PROPORTIONATE MORTALITY STUDY

OF ALCOA WORKERS

(1980-1987)

Howard E. Rockette, Ph.D.
Department of Biostatistics
University of Pittsburgh

Vincent C. Arena, Ph.D.
Department of Clinical Epidemiology
and Preventive Medicine
University of Pittsburgh

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Background

This study provides an evaluation of the mortality patterns of workers in the aluminum industry that can be used with the information from the previously reported Tripartite Study to help assess potential health problems in the aluminum industry. The Tripartite Study was initiated in May 1978 and a report of study findings was made in November 1981. Progress of the study was reported quarterly throughout the duration of the contract period to a Tripartite Committee consisting of representatives of labor, management and government. The study population consisted of 21,829 men employed at least five years in a reduction operation in one of the 14 plants between January 1, 1946 and December 31, 1973 (1). Vital Status determination as of December 31, 1977 was made on 99.3% of the cohort and death certificates were obtained for 97.6% of the men believed to be deceased. The priorities which directed the analysis of the Tripartite data were as follows:

(1) Mortality patterns of workers in the potroom and/or carbon departments were given the most attention in the analysis.

(2) Respiratory cancer was to be investigated thoroughly and was the disease category given the highest priority.

(3) Lymphopoietic cancers were to be investigated and were second only to respiratory cancer as a disease category to be given special attention.

(4) For diseases other than respiratory cancer and lymphopoietic cancer, enough preliminary analysis was

done to identify any excess mortality that was associated with a particular plant or process.

(5) Causes of death associated with the aluminum reduction process in other studies were reinvestigated using the Tripartite data.

In order to satisfy these objectives, the mortality patterns of employees in the fourteen reduction plants was compared to the total U.S. male population for 59 selected causes of death. Analysis was done by plant, process, calendar time period, time since first employment and selected exposure measurements. Industrial hygiene measurements were available for total particulates, benzene solubles, benzo(a)pyrene, particulate polycyclic organic matter, sulfur dioxide and total fluorides. Based on these analyses and the previous research literature on mortality of reduction plant workers, some categories of disease were selected for more detailed investigation.

The major findings of the Tripartite Study were as follows:

(1) There were no strong associations of lung cancer mortality and work in the reduction plant. Overall the lung cancer SMR of the total cohort based on 272 observed deaths was 96.4. Formal tests of a dose-response relationship to cumulative years employment in the potroom and carbon departments, cumulative years of employment in the reduction plant, and cumulative exposure to benzene solubles, particulate polycyclic organic matter, benzo(a)pyrene, total particulates, total fluorides and sulfur dioxide showed no statistically significant relationship.

There were two exceptions to the lack of an excess for lung cancer mortality. One plant, a horizontal Soderberg, had an SMR of 162.0 ($p<0.05$) for white males. However, the region in which the plant was located has a high lung cancer rate in the general population and when the data was reanalyzed using local rates, the SMR was below 100. The second excess was in the baked carbon department of one of the plants where there was an SMR of 266.8 ($p<0.05$) based on eight observed deaths. However, this excess was not observed in the baked carbon departments of the remainder of the prebake plants.

(2) The SMR for leukemia was 124.9 based on 43 observed deaths. This excess was not statistically significant. The SMR for the prebake process was 123.5 and for the Soderberg process was 130.2. The SMR for potroom workers in the Soderberg process was 169.1 and for potroom workers in the prebake process was 124.6. Analysis by duration of employment was not consistent by process with men in the prebake showing more excess with longer term employment and men in the Soderberg process showing greater excess with short term employment.

(3) The SMR for pancreatic cancer was 122.3 and was not statistically significant. However, there was a significant excess for men with more than 15 years employment in the potroom department in both the Soderberg (SMR=271.3, $p<0.05$) and prebake process (SMR=222.2, $p<0.05$).

(4) The SMR for kidney cancer in the prebake process was 144.9. The excess was greater in men with less than 20 years employment and greater in men employed outside the carbon and potroom departments.

(5) Although the number of observed deaths was small there was an excess of bladder cancer in men employed 5 or more years in the potroom or carbon department of the Soderberg process.

(6) The only cause of death which was statistically elevated for an entire process was benign and unspecified neoplasms. For the prebake process the SMR for this cause was 193.5 ($p<0.05$) based on 14 observed deaths. The estimated risk was greater for men employed twenty-five or more years, and was higher outside the potroom and carbon departments.

(7) There was an excess of emphysema in the potroom and carbon departments of the Soderberg process (SMR=216.5, $p<0.05$; SMR=258.9, $p<0.05$). Although the excess in the prebake process was elevated, it was not statistically significant. The emphysema risk may have been understated in the prebake process because of a tendency to code many death certificates to "chronic obstructive lung disease" after 1970. If these cases were considered to be emphysema there would be a statistically significant excess in the prebake process. For men with more than 20 years employment in the prebake process there was an SMR of 260.2, ($p<0.01$) for asthma.

The present study is a PMR Study without detailed work histories and without exposure measurements available. Thus, the conclusions that can be drawn from this study are more limited than those that could be obtained from the Tripartite Study. Nevertheless, this study provides us with an independent data base on which to confirm the interpretation of some of the findings in the Tripartite Study and also provides a means of

obtaining a preliminary evaluation of mortality patterns of nonreduction plant workers. Specifically, the primary objectives of the present study are as follows:

(1) To obtain mortality data from aluminum reduction plants independent of the Tripartite cohort that can be used to further clarify the relationship of employment in aluminum reduction plants to excess mortality from cancer. Because the majority of ALCOA workers were employed in the prebake process, it is for workers in this process that we expect the most information to be obtained. The mortality patterns in the PMR study will be contrasted with those obtained from the Tripartite Study.

(2) To obtain a profile of the mortality experience of nonreduction plant workers. Little information is available on the mortality experience of nonreduction plant workers since most studies have focussed on exposure in the potroom and carbon departments. This part of the investigation is limited because of the lack of detailed coding within the nonreduction plants. However, by investigating the consistency of any excess among plants with similar processes we may identify potential associations for future investigation.

(3) On the basis of this PMR study, the Tripartite Study and a review of the literature of potential health hazards in the aluminum industry, we will make specific recommendations of studies we feel are necessary in order to determine the association of disease with exposure in the aluminum industry. Such studies will be primarily hypotheses testing as opposed to hypothesis generating.

Methods

The study population assembled by ALCOA consisted of all deaths known to the company as determined by insurance claims during the time period 1/1/80 through 12/31/87 in one of the 37 study plants. Any former employee whose beneficiary had either filed a claim or was receiving death benefits from the company was included in the study population. The initial list supplied by ALCOA was reviewed for duplicates and incomplete or inconsistent names. The resultant study population contains 6433 workers. Death certificates were obtained for all but 60 (0.9%) of the study population. These deaths were coded by a nosologist according to the ninth revision ICD and it is these 6373 death certificates on which the analyses in the present report are based. The frequencies of deaths for each cause are given in the Appendix.

Detailed work histories were not coded and analyzed for this study, since to provide such coding for such a large variety of plants and processes would have required considerable effort. For this report an employee was classified in the plant where he was last employed. Using this method of classification, 2777 workers were coded to one of the eight reduction plants. For these eight reduction plants we further coded whether they had ever worked in the potroom or carbon department as well as the department they spent the majority of time. Nine employees could not be included in this analysis because we did not have work histories. The departments in the reduction process used to classify majority of time were potroom, carbon, ingot, mechanical maintenance, electrical maintenance, and power. A total of 1320

employees in the eight reduction plants spent the majority of their time in a nonreduction process. We have done analysis separately for the 3596 employees in nonreduction plants, the 1320 employees in a nonreduction process of a reduction plant and the 1448 employees in the reduction process.

The proportionate mortality ratio was the primary summary index of risk. The analysis was done using the computer program OCMAP (2) and five year average annual age, race and sex-specific U.S. rates for the control group. As a secondary analysis we used a proportionate cancer mortality index (PCMR) (3). This index uses "all cancer mortality" as the base on which to base proportionate mortality rather than "all cause" mortality and is believed by many investigators to be less subject to the healthy worker effect.

Both the PMR and PCMR were adjusted for age, sex, race and calendar time. To meet the primary objectives of this study we completed the following analyses:

(1) The PMR and PCMRs were computed for 62 selected causes of death by race, sex, and race-sex combinations for the total cohort, for nonreduction plants, and for plants with a reduction process (reduction plants).

(2) For plants with a reduction process PMRs and PCMRs were computed for employees with a majority of their time in each of the following: a) nonreduction process, b) potroom department, c) carbon department, d) ingot department, e) mechanical maintenance, f) electrical maintenance, and g) power. Mortality indices were also

computed for employees "ever employed in the potroom department" and employees "ever employed in the carbon department".

(3) PMRs and PCMRs were computed for each plant for all 62 selected causes of death.

Because of the large number of comparisons we expect some statistically significant excesses as well as deficits. When interpreting our data we will give emphasis to the excesses, but when interpreting excesses we will take into consideration the consistency of the result with the Tripartite Study as well as the consistency with other plants that have a similar process. In most cases we have required that either the observed or expected number of deaths be 5 before we attempt to interpret results for a specific cause of death.

Population Characteristics

A total of 6373 death certificates was obtained and coded for the years 1980 to 1987 in the 37 study plants. A total of 6112 (95.9%) death certificates were for males and 5816 (91.3%) were for whites. Table 1 summarizes the distribution of deaths by year. The number of deaths were approximately equal for each of the seven years of the study. The age at death is summarized in Table 2. Fifty-one percent of the deaths occurred at ages 65-79.

The distribution of deaths for the 37 study plants is shown in Table 3. The eight plants with a reduction process contributed 44% of the total deaths and 28% of the total deaths were for employees who at one time were in a reduction process evaluated in the Tripartite Study. Of the 2777 workers in one

of the eight plants with a reduction process, all but 9 had employment histories. Of the 2768 workers with employment histories, 1320 spent the majority of their time in a nonreduction process. The distribution of the number of employees spending the majority of their time in a specific reduction department is given in Table 4. Of the 1448 employees with the majority of time in one of the reduction departments, 556 (36%) had the majority of their time in the potroom. The second largest group was mechanical maintenance which accounted for 433 (29.9%) of the deaths.

Table 1

Distribution of Employees
by Year of Death

Year	Frequency	Percent
1980	766	12.0
1981	772	12.1
1982	781	12.3
1983	824	12.9
1984	793	12.4
1985	759	11.9
1986	819	12.9
1987	859	13.5
TOTAL	6373	100.0

Table 2
Distribution of Employees
by Age at Death

Value Label	Frequency	Percent
20 - 24	7	.1
25 - 29	19	.3
30 - 34	29	.5
35 - 39	41	.6
40 - 44	57	.9
45 - 49	80	1.3
50 - 54	172	2.7
55 - 59	293	4.6
60 - 64	573	9.0
65 - 69	1002	15.7
70 - 74	1261	19.8
75 - 79	1182	18.5
80 - 84	838	13.1
85 - 89	541	8.5
90 - 94	206	3.2
$\geq$95	72	1.1

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Table 3

Distribution of Workers by Plant

Plant Name	Frequency	Percent
Tennessee	1325	20.8
Vernon	210	3.3
Point Comfort	167	2.6
Massena	630	9.9
New Kensington	754	11.8
Cleveland	448	7.0
Cressona	231	3.6
Buffalo	7	.1
Vancouver	196	3.1
Warrick	116	1.8
Chillicothe	54	.8
Richmond	74	1.2
Detroit	76	1.2
East St. Louis	145	2.3
Edgewater	282	4.4
Chicago	27	.4
Corona	12	.2
Bridgeport	36	.6
Edison	103	1.6
Davenport	247	3.9
Wentachee	88	1.4
Lafayette	355	5.6
Lancaster	31	.5
Marshall	11	.2
Logans Ferry	16	.3
Mobile	149	2.3
Lebanon	8	.1
Anderson	2	.0
Badin	152	2.4
Bauxite	148	2.3
Addy	8	.1
Atc	89	1.4
Fort Meade	4	.1
Franklin	23	.4
Rockdale	103	1.6
Rosiclare	36	.6
Tiffon	10	.2
Total	6373	100.0

Table 4
Department Where Reduction Plant Workers
Spent Majority of Time

Department	Frequency	Percent
Potroom	556	38.4
Carbon	140	9.7
Ingot	183	12.6
Mech Maintenance	433	29.9
Elec Maintenance	113	7.8
Power	23	1.6

Results

A. Mortality for Total Cohort

The cause-specific mortality for 62 selected causes of death is shown in Table 5. The PMR for the category "all malignant neoplasms" is 103.7 based on 1605 observed deaths. Five causes of death are significantly elevated. These are cancer of the kidney (PMR=158.1, $p<0.01$), all other malignant neoplasms (PMR=134.3, $p<0.01$), benign and unspecified neoplasms (PMR=195.6, $p<0.01$), nephritis and nephrosis (PMR=242.2, $p<0.01$) and cerebral vascular disease (PMR=111.4, $p<0.05$). Since males comprise 91% of the cohort, it is not surprising that when we restrict our analysis to the population of males (Table 6) the same causes of death show a significant excess. For females (Table 7), all other malignant neoplasms (PMR=240.2, $p<0.01$), benign neoplasms (PMR=600.5, $p<0.01$) and all other causes of death (PMR=135.1, $p<0.05$) show a statistically significant excess.

When mortality patterns for the total cohort are

Table 5
Observed and Expected Deaths and Proportionate Mortality Ratios for the Total Population

Cause of Death (ICDA 8th Revision Codes)	OBS	EXP	SPMR		95% Limits LOWER	UPPER
All Causes of Death	6373	6373.00	100.0		---	---
Tuberculosis	4	8.18	48.9		18.7	127.5
All Malignant Neoplasms	1605	1545.32	103.7		99.4	108.1
Cancer of Buccal Cavity & Pharynx	18	33.58	53.6	**	34.1	84.4
Cancer of Digestive Organs & Peritoneum	385	381.80	100.8		91.5	111.1
Cancer of Esophagus	19	36.85	51.6	**	33.2	80.0
Cancer of Stomach	89	83.88	109.5		84.9	141.2
Cancer of Large Intestine	166	151.98	109.2		94.0	126.9
Cancer of Rectum	30	29.70	101.0		70.7	144.3
Cancer of Biliary Passages & Liver	30	34.79	86.2		60.4	123.2
Cancer of Pancreas	74	75.10	98.5		78.6	123.6
Cancer of All Other Digestive Organs	7	10.95	63.9		30.7	133.2
Cancer of Respiratory System	568	545.75	104.1		96.3	112.5
Cancer of Larynx	7	17.88	38.1	*	19.2	78.8
Cancer of Bronchus, Trachea, Lung	556	522.88	106.7		98.8	115.4
Cancer of All Other Respiratory	3	4.88	61.5		20.1	188.5
Cancer of Breast	13	14.29	91.0		53.8	163.9
All Uterine Cancers (Females only)	4	3.23	123.8		48.9	326.6
Cancer of Cervix Uteri (Females only)	1	1.33	75.2		10.8	524.4
Cancer of Other Female Genital Organs	4	4.17	95.9		38.4	252.9
Cancer of Prostate (Males only)	147	167.88	87.5		74.7	102.5
Cancer of Testes and Other Male Genital Organs	3	2.46	121.9		38.4	377.1
Cancer of Kidney	83	33.62	158.1	**	121.2	206.3
Cancer of Bladder and Other Urinary Organs	48	46.32	103.6		78.2	137.4
Malignant Melanoma of Skin	18	16.88	112.6		71.8	176.3
Cancer of Eye	1	0.79	127.3		18.0	899.0
Cancer of Central Nervous System	24	28.12	82.4		55.3	122.7
Cancer of Thyroid & Other Endocrine Glands	4	3.42	116.9		43.8	311.1
Cancer of Bone	3	2.50	120.0		38.6	371.3
Cancer of All Lymphatic, Haematopoietic Tissue	147	129.45	113.8		96.8	133.2
Lymphosarcoma & Reticulosarcoma	18	13.74	116.5		71.4	189.9
Hodgkins Disease	7	4.78	146.6		70.2	305.8
Leukemia & Aleukemia	85	83.81	102.0		78.4	132.7
Cancer of All Other Lymphopoietic Tissue	69	57.03	121.0		85.7	153.0
All Other Malignant Neoplasms	184	122.11	134.3	**	115.5	156.2
Benign Neoplasms	29	14.82	195.6	**	136.9	279.5
Diabetes Mellitus	82	85.41	96.4		78.7	118.1
Cerebrovascular Disease	466	418.28	111.4	*	102.1	121.6
All Heart Disease	2555	2567.57	99.5		96.6	102.5
Rheumatic Heart Disease	14	22.81	61.4		36.6	103.0
Ischemic Heart Disease	1889	2217.28	85.2	**	82.2	88.3
Chronic Endocard. Dis.; Other Myocard. Insuff.	134	125.14	107.1		90.6	126.6
Hypertension with Heart Disease	52	62.35	83.4		63.7	108.2
All Other Heart Disease	466	461.67	100.8		92.5	110.1
Hypertension w/o Heart Disease	23	17.23	133.5		88.9	200.5
Non-malignant Respiratory Disease	482	580.81	82.4	**	75.5	89.8
Influenza & Pneumonia	153	198.70	77.0	**	66.0	89.9
Bronchitis, Emphysema, Asthma	73	88.50	82.5		65.7	103.5
Bronchitis	10	15.83	64.4		34.8	119.0
Emphysema	54	68.12	79.3		60.9	103.3
Asthma	9	5.80	155.3		81.2	285.8
Other Non-malignant Respiratory Disease	236	287.62	82.1	**	72.5	92.9
Ulcer of Stomach & Duodenum	22	19.08	115.2		76.0	174.9
Cirrhosis of Liver	56	90.48	61.9	**	47.9	80.0
Nephritis & Nephrosis	85	35.09	242.2	**	197.3	297.4
All External Causes of Death	288	285.28	100.9		90.9	112.1
Accidents	191	178.11	106.6		93.2	122.1
Motor Vehicle Accidents	80	69.83	115.1		93.2	142.0
All Other Accidents	111	111.10	99.9		83.2	120.0
Suicides	74	72.56	102.0		81.8	127.5
Homicides & Other External Causes	23	33.62	68.4		46.2	101.3
All Other Causes of Death	688	651.61	105.3		98.1	113.0
Unknown Causes (In All Causes Category Only)	0					

* Significant at 5% Level; ** Significant at 1% Level

Table 6
Observed and Expected Deaths and Proportionate Mortality Ratios for Males

Cause of Death (ICDA 9th Revision Codes)	OBS	EXP	SPMR		95% Limits LOWER	UPPER
All Causes of Death	6112	6112.00	100.0		---	---
Tuberculosis	4	7.88	50.1		19.2	130.8
All Malignant Neoplasms	1533	1482.52	103.4		98.0	108.0
Cancer of Buccal Cavity & Pharynx	18	32.69	55.1	*	35.0	86.7
Cancer of Digestive Organs & Peritoneum	367	385.61	100.4		90.9	110.8
Cancer of Esophagus	19	36.20	52.5	**	33.8	81.8
Cancer of Stomach	57	52.24	109.1		84.3	141.3
Cancer of Large Intestine	156	144.54	107.9		92.4	126.0
Cancer of Rectum	29	28.48	101.8		70.8	146.4
Cancer of Biliary Passages & Liver	28	33.15	84.5		58.4	122.2
Cancer of Pancreas	71	71.57	99.2		78.7	125.0
Cancer of All Other Digestive Organs	7	10.40	67.3		32.3	140.4
Cancer of Respiratory System	557	533.38	104.4		96.5	113.0
Cancer of Larynx	7	17.88	39.6	*	18.4	80.8
Cancer of Bronchus, Trachea, Lung	547	510.87	107.1		98.9	115.9
Cancer of All Other Respiratory	3	4.73	63.4		20.6	184.5
Cancer of Breast	0	1.63	---		---	---
All Uterine Cancers (Females only)	0	0.00	---		---	---
Cancer of Cervix Uteri (Females only)	0	0.00	---		---	---
Cancer of Other Female Genital Organs	0	0.00	---		---	---
Cancer of Prostate (Males only)	147	167.98	87.5		74.7	102.6
Cancer of Testes and Other Male Genital Organs	3	2.46	121.9		39.4	377.1
Cancer of Kidney	53	32.42	163.5	**	125.3	213.3
Cancer of Bladder and Other Urinary Organs	48	45.38	105.7		78.8	140.2
Malignant Melanoma of Skin	19	16.19	117.4		75.0	183.7
Cancer of Eye	1	0.74	134.5		19.1	948.2
Cancer of Central Nervous System	21	27.66	75.9		49.6	116.1
Cancer of Thyroid & Other Endocrine Glands	4	3.16	126.5		47.6	336.2
Cancer of Bone	3	2.38	125.9		40.7	388.2
Cancer of All Lymphatic, Haematopoietic Tissue	141	123.81	114.1		96.9	134.3
Lymphosarcoma & Reticulosarcoma	18	13.03	122.8		75.3	200.1
Hodgkins Disease	7	4.55	153.9		73.9	320.9
Leukemia & Aleukemia	53	51.71	102.5		78.4	134.0
Cancer of All Other Lymphopoietic Tissue	65	54.32	118.7		94.0	152.4
All Other Malignant Neoplasms	151	116.70	128.4	**	110.5	151.5
Benign Neoplasms	24	13.99	171.5	**	115.6	254.6
Diabetes Mellitus	85	89.56	94.9		76.9	117.2
Cerebrovascular Disease	446	394.33	113.1	**	103.4	123.7
All Heart Disease	2467	2488.77	99.9		96.9	103.0
Rheumatic Heart Disease	13	20.40	63.7		37.2	108.1
Ischemic Heart Disease	1823	2137.37	85.3	**	82.2	88.5
Chronic Endocard. Dis.; Other Myocard. Insuff.	128	119.10	107.5		90.6	127.5
Hypertension with Heart Disease	52	59.04	88.1		67.2	115.4
All Other Heart Disease	451	443.35	101.7		93.1	111.2
Hypertension w/o Heart Disease	22	16.41	134.1		89.5	203.2
Non-malignant Respiratory Disease	451	543.17	83.0	**	76.1	90.6
Influenza & Pneumonia	149	190.83	78.1	**	66.8	91.3
Bronchitis, Emphysema, Asthma	72	85.91	83.8		66.7	105.4
Bronchitis	10	15.04	66.5		36.0	122.9
Emphysema	53	66.54	79.7		61.0	104.0
Asthma	9	5.36	168.1		88.1	320.6
Other Non-malignant Respiratory Disease	230	279.79	82.2	**	72.5	93.2
Ulcer of Stomach & Duodenum	20	18.28	109.3		70.6	169.4
Cirrhosis of Liver	55	87.23	63.1	**	48.7	81.7
Nephritis & Nephrosis	82	33.71	243.2	**	197.4	299.7
All External Causes of Death	278	275.54	100.9		90.7	112.3
Accidents	184	172.47	106.7		93.0	122.4
Motor Vehicle Accidents	75	66.87	112.5		90.5	139.9
All Other Accidents	109	107.28	101.6		84.5	122.2
Suicides	71	70.78	100.3		79.9	126.0
Homicides & Other External Causes	23	32.29	71.2		48.1	105.6
All Other Causes of Death	645	621.26	103.8		96.5	111.7
Unknown Causes (In All Causes Category Only)	0					

* Significant at 5% Level; ** Significant at 1% Level

Table 7
Observed and Expected Deaths and Proportionate Mortality Ratios for Females

