study county" population.

It has been indicated above that an industrial population differs from the general population from which it derives due to the action of selective factors. To become employed and remain employed in a particular industry requires a certain level of health. Individuals whose health is below the requirements for the specific industry or job in that industry do not enter that industry, and those whose health deteriorates below that level do not remain in that industry or job. Hence, unless an industry presents substantial hazards whose effects are acute and highly fatal, we would expect that the mortality of its employees would be less than that of the community from which they originate. This is clearly shown in the data presented above.

On the other hand, the employees of an industry are affected by those conditions of their community which affect health. This is exemplified by the differences in mortality between the whites and nonwhites. The higher mortality of nonwhites due to infective, parasitic, and respiratory diseases has been observed in all studies on general population groups, and reflects in large part the lower "socio-economic" status of the nonwhites. We shall probe further into this difference when we examine the relationship of wage levels and jobs to mortality.

The lower mortality of nonwhites due to ASHD and from all causes at the higher ages may or may not be related. These findings are consistent with observations that, when two populations are compared, the population that has the higher mortality in infancy or childhood often has a lower mortality in old age, and the population that has higher death rates due to acute infectious diseases has lower mortality due to degenerative disorders. This longitudinal study of a cohort of steelworkers provides an opportunity to examine in some detail this phenomenon.

Acknowledgment: Grateful acknowledgment is made to Mr. Hugh W. Rush for over-all supervision of the record processing staff and maintenance of liaison with the many groups cooperating in the study; to the personnel staffs of the steel firms for assistance in compiling employment histories; to Miss Mary Lee Dante and Mr. Arthur LeGasse for preparation of computer programs; and to the U.S. Post Office Department and the Social Security Administration for assistance in the follow-up program.

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References

1. RAMAZZINI, B.: Diseases of Workers. Translated from the Latin text De Morbis Artificum of 1713 by W. C. Wright. *Hafner,* New York, 1964.
2. POTT, P.: Chirurgical Observations. *Hawes, Clarke & Collings, London,* 1775.
3. BERMAN, C.: Primary Carcinoma of the Liver in the Bantu Races of South Africa. *South African J Med Sci,* 5:54-72, 1940.
4. HENRY, S. A.: Cancer of the Scrotum in Relation to Occupation. *Oxford Univ. Press,* London, 1946.
5. HENRY, S. A.: Occupational Cutaneous Cancer Attributable to Certain Chemicals in Industry. *Brit Med Bull,* 4:389-401, 1947.
6. DOLL, R.: Cancer of the Lung and Nose in Nickel Workers. *Brit J Indus Med,* 15:217-223, 1958.
7. GILLIAM, A. G.: A Note on Evidence Relating to the Incidence of Primary Liver Cancer Among the Bantu. *J Nat Cancer Inst,* 15:195-199, 1954.
8. ENTERLINE, P. E.: The Estimation of Expected Rates in Occupational Disease Epidemiology. *Public Health Rep,* 79:973-978, 1964.
9. MANCUSO, T. F. and COULTER, E. J.: Methods of Studying the Relation of Employment and Long-Term Illness—Cohort Analysis. *Am J Public Health,* 49:1525-1536, 1959.
10. MANCUSO, T. F. and COULTER, E. J.: Methodology in Industrial Health Studies. *Arch Environ Health,* 6:210-226, 1963.
11. MYERS, R. J.: Limitations in the Use of OASDI Records for Health Studies. *Am J. Public Health,* 55:1787-1791, 1965.
12. WAGONER, J. K.; ARCHER, V. E.; LUNDIN, F. E.; JR.; HOLADAY, D. A.; and LLOYD, J. W.: Radiation as the Cause of Lung Cancer Among Uranium Miners. *New Eng J Med,* 273:181-188, 1965.
13. TAYLOR, R. S.; CARROLL, B. E.; and LLOYD, J. W.: Mortality Among Women in Three Catholic Religious Orders with Special Reference to Cancer. *Cancer,* 12:1207-1225, 1959.
14. SWANSTON, C.: The Iron and Steel Industry. *Lancet,* 1:191-197, 1950.
15. MCLAUGHLIN, A. I. G. and HARDING, H. E.: Pneumoconiosis and Other Causes of Death in Iron and Steel Foundry Workers. *Arch Indus Health,* 14:350-378, 1956.
16. TURNER, H. M. and GRACE, H. G.: An Investigation

Into Cancer Mortality Among Males in Certain Sheffield Trades. *J Hyg,* 38:90-103, 1938.
17. KENNAWAY, E. L. and KENNAWAY, N. M.: A Further Study of the Incidence of Cancer of the Lung and Larynx. *Brit J Cancer,* 1:260-298, 1947.
18. REID, D. D. and BUCK, C.: Cancer in Coking Plant Workers. *Brit J Indus Med,* 13:265-269, 1956.
19. BRESLOW, L.; HOAGLIN, L.; RASMUSSEN, G.; and ABRAMS, H. K.: Occupations and Cigarette Smoking as Factors in Lung Cancer. *Am J Public Health,* 44:171-181, 1954.
20. MANUAL OF THE INTERNATIONAL STATISTICAL CLASSIFICATION OF DISEASES, INJURIES, and CAUSES OF DEATH. *World Health Organization,* Geneva, Switzerland, Sixth Rev., 1948; Seventh Rev., 1957.
21. JOB DESCRIPTION and CLASSIFICATION MANUAL FOR HOURLY RATED PRODUCTION, MAINTENANCE and NON-CONFIDENTIAL CLERICAL JOBS. *United Steel Workers of America-CIO and United States Steel Corporation (Steel Producing Operation),* January 1, 1953.
22. WHITE-NONWHITE MORTALITY DIFFERENTIALS IN THE UNITED STATES. Indicators. *U. S. Department of Health, Education, and Welfare,* June 1965.

Physical Fitness and Proper Conditioning

Skin and scuba diving are sports that are occasionally taxing and, thus, require a great deal of physiologic reserve. Ordinary modern living requires no such reserve. An average man has most of his hard physical tasks performed by machines; consequently, he is not prepared for any severe physical exertion. The lack of this preparation may be fatal. In 1965, a reported 86 civilian skin and scuba divers lost their lives through drowning accidents. Many of these may have occurred because of fatigue. The questions asked in this paper are, "Does the average sports diver have the proper level of physical fitness to participate in this occasionally taxing recreation?; and before he participates, can he and should he be brought to the proper level of fitness?"

This paper is concerned with the evaluation of physical fitness in a group of nonprofessional skin divers. The evaluation was begun with tests on 27 members of the Abington Submariners' Skin and Scuba Diving Club, YMCA, during their least active period, when they were doing little or no diving. Extensive cardiovascular and respiratory function studies were undertaken in January 1966. After the initial evaluation, each diver was encouraged to undertake a training program, and, if it was considered clinically necessary for good physical fitness, a diet. A final series of tests were performed on a number of these individuals as they were about to enter their most active period of diving, the latter part of April 1966. It was demonstrated that "pre-season" training and conditioning should be encouraged in anyone participating in an activity as demanding as skin and scuba diving.

—From "Cardiovascular and Respiratory Studies on Skin Divers Following Physical Training" by Peter Lynch; Alfred A. Bove; Frank Barrera; and Robert Balfour, in Archives of Environmental Health, Vol. 17, No. 1, July 1968.