Cause of Death (ICDA 8th Revision Codes)	OBS	EXP	SPMR		95% Limits LOWER	UPPER
All Causes of Death	281	281.00	100.0		---	---
Tuberculosis	0	0.20	---		---	---
All Malignant Neoplasms	72	65.80	108.4		90.3	132.8
Cancer of Buccal Cavity & Pharynx	0	0.87	---		---	---
Cancer of Digestive Organs & Peritoneum	18	16.18	111.2		71.2	173.7
Cancer of Esophagus	0	0.65	---		---	---
Cancer of Stomach	2	1.64	122.2		30.8	485.3
Cancer of Large Intestine	10	7.44	134.4		73.2	246.8
Cancer of Rectum	1	1.22	81.8		11.6	575.7
Cancer of Biliary Passages & Liver	2	1.64	121.7		30.6	483.2
Cancer of Pancreas	3	3.53	84.9		27.7	260.7
Cancer of All Other Digestive Organs	0	0.55	---		---	---
Cancer of Respiratory System	11	12.36	88.0		50.3	157.2
Cancer of Larynx	0	0.22	---		---	---
Cancer of Bronchus, Trachea, Lung	11	12.00	91.6		51.8	162.1
Cancer of All Other Respiratory	0	0.14	---		---	---
Cancer of Breast	13	12.68	102.7		60.9	173.3
All Uterine Cancers (Females only)	4	3.23	123.8		46.9	328.6
Cancer of Cervix Uteri (Females only)	1	1.33	75.2		10.8	524.4
Cancer of Other Female Genital Organs	4	4.17	85.9		36.4	252.9
Cancer of Prostate (Males only)	0	0.00	---		---	---
Cancer of Testes and Other Male Genital Organs	0	0.00	---		---	---
Cancer of Kidney	0	1.10	---		---	---
Cancer of Bladder and Other Urinary Organs	0	0.83	---		---	---
Malignant Melanoma of Skin	0	0.68	---		---	---
Cancer of Eye	0	0.04	---		---	---
Cancer of Central Nervous System	3	1.48	205.4		66.2	618.7
Cancer of Thyroid & Other Endocrine Glands	0	0.28	---		---	---
Cancer of Bone	0	0.12	---		---	---
Cancer of All Lymphatic, Haematopoietic Tissue	6	5.84	102.8		46.6	228.4
Lymphosarcoma & Reticulosarcoma	0	0.70	---		---	---
Hodgkins Disease	0	0.23	---		---	---
Leukemia & Aleukemia	2	2.20	90.8		22.8	360.6
Cancer of All Other Lymphopoietic Tissue	4	2.70	147.9		56.2	388.4
All Other Malignant Neoplasms	13	5.41	240.2	**	142.7	404.2
Benign Neoplasms	5	0.83	600.5	**	278.6	1284.5
Diabetes Mellitus	7	5.86	119.5		57.5	248.3
Cerebrovascular Disease	20	23.83	83.8		55.2	128.4
All Heart Disease	88	87.80	80.0		76.8	105.8
Rheumatic Heart Disease	1	2.41	41.5		6.3	274.4
Ischemic Heart Disease	66	79.90	82.6		67.9	100.6
Chronic Endocard. Dis.; Other Myocard. Insuff.	6	6.04	99.4		45.2	218.8
Hypertension with Heart Disease	0	3.32	---		---	---
All Other Heart Disease	15	18.22	81.9		50.4	133.1
Hypertension w/o Heart Disease	1	0.82	121.8		17.3	858.8
Non-malignant Respiratory Disease	11	17.74	62.0		35.3	108.0
Influenza & Pneumonia	4	7.87	50.8		19.8	130.4
Bronchitis, Emphysema, Asthma	1	2.58	38.7		5.8	252.8
Bronchitis	0	0.48	---		---	---
Emphysema	1	1.68	63.4		9.2	438.2
Asthma	0	0.44	---		---	---
Other Non-malignant Respiratory Disease	6	7.84	76.8		34.8	167.6
Ulcer of Stomach & Duodenum	2	0.80	250.3		85.8	852.6
Cirrhosis of Liver	1	3.27	30.8		4.8	180.4
Nephritis & Nephrosis	3	1.38	217.8		72.5	654.7
All External Causes of Death	10	9.75	102.8		56.2	180.7
Accidents	7	6.64	105.3		52.0	213.4
Motor Vehicle Accidents	5	2.87	174.4		76.8	385.7
All Other Accidents	2	3.83	52.3		13.6	201.1
Suicides	3	1.77	169.8		56.5	508.7
Homicides & Other External Causes	0	1.34	---		---	---
All Other Causes of Death	41	30.34	135.1	*	101.5	179.8
Unknown Causes (In All Causes Category Only)	0					

* Significant at 5% Level; ** Significant at 1% Level

Table 8
Observed and Expected Deaths and Proportionate Mortality Ratios for Whites

Cause of Death (ICDA 9th Revision Codes)	OBS	EXP	SPMR		90% Limits LOWER	UPPER
All Causes of Death	5816	5816.00	100.0		---	---
Tuberculosis	3	5.96	50.3		16.8	152.5
All Malignant Neoplasms	1438	1407.45	102.2		97.7	106.8
Cancer of Buccal Cavity & Pharynx	13	29.88	43.5	**	25.7	73.6
Cancer of Digestive Organs & Peritoneum	340	344.43	98.7		89.1	108.4
Cancer of Esophagus	17	30.51	55.7	*	34.9	88.9
Cancer of Stomach	46	46.47	99.0		74.2	132.0
Cancer of Large Intestine	153	140.84	108.6		92.9	127.0
Cancer of Rectum	29	27.60	105.1		73.1	151.1
Cancer of Biliary Passages & Liver	22	30.88	71.2		47.0	107.8
Cancer of Pancreas	66	59.29	96.7		76.0	122.8
Cancer of All Other Digestive Organs	7	10.17	68.8		33.0	143.7
Cancer of Respiratory System	520	498.49	104.1		96.0	112.8
Cancer of Larynx	7	15.91	44.0	*	21.4	80.3
Cancer of Bronchus, Trachea, Lung	510	478.07	106.5		98.0	115.6
Cancer of All Other Respiratory	3	4.49	66.8		21.7	205.3
Cancer of Breast	13	13.67	95.1		56.2	160.8
All Uterine Cancers (Females only)	3	3.04	98.8		32.2	303.8
Cancer of Cervix Uteri (Females only)	0	1.19	---		---	---
Cancer of Other Female Genital Organs	4	4.09	97.8		37.1	257.7
Cancer of Prostate (Males only)	123	143.49	85.7		72.0	102.0
Cancer of Testes and Other Male Genital Organs	3	2.23	134.8		43.7	418.0
Cancer of Kidney	48	31.56	152.1	**	115.0	201.3
Cancer of Bladder and Other Urinary Organs	44	43.56	101.0		75.3	135.6
Malignant Melanoma of Skin	18	16.65	108.1		68.2	171.4
Cancer of Eye	1	0.77	128.9		18.4	917.0
Cancer of Central Nervous System	22	28.05	78.4		51.8	118.8
Cancer of Thyroid & Other Endocrine Glands	4	3.22	124.2		46.7	330.2
Cancer of Bone	3	2.31	130.0		42.1	401.8
Cancer of All Lymphatic, Haematopoietic Tissue	132	120.58	109.5		92.5	129.6
Lymphosarcoma & Reticulosarcoma	13	13.13	99.0		57.5	170.4
Hodgkins Disease	7	4.51	155.1		74.4	323.3
Leukemia & Aleukemia	50	50.68	98.7		74.9	130.0
Cancer of All Other Lymphopoietic Tissue	62	52.26	118.6		92.6	152.0
All Other Malignant Neoplasms	147	110.55	133.0	**	113.4	156.0
Benign Neoplasms	26	13.60	191.2	**	131.1	278.8
Diabetes Mellitus	73	84.63	86.3		68.7	108.3
Cerebrovascular Disease	422	373.12	113.1	**	103.2	124.0
All Heart Disease	2371	2371.79	100.0		96.9	103.1
Rheumatic Heart Disease	14	21.75	64.4		38.3	108.1
Ischemic Heart Disease	1777	2082.36	85.3	**	82.2	88.6
Chronic Endocard. Dis.; Other Myocard. Insuff.	128	113.89	112.4		94.7	133.4
Hypertension with Heart Disease	36	49.63	72.5		52.5	100.3
All Other Heart Disease	416	405.89	102.5		93.4	112.4
Hypertension w/o Heart Disease	20	14.42	138.7		89.7	214.4
Non-malignant Respiratory Disease	430	521.14	82.5	**	75.4	90.3
Influenza & Pneumonia	143	180.38	79.3	**	67.6	93.0
Bronchitis, Emphysema, Asthma	88	83.92	81.0		64.0	102.6
Bronchitis	10	14.87	67.2		36.3	124.3
Emphysema	50	65.12	76.8		58.3	101.1
Asthma	8	5.02	159.4		80.2	318.6
Other Non-malignant Respiratory Disease	218	268.47	81.3	**	71.4	92.4
Ulcer of Stomach & Duodenum	21	17.56	119.6		78.0	183.1
Cirrhosis of Liver	50	83.04	60.2	**	45.8	78.9
Nephritis & Nephrosis	75	29.89	251.0	**	201.8	312.1
All External Causes of Death	261	255.72	102.1		91.4	114.0
Accidents	174	160.86	108.1		93.9	124.8
Motor Vehicle Accidents	70	63.51	110.2		88.0	138.0
All Other Accidents	104	98.78	105.3		87.2	127.2
Suicides	70	70.11	99.8		78.4	125.6
Homicides & Other External Causes	17	24.65	68.0		43.4	109.5
All Other Causes of Death	626	583.52	107.3		98.6	115.5
Unknown Causes (In All Causes Category Only)	0					

* Significant at 5% Level; ** Significant at 1% Level

Table 9
Observed and Expected Deaths and Proportionate Mortality Ratios for Nonwhites

Cause of Death (ICDA 9th Revision Codes)	OBS	EXP	SPMR		95% Limits LOWER	UPPER
All Causes of Death	557	557.00	100.0		---	---
Tuberculosis	1	2.22	45.1		6.7	302.8
All Malignant Neoplasms	187	140.88	118.5	*	104.1	135.0
Cancer of Buccal Cavity & Pharynx	5	3.66	136.6		57.3	325.6
Cancer of Digestive Organs & Peritoneum	45	37.37	120.4		90.8	159.5
Cancer of Esophagus	2	6.34	31.6		8.6	116.0
Cancer of Stomach	13	7.41	175.5	*	103.0	289.1
Cancer of Large Intestine	13	11.15	116.6		68.1	189.6
Cancer of Rectum	1	2.11	47.5		7.0	321.2
Cancer of Biliary Passages & Liver	8	3.90	205.1	*	104.4	403.1
Cancer of Pancreas	8	6.81	117.4		59.0	233.6
Cancer of All Other Digestive Organs	0	0.79	---		---	---
Cancer of Respiratory System	48	46.27	103.7		79.3	135.7
Cancer of Larynx	0	1.98	---		---	---
Cancer of Bronchus, Trachea, Lung	48	43.90	109.3		83.5	143.1
Cancer of All Other Respiratory	0	0.38	---		---	---
Cancer of Breast	0	0.62	---		---	---
All Uterine Cancers (Females only)	1	0.19	513.2		90.8	2908.6
Cancer of Cervix Uteri (Females only)	1	0.14	697.7	*	132.1	3885.8
Cancer of Other Female Genital Organs	0	0.08	---		---	---
Cancer of Prostate (Males only)	24	24.48	98.0		66.4	144.7
Cancer of Testes and Other Male Genital Organs	0	0.24	---		---	---
Cancer of Kidney	5	1.96	254.5	*	109.5	591.9
Cancer of Bladder and Other Urinary Organs	4	2.76	145.0		54.9	383.2
Malignant Melanoma of Skin	1	0.23	435.8		72.5	2818.7
Cancer of Eye	0	0.02	---		---	---
Cancer of Central Nervous System	2	1.07	187.0		47.9	728.9
Cancer of Thyroid & Other Endocrine Glands	0	0.20	---		---	---
Cancer of Bone	0	0.18	---		---	---
Cancer of All Lymphatic, Haematopoietic Tissue	15	8.87	169.2	*	103.0	277.9
Lymphosarcoma & Reticulosarcoma	3	0.61	495.0	**	178.7	1371.1
Hodgkins Disease	0	0.26	---		---	---
Leukemia & Aleukemia	5	3.23	154.9		65.1	368.8
Cancer of All Other Lymphopoietic Tissue	7	4.77	146.8		70.5	305.5
All Other Malignant Neoplasms	17	11.56	147.1		92.2	234.7
Benign Neoplasms	3	1.22	245.9		82.2	732.1
Diabetes Mellitus	19	10.78	176.1	*	113.5	273.2
Cerebrovascular Disease	44	45.14	97.5		73.5	129.3
All Heart Disease	184	195.77	94.0		83.7	105.5
Rheumatic Heart Disease	0	1.07	---		---	---
Ischemic Heart Disease	112	134.92	83.0	*	70.7	97.4
Chronic Endocard. Dis.; Other Myocard. Insuff.	6	11.25	53.3		24.5	116.1
Hypertension with Heart Disease	16	12.72	125.8		77.6	203.9
All Other Heart Disease	50	55.88	89.8		69.1	118.8
Hypertension w/o Heart Disease	3	2.80	107.0		34.6	330.7
Non-malignant Respiratory Disease	32	38.77	80.5		57.7	112.2
Influenza & Pneumonia	10	18.32	54.6	*	30.0	99.3
Bronchitis, Emphysema, Asthma	8	4.57	108.3		48.7	261.5
Bronchitis	0	0.68	---		---	---
Emphysema	4	3.00	133.4		50.4	353.2
Asthma	1	0.78	128.8		18.3	908.1
Other Non-malignant Respiratory Disease	17	18.15	93.6		58.7	149.4
Ulcer of Stomach & Duodenum	1	1.52	65.8		8.4	457.6
Cirrhosis of Liver	6	7.45	80.5		36.8	176.8
Nephritis & Nephrosis	10	5.21	192.1	*	104.8	352.0
All External Causes of Death	27	29.57	91.3		64.8	128.7
Accidents	17	18.15	93.7		59.1	148.5
Motor Vehicle Accidents	10	6.02	166.0		90.8	303.3
All Other Accidents	7	12.31	56.9		27.7	116.8
Suicides	4	2.45	163.6		62.6	427.7
Homicides & Other External Causes	6	8.98	66.8		31.8	140.7
All Other Causes of Death	60	68.09	88.1		69.6	111.6
Unknown Causes (In All Causes Category Only)	0					

* Significant at 5% Level; ** Significant at 1% Level

investigated by race, the white population shows a similar mortality pattern to that observed for the total cohort (Table 8). For nonwhites, causes of death (Table 9) for which there were five observed or expected deaths and where there was a statistically significant excess were all malignant neoplasms (PMR=118.6, $p<0.05$), cancer of the stomach (PMR=175.5, $p<0.05$), cancer of the liver (PMR=205.1, $p<0.05$), cancer of the kidney (PMR=254.5, $p<0.05$), cancer of the lymphatic and haematopoietic tissue (PMR=169.2, $p<0.05$), diabetes mellitus (PMR=176.1, $p<0.05$), and nephritis and nephrosis (PMR=192.1, $p<0.05$).

B. Nonreduction Process

A total of 3596 employees worked in a plant that had no reduction process (Table 10). The overall PMR for these employees was 105.2. The only excess within the category of neoplasms was for "all other malignant neoplasms" where the PMR was 145.9 ($p<0.01$). Other causes of death showing a statistically significant excess were benign and unspecified neoplasms with a PMR of 227.3 ($p<0.01$), "all other heart disease" with a PMR of 117.2 ($p<0.01$), and "nephritis and nephrosis" with a PMR of 293.8 ($p<0.01$). Investigation separately for males and females indicated no causes of death other than those identified in excess for the total cohort. When we evaluated mortality patterns separately for race, in addition to the four causes of death in excess for the total group of nonreduction plant workers we found for whites a PMR of 122.8 ($p<0.05$) for cancer of the large intestine and a PMR of 135.4 ($p<0.01$) for chronic endocarditis and other myocardial insufficiency. For nonwhites, we found that

the excess of stomach cancer, liver cancer, lymphatic cancer and nephritis reported in the nonwhite population comprising the total cohort occurred in these nonreduction plants. The PMR for all malignancies for nonwhites in the nonreduction plants was 128.0 ($p<0.01$).

Of the 2777 workers in the 8 plants with a reduction process, 1320 spent the majority of their time in a nonreduction process. For this group of workers the PMR for all malignant neoplasms was 93.6. There were statistically significant excesses of cancer of the lymphatic and haematopoietic tissue (PMR=140.1, $p<0.05$), cerebrovascular disease (PMR=126.9, $p<0.05$), hypertension without heart disease (PMR=230.2, $p<0.05$) and nephritis and nephrosis (PMR=196.8, $p<0.01$). We also note the excess for asthma (PMR=331.0, $p<0.05$) based on only four observed deaths. There were only 56 females in this group of workers so the mortality pattern of the total group is essentially the same as that observed for males. For whites, the excesses were the same as that observed for the total group of 1320 workers. For nonwhites, excesses occurred in hypertension with heart disease (PMR=239.2, $p<0.05$) and "all other causes of death" (PMR=202.9, $p<0.01$).

Table 10
Observed and Expected Deaths and Proportionate Mortality Ratios for Nonreduction Plant Employees

Cause of Death (ICDA 9th Revision Codes)	OBS	EXP	SPMR		95% Limits LOWER	UPPER
All Causes of Death	3596	3596.00	100.0		---	---
Tuberculosis	3	4.62	65.0		21.2	199.5
All Malignant Neoplasms	906	861.09	105.2		99.5	111.3
Cancer of Buccal Cavity & Pharynx	11	18.19	60.5		33.8	108.3
Cancer of Digestive Organs & Peritoneum	225	213.51	105.4		92.9	119.6
Cancer of Esophagus	11	20.10	54.7	*	30.7	97.7
Cancer of Stomach	36	30.13	119.5		86.4	165.4
Cancer of Large Intestine	103	85.59	120.3		99.5	145.6
Cancer of Rectum	20	16.64	120.2		77.7	186.0
Cancer of Biliary Passages & Liver	17	19.49	87.2		54.3	140.0
Cancer of Pancreas	35	41.81	83.7		60.3	116.3
Cancer of All Other Digestive Organs	3	6.17	48.6		16.1	147.0
Cancer of Respiratory System	316	297.08	106.4		95.8	118.1
Cancer of Larynx	4	9.69	41.3		16.0	106.4
Cancer of Bronchus, Trachea, Lung	310	284.73	108.9		97.9	121.0
Cancer of All Other Respiratory	2	2.65	75.4		18.9	299.8
Cancer of Breast	9	10.45	86.1		45.8	161.8
All Uterine Cancers (Females only)	3	2.45	122.7		40.0	376.1
Cancer of Cervix Uteri (Females only)	0	0.98	---		---	---
Cancer of Other Female Genital Organs	2	3.16	63.3		16.3	246.3
Cancer of Prostate (Males only)	84	96.35	87.2		70.7	107.6
Cancer of Testes and Other Male Genital Organs	1	1.29	77.4		11.0	546.2
Cancer of Kidney	25	18.32	136.5		92.5	201.4
Cancer of Bladder and Other Urinary Organs	28	26.32	106.4		73.6	153.9
Malignant Melanoma of Skin	11	8.95	123.0		68.2	221.5
Cancer of Eye	1	0.44	229.1		34.1	1539.1
Cancer of Central Nervous System	14	15.51	90.3		53.6	152.1
Cancer of Thyroid & Other Endocrine Glands	4	1.89	211.7		81.3	551.4
Cancer of Bone	1	1.36	73.5		10.4	517.5
Cancer of All Lymphatic, Haematopoietic Tissue	72	71.84	100.2		79.7	126.0
Lymphosarcoma & Reticulosarcoma	6	7.54	79.6		35.9	176.7
Hodgkins Disease	2	2.51	79.8		20.0	317.7
Leukemia & Aleukemia	27	30.06	89.8		61.7	130.8
Cancer of All Other Lymphopoietic Tissue	37	31.74	116.6		84.6	160.6
All Other Malignant Neoplasms	99	67.83	145.9	**	120.2	177.2
Benign Neoplasms	19	8.36	227.3	**	146.9	351.8
Diabetes Mellitus	55	54.16	101.6		78.1	132.0
Cerebrovascular Disease	237	245.53	96.5		85.4	109.1
All Heart Disease	1477	1457.21	101.4		97.5	105.4
Rheumatic Heart Disease	8	12.85	62.2		31.4	123.5
Ischemic Heart Disease	1038	1254.88	82.7	**	78.8	86.8
Chronic Endocard. Dis.; Other Myocard. Insuff.	95	73.19	129.8	*	106.5	158.2
Hypertension with Heart Disease	28	35.66	78.5		54.4	113.4
All Other Heart Disease	308	262.71	117.2	**	105.3	130.5
Hypertension w/o Heart Disease	11	10.03	109.7		60.8	197.8
Non-malignant Respiratory Disease	258	322.34	80.0	**	71.3	89.9
Influenza & Pneumonia	85	117.33	72.4	**	58.9	89.1
Bronchitis, Emphysema, Asthma	40	49.83	80.3		59.1	109.1
Bronchitis	4	8.85	45.2		17.4	117.2
Emphysema	34	38.27	88.8		63.6	124.1
Asthma	2	3.25	61.5		15.6	242.6
Other Non-malignant Respiratory Disease	133	163.39	81.4	*	69.0	96.0
Ulcer of Stomach & Duodenum	13	10.91	119.1		69.3	204.8
Cirrhosis of Liver	30	47.45	63.2	*	44.5	89.8
Nephritis & Nephrosis	60	20.42	293.8	**	231.0	373.6
All External Causes of Death	140	147.02	95.2		81.7	111.0
Accidents	99	93.90	105.4		87.3	127.4
Motor Vehicle Accidents	43	34.82	123.5		92.6	164.8
All Other Accidents	56	59.93	93.4		72.2	120.9
Suicides	27	36.77	73.4		50.8	106.2
Homicides & Other External Causes	14	16.36	85.6		51.5	142.3
All Other Causes of Death	387	371.99	104.0		94.7	114.3
Unknown Causes (In All Causes Category Only)	0					

* Significant at 5% Level; ** Significant at 1% Level

Table 11
Observed and Expected Deaths and Proportionate Mortality Ratios for Employees in Reduction Plants Spending the Majority of Their Time in a Nonreduction Process

Cause of Death (ICDA 9th Revision Codes)	OBS	EXP	SPMR		95% Limits LOWER	UPPER
All Causes of Death	1320	1320.00	100.0		---	---
Tuberculosis	0	1.63	---		---	---
All Malignant Neoplasms	302	322.52	93.6		85.0	103.2
Cancer of Buccal Cavity & Pharynx	2	6.98	28.7		7.8	104.7
Cancer of Digestive Organs & Peritoneum	78	79.22	98.5		79.4	122.1
Cancer of Esophagus	1	7.56	13.2	*	2.5	69.3
Cancer of Stomach	15	11.09	135.2		81.9	223.4
Cancer of Large Intestine	30	31.64	94.8		66.6	135.0
Cancer of Rectum	6	6.20	96.8		43.6	215.1
Cancer of Biliary Passages & Liver	6	7.20	83.4		37.6	185.0
Cancer of Pancreas	18	15.64	115.1		72.8	182.1
Cancer of All Other Digestive Organs	2	2.28	87.8		22.0	350.4
Cancer of Respiratory System	91	114.28	79.6	*	65.6	96.7
Cancer of Larynx	2	3.73	53.6		13.7	209.3
Cancer of Bronchus, Trachea, Lung	89	109.53	81.3	*	66.7	98.9
Cancer of All Other Respiratory	0	1.02	---		---	---
Cancer of Breast	4	3.10	128.9		50.2	331.4
All Uterine Cancers (Females only)	1	0.71	140.9		20.4	974.6
Cancer of Cervix Uteri (Females only)	1	0.32	314.6		49.7	1991.8
Cancer of Other Female Genital Organs	1	0.90	110.7		15.9	768.0
Cancer of Prostate (Males only)	32	34.15	93.7		66.6	131.8
Cancer of Testes and Other Male Genital Organs	1	0.51	194.7		28.5	1332.3
Cancer of Kidney	11	7.05	156.1		87.0	280.0
Cancer of Bladder and Other Urinary Organs	10	9.61	104.1		56.2	193.0
Malignant Melanoma of Skin	3	3.59	83.5		27.0	257.8
Cancer of Eye	0	0.17	---		---	---
Cancer of Central Nervous System	3	6.21	48.3		16.0	145.6
Cancer of Thyroid & Other Endocrine Glands	0	0.72	---		---	---
Cancer of Bone	2	0.53	375.9	*	103.5	1364.5
Cancer of All Lymphatic, Haematopoietic Tissue	38	27.12	140.1	*	102.5	191.6
Lymphosarcoma & Reticulosarcoma	6	2.91	206.3		94.4	450.9
Hodgkins Disease	3	1.03	291.2		99.0	856.3
Leukemia & Aleukemia	13	11.31	115.0		66.9	197.4
Cancer of All Other Lymphopoietic Tissue	16	11.87	134.8		82.9	219.1
All Other Malignant Neoplasms	25	25.39	98.5		66.8	145.1
Benign Neoplasms	5	3.08	162.2		68.1	386.0
Diabetes Mellitus	15	19.66	76.3		46.2	125.9
Cerebrovascular Disease	108	85.13	126.9	*	105.9	152.0
All Heart Disease	531	530.71	100.1		93.7	106.8
Rheumatic Heart Disease	4	4.81	83.1		31.3	220.7
Ischemic Heart Disease	422	460.01	91.7	*	85.0	99.0
Chronic Endocard. Dis.; Other Myocard. Insuff.	18	25.51	70.6		44.8	111.2
Hypertension with Heart Disease	11	12.55	87.6		48.7	157.6
All Other Heart Disease	76	94.56	80.4	*	64.8	99.7
Hypertension w/o Heart Disease	8	3.48	230.2	*	117.5	450.8
Non-malignant Respiratory Disease	103	115.44	89.2		74.3	107.2
Influenza & Pneumonia	39	40.23	96.9		71.3	131.8
Bronchitis, Emphysema, Asthma	17	18.47	92.1		57.4	147.5
Bronchitis	4	3.23	123.8		46.6	328.9
Emphysema	9	14.23	63.3		33.2	120.4
Asthma	4	1.21	331.0	*	131.4	833.2
Other Non-malignant Respiratory Disease	47	59.55	78.9		59.8	104.2
Ulcer of Stomach & Duodenum	3	3.93	76.3		24.7	235.3
Cirrhosis of Liver	15	19.05	78.7		47.8	129.6
Nephritis & Nephrosis	14	7.11	196.8	**	117.9	328.6
All External Causes of Death	66	61.82	106.8		86.0	132.6
Accidents	44	38.34	114.8		86.8	151.8
Motor Vehicle Accidents	19	15.37	123.7		80.5	190.0
All Other Accidents	25	23.28	107.4		73.1	157.8
Suicides	21	15.70	133.8		88.1	203.0
Homicides & Other External Causes	1	7.79	12.8	*	2.7	61.7
All Other Causes of Death	150	133.99	111.9		96.2	130.2
Unknown Causes (In All Causes Category Only)	0					

* Significant at 5% Level; ** Significant at 1% Level.

C. Mortality for the Reduction Process

There were 1866 workers who had some employment in the reduction process. The overall PMR for cancer was 106.6 which was not statistically significant (Table 12). The PMR for lung cancer was 117.8 with a corresponding 95% confidence interval of (103.1, 134.5). Cancer of the kidney was also elevated with a PMR of 200.1 and a corresponding 95% confidence interval of (131.7, 303.8). The only nonmalignant cause of death with a statistically significant excess was cerebral vascular disease with a PMR of 135.3 and a corresponding 95% confidence interval of (116.0, 157.7). The PMR for the category ischemic heart disease was low [PMR=87.2 with corresponding confidence interval of (81.6, 93.2)]. Since only 6 women were employed in the reduction process, the mortality patterns in Table 12 are essentially the same for males. When analysis was done by race, some additional causes were in excess. For whites, in addition to respiratory and kidney cancer, there was an excess in cancer of the lymphatic and haematopoietic tissue (PMR=132.2, $p<0.05$). For nonwhites, the only excess was for diabetes where the PMR was 389.5 ($p<0.01$).

When the 62 causes of death were re-evaluated for men spending the majority of their time in the reduction process, the mortality patterns were similar to those "ever employed in the reduction process" but tended to be slightly increased for many of the malignancies (Table 13). The PMR for the category all malignant neoplasms increased from 106.6 to 109.5 ($p<0.05$). Similarly, the PMRs for cancer of the lung and kidney were

Table 12

Observed and Expected Deaths and Proportionate Mortality Ratios for Employees Ever Employed in a Reduction Process

Cause of Death (ICDA 8th Revision Codes)	OBS	EXP	SPMR		95% Limits LOWER	UPPER
All Causes of Death	1888	1886.00	100.0		---	---
Tuberculosis	1	2.48	40.3		6.1	267.2
All Malignant Neoplasms	499	488.17	106.6		98.9	114.9
Cancer of Buccal Cavity & Pharynx	6	10.80	85.8		25.3	121.8
Cancer of Digestive Organs & Peritoneum	105	114.26	91.9		78.4	110.6
Cancer of Esophagus	7	11.86	59.0		28.5	122.4
Cancer of Stomach	13	16.25	80.0		46.6	137.3
Cancer of Large Intestine	39	44.50	87.6		64.3	119.5
Cancer of Rectum	5	8.81	56.8		24.0	134.5
Cancer of Biliary Passages & Liver	9	10.39	86.7		45.2	166.1
Cancer of Pancreas	29	22.68	127.8		89.2	183.4
Cancer of All Other Digestive Organs	3	3.21	93.5		30.2	289.5
Cancer of Respiratory System	187	172.88	114.0		98.9	130.0
Cancer of Larynx	1	5.76	17.4	*	3.1	97.6
Cancer of Bronchus, Trachea, Lung	195	185.57	117.8	*	103.1	134.5
Cancer of All Other Respiratory	1	1.54	64.8		9.3	452.4
Cancer of Breast	0	1.00	---		---	---
All Uterine Cancers (Females only)	0	0.11	---		---	---
Cancer of Cervix Uteri (Females only)	0	0.05	---		---	---
Cancer of Other Female Genital Organs	1	0.16	643.6	*	120.0	3450.7
Cancer of Prostate (Males only)	39	47.68	81.8		60.1	111.3
Cancer of Testes and Other Male Genital Organs	2	0.83	240.0		82.7	918.1
Cancer of Kidney	21	10.50	200.1	**	131.7	303.8
Cancer of Bladder and Other Urinary Organs	14	13.26	105.6		62.7	177.8
Malignant Melanoma of Skin	7	5.58	125.2		59.9	281.7
Cancer of Eye	0	0.24	---		---	---
Cancer of Central Nervous System	8	8.56	83.7		42.0	166.7
Cancer of Thyroid & Other Endocrine Glands	0	1.04	---		---	---
Cancer of Bone	2	0.78	256.7		67.5	978.1
Cancer of All Lymphatic, Haematopoietic Tissue	50	39.07	128.0		97.4	168.2
Lymphosarcoma & Reticulosarcoma	5	4.22	118.5		49.4	284.0
Hodgkins Disease	3	1.59	188.9		62.2	574.3
Leukemia & Aleukemia	20	16.05	124.6		80.6	192.8
Cancer of All Other Lymphopoietic Tissue	22	17.21	127.8		84.4	193.8
All Other Malignant Neoplasms	47	37.12	126.6		95.5	167.9
Benign Neoplasms	5	4.33	115.5		48.1	276.9
Diabetes Mellitus	28	27.65	101.3		70.1	146.3
Cerebrovascular Disease	151	111.84	135.3	**	116.0	157.7
All Heart Disease	710	742.22	95.7		90.4	101.2
Rheumatic Heart Disease	3	6.62	45.3		15.1	138.2
Ischemic Heart Disease	561	643.10	87.2	**	81.6	93.2
Chronic Endocard. Dis.; Other Myocard. Insuff.	25	33.76	74.1		50.3	109.0
Hypertension with Heart Disease	17	18.13	93.8		58.5	150.4
All Other Heart Disease	104	133.69	77.7	**	64.6	93.4
Hypertension w/o Heart Disease	8	4.76	168.1		86.8	278.8
Non-malignant Respiratory Disease	128	158.88	80.3	**	68.0	94.8
Influenza & Pneumonia	42	52.52	80.0		59.5	107.5
Bronchitis, Emphysema, Asthma	22	25.71	85.6		56.5	129.5
Bronchitis	3	4.39	68.4		22.2	210.2
Emphysema	16	19.86	80.6		48.5	131.0
Asthma	3	1.72	174.7		57.2	533.7
Other Non-malignant Respiratory Disease	82	82.30	75.3	*	59.1	96.0
Ulcer of Stomach & Duodenum	7	5.42	129.2		61.8	270.1
Cirrhosis of Liver	15	31.06	48.3	**	28.6	78.7
Nephritis & Nephrosis	15	9.66	155.3		94.1	256.1
All External Causes of Death	105	88.28	106.8		90.0	126.8
Accidents	67	59.94	111.8		89.1	140.1
Motor Vehicle Accidents	25	24.64	101.4		69.6	147.8
All Other Accidents	42	35.77	117.4		87.3	157.9
Suicides	30	25.77	116.4		82.1	165.0
Homicides & Other External Causes	8	12.57	63.6		32.8	123.5
All Other Causes of Death	198	186.30	106.3		93.1	121.3
Unknown Causes (In All Causes Category Only)	0					

* Significant at 5% Level; ** Significant at 1% Level

Table 13
Observed and Expected Deaths and Proportionate Mortality Ratios for Employees Spending a Majority of Time in a Reduction Process

Cause of Death (ICDA 8th Revision Codes)	OBS	EXP	SPMR		95% Limits LOWER	UPPER
All Causes of Death	1449	1448.00	100.0		---	---
Tuberculosis	1	1.83	51.8		7.8	355.1
All Malignant Neoplasms	397	362.63	109.5	*	100.8	118.1
Cancer of Buccal Cavity & Pharynx	5	8.34	60.0		25.3	142.2
Cancer of Digestive Organs & Peritoneum	82	88.56	92.6		78.1	114.2
Cancer of Esophagus	7	9.15	76.5		36.7	159.6
Cancer of Stomach	8	12.59	63.5		32.1	125.9
Cancer of Large Intestine	33	34.55	85.5		68.2	133.8
Cancer of Rectum	4	6.83	58.6		22.3	153.9
Cancer of Biliary Passages & Liver	7	8.06	86.8		41.5	181.8
Cancer of Pancreas	21	17.55	119.6		78.3	182.9
Cancer of All Other Digestive Organs	2	2.49	80.3		20.2	320.0
Cancer of Respiratory System	161	133.59	120.5	*	104.2	139.4
Cancer of Larynx	1	4.45	22.5		3.8	134.2
Cancer of Bronchus, Trachea, Lung	159	127.85	124.3	**	107.3	144.0
Cancer of All Other Respiratory	1	1.20	83.7		11.8	591.9
Cancer of Breast	0	0.73	---		---	---
All Uterine Cancers (Females only)	0	0.08	---		---	---
Cancer of Cervix Uteri (Females only)	0	0.04	---		---	---
Cancer of Other Female Genital Organs	1	0.11	948.8	**	195.9	4597.1
Cancer of Prostate (Males only)	31	37.27	83.2		58.9	117.5
Cancer of Testes and Other Male Genital Organs	1	0.65	153.1		21.9	1068.9
Cancer of Kidney	17	8.11	209.7	**	132.0	333.3
Cancer of Bladder and Other Urinary Organs	10	10.34	96.7		52.2	178.3
Malignant Melanoma of Skin	5	4.31	115.9		48.4	277.7
Cancer of Eye	0	0.18	---		---	---
Cancer of Central Nervous System	7	7.38	95.1		45.5	199.0
Cancer of Thyroid & Other Endocrine Glands	0	0.81	---		---	---
Cancer of Bone	0	0.60	---		---	---
Cancer of All Lymphatic, Haematopoietic Tissue	37	30.31	122.1		88.8	167.8
Lymphosarcoma & Reticulosarcoma	4	3.27	122.2		46.0	324.8
Hodgkins Disease	2	1.23	162.2		41.2	639.1
Leukemia & Aleukemia	15	12.47	120.3		72.7	198.8
Cancer of All Other Lymphopoietic Tissue	15	13.33	120.0		73.7	195.3
All Other Malignant Neoplasms	40	28.72	139.3	*	102.6	189.0
Benign Neoplasms	5	3.36	148.7		62.3	354.8
Diabetes Mellitus	22	21.48	102.4		67.7	155.1
Cerebrovascular Disease	121	87.15	138.8	**	117.0	164.7
All Heart Disease	545	576.37	94.6		88.6	100.9
Rheumatic Heart Disease	2	5.12	39.1		10.3	148.3
Ischemic Heart Disease	428	488.52	95.7	**	79.4	92.4
Chronic Endocard. Dis.; Other Myocard. Insuff.	20	26.28	76.1		48.4	117.2
Hypertension with Heart Disease	13	14.07	92.4		53.8	158.6
All Other Heart Disease	82	103.83	79.0	*	64.2	97.2
Hypertension w/o Heart Disease	4	3.70	108.0		40.6	287.2
Non-malignant Respiratory Disease	99	122.38	80.9	*	67.1	97.6
Influenza & Pneumonia	28	40.89	68.5	*	47.7	98.3
Bronchitis, Emphysema, Asthma	16	20.08	79.7	-	49.1	129.5
Bronchitis	2	3.43	58.3		14.9	229.0
Emphysema	11	15.52	70.9		39.5	127.1
Asthma	3	1.33	225.5		75.0	677.7
Other Non-malignant Respiratory Disease	55	64.27	85.6		66.1	110.7
Ulcer of Stomach & Duodenum	6	4.22	142.2		64.2	314.8
Cirrhosis of Liver	11	23.88	46.1	**	26.1	81.3
Nephritis & Nephrosis	11	7.51	146.4		81.5	262.9
All External Causes of Death	82	78.20	107.6		88.7	130.6
Accidents	48	48.72	102.7		78.7	134.1
Motor Vehicle Accidents	18	18.30	83.3		59.9	145.1
All Other Accidents	30	27.78	108.0		76.1	153.3
Suicides	26	20.01	129.8		89.4	188.8
Homicides & Other External Causes	8	9.46	84.5		43.1	165.8
All Other Causes of Death	145	144.85	100.1		85.8	116.8
Unknown Causes (In All Causes Category Only)	0					

* Significant at 5% Level; ** Significant at 1% Level

increased slightly (PMR=124.3 and 209.7, respectively). The remainder category "all other malignant neoplasms" is also significant with a PMR of 139.3 ($p<0.05$).

Since the primary departments of interest in the Tripartite Study were the potroom and carbon departments, we investigated mortality patterns separately for these two departments. There were 943 employees with some experience in the potroom department. The PMR for all malignancies was 106.8 with a corresponding 95% confidence interval of (96.1, 118.6) (Table 14). The PMR for cancer of the lung was 111.9 with a corresponding confidence interval of (92.6, 135.2). The only malignancy with five or more observed deaths and a statistically significant elevation was kidney cancer with a PMR of 297.9 and a corresponding 95% confidence interval of (187.1, 474.2). There was also an excess of ulcer of the stomach and duodenum based on six observed deaths and 2.69 expected (PMR=223.0, $p<0.05$). For employees with a majority of time in the potroom the PMR for all malignant neoplasms was 114.8 with a corresponding 95% confidence interval of (100.7, 130.9) (Table 15). Of those causes with more than 5 observed or expected deaths, cancer of the kidney and ulcer of the stomach were elevated (PMR=285.8, $p<0.01$ and PMR=317.2, $p<0.05$, respectively). Ischemic heart disease was significantly low (PMR=80.6, $p<0.01$).

The carbon department had fewer workers than the potroom department. For the 489 employees with some employment in the carbon department, the PMR for all malignancies was 105.8 (Table 16). Both cancer of the kidney (PMR=250.7, $p<0.01$) and

Table 14
Observed and Expected Deaths and Proportionate Mortality Ratios for Employees Ever Employed in the Potroom Department

Cause of Death (ICDA 9th Revision Codes)	OBS	EXP	SPMR		95% Limits LOWER	UPPER
All Causes of Death	943	943.00	100.0		---	---
Tuberculosis	0	1.34	---		---	---
All Malignant Neoplasms	256	239.81	106.8		96.1	118.6
Cancer of Buccal Cavity & Pharynx	5	5.67	88.2		36.9	211.1
Cancer of Digestive Organs & Peritoneum	51	58.46	87.2		66.9	113.7
Cancer of Esophagus	4	6.36	62.8		23.9	165.5
Cancer of Stomach	7	8.41	83.2		39.9	173.8
Cancer of Large Intestine	17	22.42	75.8		47.5	121.1
Cancer of Rectum	3	4.44	67.5		22.0	207.3
Cancer of Biliary Passages & Liver	6	5.35	112.2		50.5	249.0
Cancer of Pancreas	12	11.63	103.2		58.8	181.1
Cancer of All Other Digestive Organs	2	1.61	123.9		31.1	493.8
Cancer of Respiratory System	97	88.62	108.2		88.7	130.8
Cancer of Larynx	1	3.02	33.1		5.2	212.5
Cancer of Bronchus, Trachea, Lung	96	85.80	111.9		92.6	135.2
Cancer of All Other Respiratory	0	0.80	---		---	---
Cancer of Breast	0	0.26	---		---	---
All Uterine Cancers (Females only)	0	0.00	---		---	---
Cancer of Cervix Uteri (Females only)	0	0.00	---		---	---
Cancer of Other Female Genital Organs	0	0.00	---		---	---
Cancer of Prostate (Males only)	24	23.91	100.4		67.7	148.8
Cancer of Testes and Other Male Genital Organs	2	0.45	441.4	*	124.5	1564.5
Cancer of Kidney	16	5.37	297.9	**	187.1	474.2
Cancer of Bladder and Other Urinary Organs	6	6.51	92.2		41.6	204.6
Malignant Melanoma of Skin	3	2.88	104.2		33.7	322.1
Cancer of Eye	0	0.12	---		---	---
Cancer of Central Nervous System	1	4.97	20.1		3.5	118.9
Cancer of Thyroid & Other Endocrine Glands	0	0.54	---		---	---
Cancer of Bone	2	0.41	493.7	*	141.6	1720.8
Cancer of All Lymphatic, Haematopoietic Tissue	27	19.86	135.9		83.7	197.1
Lymphosarcoma & Reticulosarcoma	1	2.15	46.6		6.8	314.7
Hodgkins Disease	3	0.84	355.5	*	123.4	1024.2
Leukemia & Aleukemia	11	8.08	136.1		75.7	244.5
Cancer of All Other Lymphopoietic Tissue	12	8.78	136.5		77.8	239.2
All Other Malignant Neoplasms	22	19.08	115.2		76.2	174.2
Benign Neoplasms	0	2.18	---		---	---
Diabetes Mellitus	12	14.11	85.1		48.6	149.1
Cerebrovascular Disease	68	54.84	124.0		98.6	155.9
All Heart Disease	364	370.47	98.3		90.7	106.4
Rheumatic Heart Disease	2	3.34	60.0		15.3	235.8
Ischemic Heart Disease	278	319.30	87.1	**	78.2	95.7
Chronic Endocard. Dis.; Other Myocard. Insuff.	14	16.49	84.9		50.6	142.5
Hypertension with Heart Disease	10	9.55	104.7		56.6	193.8
All Other Heart Disease	60	68.15	88.0		69.0	112.3
Hypertension w/o Heart Disease	2	2.42	82.7		20.8	329.4
Non-malignant Respiratory Disease	68	76.81	88.5		70.8	111.0
Influenza & Pneumonia	20	25.28	79.1		51.5	121.5
Bronchitis, Emphysema, Asthma	13	12.71	102.2		59.6	175.4
Bronchitis	0	2.14	---		---	---
Emphysema	11	9.79	112.3		62.4	202.0
Asthma	2	0.89	223.7		58.1	861.6
Other Non-malignant Respiratory Disease	35	40.59	86.2		62.4	119.1
Ulcer of Stomach & Duodenum	8	2.69	223.0	*	102.4	485.5
Cirrhosis of Liver	7	16.45	42.5	*	20.9	86.4
Nephritis & Nephrosis	7	4.85	144.2		69.2	300.6
All External Causes of Death	54	54.64	98.8		78.2	124.8
Accidents	34	32.91	103.3		75.4	141.5
Motor Vehicle Accidents	13	13.99	92.9		55.4	156.0
All Other Accidents	21	18.18	109.6		72.2	166.4
Suicides	14	13.99	100.1		60.1	166.6
Homicides & Other External Causes	6	7.74	77.5		36.2	166.0
All Other Causes of Death	89	93.78	105.6		87.6	127.2
Unknown Causes (In All Causes Category Only)	0					

* Significant at 5% Level; ** Significant at 1% Level

Table 15
Observed and Expected Deaths and Proportionate Mortality Ratios for Employees Spending a Majority of Time in the Potroom Department

Cause of Death (ICDA 8th Revision Codes)	OBS	EXP	SPMR		95% Limits LOWER	UPPER
All Causes of Death	556	556.00	100.0		---	---
Tuberculosis	0	0.82	---		---	---
All Malignant Neoplasms	183	141.98	114.8	*	100.7	130.9
Cancer of Buccal Cavity & Pharynx	4	3.35	118.5		45.1	318.8
Cancer of Digestive Organs & Peritoneum	33	34.83	95.3		68.5	132.5
Cancer of Esophagus	3	3.82	78.6		25.6	241.8
Cancer of Stomach	5	5.03	99.4		41.5	237.7
Cancer of Large Intestine	13	13.21	98.4		57.5	168.4
Cancer of Rectum	1	2.80	38.4		5.8	252.2
Cancer of Biliary Passages & Liver	4	3.18	125.7		47.4	333.2
Cancer of Pancreas	6	8.88	97.2		39.4	182.9
Cancer of All Other Digestive Organs	1	0.95	105.7		14.9	748.9
Cancer of Respiratory System	62	53.04	116.9		92.4	147.6
Cancer of Larynx	0	1.78	---		---	---
Cancer of Bronchus, Trachea, Lung	62	50.77	122.1		96.5	154.5
Cancer of All Other Respiratory	0	0.47	---		---	---
Cancer of Breast	0	0.16	---		---	---
All Uterine Cancers (Females only)	0	0.00	---		---	---
Cancer of Cervix Uteri (Females only)	0	0.00	---		---	---
Cancer of Other Female Genital Organs	0	0.00	---		---	---
Cancer of Prostate (Males only)	17	14.32	118.7		74.4	189.3
Cancer of Testes and Other Male Genital Organs	1	0.28	358.2		57.6	2241.7
Cancer of Kidney	9	3.15	285.8	**	153.4	532.5
Cancer of Bladder and Other Urinary Organs	2	3.80	52.6		13.5	204.5
Malignant Melanoma of Skin	2	1.68	118.2		30.0	474.3
Cancer of Eye	0	0.07	---		---	---
Cancer of Central Nervous System	2	2.91	68.7		17.4	271.1
Cancer of Thyroid & Other Endocrine Glands	0	0.32	---		---	---
Cancer of Bone	0	0.24	---		---	---
Cancer of All Lymphatic, Haematopoietic Tissue	17	11.73	144.8		90.8	231.3
Lymphosarcoma & Reticulosarcoma	1	1.26	79.5		11.3	560.6
Hodgkins Disease	2	0.50	398.9	*	110.3	1428.6
Leukemia & Aleukemia	8	4.75	168.3		85.1	333.0
Cancer of All Other Lymphopoietic Tissue	8	5.22	115.0		51.9	254.9
All Other Malignant Neoplasms	14	11.31	123.8		73.8	207.7
Benign Neoplasms	0	1.29	---		---	---
Diabetes Mellitus	8	8.39	95.3		47.9	189.6
Cerebrovascular Disease	41	32.26	127.1		94.6	170.7
All Heart Disease	202	216.80	93.2		83.7	103.7
Rheumatic Heart Disease	2	1.94	103.0		25.8	410.6
Ischemic Heart Disease	150	186.07	80.6	**	70.9	91.7
Chronic Endocard. Dis.; Other Myocard. Insuff.	7	9.63	72.7		35.0	150.9
Hypertension with Heart Disease	7	5.78	121.1		58.1	252.5
All Other Heart Disease	36	40.39	89.1		65.1	122.0
Hypertension w/o Heart Disease	1	1.44	69.3		9.9	485.1
Non-malignant Respiratory Disease	41	44.95	91.2		68.1	122.1
Influenza & Pneumonia	10	14.66	68.2		37.2	124.9
Bronchitis, Emphysema, Asthma	8	7.47	107.2		53.9	213.1
Bronchitis	0	1.24	---		---	---
Emphysema	6	5.75	104.4		47.1	231.2
Asthma	2	0.53	374.4	*	103.1	1359.3
Other Non-malignant Respiratory Disease	23	23.85	96.5		64.7	143.7
Ulcer of Stomach & Duodenum	5	1.58	317.2	**	138.5	726.4
Cirrhosis of Liver	5	9.62	52.0		22.2	121.5
Nephritis & Nephrosis	5	2.88	173.4		73.2	410.8
All External Causes of Death	34	33.36	101.9		76.2	136.3
Accidents	17	20.30	83.7		54.0	129.9
Motor Vehicle Accidents	7	8.88	78.8		38.3	158.1
All Other Accidents	10	11.56	86.5		47.3	158.2
Suicides	11	8.51	129.3		73.0	228.0
Homicides & Other External Causes	6	4.55	132.0		61.0	285.5
All Other Causes of Death	51	55.58	91.8		70.8	119.0
Unknown Causes (In All Causes Category Only)	0					

* Significant at 5% Level; ** Significant at 1% Level

cerebrovascular disease (PMR=136.2, $p<0.05$) were significantly elevated. There were only 140 men spending the majority of their time in the carbon department (Table 17). Thus the statistical power to a true excess is limited. The only cause of death with a statistically significant excess is cerebrovascular disease with a PMR of 195.3 and corresponding 95% confidence interval of (124.6, 306.3).

The PMRs were also computed for the employees spending the majority of their time in mechanical maintenance, electrical maintenance, ingot and power. For most of these departments the number of employees was not sufficient to evaluate many of the specific cancer sites. Table 18 summarizes the observed and expected deaths and PMRs for all malignant neoplasms for employees with the majority of their time in each of the departments in the reduction plant. Those workers with the majority of time in the potrooms show an elevated PMR of 114.8 ($p<0.05$). The site-specific PMRs for cancer have already been discussed for the potroom and carbon departments. For the other four departments the only significant excess was for lung cancer in mechanical maintenance. The PMR was 138.3 with a corresponding 95% confidence interval of (107.2, 176.4).

Table 16
Observed and Expected Deaths and Proportionate Mortality Ratios for Employees Ever Employed in the Carbon Department

Cause of Death (ICDA 8th Revision Codes)	OBS	EXP	SPMR		95% Limits LOWER	UPPER
All Causes of Death	489	489.00	100.0		---	---
Tuberculosis	0	0.78	---		---	---
All Malignant Neoplasms	133	125.72	105.8		91.5	122.3
Cancer of Buccal Cavity & Pharynx	2	3.06	65.4		16.8	257.2
Cancer of Digestive Organs & Peritoneum	27	30.64	88.1		61.2	126.8
Cancer of Esophagus	1	3.59	27.8		4.5	172.7
Cancer of Stomach	5	4.52	110.7		46.3	264.8
Cancer of Large Intestine	10	11.44	87.4		47.4	161.1
Cancer of Rectum	1	2.26	44.3		6.6	296.6
Cancer of Biliary Passages & Liver	3	2.84	105.7		34.2	326.4
Cancer of Pancreas	6	6.08	98.5		44.5	218.1
Cancer of All Other Digestive Organs	1	0.82	121.4		17.2	857.5
Cancer of Respiratory System	51	47.16	108.1		83.5	140.1
Cancer of Larynx	0	1.62	---		---	---
Cancer of Bronchus, Trachea, Lung	51	45.12	113.0		87.2	148.5
Cancer of All Other Respiratory	0	0.42	---		---	---
Cancer of Breast	0	0.14	---		---	---
All Uterine Cancers (Females only)	0	0.00	---		---	---
Cancer of Cervix Uteri (Females only)	0	0.00	---		---	---
Cancer of Other Female Genital Organs	0	0.00	---		---	---
Cancer of Prostate (Males only)	12	12.34	97.2		55.8	169.5
Cancer of Testes and Other Male Genital Organs	1	0.26	388.4		63.4	2382.3
Cancer of Kidney	7	2.78	250.7	*	122.9	511.5
Cancer of Bladder and Other Urinary Organs	3	3.19	94.1		30.5	290.6
Malignant Melanoma of Skin	2	1.55	128.9		32.5	511.5
Cancer of Eye	0	0.06	---		---	---
Cancer of Central Nervous System	0	2.65	---		---	---
Cancer of Thyroid & Other Endocrine Glands	0	0.28	---		---	---
Cancer of Bone	1	0.22	456.9		76.8	2717.1
Cancer of All Lymphatic, Haematopoietic Tissue	12	10.37	115.7		66.2	202.4
Lymphosarcoma & Reticulosarcoma	1	1.10	91.2		12.9	645.4
Hodgkins Disease	1	0.47	213.5		31.6	1444.0
Leukemia & Aleukemia	3	4.15	72.2		23.5	221.8
Cancer of All Other Lymphopoietic Tissue	7	4.65	150.5		72.4	313.0
All Other Malignant Neoplasms	15	10.12	148.2		90.1	243.7
Benign Neoplasms	1	1.14	87.9		12.4	621.6
Diabetes Mellitus	11	7.52	146.2		81.6	291.9
Cerebrovascular Disease	38	27.80	136.2	*	100.3	184.9
All Heart Disease	190	187.93	101.1		90.5	112.9
Rheumatic Heart Disease	1	1.70	58.9		8.5	407.6
Ischemic Heart Disease	149	159.73	93.3		81.9	106.3
Chronic Endocard. Dis.; Other Myocard. Insuff.	10	8.25	121.2		65.7	223.7
Hypertension with Heart Disease	3	5.37	55.9		18.5	169.1
All Other Heart Disease	27	36.11	74.8		52.1	107.3
Hypertension w/o Heart Disease	1	1.28	77.2		11.0	543.6
Non-malignant Respiratory Disease	25	38.08	65.6	*	45.3	95.2
Influenza & Pneumonia	9	12.61	71.4		37.7	135.2
Bronchitis, Emphysema, Asthma	3	6.26	47.9		16.0	143.8
Bronchitis	0	1.03	---		---	---
Emphysema	1	4.77	20.9		3.6	122.2
Asthma	2	0.49	407.2	*	113.5	1461.2
Other Non-malignant Respiratory Disease	13	20.10	64.7		38.2	109.5
Ulcer of Stomach & Duodenum	1	1.36	73.3		10.4	515.1
Cirrhosis of Liver	7	8.17	76.4		36.9	158.1
Nephritis & Nephrosis	4	2.55	157.1		59.6	413.9
All External Causes of Death	31	31.90	97.2		71.6	131.9
Accidents	17	19.10	89.0		57.2	138.5
Motor Vehicle Accidents	6	8.35	71.9		33.7	153.1
All Other Accidents	11	10.88	101.1		56.8	179.6
Suicides	12	8.03	149.5		86.7	257.8
Homicides & Other External Causes	2	4.77	41.9		11.5	152.3
All Other Causes of Death	47	49.22	95.5		72.9	125.1
Unknown Causes (In All Causes Category Only)	0					

* Significant at 5% Level; ** Significant at 1% Level

Table 17
Observed and Expected Deaths and Proportionate Mortality Ratios for Employees Spending a Majority of Time in the Carbon Department

Cause of Death (ICDA 9th Revision Codes)	OBS	EXP	SPMR		95% Limits LOWER	UPPER
All Causes of Death	140	140.00	100.0		---	---
Tuberculosis	0	0.25	---		---	---
All Malignant Neoplasms	38	35.48	107.1		81.5	140.7
Cancer of Buccal Cavity & Pharynx	0	0.86	---		---	---
Cancer of Digestive Organs & Peritoneum	8	8.78	91.2		46.7	178.1
Cancer of Esophagus	1	1.04	96.0		13.7	674.5
Cancer of Stomach	0	1.31	---		---	---
Cancer of Large Intestine	3	3.28	91.6		29.9	278.9
Cancer of Rectum	1	0.64	156.0		22.4	1084.9
Cancer of Biliary Passages & Liver	0	0.82	---		---	---
Cancer of Pancreas	3	1.71	175.0		57.7	530.9
Cancer of All Other Digestive Organs	0	0.23	---		---	---
Cancer of Respiratory System	16	13.01	123.0		77.4	195.4
Cancer of Larynx	0	0.45	---		---	---
Cancer of Bronchus, Trachea, Lung	16	12.44	128.6		80.9	204.5
Cancer of All Other Respiratory	0	0.11	---		---	---
Cancer of Breast	0	0.04	---		---	---
All Uterine Cancers (Females only)	0	0.00	---		---	---
Cancer of Cervix Uteri (Females only)	0	0.00	---		---	---
Cancer of Other Female Genital Organs	0	0.00	---		---	---
Cancer of Prostate (Males only)	3	3.90	76.9		25.4	233.0
Cancer of Testes and Other Male Genital Organs	0	0.08	---		---	---
Cancer of Kidney	2	0.75	265.2		70.3	1001.3
Cancer of Bladder and Other Urinary Organs	1	0.95	105.5		15.0	743.4
Malignant Melanoma of Skin	0	0.37	---		---	---
Cancer of Eye	0	0.02	---		---	---
Cancer of Central Nervous System	0	0.88	---		---	---
Cancer of Thyroid & Other Endocrine Glands	0	0.08	---		---	---
Cancer of Bone	0	0.08	---		---	---
Cancer of All Lymphatic, Haematopoietic Tissue	3	2.86	105.0		34.3	321.5
Lymphosarcoma & Reticulosarcoma	0	0.29	---		---	---
Hodgkins Disease	0	0.11	---		---	---
Leukemia & Aleukemia	1	1.15	86.7		12.3	609.6
Cancer of All Other Lymphopoietic Tissue	2	1.30	153.7		38.1	604.1
All Other Malignant Neoplasms	5	2.84	175.8		74.7	413.7
Benign Neoplasms	1	0.32	309.5		46.3	1982.7
Diabetes Mellitus	3	2.19	136.9		44.6	418.8
Cerebrovascular Disease	17	8.70	195.3	**	124.6	306.3
All Heart Disease	50	54.44	91.8		74.1	113.9
Rheumatic Heart Disease	0	0.48	---		---	---
Ischemic Heart Disease	40	45.89	87.2		67.8	112.1
Chronic Endocard. Dis.; Other Myocard. Insuff.	2	2.52	79.4		20.2	312.2
Hypertension with Heart Disease	0	1.85	---		---	---
All Other Heart Disease	8	10.59	75.5		38.9	146.5
Hypertension w/o Heart Disease	0	0.40	---		---	---
Non-malignant Respiratory Disease	5	11.52	43.4	*	18.3	97.8
Influenza & Pneumonia	0	3.91	---		---	---
Bronchitis, Emphysema, Asthma	0	1.85	---		---	---
Bronchitis	0	0.31	---		---	---
Emphysema	0	1.41	---		---	---
Asthma	0	0.14	---		---	---
Other Non-malignant Respiratory Disease	5	6.03	82.9		35.3	194.7
Ulcer of Stomach & Duodenum	0	0.40	---		---	---
Cirrhosis of Liver	2	2.34	85.6		21.8	334.9
Nephritis & Nephrosis	1	0.79	126.5		18.0	887.9
All External Causes of Death	9	7.43	121.1		67.0	218.8
Accidents	6	4.54	132.2		61.9	282.3
Motor Vehicle Accidents	4	1.81	221.4		97.9	557.5
All Other Accidents	2	2.77	72.2		18.7	278.2
Suicides	3	1.79	167.8		58.3	500.1
Homicides & Other External Causes	0	1.11	---		---	---
All Other Causes of Death	14	14.41	97.2		59.2	158.5
Unknown Causes (In All Causes Category Only)	0					

* Significant at 5% Level; ** Significant at 1% Level

Table 18
Observed and Expected Deaths and Proportionate Mortality Ratios
by Department for All Malignant Neoplasms

	OBS	EXP	PMR	95% LOWER	UPPER
POTROOM	163	141.98	114.8*	100.7	130.9
CARBON	38	35.48	107.1	81.5	140.7
INGOT	44	44.33	99.3	76.9	128.1
MECH. MAINT.	117	108.00	108.3	92.7	126.6
ELECT. MAINT.	30	27.60	108.7	79.8	148.0
POWER	5	5.05	99.0	46.2	212.3

D. Selected Causes of Death

For those causes of death that were in excess or for which we have particular interest because of the Tripartite Study, we now present more detailed analysis.

(1) Kidney cancer - The PMR for kidney cancer for the total cohort is 158.1 based on 53 observed deaths and 33.52 expected. All cases of kidney cancer were in males and both white males and nonwhite males had an excess (PMR=157.5 and 257.8, respectively. Of the 53 employees with kidney cancer as a cause of death, 49 had more than 20 years employment. For those employees ever employed in the reduction process, the PMR is 200.1 based on 21 observed deaths and 10.5 expected and a corresponding 95% confidence interval of (131.7, 303.8). This compares to a PMR of 136.5 with a corresponding 95% confidence interval of (92.5, 201.4) for workers in nonreduction plants.

Further investigation within the reduction process indicates

that there is no particular area that appears to have a concentration of excess deaths (Table 19). The excess is not much affected when a PCMR is used instead of a PMR (Table 20). The investigation of kidney cancer by individual plant indicated no pattern for the excess although the distribution of only 53 observed deaths among 37 plants results in numbers too small to conclude that no clustering exists.

Table 19
Observed and Expected Deaths and Proportionate Mortality Ratios by Job Location for Kidney Cancer

	OBS	EXP	PMR	95% LOWER	UPPER
NONREDUCTION PLANT	25	18.32	136.5	92.5	201.4
REDUCTION PLANT	28	15.20	184.2**	128.1	265.0
NONREDUCTION PROCESS	11	7.05	156.1	87.0	280.0
REDUCTION PROCESS	17	8.11	209.7**	132.0	333.3
POTROOM	9	3.15	285.8**	153.4	532.5
CARBON	2	.75	265.2	70.3	1001.3
INGOT	2	.99	201.8	52.1	781.4
MECH. MAINTAIN.	4	2.48	161.1	61.2	423.7
ELECT. MAINTAIN.	0	.61	--	--	--
POWER	0	.11	--	--	--

Table 20
Observed and Expected Deaths and Proportionate Cancer Ratios
by Job Location for Kidney Cancer

	OBS	EXP	PMR	95% LOWER	UPPER
NONREDUCTION PLANT	25	19.25	129.9	88.2	191.1
REDUCTION PLANT	28	15.62	179.3**	125.0	257.2
NONREDUCTION PROCESS	11	6.60	166.6	93.5	296.9
REDUCTION PROCESS	17	9.01	188.6**	118.8	299.4
POTROOM	9	3.64	247.1**	132.4	461.2
CARBON	2	.84	237.9	63.1	897.5
INGOT	2	1.02	195.8	51.1	750.7
MECH. MAINTAIN.	4	2.74	146.2	55.8	382.7
ELECT. MAINTAIN.	0	.67	--	--	--
POWER	0	.10	--	--	--

(2) All other cancers - The PMR for the category "all other cancers" was 134.3 ($p<0.01$) with 164 observed deaths and 122.1 expected. The excess did not appear to be restricted to any particular race or sex. Of these, 138 were cancer of an unspecified site, 14 were cancer of multiple sites, and 12 were cancer of soft or connective tissue.

(3) Benign and unspecified neoplasms - The PMR for benign and unspecified neoplasms was 195.6 with a corresponding 95% confidence interval of (136.9, 279.5). The PMR was higher in the nonreduction plants than in the reduction plants (PMR=227.3, $p<0.01$) and PMR=154.7, respectively. The cases did not appear confined to any specific race or sex. The median age at death

for the 29 workers with this cause of death was 70.9. Of the 29 observed deaths, 2 were benign brain tumors and 10 were brain tumors of unspecified nature.

(4) Nephritis and nephrosis - The PMR for nephritis and nephrosis was 242.2 based on 85 observed deaths and 35.09 expected. The excess appeared in reduction as well as nonreduction processes and was not restricted to a specific sex or race group. This ICD classification is often a result of insufficient coding of the death certificate and a review of individual death certificates indicated "renal failure" as a frequent cause of death designated on the death certificates with this cause. Investigation of individual plants indicates that five plants accounted for 52 observed deaths when 13.95 were expected. These plants were both reduction and nonreduction plants.

(5) Cerebral vascular disease - The total cohort had approximately an 11% excess in cerebrovascular disease. This excess appeared restricted to white males where the PMR was 115.2 ($p<0.01$) based on 403 observed deaths and 349.8 expected and was higher in plants with a reduction process where the PMR was 135.3 ($p<0.01$) based on 151 observed deaths compared to a PMR of 98.9 for the remainder of the white male population. For reduction plant workers this represents 30 observed deaths in excess which is approximately the same as the deficit observed for the category "all heart disease". Although the excess occurs in reduction plants it is not confined to the reduction process. The white males who spent the majority of their time in a nonreduction process had a PMR of 132.1 ($p<0.01$) compared to

138.8 ($p<0.01$) for the white males spending the majority of their time in a reduction process.

(6) Respiratory cancer - The primary hypothesis in the Tripartite Study was to determine if there was an excess of lung cancer in the potroom and carbon departments of the reduction process. The overall SMR for lung cancer in that study was 96.4 with a corresponding 95% confidence interval of (83.2, 105.9). The corresponding SMR of the plants in the Tripartite Study which have been included in this study is 91.7 with a corresponding 95% confidence interval of (78.4, 106.5).

For this study the PMR for lung cancer shows a slight excess. The PMR for lung cancer for employees in the reduction process is 124.3 with a corresponding confidence interval of (107.3, 144.0). This compares to a PMR of 108.9 for workers in plants with no reduction process and a PMR of 81.3 ($p<0.05$) for workers in a reduction plant that spent the majority of their time in a nonreduction process. Further investigation was conducted by department within the reduction process (Table 21). Workers spending the majority of their time in the potroom, carbon or ingot department all have excesses of 20%-30% that are not statistically significant. Workers spending the majority of time in mechanical maintenance have a significantly elevated PMR of 136.3 ($p<0.05$).

When the risk is estimated using a proportionate cancer mortality ratio (Table 22), the risk is slightly increased for employees in the nonreduction process of the reduction plant (PCMR=87.9) and decreased for employees in the reduction process

(PCMR=111.9). Neither of these is significantly different from 100. The only significant excess using the PCMR occurs for maintenance workers where the PCMR is 125.7 with a corresponding 95% confidence interval of (101.6, 155.6).

Table 21
Observed and Expected Deaths and Proportionate Mortality Ratios by Job Location for Cancer of Bronchus, Trachea and Lung

	OBS	EXP	PMR	95% LOWER	UPPER
NONREDUCTION PLANT	310	284.73	108.9	97.9	121.0
REDUCTION PLANT	248	238.24	104.1	92.5	117.1
NONREDUCTION PROCESS	89	109.53	81.3*	66.7	98.9
REDUCTION PROCESS	159	127.95	124.3**	107.3	144.0
POTROOM	62	50.77	122.1	96.5	154.5
CARBON	16	12.44	128.6	80.9	204.5
INGOT	19	15.13	125.6	82.0	192.4
MECH. MAINTAIN.	53	38.34	136.3*	107.2	178.3
ELECT. MAINTAIN.	8	9.53	83.9	43.5	162.0
POWER	1	1.69	59.2	9.4	372.4

The observed and expected deaths and PMRs are shown for each plant in Table 23. There was a statistically significant excess. at both the Mobile and Vancouver plants (PMR=161.2 and 154.4, respectively). Two other plants with Soderberg processes, had excesses greater than 40% that failed to achieve statistical significance. When we restricted analysis within each plant to employees with reduction experience, the PMR for Vancouver was 162.4 ($p<0.01$), for Point Comfort was 164.6 ($p<0.05$) and for Warrick was 161.8 (not statistically significant).

Table 22
Observed and Expected Deaths and Proportionate Cancer Mortality Ratios by Job Location for Bronchus, Trachea and Lung

	OBS	EXP	PCMR	95% LOWER	UPPER
NONREDUCTION PLANT	310	300.93	103.0	94.2	112.7
REDUCTION PLANT	248	243.32	101.9	92.3	112.6
NONREDUCTION PROCESS	89	101.23	87.9	74.4	103.9
REDUCTION PROCESS	159	142.09	111.9	98.6	126.6
POTROOM	62	59.27	104.6	85.9	127.4
CARBON	16	13.09	122.2	82.6	180.8
INGOT	19	15.70	121.0	84.7	172.9
MECH. MAINTAIN.	53	42.15	125.7*	101.6	155.6
ELECT. MAINTAIN.	8	10.39	77.0	44.3	133.8
POWER	1	1.50	66.5	13.6	324.5

The PCMRs for the Point Comfort and Vancouver plants were also significant (151.9, $p<0.01$ and 143.2, $p<0.05$, respectively). The PCMR for Warrick was 112.0.

Table 23
Observed and Expected Deaths and Proportionate Mortality Ratios for Lung Cancer by Plant

Plant	OBS	EXP	PMR	95% LOWER	95% UPPER
ADDY	3	.71	--	--	--
ANDERSON	1	.11	--	--	--
ALCOA	8	7.47	107.2	55.5	206.8
BADIN	12	12.19	98.5	57.5	168.7
BAUXITE	13	12.29	105.8	63.1	177.3
BRIDGEPORT	4	1.94	--	--	--
BUFFALO	0	.16	--	--	--
CHICAGO	3	2.45	--	--	--
CHILLICOTHE	6	4.87	123.2	57.8	262.6
CLEVELAND	42	36.63	114.7	86.0	152.8
CORONA	0	1.08	--	--	--
CRESSONA	23	23.53	97.8	66.5	143.8
DAVENPORT	29	23.39	124.0	88.0	174.8
DETROIT	2	4.39	--	--	--
EAST ST. LOUIS	5	7.99	62.6	27.1	144.5
EDGEWATER	17	18.26	93.1	59.0	146.8
EDISON	11	8.17	134.6	76.9	235.7
FORT MEADE	0	.31	--	--	--
FRANKLIN	2	1.95	--	--	--
LAFAYETTE	21	30.36	69.2	46.2	103.6
LANCASTER	5	2.69	185.5	81.8	420.8
LEBANON	2	.85	--	--	--
LOGANS FERRY	3	1.60	--	--	--
MARSHALL	3	1.09	--	--	--
MASSENA	47	53.08	88.5	67.5	116.1
MOBILE	22	13.65	161.2*	108.8	238.7
NEW KENSINGTON	54	52.96	102.0	79.0	131.5
POINT COMFORT	25	17.42	143.5	99.4	207.3
RICHMOND	4	5.94	67.3	26.7	170.0
ROCKDALE	5	9.58	52.2	23.1	117.7
ROSICLARE	5	2.45	204.4	89.9	464.8
TENNESSEE	107	109.3	97.9	81.7	117.2
TIFFON	1	.72	--	--	--
VANCOUVER	27	17.49	154.4*	108.3	220.1
VERNON	21	16.75	125.4	83.6	188.1
WARRICK	16	11.10	144.2	91.0	228.4
WENTACHEE	9	8.07	111.5	60.1	207.0

(7) Cancer of the Lymphatic and Haematopoietic Cancer - The PMR for the total cohort for lymphatic and haematopoietic cancer was 113.6 with a 95% confidence interval of (96.8, 133.2). The PMR for workers in nonreduction plants was 100.2 compared to a PMR of 130.2 ($p<0.05$) for workers in reduction plants. Within the reduction plants, those workers spending the majority of their time in a nonreduction process had a higher PMR than those in a reduction process [PMR=140.1, $p<0.05$ and PMR=122.1 (not significant), respectively]. The PCMR was 146.7 ($p<0.05$) for workers in the nonreduction process and 111.3 for workers in the reduction process. Analysis based on majority of time in individual departments yielded no statistically significant results. Potroom workers had a PMR of 144.9 with a 95% confidence interval of (90.8, 231.3) and electrical maintenance workers had a PMR of 217.3 with a corresponding 95% confidence interval of (93.3, 506.3). The only individual plant with a significant excess was Tennessee which had a PMR of 172.1 ($p<0.01$. The PMR for leukemia in the total cohort was 102.0. The PMR for those in reduction plants was 117.4 compared to 89.8 for those in nonreduction plants. The number of deaths was small on which to do an analysis by department. However, 8 of the 15 deaths occurred in the potroom with a subsequent PMR of 168.3 based on 8 observed deaths and 4.75 expected with a corresponding 95% confidence interval of (85.1, 333.0). The only individual plant with a significant excess was Edgewater with a PMR of 260.7 ($p<0.05$).

(8) Pancreatic cancer - In this study, the PMRs for

pancreatic cancer did not show a significant excess for either reduction plant workers or workers spending the majority of their time in the potrooms (PMR=103.2 and 87.2). This compares to an SMR of 134.8 for workers in the potrooms of the Tripartite Study. The significant finding of the Tripartite Study was for potroom workers with more than 15 years employment, where the excess was more than twofold. With the data available in the present study a risk for longterm employees could not be obtained.

E. Analysis by Plant

Mortality for each of the 62 selected causes of death was done for each of the 37 study plants. Such analysis must be interpreted with caution since by random chance alone some plants would be expected to deviate from the average value. In addition, many of the plants did not have sufficient numbers for an individual analysis. Because of these limitations, we view the results as preliminary and any plants that are identified should be given consideration for a more detailed study (if feasible) in a second phase.

Table 24 summarizes the observed, expected deaths and Proportionate Mortality Ratios by plant. Of the 29 plants with sufficient sample size to compute a PMR, 14 had a PMR less than 100 and 15 had a PMR greater than 100. Four plants had a statistically significant excess, but one was based on only 5 observed deaths. One plant had a borderline excess of PMR=130.5 with a corresponding 95% confidence interval of (99.9, 170.4).

Numbers were often too small to do an analysis of individual plants for many of the specific cancers. Nevertheless, in reviewing the results from those plants we note the following

Table 24
Observed and Expected Deaths and Proportionate Mortality Ratios for All Malignant Neoplasms by Plant

Plant	OBS	EXP	PMR	95% LOWER	95% UPPER
ADDY	5	2.00	250.6*	123.2	509.9
ANDERSON	1	.37	--	--	--
ALCOA	21	22.02	95.3	66.1	137.6
BADIN	40	37.11	107.8	82.5	140.7
BAUXITE	34	36.16	94.0	70.4	125.5
BRIDGEPORT	12	7.04	170.5*	103.7	280.3
BUFFALO	0	.91	--	--	--
CHICAGO	5	7.06	70.8	33.5	149.4
CHILLICOTHE	16	14.98	106.8	70.8	161.0
CLEVELAND	138	110.16	125.3**	108.6	144.6
CORONA	1	2.85	--	--	--
CRESSONA	64	62.75	102.0	82.8	125.6
DAVENPORT	85	64.20	132.4**	110.5	158.6
DETROIT	14	16.17	86.6	54.6	137.3
EAST ST. LOUIS	28	29.04	96.4	69.5	133.9
EDGEWATER	60	61.07	98.2	78.7	122.6
EDISON	30	24.75	121.2	89.1	165.0
FORT MEADE	1	.88	--	--	--
FRANKLIN	5	5.85	85.4	40.4	180.5
LAFAYETTE	78	87.57	89.1	73.6	107.8
LANCASTER	7	7.83	89.4	47.4	168.3
LEBANON	3	2.16	--	--	--
LOGANS FERRY	5	4.36	104.7	54.5	24.7
MARSHALL	3	2.78	--	--	--
MASSENA	148	152.68	96.4	84.4	111.4
MOBILE	45	38.58	116.6	90.8	149.8
NEW KENSINGTON	160	168.55	94.9	83.0	108.6
POINT COMFORT	45	45.95	97.9	76.5	125.4
RICHMOND	19	19.81	95.9	65.6	140.1
ROCKDALE	23	26.44	87.0	61.4	123.2
ROSICLARE	10	7.78	128.5	74.7	220.9
TENNESSEE	330	323.35	102.1	93.0	112.0
TIFFON	4	2.33	--	--	--
VANCOUVER	52	49.27	105.8	83.6	133.2
VERNON	52	51.06	101.8	80.6	128.7
WARRICK	39	29.89	130.5	99.9	170.4
WENTACHEE	22	22.55	97.6	68.3	139.5

neoplasms which were in excess at particular plants:

(1) The Cleveland plant had PMRs of 280.5 for stomach cancer (based on 12 observed deaths, $p<0.01$), 298.8 for cancer of

the rectum (based on six observed deaths, $p<0.05$) and 464.7 for cancer of the breast (based on 4 observed deaths, $p<0.01$).

(2) The Cressona plant had a PMR of 247.4 for stomach cancer (based on five deaths, $p<0.05$), 261.9 for kidney cancer (based on four deaths, $p<0.05$), and 530.4 for melanoma (based on four deaths, $p<0.01$).

(3) The Davenport plant had a PMR of 177.0 for all digestive cancers (based on 27 observed deaths, $p<0.01$). The PCMR was not significantly elevated for this cause.

(4) The Edgewater plant had a PMR of 260.7 for leukemia (based on six observed deaths, $p<0.05$).

(5) The Massena plant had a PMR of 283.2 for lymphosarcoma (based on 4 observed deaths, $p<0.05$).

(6) The Mobile plant had a PMR of 161.2 ($p<0.05$) for lung cancer. The PCMR was 135.3.

(7) The Tennessee (Alc) plant had a PMR of 172.1 (based on 46 observed deaths, $p<0.01$) for cancer of the lymphatic and haematopoietic tissue.

(8) The Vancouver plant had a PMR of 154.4 for lung cancer (based on 27 observed deaths, $p<0.05$) and a PMR of 356.1 (based on 4 observed deaths, $p<0.05$) for kidney cancer.

Summary

Conclusions from this study must be drawn more cautiously than was necessary for the Tripartite Study because of the inherent limitations of the PMR study design as well as the less specific job classification used in the present study. Furthermore, the large number of estimates of risk that were computed will result in a larger number of false positive findings than can be inferred from the p-values. Conversely, the small number of workers available for many of the estimates of risk precludes any strong statements in regard to those findings that were negative. With these limitations stated, we now summarize the findings we feel are most important. Consistent with the study objectives, we have given most attention in our summary to malignant neoplasms.

The PMR for malignant neoplasms for the total study population was 103.7 and was not significantly different from the total U.S. population. The only specific cancer site which was significantly elevated was kidney cancer with a PMR of 158.1 and a corresponding 95% confidence interval of (121.2, 206.3). The nonspecific disease categories of benign and unspecified neoplasms, nephritis and nephrosis and "all other malignant neoplasms" were elevated and appeared to result from lack of complete specification of cause of death on the certificate. The only other disease category that was elevated for the total cohort was cerebral vascular disease with a PMR of 111.4 ($p<0.05$) and this was accompanied by a deficit in ischemic heart disease (PMR=85.2, $p<0.01$).

The analysis by work area yielded the following:

(1) For the combined group of workers in nonreduction plants the PMR for all malignant neoplasms was 105.2. The only statistically significant excesses occurred for nonspecific disease categories (i.e., nephritis, benign and unspecified neoplasms, all other cancers). Analysis by race indicated that whites had an excess of colon cancer and nonwhites had an excess of stomach, liver and lymphatic cancer.

(2) For the 1320 workers in a reduction plant who spent the majority of their time in a nonreduction process, the PMR for all malignant neoplasms was 93.6. The only specific neoplastic site with a significant elevation was cancer of the lymphatic and haematopoietic tissue (PMR=140, $p<0.05$).

(3) Workers with the majority of their employment in the reduction process had a PMR of 109.5 ($p<0.05$) for all malignant neoplasms. These workers had a PMR of 124.3 for lung cancer ($p<0.01$) and a PMR of 209.2 for kidney cancer ($p<0.01$). When a PCMR was computed, the estimate of risk for lung cancer was a nonsignificant 111.9 but remained significant for kidney cancer (PCMR=188.6, $p<0.01$). The workers spending the majority of their time in the reduction process had a significant excess for two of the study plants. Neither of these plants had an excess in the Tripartite Study. Workers spending the majority of their time in mechanical maintenance also had an excess of lung cancer.

(4) Although workers in reduction plants had a significantly elevated PMR of 130.2 ($p<0.05$), for cancer of the lymphatic and haematopoietic tissue it was greater in workers in the reduction plant spending the majority of their time in a

nonreduction process (PMR=140.1, $p<0.05$). No individual department had a statistically significant excess, although the small number of observed deaths when analyzed by department makes the results inconclusive.

(5) Analysis by plant is limited by small numbers and a further increase in the expected false positives due to the larger number of estimates of risk. Overall, 14 plants had a PMR for "all malignant neoplasms" below 100, 15 plants were above, and 8 had less than 5 observed deaths from neoplasms. Of plants with greater than 5 observed deaths for "all malignant neoplasms", three had a statistically significant excess and one had borderline significance. Eight of the plants had at least one specific site that showed a statistically significant excess. We could identify no consistent pattern in site-specific cancers among plants with similar processes, although such inferences are clearly limited by small numbers and lack of more detailed job classifications in plants with multiple processes.

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Appendix

Distribution of causes of death using 4 digit ICD codes

ICD	Freq.	ICD	Freq.	ICD	Freq.
88	1	1562	1	2008	4
119	3	1569	1	2019	7
189	1	1570	5	2020	1
310	1	1579	69	2021	1
360	1	1590	3	2024	1
381	3	1599	1	2028	41
384	7	1619	7	2030	25
388	1	1625	1	2040	5
389	54	1629	557	2041	8
419	1	1639	2	2049	2
498	1	1640	1	2050	17
499	1	1701	1	2051	6
539	1	1706	1	2080	9
543	1	1709	1	2081	1
703	2	1712	1	2089	7
1159	2	1713	1	2159	1
1169	1	1716	1	2169	1
1175	1	1719	9	2251	1
1179	2	1722	1	2252	1
1350	1	1725	2	2302	1
1363	2	1727	1	2373	1
1369	1	1729	15	2384	1
1409	1	1734	1	2387	4
1419	2	1749	13	2389	2
1449	1	1790	2	2390	2
1459	2	1809	1	2391	1
1460	2	1820	1	2395	1
1469	1	1830	4	2396	10
1479	3	1850	147	2398	1
1481	1	1869	1	2399	1
1490	5	1874	2	2429	1
1505	2	1889	47	2449	1
1509	17	1890	48	2500	72
1510	3	1891	1	2501	2
1519	56	1892	4	2502	2
1522	2	1899	1	2503	6
1529	1	1909	1	2504	1
1531	1	1910	1	2505	1
1532	2	1913	2	2506	6
1533	4	1916	1	2507	1
1534	2	1919	20	2509	1
1536	5	1930	1	2535	1
1539	152	1940	2	2554	1
1540	6	1946	1	2558	1
1541	24	1950	1	2599	1
1550	12	1990	14	2639	3
1551	2	1991	136	2651	1
1552	8	2000	5	2733	1

Table (continued)

Distribution of causes of death using 4 digit ICD codes

ICD	Freq.	ICD	Freq.	ICD	Freq.
1560	4	2001	6	2738	1
1561	2	2002	1	2754	1
2761	1	4049	4	4402	3
2762	2	4100	1017	4409	65
2765	4	4109	16	4410	4
2773	2	4110	11	4411	1
2780	1	4120	9	4412	1
2793	1	4130	1	4413	41
2810	1	4140	617	4414	3
2848	2	4141	1	4415	7
2849	2	4148	14	4416	3
2859	1	4149	203	4429	1
2866	2	4151	36	4439	8
2888	2	4160	3	4440	1
2898	1	4169	5	4449	5
2899	1	4210	3	4472	1
2900	4	4239	1	4479	1
2901	2	4240	5	4512	1
2910	1	4241	23	4519	2
3030	1	4249	6	4539	1
3089	1	4254	67	4549	1
3109	5	4255	2	4560	4
3229	1	4271	1	4578	1
3239	2	4273	3	4589	3
3240	1	4274	4	4590	5
3310	19	4275	164	4599	1
3312	1	4278	1	4660	1
3314	2	4279	19	4787	1
3319	2	4280	80	4809	1
3320	16	4281	2	4810	4
3334	3	4284	4	4820	3
3352	12	4289	14	4823	1
3400	3	4290	2	4824	1
3418	1	4291	1	4828	1
3419	1	4292	150	4829	1
3429	2	4299	4	4830	1
3481	3	4300	6	4850	35
3483	1	4301	5	4860	103
3485	1	4310	46	4870	1
3489	1	4321	6	4878	1
3561	1	4329	5	4900	3
3570	2	4330	1	4912	6
3760	1	4331	4	4919	1
3940	2	4340	49	4920	54
3941	1	4341	2	4939	9
3949	5	4349	27	4940	1
3959	1	4360	275	4960	141

Table (continued)

Distribution of causes of death using 4 digit ICD codes

ICD	Freq.	ICD	Freq.	ICD	Freq.
3980	1	4370	16	5000	18
3989	4	4371	1	5010	1
4019	11	4378	1	5020	1
4029	48	4379	15	5050	1
4039	12	4380	7	5064	1
5070	17	5715	34	8120	9
5109	3	5718	2	8121	1
5118	1	5719	3	8122	3
5119	4	5722	1	8129	16
5120	4	5724	3	8130	4
5130	3	5728	19	8147	6
5140	6	5733	4	8150	2
5150	13	5739	2	8159	2
5163	1	5742	2	8169	2
5168	2	5743	1	8190	7
5183	1	5750	3	8191	2
5184	2	5751	1	8192	3
5185	3	5754	1	8199	16
5188	9	5761	3	8209	1
5199	1	5770	5	8219	1
5301	1	5771	1	8220	1
5304	1	5789	11	8249	1
5309	1	5809	1	8259	1
5314	4	5829	4	8261	1
5315	2	5838	1	8300	1
5319	1	5839	2	8309	1
5324	2	5845	1	8329	1
5325	2	5849	12	8480	1
5326	1	5850	19	8682	1
5329	1	5860	45	8689	3
5334	6	5900	1	8698	1
5335	2	5901	2	8781	1
5339	1	5908	3	8782	2
5369	1	5920	1	8789	1
5400	1	5938	1	8799	5
5409	1	5939	4	8809	7
5532	2	5959	1	8810	4
5539	1	5990	25	8811	1
5560	1	6019	1	8820	1
5570	8	6029	1	8839	1
5579	1	6821	1	8849	2
5580	1	6829	1	8870	1
5601	1	6861	1	8880	10
5602	1	6954	1	8902	4
5608	1	7070	6	8903	2
5609	5	7101	1	8909	4
5621	5	7802	2	8920	1
5660	1	7855	6	8939	1

Table (continued)

Distribution of causes of death using 4 digit ICD codes

ICD	Freq.	ICD	Freq.	ICD	Freq.
5679	1	7860	1	9000	1
5698	4	7970	2	9053	1
5699	1	7981	5	9068	1
5710	1	7982	44	9102	1
5712	13	7991	41	9108	3
5713	2	7999	62	9110	4
5714	1	8109	2	9120	2
9138	1	9251	1	9571	1
9190	5	9289	15	9600	1
9192	1	9323	1	9651	1
9198	2	9345	1	9652	1
9199	2	9520	4	9654	7
9220	1	9530	5	9660	2
9221	1	9538	1	9689	2
9222	1	9540	1	9821	4
9229	5	9550	4	9830	1
9239	1	9551	4	9851	1
9240	1	9552	2	9854	2
9250	1	9554	52	9947	1

PROPORTIONATE MORTALITY STUDY

OF ALCOA WORKERS

(1980-1987)

Howard E. Rockette, Ph.D.
Department of Biostatistics
University of Pittsburgh

Vincent C. Arena, Ph.D.
Department of Clinical Epidemiology
and Preventive Medicine
University of Pittsburgh

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Background

This study provides an evaluation of the mortality patterns of workers in the aluminum industry that can be used with the information from the previously reported Tripartite Study to help assess potential health problems in the aluminum industry. The Tripartite Study was initiated in May 1978 and a report of study findings was made in November 1981. Progress of the study was reported quarterly throughout the duration of the contract period to a Tripartite Committee consisting of representatives of labor, management and government. The study population consisted of 21,829 men employed at least five years in a reduction operation in one of the 14 plants between January 1, 1946 and December 31, 1973 (1). Vital Status determination as of December 31, 1977 was made on 99.3% of the cohort and death certificates were obtained for 97.6% of the men believed to be deceased. The priorities which directed the analysis of the Tripartite data were as follows:

(1) Mortality patterns of workers in the potroom and/or carbon departments were given the most attention in the analysis.

(2) Respiratory cancer was to be investigated thoroughly and was the disease category given the highest priority.

(3) Lymphopoietic cancers were to be investigated and were second only to respiratory cancer as a disease category to be given special attention.

(4) For diseases other than respiratory cancer and lymphopoietic cancer, enough preliminary analysis was

done to identify any excess mortality that was associated with a particular plant or process.

(5) Causes of death associated with the aluminum reduction process in other studies were reinvestigated using the Tripartite data.

In order to satisfy these objectives, the mortality patterns of employees in the fourteen reduction plants was compared to the total U.S. male population for 59 selected causes of death. Analysis was done by plant, process, calendar time period, time since first employment and selected exposure measurements. Industrial hygiene measurements were available for total particulates, benzene solubles, benzo(a)pyrene, particulate polycyclic organic matter, sulfur dioxide and total fluorides. Based on these analyses and the previous research literature on mortality of reduction plant workers, some categories of disease were selected for more detailed investigation.

The major findings of the Tripartite Study were as follows:

(1) There were no strong associations of lung cancer mortality and work in the reduction plant. Overall the lung cancer SMR of the total cohort based on 272 observed deaths was 96.4. Formal tests of a dose-response relationship to cumulative years employment in the potroom and carbon departments, cumulative years of employment in the reduction plant, and cumulative exposure to benzene solubles, particulate polycyclic organic matter, benzo(a)pyrene, total particulates, total fluorides and sulfur dioxide showed no statistically significant relationship.

There were two exceptions to the lack of an excess for lung cancer mortality. One plant, a horizontal Soderberg, had an SMR of 162.0 ($p<0.05$) for white males. However, the region in which the plant was located has a high lung cancer rate in the general population and when the data was reanalyzed using local rates, the SMR was below 100. The second excess was in the baked carbon department of one of the plants where there was an SMR of 266.8 ($p<0.05$) based on eight observed deaths. However, this excess was not observed in the baked carbon departments of the remainder of the prebake plants.

(2) The SMR for leukemia was 124.9 based on 43 observed deaths. This excess was not statistically significant. The SMR for the prebake process was 123.5 and for the Soderberg process was 130.2. The SMR for potroom workers in the Soderberg process was 169.1 and for potroom workers in the prebake process was 124.6. Analysis by duration of employment was not consistent by process with men in the prebake showing more excess with longer term employment and men in the Soderberg process showing greater excess with short term employment.

(3) The SMR for pancreatic cancer was 122.3 and was not statistically significant. However, there was a significant excess for men with more than 15 years employment in the potroom department in both the Soderberg (SMR=271.3, $p<0.05$) and prebake process (SMR=222.2, $p<0.05$).

(4) The SMR for kidney cancer in the prebake process was 144.9. The excess was greater in men with less than 20 years employment and greater in men employed outside the carbon and potroom departments.

(5) Although the number of observed deaths was small there was an excess of bladder cancer in men employed 5 or more years in the potroom or carbon department of the Soderberg process.

(6) The only cause of death which was statistically elevated for an entire process was benign and unspecified neoplasms. For the prebake process the SMR for this cause was 193.5 ($p<0.05$) based on 14 observed deaths. The estimated risk was greater for men employed twenty-five or more years, and was higher outside the potroom and carbon departments.

(7) There was an excess of emphysema in the potroom and carbon departments of the Soderberg process (SMR=216.5, $p<0.05$; SMR=258.9, $p<0.05$). Although the excess in the prebake process was elevated, it was not statistically significant. The emphysema risk may have been understated in the prebake process because of a tendency to code many death certificates to "chronic obstructive lung disease" after 1970. If these cases were considered to be emphysema there would be a statistically significant excess in the prebake process. For men with more than 20 years employment in the prebake process there was an SMR of 260.2, ($p<0.01$) for asthma.

The present study is a PMR Study without detailed work histories and without exposure measurements available. Thus, the conclusions that can be drawn from this study are more limited than those that could be obtained from the Tripartite Study. Nevertheless, this study provides us with an independent data base on which to confirm the interpretation of some of the findings in the Tripartite Study and also provides a means of

obtaining a preliminary evaluation of mortality patterns of nonreduction plant workers. Specifically, the primary objectives of the present study are as follows:

(1) To obtain mortality data from aluminum reduction plants independent of the Tripartite cohort that can be used to further clarify the relationship of employment in aluminum reduction plants to excess mortality from cancer. Because the majority of ALCOA workers were employed in the prebake process, it is for workers in this process that we expect the most information to be obtained. The mortality patterns in the PMR study will be contrasted with those obtained from the Tripartite Study.

(2) To obtain a profile of the mortality experience of nonreduction plant workers. Little information is available on the mortality experience of nonreduction plant workers since most studies have focussed on exposure in the potroom and carbon departments. This part of the investigation is limited because of the lack of detailed coding within the nonreduction plants. However, by investigating the consistency of any excess among plants with similar processes we may identify potential associations for future investigation.

(3) On the basis of this PMR study, the Tripartite Study and a review of the literature of potential health hazards in the aluminum industry, we will make specific recommendations of studies we feel are necessary in order to determine the association of disease with exposure in the aluminum industry. Such studies will be primarily hypotheses testing as opposed to hypothesis generating.

Methods

The study population assembled by ALCOA consisted of all deaths known to the company as determined by insurance claims during the time period 1/1/80 through 12/31/87 in one of the 37 study plants. Any former employee whose beneficiary had either filed a claim or was receiving death benefits from the company was included in the study population. The initial list supplied by ALCOA was reviewed for duplicates and incomplete or inconsistent names. The resultant study population contains 6433 workers. Death certificates were obtained for all but 60 (0.9%) of the study population. These deaths were coded by a nosologist according to the ninth revision ICD and it is these 6373 death certificates on which the analyses in the present report are based. The frequencies of deaths for each cause are given in the Appendix.

Detailed work histories were not coded and analyzed for this study, since to provide such coding for such a large variety of plants and processes would have required considerable effort. For this report an employee was classified in the plant where he was last employed. Using this method of classification, 2777 workers were coded to one of the eight reduction plants. For these eight reduction plants we further coded whether they had ever worked in the potroom or carbon department as well as the department they spent the majority of time. Nine employees could not be included in this analysis because we did not have work histories. The departments in the reduction process used to classify majority of time were potroom, carbon, ingot, mechanical maintenance, electrical maintenance, and power. A total of 1320

employees in the eight reduction plants spent the majority of their time in a nonreduction process. We have done analysis separately for the 3596 employees in nonreduction plants, the 1320 employees in a nonreduction process of a reduction plant and the 1448 employees in the reduction process.

The proportionate mortality ratio was the primary summary index of risk. The analysis was done using the computer program OCMAP (2) and five year average annual age, race and sex-specific U.S. rates for the control group. As a secondary analysis we used a proportionate cancer mortality index (PCMR) (3). This index uses "all cancer mortality" as the base on which to base proportionate mortality rather than "all cause" mortality and is believed by many investigators to be less subject to the healthy worker effect.

Both the PMR and PCMR were adjusted for age, sex, race and calendar time. To meet the primary objectives of this study we completed the following analyses:

(1) The PMR and PCMRs were computed for 62 selected causes of death by race, sex, and race-sex combinations for the total cohort, for nonreduction plants, and for plants with a reduction process (reduction plants).

(2) For plants with a reduction process PMRs and PCMRs were computed for employees with a majority of their time in each of the following: a) nonreduction process, b) potroom department, c) carbon department, d) ingot department, e) mechanical maintenance, f) electrical maintenance, and g) power. Mortality indices were also

computed for employees "ever employed in the potroom department" and employees "ever employed in the carbon department".

(3) PMRs and PCMRs were computed for each plant for all 62 selected causes of death.

Because of the large number of comparisons we expect some statistically significant excesses as well as deficits. When interpreting our data we will give emphasis to the excesses, but when interpreting excesses we will take into consideration the consistency of the result with the Tripartite Study as well as the consistency with other plants that have a similar process. In most cases we have required that either the observed or expected number of deaths be 5 before we attempt to interpret results for a specific cause of death.

Population Characteristics

A total of 6373 death certificates was obtained and coded for the years 1980 to 1987 in the 37 study plants. A total of 6112 (95.9%) death certificates were for males and 5816 (91.3%) were for whites. Table 1 summarizes the distribution of deaths by year. The number of deaths were approximately equal for each of the seven years of the study. The age at death is summarized in Table 2. Fifty-one percent of the deaths occurred at ages 65-79.

The distribution of deaths for the 37 study plants is shown in Table 3. The eight plants with a reduction process contributed 44% of the total deaths and 28% of the total deaths were for employees who at one time were in a reduction process evaluated in the Tripartite Study. Of the 2777 workers in one

of the eight plants with a reduction process, all but 9 had employment histories. Of the 2768 workers with employment histories, 1320 spent the majority of their time in a nonreduction process. The distribution of the number of employees spending the majority of their time in a specific reduction department is given in Table 4. Of the 1448 employees with the majority of time in one of the reduction departments, 556 (36%) had the majority of their time in the potroom. The second largest group was mechanical maintenance which accounted for 433 (29.9%) of the deaths.

Table 1

Distribution of Employees
by Year of Death

Year	Frequency	Percent
1980	766	12.0
1981	772	12.1
1982	781	12.3
1983	824	12.9
1984	793	12.4
1985	759	11.9
1986	819	12.9
1987	859	13.5
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TOTAL	6373	100.0

Table 2
Distribution of Employees
by Age at Death

Value Label	Frequency	Percent
20 - 24	7	.1
25 - 29	19	.3
30 - 34	29	.5
35 - 39	41	.6
40 - 44	57	.9
45 - 49	80	1.3
50 - 54	172	2.7
55 - 59	293	4.6
60 - 64	573	9.0
65 - 69	1002	15.7
70 - 74	1261	19.8
75 - 79	1182	18.5
80 - 84	838	13.1
85 - 89	541	8.5
90 - 94	206	3.2
$\geq$95	72	1.1

Table 3

Distribution of Workers by Plant

Plant Name	Frequency	Percent
Tennessee	1325	20.8
Vernon	210	3.3
Point Comfort	167	2.6
Massena	630	9.9
New Kensington	754	11.8
Cleveland	448	7.0
Cressona	231	3.6
Buffalo	7	.1
Vancouver	196	3.1
Warrick	116	1.8
Chillicothe	54	.8
Richmond	74	1.2
Detroit	76	1.2
East St. Louis	145	2.3
Edgewater	282	4.4
Chicago	27	.4
Corona	12	.2
Bridgeport	36	.6
Edison	103	1.6
Davenport	247	3.9
Wentachee	88	1.4
Lafayette	355	5.6
Lancaster	31	.5
Marshall	11	.2
Logans Ferry	16	.3
Mobile	149	2.3
Lebanon	8	.1
Anderson	2	.0
Badin	152	2.4
Bauxite	148	2.3
Addy	8	.1
Atc	89	1.4
Fort Meade	4	.1
Franklin	23	.4
Rockdale	103	1.6
Rosiclare	36	.6
Tiffon	10	.2
Total	6373	100.0

Table 4
Department Where Reduction Plant Workers
Spent Majority of Time

Department	Frequency	Percent
Potroom	556	38.4
Carbon	140	9.7
Ingot	183	12.6
Mech Maintenance	433	29.9
Elec Maintenance	113	7.8
Power	23	1.6

Results

A. Mortality for Total Cohort

The cause-specific mortality for 62 selected causes of death is shown in Table 5. The PMR for the category "all malignant neoplasms" is 103.7 based on 1605 observed deaths. Five causes of death are significantly elevated. These are cancer of the kidney (PMR=158.1, $p<0.01$), all other malignant neoplasms (PMR=134.3, $p<0.01$), benign and unspecified neoplasms (PMR=195.6, $p<0.01$), nephritis and nephrosis (PMR=242.2, $p<0.01$) and cerebral vascular disease (PMR=111.4, $p<0.05$). Since males comprise 91% of the cohort, it is not surprising that when we restrict our analysis to the population of males (Table 6) the same causes of death show a significant excess. For females (Table 7), all other malignant neoplasms (PMR=240.2, $p<0.01$), benign neoplasms (PMR=600.5, $p<0.01$) and all other causes of death (PMR=135.1, $p<0.05$) show a statistically significant excess.

When mortality patterns for the total cohort are

Table 5
Observed and Expected Deaths and Proportionate Mortality Ratios for the Total Population

Cause of Death (ICDA 9th Revision Codes)	OBS	EXP	SPMR		95% Limits LOWER	UPPER
All Causes of Death	6373	6373.00	100.0		---	---
Tuberculosis	4	8.18	48.9		18.7	127.5
All Malignant Neoplasms	1605	1548.32	103.7		98.4	108.1
Cancer of Buccal Cavity & Pharynx	18	33.56	53.6	**	34.1	84.4
Cancer of Digestive Organs & Peritoneum	385	381.80	100.8		91.5	111.1
Cancer of Esophagus	19	36.85	51.6	**	33.2	80.0
Cancer of Stomach	59	53.88	109.5		84.9	141.2
Cancer of Large Intestine	166	151.98	109.2		94.0	126.9
Cancer of Rectum	30	29.70	101.0		70.7	144.3
Cancer of Biliary Passages & Livar	30	34.79	86.2		60.4	123.2
Cancer of Pancreas	74	75.10	98.5		78.6	123.6
Cancer of All Other Digestive Organs	7	10.95	63.9		30.7	133.2
Cancer of Respiratory System	568	545.76	104.1		96.3	112.5
Cancer of Larynx	7	17.89	39.1	*	19.2	79.8
Cancer of Bronchus, Trachea, Lung	558	522.96	106.7		98.6	115.4
Cancer of All Other Respiratory	3	4.88	61.5		20.1	188.5
Cancer of Breast	13	14.29	91.0		53.8	153.9
All Uterine Cancers (Females only)	4	3.23	123.8		46.9	326.6
Cancer of Cervix Uteri (Females only)	1	1.33	75.2		10.8	524.4
Cancer of Other Female Genital Organs	4	4.17	95.9		36.4	252.9
Cancer of Prostate (Males only)	147	167.98	87.5		74.7	102.8
Cancer of Testes and Other Male Genital Organs	3	2.46	121.9		39.4	377.1
Cancer of Kidney	53	33.52	158.1	**	121.2	206.3
Cancer of Bladder and Other Urinary Organs	48	46.32	103.6		78.2	137.4
Malignant Melanoma of Skin	19	16.88	112.6		71.9	176.3
Cancer of Eye	1	0.79	127.3		18.0	898.0
Cancer of Central Nervous System	24	29.12	82.4		55.3	122.7
Cancer of Thyroid & Other Endocrine Glands	4	3.42	116.9		43.9	311.1
Cancer of Bone	3	2.50	120.0		38.8	371.3
Cancer of All Lymphatic, Haematopoietic Tissue	147	129.45	113.6		96.8	133.2
Lymphosarcoma & Reticulosarcoma	18	13.74	118.5		71.4	188.8
Hodgkins Disease	7	4.78	148.6		70.2	305.9
Leukemia & Aleukemia	55	53.91	102.0		78.4	132.7
Cancer of All Other Lymphopoietic Tissue	89	57.03	121.0		95.7	153.0
All Other Malignant Neoplasms	184	122.11	134.3	**	115.5	156.2
Benign Neoplasms	29	14.82	195.6	**	136.9	278.5
Diabetes Mellitus	82	85.41	96.4		78.7	118.1
Cerebrovascular Disease	466	418.26	111.4	*	102.1	121.6
All Heart Disease	2555	2567.57	99.5		96.6	102.5
Rheumatic Heart Disease	14	22.81	61.4		36.6	103.0
Ischemic Heart Disease	1888	2217.28	85.2	**	82.2	88.3
Chronic Endocard. Dis.; Other Myocard. Insuff.	134	125.14	107.1		90.6	126.6
Hypertension with Heart Disease	52	62.35	83.4		63.7	109.2
All Other Heart Disease	466	461.67	100.9		92.5	110.1
Hypertension w/o Heart Disease	23	17.23	133.5		88.9	200.5
Non-malignant Respiratory Disease	462	560.91	82.4	**	75.5	89.8
Influenza & Pneumonia	153	198.70	77.0	**	66.0	90.9
Bronchitis, Emphysema, Asthma	73	88.50	82.5		65.7	103.5
Bronchitis	10	15.53	64.4	-	34.6	118.0
Emphysema	54	68.12	79.3		60.9	103.3
Asthma	9	5.80	155.3		81.2	296.8
Other Non-malignant Respiratory Disease	236	287.82	82.1	**	72.5	92.9
Ulcer of Stomach & Duodenum	22	19.09	115.2		76.0	174.9
Cirrhosis of Liver	56	90.49	61.9	**	47.9	80.0
Nephritis & Nephrosis	85	35.09	242.2	**	197.3	297.4
All External Causes of Death	288	285.29	100.9		90.9	112.1
Accidents	191	178.11	106.8		93.2	122.1
Motor Vehicle Accidents	80	69.53	115.1		93.2	142.0
All Other Accidents	111	111.10	99.9		83.2	120.0
Suicides	74	72.56	102.0		81.6	127.5
Homicides & Other External Causes	23	33.82	68.4		46.2	101.3
All Other Causes of Death	686	651.61	105.3		98.1	113.0
Unknown Causes (In All Causes Category Only)	0					

* Significant at 5% Level; ** Significant at 1% Level

Table 6
Observed and Expected Deaths and Proportionate Mortality Ratios for Males

Cause of Death (ICDA 9th Revision Codes)	OBS	EXP	SPMR		95% Limits LOWER	UPPER
All Causes of Death	8112	8112.00	100.0		---	---
Tuberculosis	4	7.88	50.1		18.2	130.8
All Malignant Neoplasms	1533	1482.52	103.4		98.0	108.0
Cancer of Buccal Cavity & Pharynx	18	32.89	55.1	*	35.0	88.7
Cancer of Digestive Organs & Peritoneum	367	365.61	100.4		90.9	110.8
Cancer of Esophagus	19	36.20	52.5	**	33.8	81.5
Cancer of Stomach	57	52.24	109.1		84.3	141.3
Cancer of Large Intestine	156	144.54	107.9		92.4	126.0
Cancer of Rectum	28	28.48	101.8		70.8	148.4
Cancer of Biliary Passages & Liver	28	33.15	84.5		58.4	122.2
Cancer of Pancreas	71	71.57	99.2		78.7	125.0
Cancer of All Other Digestive Organs	7	10.40	67.3		32.3	140.4
Cancer of Respiratory System	557	533.38	104.4		96.5	113.0
Cancer of Larynx	7	17.68	39.6	*	19.4	80.8
Cancer of Bronchus, Trachea, Lung	547	510.97	107.1		98.9	115.9
Cancer of All Other Respiratory	3	4.73	63.4		20.6	194.5
Cancer of Breast	0	1.63	---		---	---
All Uterine Cancers (Females only)	0	0.00	---		---	---
Cancer of Cervix Uteri (Females only)	0	0.00	---		---	---
Cancer of Other Female Genital Organs	0	0.00	---		---	---
Cancer of Prostate (Males only)	147	167.98	87.5		74.7	102.6
Cancer of Testes and Other Male Genital Organs	3	2.48	121.9		39.4	377.1
Cancer of Kidney	53	32.42	163.5	**	125.3	213.3
Cancer of Bladder and Other Urinary Organs	48	45.38	105.7		79.8	140.2
Malignant Melanoma of Skin	19	16.18	117.4		75.0	183.7
Cancer of Eye	1	0.74	134.5		19.1	948.2
Cancer of Central Nervous System	21	27.66	75.9		49.6	116.1
Cancer of Thyroid & Other Endocrine Glands	4	3.16	126.5		47.6	336.2
Cancer of Bone	3	2.38	125.9		40.7	388.2
Cancer of All Lymphatic, Haematopoietic Tissue	141	123.61	114.1		96.9	134.3
Lymphosarcoma & Reticulosarcoma	16	13.03	122.8		75.3	200.1
Hodgkins Disease	7	4.55	153.9		73.9	320.9
Leukemia & Aleukemia	53	51.71	102.5		78.4	134.0
Cancer of All Other Lymphopoietic Tissue	65	54.32	119.7		94.0	152.4
All Other Malignant Neoplasms	151	116.70	129.4	**	110.5	151.5
Benign Neoplasms	34	13.99	171.6	**	118.8	254.8
Diabetes Mellitus	85	89.56	94.9		76.9	117.2
Cerebrovascular Disease	448	394.33	113.1	**	103.4	123.7
All Heart Disease	2467	2469.77	99.9		96.9	103.0
Rheumatic Heart Disease	13	20.40	63.7		37.2	109.1
Ischemic Heart Disease	1823	2137.37	85.3	**	82.2	88.5
Chronic Endocard. Dis.; Other Myocard. Insuff.	128	119.10	107.5		90.6	127.5
Hypertension with Heart Disease	52	59.04	88.1		67.2	115.4
All Other Heart Disease	451	443.35	101.7		93.1	111.2
Hypertension w/o Heart Disease	22	16.41	134.1		88.5	203.2
Non-malignant Respiratory Disease	451	543.17	83.0	**	76.1	90.6
Influenza & Pneumonia	149	190.83	78.1	**	66.8	91.3
Bronchitis, Emphysema, Asthma	72	85.81	83.8		66.7	105.4
Bronchitis	10	15.04	66.5		36.0	122.9
Emphysema	53	66.54	79.7		61.0	104.0
Asthma	9	5.36	168.1		88.1	320.6
Other Non-malignant Respiratory Disease	230	278.78	82.2	**	72.5	93.2
Ulcer of Stomach & Duodenum	20	18.28	109.3		70.6	169.4
Cirrhosis of Liver	55	67.23	83.1	**	48.7	81.7
Nephritis & Nephrosis	82	33.71	243.2	**	197.4	299.7
All External Causes of Death	278	275.54	100.9		90.7	112.3
Accidents	184	172.47	106.7		93.0	122.4
Motor Vehicle Accidents	75	66.67	112.5		90.5	139.9
All Other Accidents	109	107.28	101.6		84.5	122.2
Suicides	71	70.78	100.3		79.9	126.0
Homicides & Other External Causes	23	32.28	71.2		48.1	105.6
All Other Causes of Death	645	621.26	103.8		96.5	111.7
Unknown Causes (In All Causes Category Only)	0					

* Significant at 5% Level; ** Significant at 1% Level

Table 7
Observed and Expected Deaths and Proportionate Mortality Ratios for Females

Cause of Death (ICDA 9th Revision Codes)	OBS	EXP	SPMR		95% Limits LOWER	UPPER
All Causes of Death	281	281.00	100.0		---	---
Tuberculosis	0	0.20	---		---	---
All Malignant Neoplasms	72	65.80	109.4		90.3	132.8
Cancer of Buccal Cavity & Pharynx	0	0.87	---		---	---
Cancer of Digestive Organs & Peritoneum	18	16.18	111.2		71.2	173.7
Cancer of Esophagus	0	0.65	---		---	---
Cancer of Stomach	2	1.64	122.2		30.8	485.3
Cancer of Large Intestine	10	7.44	134.4		73.2	246.9
Cancer of Rectum	1	1.22	81.8		11.6	575.7
Cancer of Biliary Passages & Liver	2	1.64	121.7		30.6	483.2
Cancer of Pancreas	3	3.53	84.9		27.7	260.7
Cancer of All Other Digestive Organs	0	0.55	---		---	---
Cancer of Respiratory System	11	12.36	89.0		50.3	157.2
Cancer of Larynx	0	0.22	---		---	---
Cancer of Bronchus, Trachea, Lung	11	12.00	91.8		51.8	162.1
Cancer of All Other Respiratory	0	0.14	---		---	---
Cancer of Breast	13	12.66	102.7		60.8	173.3
All Uterine Cancers (Females only)	4	3.23	123.8		46.9	326.6
Cancer of Cervix Uteri (Females only)	1	1.33	75.2		10.8	524.4
Cancer of Other Female Genital Organs	4	4.17	95.9		36.4	252.9
Cancer of Prostate (Males only)	0	0.00	---		---	---
Cancer of Testes and Other Male Genital Organs	0	0.00	---		---	---
Cancer of Kidney	0	1.10	---		---	---
Cancer of Bladder and Other Urinary Organs	0	0.83	---		---	---
Malignant Melanoma of Skin	0	0.68	---		---	---
Cancer of Eye	0	0.04	---		---	---
Cancer of Central Nervous System	3	1.46	205.4		68.2	618.7
Cancer of Thyroid & Other Endocrine Glands	0	0.26	---		---	---
Cancer of Bone	0	0.12	---		---	---
Cancer of All Lymphatic, Haematopoietic Tissue	5	5.84	102.8		46.8	226.4
Lymphosarcoma & Reticulosarcoma	0	0.70	---		---	---
Hodgkins Disease	0	0.23	---		---	---
Leukemia & Aleukemia	2	2.20	90.8		22.9	360.6
Cancer of All Other Lymphopoietic Tissue	4	2.70	147.8		58.2	388.4
All Other Malignant Neoplasms	13	5.41	240.2	**	142.7	404.2
Benign Neoplasms	5	0.83	600.5	**	278.8	1294.5
Diabetes Mellitus	7	5.86	119.5		57.5	248.3
Cerebrovascular Disease	20	23.93	83.6		55.2	128.4
All Heart Disease	88	97.80	90.0		78.8	105.8
Rheumatic Heart Disease	1	2.41	41.5		6.3	274.4
Ischemic Heart Disease	66	79.90	82.6		67.8	100.6
Chronic Endocard. Dis.; Other Myocard. Insuff.	6	6.04	99.4		45.2	218.8
Hypertension with Heart Disease	0	2.32	---		---	---
All Other Heart Disease	15	16.22	81.9		50.4	133.1
Hypertension w/o Heart Disease	1	0.82	121.8		17.3	858.8
Non-malignant Respiratory Disease	11	17.74	62.0		35.3	109.0
Influenza & Pneumonia	4	7.87	50.8		19.8	130.4
Bronchitis, Emphysema, Asthma	1	2.58	38.7		5.8	252.6
Bronchitis	0	0.48	---		---	---
Emphysema	1	1.58	63.4		9.2	438.2
Asthma	0	0.44	---		---	---
Other Non-malignant Respiratory Disease	6	7.84	76.6		34.9	167.8
Ulcer of Stomach & Duodenum	2	0.80	250.3		65.8	852.6
Cirrhosis of Liver	1	3.27	30.8		4.9	190.4
Nephritis & Nephrosis	3	1.38	217.8		72.5	654.7
All External Causes of Death	10	9.75	102.6		58.2	180.7
Accidents	7	6.64	105.3		52.0	213.4
Motor Vehicle Accidents	5	2.87	174.4		76.9	385.7
All Other Accidents	2	3.83	52.3		13.6	201.1
Suicides	3	1.77	169.6		56.5	508.7
Homicides & Other External Causes	0	1.34	---		---	---
All Other Causes of Death	41	30.34	135.1	*	101.5	178.8
Unknown Causes (In All Causes Category Only)	0					

* Significant at 5% Level; ** Significant at 1% Level

Table 8
Observed and Expected Deaths and Proportionate Mortality Ratios for Whites

Cause of Death (ICDA 8th Revision Codes)	OBS	EXP	SPMR		95% Limits LOWER	UPPER
All Causes of Death	5816	5816.00	100.0		---	---
Tuberculosis	3	5.96	50.3		16.6	152.5
All Malignant Neoplasms	1438	1407.45	102.2		97.7	108.8
Cancer of Buccal Cavity & Pharynx	13	29.89	43.5	**	25.7	73.6
Cancer of Digestive Organs & Peritoneum	340	344.43	98.7		89.1	109.4
Cancer of Esophagus	17	30.51	55.7	*	34.9	88.9
Cancer of Stomach	46	46.47	99.0		74.2	132.0
Cancer of Large Intestine	153	140.84	108.6		92.9	127.0
Cancer of Rectum	29	27.80	105.1		73.1	151.1
Cancer of Biliary Passages & Liver	22	30.89	71.2		47.0	107.8
Cancer of Pancreas	66	66.29	96.7		76.0	122.8
Cancer of All Other Digestive Organs	7	10.17	68.9		33.0	143.7
Cancer of Respiratory System	520	489.48	104.1		96.0	112.8
Cancer of Larynx	7	15.91	44.0	*	21.4	90.3
Cancer of Bronchus, Trachea, Lung	510	478.07	106.5		98.0	115.6
Cancer of All Other Respiratory	3	4.49	66.8		21.7	205.3
Cancer of Breast	13	13.67	95.1		56.2	160.8
All Uterine Cancers (Females only)	3	3.04	98.8		32.2	303.6
Cancer of Cervix Uteri (Females only)	0	1.19	---		---	---
Cancer of Other Female Genital Organs	4	4.09	97.8		37.1	257.7
Cancer of Prostate (Males only)	123	143.49	85.7		72.0	102.0
Cancer of Testes and Other Male Genital Organs	3	2.23	134.8		43.7	418.0
Cancer of Kidney	48	31.56	152.1	**	115.0	201.3
Cancer of Bladder and Other Urinary Organs	44	43.56	101.0		75.3	135.8
Malignant Melanoma of Skin	18	16.65	108.1		68.2	171.4
Cancer of Eye	1	0.77	129.9		18.4	917.0
Cancer of Central Nervous System	22	29.06	78.4		51.8	118.8
Cancer of Thyroid & Other Endocrine Glands	4	3.22	124.2		48.7	330.2
Cancer of Bone	3	2.31	130.0		42.1	401.8
Cancer of All Lymphatic, Haematopoietic Tissue	132	120.58	109.5		92.5	128.6
Lymphosarcoma & Reticulosarcoma	13	13.13	99.0		57.5	170.4
Hodgkins Disease	7	4.51	155.1		74.4	323.3
Leukemia & Aleukemia	50	50.68	98.7		74.9	130.0
Cancer of All Other Lymphopoietic Tissue	62	52.26	118.6		92.6	152.0
All Other Malignant Neoplasms	147	110.55	133.0	**	113.4	156.0
Benign Neoplasms	26	13.60	191.2	**	131.1	278.8
Diabetes Mellitus	73	84.63	86.3		68.7	108.3
Cerebrovascular Disease	422	373.12	113.1	**	103.2	124.0
All Heart Disease	2371	2371.79	100.0		96.8	103.1
Rheumatic Heart Disease	14	21.75	64.4		38.3	108.1
Ischemic Heart Disease	1777	2082.38	85.3	**	82.2	88.6
Chronic Endocard. Dis.; Other Myocard. Insuff.	128	113.88	112.4		94.7	133.4
Hypertension with Heart Disease	38	48.63	72.5		52.5	100.3
All Other Heart Disease	416	405.99	102.5		93.4	112.4
Hypertension w/o Heart Disease	20	14.42	138.7		89.7	214.4
Non-malignant Respiratory Disease	430	521.14	82.5	**	75.4	90.3
Influenza & Pneumonia	143	180.38	79.3	**	67.8	93.0
Bronchitis, Emphysema, Asthma	88	83.82	81.0		64.0	102.5
Bronchitis	10	14.87	67.2		36.3	124.3
Emphysema	50	65.12	76.8		58.3	101.1
Asthma	8	5.02	159.4		80.2	316.6
Other Non-malignant Respiratory Disease	219	289.47	81.3	**	71.4	92.4
Ulcer of Stomach & Duodenum	21	17.56	119.6		78.0	183.1
Cirrhosis of Liver	50	83.04	60.2	**	45.8	78.9
Nephritis & Nephrosis	75	29.89	251.0	**	201.8	312.1
All External Causes of Death	281	255.72	102.1		91.4	114.0
Accidents	174	160.96	108.1		93.2	124.5
Motor Vehicle Accidents	70	63.51	110.2		88.0	138.0
All Other Accidents	104	99.79	105.3		87.2	127.2
Suicides	70	70.11	99.8		78.4	125.6
Homicides & Other External Causes	17	24.65	69.0		43.4	109.5
All Other Causes of Death	626	583.52	107.3		99.6	115.5
Unknown Causes (In All Causes Category Only)	0					

* Significant at 5% Level; ** Significant at 1% Level

Table 9
Observed and Expected Deaths and Proportionate Mortality Ratios for Nonwhites

Cause of Death (ICDA 8th Revision Codes)	OBS	EXP	SPMR		95% Limits LOWER	UPPER
All Causes of Death	557	557.00	100.0		---	---
Tuberculosis	1	2.22	45.1		6.7	302.8
All Malignant Neoplasms	167	140.88	118.5	*	104.1	135.0
Cancer of Buccal Cavity & Pharynx	5	3.68	136.8		57.3	325.8
Cancer of Digestive Organs & Peritoneum	45	37.37	120.4		90.9	159.5
Cancer of Esophagus	2	6.34	31.6		8.6	116.0
Cancer of Stomach	13	7.41	175.5	*	103.0	289.1
Cancer of Large Intestine	13	11.15	116.6		68.1	189.6
Cancer of Rectum	1	2.11	47.5		7.0	321.2
Cancer of Biliary Passages & Liver	8	3.80	205.1	*	104.4	403.1
Cancer of Pancreas	8	6.81	117.4		59.0	233.8
Cancer of All Other Digestive Organs	0	0.79	---		---	---
Cancer of Respiratory System	48	46.27	103.7		78.3	135.7
Cancer of Larynx	0	1.98	---		---	---
Cancer of Bronchus, Trachea, Lung	48	43.80	109.3		83.5	143.1
Cancer of All Other Respiratory	0	0.38	---		---	---
Cancer of Breast	0	0.62	---		---	---
All Uterine Cancers (Females only)	1	0.18	513.2		90.6	2908.8
Cancer of Cervix Uteri (Females only)	1	0.14	687.7	*	132.1	3885.8
Cancer of Other Female Genital Organs	0	0.08	---		---	---
Cancer of Prostate (Males only)	24	24.48	98.0		66.4	144.7
Cancer of Testes and Other Male Genital Organs	0	0.24	---		---	---
Cancer of Kidney	5	1.96	254.5	*	109.5	591.9
Cancer of Bladder and Other Urinary Organs	4	2.76	145.0		54.9	383.2
Malignant Melanoma of Skin	1	0.23	435.8		72.5	2618.7
Cancer of Eye	0	0.02	---		---	---
Cancer of Central Nervous System	2	1.07	187.0		47.8	728.9
Cancer of Thyroid & Other Endocrine Glands	0	0.20	---		---	---
Cancer of Bone	0	0.19	---		---	---
Cancer of All Lymphatic, Haematopoietic Tissue	15	8.87	169.2	*	103.0	277.9
Lymphosarcoma & Reticulosarcoma	3	0.81	485.0	**	178.7	1371.1
Hodgkins Disease	0	0.26	---		---	---
Leukemia & Aleukemia	5	3.23	154.9		65.1	388.8
Cancer of All Other Lymphopoietic Tissue	7	4.77	146.8		70.5	305.5
All Other Malignant Neoplasms	17	11.58	147.1		92.2	234.7
Benign Neoplasms	3	1.22	245.3		82.2	732.1
Diabetes Mellitus	19	10.79	176.1	*	113.5	273.2
Cerebrovascular Disease	44	45.14	97.5		73.5	129.3
All Heart Disease	184	186.77	94.0		83.7	105.5
Rheumatic Heart Disease	0	1.07	---		---	---
Ischemic Heart Disease	112	134.92	83.0	*	70.7	97.4
Chronic Endocard. Dis.; Other Myocard. Insuff.	8	11.25	53.3		24.5	116.1
Hypertension with Heart Disease	18	12.72	125.8		77.6	203.9
All Other Heart Disease	50	55.68	89.8		69.1	116.8
Hypertension w/o Heart Disease	3	2.80	107.0		34.8	330.7
Non-malignant Respiratory Disease	32	39.77	80.5		57.7	112.2
Influenza & Pneumonia	10	18.32	54.6	*	30.0	99.3
Bronchitis, Emphysema, Asthma	5	4.57	109.3		45.7	261.5
Bronchitis	0	0.68	---		---	---
Emphysema	4	3.00	133.4		50.4	353.2
Asthma	1	0.78	128.8		18.3	808.1
Other Non-malignant Respiratory Disease	17	16.15	93.8		58.7	149.4
Ulcer of Stomach & Duodenum	1	1.52	65.6		9.4	457.6
Cirrhosis of Liver	5	7.45	80.5		36.6	176.8
Nephritis & Nephrosis	10	5.21	192.1	*	104.8	352.0
All External Causes of Death	27	28.57	81.3		64.8	128.7
Accidents	17	18.15	93.7		59.1	148.5
Motor Vehicle Accidents	10	8.02	166.0		90.8	303.3
All Other Accidents	7	12.31	56.9		27.7	116.8
Suicides	4	2.45	163.8		62.6	427.7
Homicides & Other External Causes	6	8.98	66.8		31.8	140.7
All Other Causes of Death	60	68.08	88.1		69.6	111.6
Unknown Causes (In All Causes Category Only)	0					

* Significant at 5% Level; ** Significant at 1% Level

investigated by race, the white population shows a similar mortality pattern to that observed for the total cohort (Table 8). For nonwhites, causes of death (Table 9) for which there were five observed or expected deaths and where there was a statistically significant excess were all malignant neoplasms (PMR=118.6, $p<0.05$), cancer of the stomach (PMR=175.5, $p<0.05$), cancer of the liver (PMR=205.1, $p<0.05$), cancer of the kidney (PMR=254.5, $p<0.05$), cancer of the lymphatic and haematopoietic tissue (PMR=169.2, $p<0.05$), diabetes mellitus (PMR=176.1, $p<0.05$), and nephritis and nephrosis (PMR=192.1, $p<0.05$).

B. Nonreduction Process

A total of 3596 employees worked in a plant that had no reduction process (Table 10). The overall PMR for these employees was 105.2. The only excess within the category of neoplasms was for "all other malignant neoplasms" where the PMR was 145.9 ($p<0.01$). Other causes of death showing a statistically significant excess were benign and unspecified neoplasms with a PMR of 227.3 ($p<0.01$), "all other heart disease" with a PMR of 117.2 ($p<0.01$), and "nephritis and nephrosis" with a PMR of 293.8 ($p<0.01$). Investigation separately for males and females indicated no causes of death other than those identified in excess for the total cohort. When we evaluated mortality patterns separately for race, in addition to the four causes of death in excess for the total group of nonreduction plant workers we found for whites a PMR of 122.8 ($p<0.05$) for cancer of the large intestine and a PMR of 135.4 ($p<0.01$) for chronic endocarditis and other myocardial insufficiency. For nonwhites, we found that

the excess of stomach cancer, liver cancer, lymphatic cancer and nephritis reported in the nonwhite population comprising the total cohort occurred in these nonreduction plants. The PMR for all malignancies for nonwhites in the nonreduction plants was 128.0 ($p<0.01$).

Of the 2777 workers in the 8 plants with a reduction process, 1320 spent the majority of their time in a nonreduction process. For this group of workers the PMR for all malignant neoplasms was 93.6. There were statistically significant excesses of cancer of the lymphatic and haematopoietic tissue (PMR=140.1, $p<0.05$), cerebrovascular disease (PMR=126.9, $p<0.05$), hypertension without heart disease (PMR=230.2, $p<0.05$) and nephritis and nephrosis (PMR=196.8, $p<0.01$). We also note the excess for asthma (PMR=331.0, $p<0.05$) based on only four observed deaths. There were only 56 females in this group of workers so the mortality pattern of the total group is essentially the same as that observed for males. For whites, the excesses were the same as that observed for the total group of 1320 workers. For nonwhites, excesses occurred in hypertension with heart disease (PMR=239.2, $p<0.05$) and "all other causes of death" (PMR=202.9, $p<0.01$).

Table 10
Observed and Expected Deaths and Proportionate Mortality Ratios for Nonreduction Plant Employees

Cause of Death (ICDA 9th Revision Codes)	OBS	EXP	SPMR		95% Limits LOWER	UPPER
All Causes of Death	3596	3596.00	100.0		---	---
Tuberculosis	3	4.62	65.0		21.2	199.5
All Malignant Neoplasms	906	861.09	105.2		99.5	111.3
Cancer of Buccal Cavity & Pharynx	11	18.19	60.5		33.8	108.3
Cancer of Digestive Organs & Peritoneum	225	213.51	105.4		92.9	119.6
Cancer of Esophagus	11	20.10	54.7	*	30.7	97.7
Cancer of Stomach	36	30.13	119.5		86.4	165.4
Cancer of Large Intestine	103	85.59	120.3		99.5	145.6
Cancer of Rectum	20	16.64	120.2		77.7	186.0
Cancer of Biliary Passages & Liver	17	19.49	87.2		54.3	140.0
Cancer of Pancreas	35	41.81	83.7		60.3	116.3
Cancer of All Other Digestive Organs	3	6.17	48.6		16.1	147.0
Cancer of Respiratory System	316	297.08	106.4		95.8	118.1
Cancer of Larynx	4	9.69	41.3		16.0	106.4
Cancer of Bronchus, Trachea, Lung	310	284.73	108.9		97.9	121.0
Cancer of All Other Respiratory	2	2.65	75.4		18.9	299.8
Cancer of Breast	9	10.45	86.1		45.8	161.8
All Uterine Cancers (Females only)	3	2.45	122.7		40.0	376.1
Cancer of Cervix Uteri (Females only)	0	0.98	---		---	---
Cancer of Other Female Genital Organs	2	3.16	63.3		16.3	246.3
Cancer of Prostate (Males only)	84	96.35	87.2		70.7	107.6
Cancer of Testes and Other Male Genital Organs	1	1.29	77.4		11.0	546.2
Cancer of Kidney	25	18.32	136.5		92.5	201.4
Cancer of Bladder and Other Urinary Organs	28	26.32	106.4		73.6	153.9
Malignant Melanoma of Skin	11	8.95	123.0		68.2	221.5
Cancer of Eye	1	0.44	229.1		34.1	1539.1
Cancer of Central Nervous System	14	15.51	90.3		53.6	152.1
Cancer of Thyroid & Other Endocrine Glands	4	1.89	211.7		81.3	551.4
Cancer of Bone	1	1.36	73.5		10.4	517.5
Cancer of All Lymphatic, Haematopoietic Tissue	72	71.84	100.2		79.7	126.0
Lymphosarcoma & Reticulosarcoma	6	7.54	79.6		35.9	176.7
Hodgkins Disease	2	2.51	79.8		20.0	317.7
Leukemia & Aleukemia	27	30.06	89.8		61.7	130.8
Cancer of All Other Lymphopoietic Tissue	37	31.74	116.6		84.6	160.6
All Other Malignant Neoplasms	99	67.83	145.9	**	120.2	177.2
Benign Neoplasms	19	8.36	227.3	**	146.9	351.8
Diabetes Mellitus	55	54.16	101.6		78.1	132.0
Cerebrovascular Disease	237	245.53	96.5		85.4	109.1
All Heart Disease	1477	1457.21	101.4		97.5	105.4
Rheumatic Heart Disease	8	12.85	62.2		31.4	123.5
Ischemic Heart Disease	1038	1254.88	82.7	**	78.8	86.8
Chronic Endocard. Dis.; Other Myocard. Insuff.	95	73.19	129.8	*	106.5	158.2
Hypertension with Heart Disease	28	35.66	78.5		54.4	113.4
All Other Heart Disease	308	262.71	117.2	**	105.3	130.5
Hypertension w/o Heart Disease	11	10.03	109.7		60.8	197.8
Non-malignant Respiratory Disease	258	322.34	80.0	**	71.3	89.9
Influenza & Pneumonia	85	117.33	72.4	**	58.9	89.1
Bronchitis, Emphysema, Asthma	40	49.83	80.3		59.1	109.1
Bronchitis	4	8.85	45.2		17.4	117.2
Emphysema	34	38.27	88.8		63.6	124.1
Asthma	2	3.25	61.5		15.6	242.6
Other Non-malignant Respiratory Disease	133	163.39	81.4	*	69.0	96.0
Ulcer of Stomach & Duodenum	13	10.91	119.1		69.3	204.8
Cirrhosis of Liver	30	47.45	63.2	*	44.5	89.8
Nephritis & Nephrosis	60	20.42	293.8	**	231.0	373.6
All External Causes of Death	140	147.02	95.2		81.7	111.0
Accidents	99	93.90	105.4		87.3	127.4
Motor Vehicle Accidents	43	34.82	123.5		92.6	164.8
All Other Accidents	56	59.93	93.4		72.2	120.9
Suicides	27	36.77	73.4		50.8	106.2
Homicides & Other External Causes	14	16.36	85.6		51.5	142.3
All Other Causes of Death	387	371.99	104.0		94.7	114.3
Unknown Causes (In All Causes Category Only)	0					

* Significant at 5% Level; ** Significant at 1% Level

Table 11
Observed and Expected Deaths and Proportionate Mortality Ratios for Employees in Reduction Plants Spending the Majority of Their Time in a Nonreduction Process

Cause of Death (ICDA 9th Revision Codes)	OBS	EXP	SPMR		95% Limits LOWER	UPPER
All Causes of Death	1320	1320.00	100.0		---	---
Tuberculosis	0	1.63	---		---	---
All Malignant Neoplasms	302	322.52	93.6		85.0	103.2
Cancer of Buccal Cavity & Pharynx	2	6.98	28.7		7.8	104.7
Cancer of Digestive Organs & Peritoneum	78	79.22	98.5		79.4	122.1
Cancer of Esophagus	1	7.56	13.2	*	2.5	69.3
Cancer of Stomach	15	11.09	135.2		81.9	223.4
Cancer of Large Intestine	30	31.64	94.8		66.6	135.0
Cancer of Rectum	6	6.20	96.8		43.6	215.1
Cancer of Biliary Passages & Liver	6	7.20	83.4		37.6	185.0
Cancer of Pancreas	18	15.64	115.1		72.8	182.1
Cancer of All Other Digestive Organs	2	2.28	87.8		22.0	350.4
Cancer of Respiratory System	91	114.28	79.6	*	65.6	96.7
Cancer of Larynx	2	3.73	53.6		13.7	209.3
Cancer of Bronchus, Trachea, Lung	89	109.53	81.3	*	66.7	98.9
Cancer of All Other Respiratory	0	1.02	---		---	---
Cancer of Breast	4	3.10	128.9		50.2	331.4
All Uterine Cancers (Females only)	1	0.71	140.9		20.4	974.6
Cancer of Cervix Uteri (Females only)	1	0.32	314.6		49.7	1991.8
Cancer of Other Female Genital Organs	1	0.90	110.7		15.9	768.0
Cancer of Prostate (Males only)	32	34.15	93.7		66.6	131.8
Cancer of Testes and Other Male Genital Organs	1	0.51	194.7		28.5	1332.3
Cancer of Kidney	11	7.05	156.1		87.0	280.0
Cancer of Bladder and Other Urinary Organs	10	9.61	104.1		56.2	193.0
Malignant Melanoma of Skin	3	3.59	83.5		27.0	257.8
Cancer of Eye	0	0.17	---		---	---
Cancer of Central Nervous System	3	6.21	48.3		16.0	145.6
Cancer of Thyroid & Other Endocrine Glands	0	0.72	---		---	---
Cancer of Bone	2	0.53	375.9	*	103.5	1364.5
Cancer of All Lymphatic, Haematopoietic Tissue	38	27.12	140.1	*	102.5	191.6
Lymphosarcoma & Reticulosarcoma	6	2.91	206.3		94.4	450.9
Hodgkins Disease	3	1.03	291.2		99.0	856.3
Leukemia & Aleukemia	13	11.31	115.0		66.9	197.4
Cancer of All Other Lymphopoietic Tissue	16	11.87	134.8		82.9	219.1
All Other Malignant Neoplasms	25	25.39	98.5		66.8	145.1
Benign Neoplasms	5	3.08	162.2		68.1	386.0
Diabetes Mellitus	15	19.66	76.3		46.2	125.9
Cerebrovascular Disease	108	85.13	126.9	*	105.9	152.0
All Heart Disease	531	530.71	100.1		93.7	106.8
Rheumatic Heart Disease	4	4.81	83.1		31.3	220.7
Ischemic Heart Disease	422	460.01	91.7	*	85.0	99.0
Chronic Endocard. Dis.; Other Myocard. Insuff.	18	25.51	70.6		44.8	111.2
Hypertension with Heart Disease	11	12.55	87.6		48.7	157.6
All Other Heart Disease	76	94.56	80.4	*	64.8	99.7
Hypertension w/o Heart Disease	8	3.48	230.2	*	117.5	450.8
Non-malignant Respiratory Disease	103	115.44	89.2		74.3	107.2
Influenza & Pneumonia	39	40.23	96.9		71.3	131.8
Bronchitis, Emphysema, Asthma	17	18.47	92.1		57.4	147.5
Bronchitis	4	3.23	123.8		46.6	328.9
Emphysema	9	14.23	63.3		33.2	120.4
Asthma	4	1.21	331.0	*	131.4	833.2
Other Non-malignant Respiratory Disease	47	59.55	78.9		59.8	104.2
Ulcer of Stomach & Duodenum	3	3.93	76.3		24.7	235.3
Cirrhosis of Liver	15	19.05	78.7		47.8	129.6
Nephritis & Nephrosis	14	7.11	196.8	**	117.9	328.6
All External Causes of Death	66	61.82	106.8		86.0	132.6
Accidents	44	38.34	114.8		86.8	151.8
Motor Vehicle Accidents	19	15.37	123.7		80.5	190.0
All Other Accidents	25	23.28	107.4		73.1	157.8
Suicides	21	15.70	133.8		88.1	203.0
Homicides & Other External Causes	1	7.79	12.8	*	2.7	61.7
All Other Causes of Death	150	133.99	111.9		96.2	130.2
Unknown Causes (In All Causes Category Only)	0					

* Significant at 5% Level; ** Significant at 1% Level

C. Mortality for the Reduction Process

There were 1866 workers who had some employment in the reduction process. The overall PMR for cancer was 106.6 which was not statistically significant (Table 12). The PMR for lung cancer was 117.8 with a corresponding 95% confidence interval of (103.1, 134.5). Cancer of the kidney was also elevated with a PMR of 200.1 and a corresponding 95% confidence interval of (131.7, 303.8). The only nonmalignant cause of death with a statistically significant excess was cerebral vascular disease with a PMR of 135.3 and a corresponding 95% confidence interval of (116.0, 157.7). The PMR for the category ischemic heart disease was low [PMR=87.2 with corresponding confidence interval of (81.6, 93.2)]. Since only 6 women were employed in the reduction process, the mortality patterns in Table 12 are essentially the same for males. When analysis was done by race, some additional causes were in excess. For whites, in addition to respiratory and kidney cancer, there was an excess in cancer of the lymphatic and haematopoietic tissue (PMR=132.2, $p<0.05$). For nonwhites, the only excess was for diabetes where the PMR was 389.5 ($p<0.01$).

When the 62 causes of death were re-evaluated for men spending the majority of their time in the reduction process, the mortality patterns were similar to those "ever employed in the reduction process" but tended to be slightly increased for many of the malignancies (Table 13). The PMR for the category all malignant neoplasms increased from 106.6 to 109.5 ($p<0.05$). Similarly, the PMRs for cancer of the lung and kidney were

Table 12

Observed and Expected Deaths and Proportionate Mortality Ratios for Employees Ever Employed in a Reduction Process

Cause of Death (ICDA 9th Revision Codes)	OBS	EXP	SPMR		95% Limits LOWER	UPPER
All Causes of Death	1886	1886.00	100.0		---	---
Tuberculosis	1	2.48	40.3		6.1	267.2
All Malignant Neoplasms	488	468.17	106.8		88.9	114.9
Cancer of Buccal Cavity & Pharynx	6	10.80	55.6		25.3	121.9
Cancer of Digestive Organs & Peritoneum	105	114.26	91.8		76.4	110.6
Cancer of Esophagus	7	11.86	59.0		28.5	122.4
Cancer of Stomach	13	16.25	80.0		46.6	137.3
Cancer of Large Intestine	39	44.50	87.6		64.3	119.5
Cancer of Rectum	5	8.81	56.8		24.0	134.5
Cancer of Biliary Passages & Liver	9	10.39	86.7		45.2	166.1
Cancer of Pancreas	29	22.68	127.9		88.2	183.4
Cancer of All Other Digestive Organs	3	3.21	93.5		30.2	289.5
Cancer of Respiratory System	197	172.88	114.0		98.9	130.0
Cancer of Larynx	1	5.76	17.4	*	3.1	97.8
Cancer of Bronchus, Trachea, Lung	195	165.57	117.8	*	103.1	134.5
Cancer of All Other Respiratory	1	1.54	64.8		9.3	452.4
Cancer of Breast	0	1.00	---		---	---
All Uterine Cancers (Females only)	0	0.11	---		---	---
Cancer of Cervix Uteri (Females only)	0	0.05	---		---	---
Cancer of Other Female Genital Organs	1	0.16	643.6	*	120.0	3450.7
Cancer of Prostate (Males only)	39	47.88	81.8		60.1	111.3
Cancer of Testes and Other Male Genital Organs	2	0.83	240.0		62.7	818.1
Cancer of Kidney	21	10.50	200.1	**	131.7	303.8
Cancer of Bladder and Other Urinary Organs	14	13.26	105.6		62.7	177.8
Malignant Melanoma of Skin	7	5.58	125.2		59.9	261.7
Cancer of Eye	0	0.24	---		---	---
Cancer of Central Nervous System	8	9.56	83.7		42.0	166.7
Cancer of Thyroid & Other Endocrine Glands	0	1.04	---		---	---
Cancer of Bone	2	0.78	256.7		67.5	976.1
Cancer of All Lymphatic, Haematopoietic Tissue	50	38.07	128.0		97.4	168.2
Lymphosarcoma & Reticulosarcoma	5	4.22	118.5		49.4	284.0
Hodgkins Disease	3	1.59	188.8		62.2	574.3
Leukemia & Aleukemia	20	16.05	124.6		80.8	192.8
Cancer of All Other Lymphopoietic Tissue	22	17.21	127.9		84.4	193.6
All Other Malignant Neoplasms	47	37.12	126.6		95.5	167.9
Benign Neoplasms	5	4.33	115.5		48.1	278.9
Diabetes Mellitus	28	27.65	101.3		70.1	146.3
Cerebrovascular Disease	151	111.84	135.3	**	116.0	157.7
All Heart Disease	710	742.22	95.7		90.4	101.2
Rheumatic Heart Disease	3	6.82	45.3		15.1	136.2
Ischaemic Heart Disease	561	643.10	87.2	**	81.6	93.2
Chronic Endocard. Dis.; Other Myocard. Insuff.	25	33.78	74.1		50.3	109.0
Hypertension with Heart Disease	17	18.13	93.8		58.5	150.4
All Other Heart Disease	104	133.89	77.7	**	64.6	93.4
Hypertension w/o Heart Disease	6	4.78	126.1		56.8	279.8
Non-malignant Respiratory Disease	126	156.66	80.3	**	68.0	94.8
Influenza & Pneumonia	42	52.52	80.0		59.5	107.5
Bronchitis, Emphysema, Asthma	22	25.71	85.6		56.5	129.5
Bronchitis	3	4.39	68.4		22.2	210.2
Emphysema	16	19.88	80.6		48.5	131.0
Asthma	3	1.72	174.7		57.2	533.7
Other Non-malignant Respiratory Disease	62	82.30	75.3	*	59.1	96.0
Ulcer of Stomach & Duodenum	7	5.42	129.2		61.8	270.1
Cirrhosis of Liver	15	31.06	48.3	**	29.6	78.7
Nephritis & Nephrosis	15	9.66	155.3		94.1	256.1
All External Causes of Death	105	98.28	106.8		90.0	126.8
Accidents	67	59.94	111.8		89.1	140.1
Motor Vehicle Accidents	25	24.64	101.4		69.6	147.8
All Other Accidents	42	35.77	117.4		87.3	157.9
Suicides	30	25.77	116.4		82.1	165.0
Homicides & Other External Causes	8	12.57	63.8		32.8	123.5
All Other Causes of Death	198	188.30	108.3		93.1	121.3
Unknown Causes (In All Causes Category Only)	0					

* Significant at 5% Level; ** Significant at 1% Level

Table 13
Observed and Expected Deaths and Proportionate Mortality Ratios for Employees Spending a Majority of Time in a Reduction Process

Cause of Death (ICDA 8th Revision Codes)	OBS	EXP	SPMR		95% Limits LOWER	UPPER
All Causes of Death	1449	1448.00	100.0		---	---
Tuberculosis	1	1.83	51.9		7.6	355.1
All Malignant Neoplasms	397	362.63	109.5	*	100.6	119.1
Cancer of Buccal Cavity & Pharynx	5	8.34	60.0		25.3	142.2
Cancer of Digestive Organs & Peritoneum	82	88.56	92.6		75.1	114.2
Cancer of Esophagus	7	9.15	76.5		36.7	159.8
Cancer of Stomach	8	12.58	63.5		32.1	125.8
Cancer of Large Intestine	33	34.55	95.5		68.2	133.8
Cancer of Rectum	4	6.83	58.6		22.3	153.9
Cancer of Biliary Passages & Liver	7	8.06	86.9		41.5	181.8
Cancer of Pancreas	21	17.85	118.6		78.3	182.9
Cancer of All Other Digestive Organs	2	2.49	80.3		20.2	320.0
Cancer of Respiratory System	161	133.58	120.5	*	104.2	139.4
Cancer of Larynx	1	4.45	22.5		3.8	134.2
Cancer of Bronchus, Trachea, Lung	158	127.95	124.3	**	107.3	144.0
Cancer of All Other Respiratory	1	1.20	83.7		11.8	591.9
Cancer of Breast	0	0.73	---		---	---
All Uterine Cancers (Females only)	0	0.08	---		---	---
Cancer of Cervix Uteri (Females only)	0	0.04	---		---	---
Cancer of Other Female Genital Organs	1	0.11	948.9	**	195.9	4587.1
Cancer of Prostate (Males only)	31	37.27	83.2		58.8	117.5
Cancer of Testes and Other Male Genital Organs	1	0.65	153.1		21.8	1068.9
Cancer of Kidney	17	8.11	209.7	**	132.0	333.3
Cancer of Bladder and Other Urinary Organs	10	10.34	96.7		52.2	178.3
Malignant Melanoma of Skin	5	4.31	115.8		48.4	277.7
Cancer of Eye	0	0.18	---		---	---
Cancer of Central Nervous System	7	7.38	95.1		45.5	199.0
Cancer of Thyroid & Other Endocrine Glands	0	0.81	---		---	---
Cancer of Bone	0	0.60	---		---	---
Cancer of All Lymphatic, Haematopoietic Tissue	37	30.31	122.1		86.8	167.8
Lymphosarcoma & Reticulosarcoma	4	3.27	122.2		46.0	324.8
Hodgkins Disease	2	1.23	162.2		41.2	638.1
Leukemia & Aleukemia	15	12.47	120.3		72.7	189.8
Cancer of All Other Lymphopoietic Tissue	16	13.33	120.0		73.7	185.3
All Other Malignant Neoplasms	40	28.72	139.3	*	102.6	189.0
Benign Neoplasms	5	3.36	148.7		62.3	354.8
Diabetes Mellitus	22	21.48	102.4		67.7	155.1
Cerebrovascular Disease	121	87.15	138.8	**	117.0	164.7
All Heart Disease	545	576.37	94.6		86.8	100.9
Rheumatic Heart Disease	2	5.12	38.1		10.3	148.3
Ischemic Heart Disease	428	488.52	85.7	**	78.4	92.4
Chronic Endocard. Dis.; Other Myocard. Insuff.	20	26.28	76.1		48.4	117.2
Hypertension with Heart Disease	13	14.07	92.4		53.8	158.6
All Other Heart Disease	82	103.83	78.0	*	64.2	97.2
Hypertension w/o Heart Disease	4	3.70	108.0		40.6	287.2
Non-malignant Respiratory Disease	99	122.38	80.9	*	67.1	97.6
Influenza & Pneumonia	28	40.89	68.5	*	47.7	98.3
Bronchitis, Emphysema, Asthma	16	20.08	79.7		49.1	128.5
Bronchitis	2	3.43	58.3		14.8	228.0
Emphysema	11	15.52	70.9		38.5	127.1
Asthma	3	1.33	225.5		75.0	677.7
Other Non-malignant Respiratory Disease	55	64.27	85.6		66.1	110.7
Ulcer of Stomach & Duodenum	6	4.22	142.2		64.2	314.8
Cirrhosis of Liver	11	23.88	46.1	**	26.1	81.3
Nephritis & Nephrosis	11	7.51	146.4		81.5	262.9
All External Causes of Death	82	78.20	107.6		86.7	130.6
Accidents	48	46.72	102.7		76.7	134.1
Motor Vehicle Accidents	18	18.30	83.3		59.9	145.1
All Other Accidents	30	27.78	108.0		76.1	153.3
Suicides	26	20.01	129.9		89.4	188.8
Homicides & Other External Causes	8	9.46	84.5		43.1	165.8
All Other Causes of Death	145	144.85	100.1		85.9	118.8
Unknown Causes (In All Causes Category Only)	0					

* Significant at 5% Level; ** Significant at 1% Level

increased slightly (PMR=124.3 and 209.7, respectively). The remainder category "all other malignant neoplasms" is also significant with a PMR of 139.3 ($p<0.05$).

Since the primary departments of interest in the Tripartite Study were the potroom and carbon departments, we investigated mortality patterns separately for these two departments. There were 943 employees with some experience in the potroom department. The PMR for all malignancies was 106.8 with a corresponding 95% confidence interval of (96.1, 118.6) (Table 14). The PMR for cancer of the lung was 111.9 with a corresponding confidence interval of (92.6, 135.2). The only malignancy with five or more observed deaths and a statistically significant elevation was kidney cancer with a PMR of 297.9 and a corresponding 95% confidence interval of (187.1, 474.2). There was also an excess of ulcer of the stomach and duodenum based on six observed deaths and 2.69 expected (PMR=223.0, $p<0.05$). For employees with a majority of time in the potroom the PMR for all malignant neoplasms was 114.8 with a corresponding 95% confidence interval of (100.7, 130.9) (Table 15). Of those causes with more than 5 observed or expected deaths, cancer of the kidney and ulcer of the stomach were elevated (PMR=285.8, $p<0.01$ and PMR=317.2, $p<0.05$, respectively). Ischemic heart disease was significantly low (PMR=80.6, $p<0.01$).

The carbon department had fewer workers than the potroom department. For the 489 employees with some employment in the carbon department, the PMR for all malignancies was 105.8 (Table 16). Both cancer of the kidney (PMR=250.7, $p<0.01$) and

Table 14
Observed and Expected Deaths and Proportionate Mortality Ratios for Employees Ever Employed in the Potroom Department

Cause of Death (ICDA 8th Revision Codes)	OBS	EXP	SPMR		95% Limits LOWER	UPPER
All Causes of Death	943	943.00	100.0		---	---
Tuberculosis	0	1.34	---		---	---
All Malignant Neoplasms	256	239.81	106.8		94.1	118.6
Cancer of Buccal Cavity & Pharynx	5	5.67	88.2		36.9	211.1
Cancer of Digestive Organs & Peritoneum	51	58.46	87.2		66.9	113.7
Cancer of Esophagus	4	6.36	62.9		23.9	165.5
Cancer of Stomach	7	8.41	83.2		39.9	173.8
Cancer of Large Intestine	17	22.42	75.8		47.5	121.1
Cancer of Rectum	3	4.44	67.5		22.0	207.3
Cancer of Biliary Passages & Liver	6	5.35	112.2		50.5	249.0
Cancer of Pancreas	12	11.63	103.2		58.6	181.1
Cancer of All Other Digestive Organs	2	1.61	123.9		31.1	493.6
Cancer of Respiratory System	97	89.62	108.2		89.7	130.6
Cancer of Larynx	1	3.02	33.1		5.2	212.5
Cancer of Bronchus, Trachea, Lung	96	85.80	111.9		92.6	135.2
Cancer of All Other Respiratory	0	0.80	---		---	---
Cancer of Breast	0	0.28	---		---	---
All Uterine Cancers (Females only)	0	0.00	---		---	---
Cancer of Cervix Uteri (Females only)	0	0.00	---		---	---
Cancer of Other Female Genital Organs	0	0.00	---		---	---
Cancer of Prostate (Males only)	24	23.91	100.4		67.7	148.8
Cancer of Testes and Other Male Genital Organs	2	0.45	441.4	*	124.5	1584.5
Cancer of Kidney	16	5.37	297.9	**	187.1	474.2
Cancer of Bladder and Other Urinary Organs	6	6.51	92.2		41.6	204.6
Malignant Melanoma of Skin	3	2.88	104.2		33.7	322.1
Cancer of Eye	0	0.12	---		---	---
Cancer of Central Nervous System	1	4.87	20.1		3.5	116.9
Cancer of Thyroid & Other Endocrine Glands	0	0.54	---		---	---
Cancer of Bone	2	0.41	493.7	*	141.6	1720.8
Cancer of All Lymphatic, Haematopoietic Tissue	27	19.88	135.9		93.7	187.1
Lymphosarcoma & Reticulosarcoma	1	2.18	46.6		6.8	314.7
Hodgkins Disease	3	0.84	355.5	*	123.4	1024.2
Leukemia & Aleukemia	11	8.08	136.1		75.7	244.5
Cancer of All Other Lymphopoietic Tissue	12	8.79	136.5		77.9	239.2
All Other Malignant Neoplasms	22	19.09	115.2		76.2	174.2
Benign Neoplasms	0	2.18	---		---	---
Diabetes Mellitus	12	14.11	85.1		48.8	149.1
Cerebrovascular Disease	68	54.84	124.0		98.8	155.9
All Heart Disease	384	370.47	98.3		90.7	106.4
Rheumatic Heart Disease	2	3.34	60.0		15.3	235.8
Ischemic Heart Disease	278	319.30	87.1	**	78.2	95.7
Chronic Endocard. Dis.; Other Myocard. Insuff.	14	16.48	84.9		50.6	142.5
Hypertension with Heart Disease	10	9.55	104.7		56.6	183.8
All Other Heart Disease	80	81.15	98.0		89.0	112.3
Hypertension w/o Heart Disease	2	2.42	82.7		20.8	328.4
Non-malignant Respiratory Disease	68	76.81	88.5		70.8	111.0
Influenza & Pneumonia	20	25.28	79.1		51.5	121.5
Bronchitis, Emphysema, Asthma	13	12.71	102.2		59.8	176.4
Bronchitis	0	2.14	---		---	---
Emphysema	11	9.78	112.3		62.4	202.0
Asthma	2	0.89	223.7		58.1	881.6
Other Non-malignant Respiratory Disease	35	40.59	86.2		62.4	118.1
Ulcer of Stomach & Duodenum	6	2.69	223.0	*	102.4	485.5
Cirrhosis of Liver	7	16.45	42.5	*	20.9	86.4
Nephritis & Nephrosis	7	4.85	144.2		69.2	300.6
All External Causes of Death	54	54.64	98.8		78.2	124.8
Accidents	34	32.91	103.3		75.4	141.5
Motor Vehicle Accidents	13	13.99	92.9		55.4	156.0
All Other Accidents	21	18.18	109.8		72.2	166.4
Suicides	14	13.89	100.1		60.1	166.6
Homicides & Other External Causes	6	7.74	77.5		36.2	166.0
All Other Causes of Death	89	83.78	106.6		87.6	127.2
Unknown Causes (In All Causes Category Only)	0					

* Significant at 5% Level; ** Significant at 1% Level

Table 15
Observed and Expected Deaths and Proportionate Mortality Ratios for Employees Spending a Majority of Time in the Potroom Department

Cause of Death (ICDA 8th Revision Codes)	OBS	EXP	SPMR		95% Limits LOWER	UPPER
All Causes of Death	556	556.00	100.0		---	---
Tuberculosis	0	0.82	---		---	---
All Malignant Neoplasms	163	141.88	114.8	*	100.7	130.9
Cancer of Buccal Cavity & Pharynx	4	3.35	119.5		45.1	316.8
Cancer of Digestive Organs & Peritoneum	33	34.63	95.3		68.5	132.5
Cancer of Esophagus	3	3.82	78.6		25.6	241.8
Cancer of Stomach	5	5.03	99.4		41.5	237.7
Cancer of Large Intestine	13	13.21	98.4		57.5	168.4
Cancer of Rectum	1	2.60	38.4		5.8	252.2
Cancer of Biliary Passages & Liver	4	3.18	125.7		47.4	333.2
Cancer of Pancreas	6	6.88	87.2		39.4	182.9
Cancer of All Other Digestive Organs	1	0.95	105.7		14.9	748.9
Cancer of Respiratory System	62	53.04	116.9		92.4	147.8
Cancer of Larynx	0	1.79	---		---	---
Cancer of Bronchus, Trachea, Lung	62	50.77	122.1		96.5	154.5
Cancer of All Other Respiratory	0	0.47	---		---	---
Cancer of Breast	0	0.16	---		---	---
All Uterine Cancers (Females only)	0	0.00	---		---	---
Cancer of Cervix Uteri (Females only)	0	0.00	---		---	---
Cancer of Other Female Genital Organs	0	0.00	---		---	---
Cancer of Prostate (Males only)	17	14.32	118.7		74.4	189.3
Cancer of Testes and Other Male Genital Organs	1	0.28	359.2		57.6	2241.7
Cancer of Kidney	9	3.15	285.8	**	153.4	532.5
Cancer of Bladder and Other Urinary Organs	2	3.80	52.6		13.5	204.5
Malignant Melanoma of Skin	2	1.68	119.2		30.0	474.3
Cancer of Eye	0	0.07	---		---	---
Cancer of Central Nervous System	2	2.91	68.7		17.4	271.1
Cancer of Thyroid & Other Endocrine Glands	0	0.32	---		---	---
Cancer of Bone	0	0.24	---		---	---
Cancer of All Lymphatic, Haematopoietic Tissue	17	11.73	144.9		90.8	231.3
Lymphosarcoma & Reticulosarcoma	1	1.26	79.5		11.3	560.6
Hodgkins Disease	2	0.50	398.8	*	110.3	1428.6
Leukemia & Aleukemia	8	4.75	168.3		85.1	333.0
Cancer of All Other Lymphopoietic Tissue	6	5.22	115.0		51.9	254.9
All Other Malignant Neoplasms	14	11.31	123.8		73.8	207.7
Benign Neoplasms	0	1.29	---		---	---
Diabetes Mellitus	8	8.39	95.3		47.9	188.6
Cerebrovascular Disease	41	32.26	127.1		94.6	170.7
All Heart Disease	202	218.80	93.2		83.7	103.7
Rheumatic Heart Disease	2	1.94	103.0		25.8	410.6
Ischemic Heart Disease	150	186.07	80.6	**	70.9	91.7
Chronic Endocard. Dis.; Other Myocard. Insuff.	7	9.63	72.7		35.0	150.9
Hypertension with Heart Disease	7	5.78	121.1		58.1	252.5
All Other Heart Disease	36	40.39	88.1		65.1	122.0
Hypertension w/o Heart Disease	1	1.44	69.3		9.9	485.1
Non-malignant Respiratory Disease	41	44.95	91.2		68.1	122.1
Influenza & Pneumonia	10	14.66	68.2		37.2	124.9
Bronchitis, Emphysema, Asthma	8	7.47	107.2		53.9	213.1
Bronchitis	0	1.24	---		---	---
Emphysema	8	5.75	104.4		47.1	231.2
Asthma	2	0.53	374.4	*	103.1	1359.3
Other Non-malignant Respiratory Disease	23	23.85	96.5		64.7	143.7
Ulcer of Stomach & Duodenum	5	1.58	317.2	**	138.5	726.4
Cirrhosis of Liver	5	9.62	52.0		22.2	121.5
Nephritis & Nephrosis	5	2.88	173.4		73.2	410.8
All External Causes of Death	34	33.36	101.9		76.2	136.3
Accidents	17	20.30	83.7		54.0	129.9
Motor Vehicle Accidents	7	8.88	78.8		38.3	158.1
All Other Accidents	10	11.58	86.5		47.3	158.2
Suicides	11	8.51	129.3		73.0	228.0
Homicides & Other External Causes	6	4.55	132.0		61.0	285.5
All Other Causes of Death	51	55.58	91.8		70.8	119.0
Unknown Causes (In All Causes Category Only)	0					

* Significant at 5% Level; ** Significant at 1% Level

cerebrovascular disease (PMR=136.2, $p<0.05$) were significantly elevated. There were only 140 men spending the majority of their time in the carbon department (Table 17). Thus the statistical power to a true excess is limited. The only cause of death with a statistically significant excess is cerebrovascular disease with a PMR of 195.3 and corresponding 95% confidence interval of (124.6, 306.3).

The PMRs were also computed for the employees spending the majority of their time in mechanical maintenance, electrical maintenance, ingot and power. For most of these departments the number of employees was not sufficient to evaluate many of the specific cancer sites. Table 18 summarizes the observed and expected deaths and PMRs for all malignant neoplasms for employees with the majority of their time in each of the departments in the reduction plant. Those workers with the majority of time in the potrooms show an elevated PMR of 114.8 ($p<0.05$). The site-specific PMRs for cancer have already been discussed for the potroom and carbon departments. For the other four departments the only significant excess was for lung cancer in mechanical maintenance. The PMR was 138.3 with a corresponding 95% confidence interval of (107.2, 176.4).

Table 16
Observed and Expected Deaths and Proportionate Mortality Ratios for Employees Ever Employed in the Carbon Department

Cause of Death (ICDA 9th Revision Codes)	OBS	EXP	SPMR	95% Limits LOWER	UPPER
All Causes of Death	489	489.00	100.0	---	---
Tuberculosis	0	0.78	---	---	---
All Malignant Neoplasms	133	125.72	105.8	91.5	122.3
Cancer of Buccal Cavity & Pharynx	2	3.08	65.4	16.6	257.2
Cancer of Digestive Organs & Peritoneum	27	30.64	88.1	61.2	126.8
Cancer of Esophagus	1	3.59	27.9	4.5	172.7
Cancer of Stomach	5	4.52	110.7	46.3	264.8
Cancer of Large Intestine	10	11.44	87.4	47.4	161.1
Cancer of Rectum	1	2.26	44.3	6.6	296.6
Cancer of Biliary Passages & Liver	3	2.84	105.7	34.2	326.4
Cancer of Pancreas	6	6.09	98.5	44.5	218.1
Cancer of All Other Digestive Organs	1	0.82	121.4	17.2	857.5
Cancer of Respiratory System	51	47.16	108.1	83.5	140.1
Cancer of Larynx	0	1.62	---	---	---
Cancer of Bronchus, Trachea, Lung	51	45.12	113.0	87.2	146.5
Cancer of All Other Respiratory	0	0.42	---	---	---
Cancer of Breast	0	0.14	---	---	---
All Uterine Cancers (Females only)	0	0.00	---	---	---
Cancer of Cervix Uteri (Females only)	0	0.00	---	---	---
Cancer of Other Female Genital Organs	0	0.00	---	---	---
Cancer of Prostate (Males only)	12	12.34	97.2	55.8	169.5
Cancer of Testes and Other Male Genital Organs	1	0.26	389.4	63.4	2392.3
Cancer of Kidney	7	2.79	250.7 *	122.9	511.5
Cancer of Bladder and Other Urinary Organs	3	3.19	94.1	30.5	290.6
Malignant Melanoma of Skin	2	1.55	128.9	32.5	511.5
Cancer of Eye	0	0.06	---	---	---
Cancer of Central Nervous System	0	2.65	---	---	---
Cancer of Thyroid & Other Endocrine Glands	0	0.28	---	---	---
Cancer of Bone	1	0.22	456.9	76.6	2717.1
Cancer of All Lymphatic, Haematopoietic Tissue	12	10.37	115.7	66.2	202.4
Lymphosarcoma & Reticulosarcoma	1	1.10	91.2	12.9	645.4
Hodgkins Disease	1	0.47	213.5	31.6	1444.0
Leukemia & Aleukemia	3	4.15	72.2	23.5	221.8
Cancer of All Other Lymphopoietic Tissue	7	4.65	150.5	72.4	313.0
All Other Malignant Neoplasms	15	10.12	148.2	90.1	243.7
Benign Neoplasms	1	1.14	87.9	12.4	621.6
Diabetes Mellitus	11	7.52	146.2	81.6	261.8
Cerebrovascular Disease	38	27.90	136.2 *	100.3	184.9
All Heart Disease	190	187.93	101.1	90.5	112.9
Rheumatic Heart Disease	1	1.70	58.8	8.5	407.6
Ischemic Heart Disease	149	159.73	93.3	81.9	106.3
Chronic Endocard. Dis.; Other Myocard. Insuff.	10	8.25	121.2	65.7	223.7
Hypertension with Heart Disease	3	5.37	55.9	18.5	169.1
All Other Heart Disease	27	36.11	74.8	52.1	107.3
Hypertension w/o Heart Disease	1	1.29	77.2	11.0	543.6
Non-malignant Respiratory Disease	25	38.08	65.6 *	45.3	95.2
Influenza & Pneumonia	8	12.61	71.4	37.7	135.2
Bronchitis, Emphysema, Asthma	3	6.26	47.9	16.0	143.8
Bronchitis	0	1.03	---	---	---
Emphysema	1	4.77	20.9	3.6	122.2
Asthma	2	0.49	407.2 *	113.5	1461.2
Other Non-malignant Respiratory Disease	13	20.10	64.7	38.2	109.5
Ulcer of Stomach & Duodenum	1	1.36	73.3	10.4	515.1
Cirrhosis of Liver	7	9.17	76.4	36.9	158.1
Nephritis & Nephrosis	4	2.55	157.1	59.6	413.8
All External Causes of Death	31	31.90	97.2	71.6	131.9
Accidents	17	19.10	89.0	57.2	138.5
Motor Vehicle Accidents	6	8.35	71.9	33.7	153.1
All Other Accidents	11	10.89	101.1	56.8	179.8
Suicides	12	8.03	149.5	96.7	257.8
Homicides & Other External Causes	2	4.77	41.9	11.5	152.3
All Other Causes of Death	47	49.22	85.5	72.8	125.1
Unknown Causes (In All Causes Category Only)	0				

* Significant at 5% Level; ** Significant at 1% Level

Table 17
Observed and Expected Deaths and Proportionate Mortality Ratios for Employees Spending a Majority of Time in the Carbon Department

Cause of Death (ICDA 9th Revision Codes)	OBS	EXP	SPMR		95% Limits LOWER	UPPER
All Causes of Death	140	140.00	100.0		---	---
Tuberculosis	0	0.25	---		---	---
All Malignant Neoplasms	38	35.48	107.1		81.5	140.7
Cancer of Buccal Cavity & Pharynx	0	0.86	---		---	---
Cancer of Digestive Organs & Peritoneum	8	8.78	91.2		46.7	178.1
Cancer of Esophagus	1	1.04	96.0		13.7	674.5
Cancer of Stomach	0	1.31	---		---	---
Cancer of Large Intastine	3	3.28	91.6		29.9	279.9
Cancer of Rectum	1	0.84	156.0		22.4	1084.9
Cancer of Biliary Passages & Liver	0	0.82	---		---	---
Cancer of Pancreas	3	1.71	175.0		57.7	530.9
Cancer of All Other Digestive Organs	0	0.23	---		---	---
Cancer of Respiratory System	16	13.01	123.0		77.4	195.4
Cancer of Larynx	0	0.45	---		---	---
Cancer of Bronchus, Trachea, Lung	16	12.44	128.6		80.9	204.5
Cancer of All Other Respiratory	0	0.11	---		---	---
Cancer of Breast	0	0.04	---		---	---
All Uterine Cancers (Females only)	0	0.00	---		---	---
Cancer of Cervix Uteri (Females only)	0	0.00	---		---	---
Cancer of Other Female Genital Organs	0	0.00	---		---	---
Cancer of Prostate (Males only)	3	3.90	76.9		25.4	233.0
Cancer of Testes and Other Male Genital Organs	0	0.06	---		---	---
Cancer of Kidney	2	0.75	265.2		70.3	1001.3
Cancer of Bladder and Other Urinary Organs	1	0.95	105.5		15.0	743.4
Malignant Melanoma of Skin	0	0.37	---		---	---
Cancer of Eye	0	0.02	---		---	---
Cancer of Central Nervous System	0	0.66	---		---	---
Cancer of Thyroid & Other Endocrine Glands	0	0.08	---		---	---
Cancer of Bone	0	0.06	---		---	---
Cancer of All Lymphatic, Haematopoietic Tissue	3	2.86	105.0		34.3	321.5
Lymphosarcoma & Reticulosarcoma	0	0.29	---		---	---
Hodgkins Disease	0	0.11	---		---	---
Leukemia & Aleukemia	1	1.15	86.7		12.3	609.6
Cancer of All Other Lymphopoietic Tissue	2	1.30	153.7		39.1	604.1
All Other Malignant Neoplasms	5	2.84	175.8		74.7	413.7
Benign Neoplasms	1	0.32	309.5		46.3	1982.7
Diabetes Mellitus	3	2.19	136.9		44.8	418.8
Cerebrovascular Disease	17	8.70	195.3	**	124.6	306.3
All Heart Disease	50	54.44	91.8		74.1	113.9
Rheumatic Heart Disease	0	0.46	---		---	---
Ischemic Heart Disease	40	45.89	87.2		67.8	112.1
Chronic Endocard. Dis.; Other Myocard. Insuff.	2	2.52	79.4		20.2	312.2
Hypertension with Heart Disease	0	1.65	---		---	---
All Other Heart Disease	8	10.59	75.5		38.9	146.5
Hypertension w/o Heart Disease	0	0.40	---		---	---
Non-malignant Respiratory Disease	5	11.52	43.4	*	19.3	97.8
Influenza & Pneumonia	0	3.91	---		---	---
Bronchitis, Emphysema, Asthma	0	1.85	---		---	---
Bronchitis	0	0.31	---		---	---
Emphysema	0	1.41	---		---	---
Asthma	0	0.14	---		---	---
Other Non-malignant Respiratory Disease	5	6.03	82.9		35.3	194.7
Ulcer of Stomach & Duodenum	0	0.40	---		---	---
Cirrhosis of Liver	2	2.34	85.6		21.9	334.9
Nephritis & Nephrosis	1	0.79	126.5		18.0	887.9
All External Causes of Death	8	7.43	121.1		67.0	218.8
Accidents	6	4.54	132.2		61.9	282.3
Motor Vehicle Accidents	4	1.81	221.4		87.9	557.5
All Other Accidents	2	2.77	72.2		18.7	278.2
Suicides	3	1.79	167.8		56.3	500.1
Homicides & Other External Causes	0	1.11	---		---	---
All Other Causes of Death	14	14.41	97.2		59.2	159.5
Unknown Causes (In All Causes Category Only)	0					

* Significant at 5% Level; ** Significant at 1% Level

Table 18
Observed and Expected Deaths and Proportionate Mortality Ratios
by Department for All Malignant Neoplasms

	OBS	EXP	PMR	95% LOWER	UPPER
POTROOM	163	141.98	114.8*	100.7	130.9
CARBON	38	35.48	107.1	81.5	140.7
INGOT	44	44.33	99.3	76.9	128.1
MECH. MAINT.	117	108.00	108.3	92.7	126.6
ELECT. MAINT.	30	27.60	108.7	79.8	148.0
POWER	5	5.05	99.0	46.2	212.3

D. Selected Causes of Death

For those causes of death that were in excess or for which we have particular interest because of the Tripartite Study, we now present more detailed analysis.

(1) Kidney cancer - The PMR for kidney cancer for the total cohort is 158.1 based on 53 observed deaths and 33.52 expected. All cases of kidney cancer were in males and both white males and nonwhite males had an excess (PMR=157.5 and 257.8, respectively. Of the 53 employees with kidney cancer as a cause of death, 49 had more than 20 years employment. For those employees ever employed in the reduction process, the PMR is 200.1 based on 21 observed deaths and 10.5 expected and a corresponding 95% confidence interval of (131.7, 303.8). This compares to a PMR of 136.5 with a corresponding 95% confidence interval of (92.5, 201.4) for workers in nonreduction plants.

Further investigation within the reduction process indicates

Table 17
Observed and Expected Deaths and Proportionate Mortality Ratios for Employees Spending a Majority of Time in the Carbon Department

Cause of Death (ICDA 9th Revision Codes)	OBS	EXP	SPMR		95% Limits LOWER	UPPER
All Causes of Death	140	140.00	100.0		---	---
Tuberculosis	0	0.25	---		---	---
All Malignant Neoplasms	38	35.48	107.1		81.5	140.7
Cancer of Buccal Cavity & Pharynx	0	0.86	---		---	---
Cancer of Digestive Organs & Peritoneum	8	8.78	91.2		46.7	178.1
Cancer of Esophagus	1	1.04	96.0		13.7	674.5
Cancer of Stomach	0	1.31	---		---	---
Cancer of Large Intestine	3	3.28	91.6		29.9	279.9
Cancer of Rectum	1	0.64	156.0		22.4	1084.9
Cancer of Biliary Passages & Liver	0	0.82	---		---	---
Cancer of Pancreas	3	1.71	175.0		57.7	530.9
Cancer of All Other Digestive Organs	0	0.23	---		---	---
Cancer of Respiratory System	16	13.01	123.0		77.4	195.4
Cancer of Larynx	0	0.45	---		---	---
Cancer of Bronchus, Trachea, Lung	16	12.44	128.6		80.9	204.5
Cancer of All Other Respiratory	0	0.11	---		---	---
Cancer of Breast	0	0.04	---		---	---
All Uterine Cancers (Females only)	0	0.00	---		---	---
Cancer of Cervix Uteri (Females only)	0	0.00	---		---	---
Cancer of Other Female Genital Organs	0	0.00	---		---	---
Cancer of Prostate (Males only)	3	3.90	76.9		25.4	233.0
Cancer of Testes and Other Male Genital Organs	0	0.06	---		---	---
Cancer of Kidney	2	0.75	265.2		70.3	1001.3
Cancer of Bladder and Other Urinary Organs	1	0.95	105.5		15.0	743.4
Malignant Melanoma of Skin	0	0.37	---		---	---
Cancer of Eye	0	0.02	---		---	---
Cancer of Central Nervous System	0	0.86	---		---	---
Cancer of Thyroid & Other Endocrine Glands	0	0.08	---		---	---
Cancer of Bone	0	0.06	---		---	---
Cancer of All Lymphatic, Haematopoietic Tissue	3	2.86	105.0		34.3	321.5
Lymphosarcoma & Reticulosarcoma	0	0.29	---		---	---
Hodgkins Disease	0	0.11	---		---	---
Leukemia & Aleukemia	1	1.15	86.7		12.3	609.6
Cancer of All Other Lymphopoietic Tissue	2	1.30	153.7		39.1	604.1
All Other Malignant Neoplasms	5	2.84	175.8		74.7	413.7
Benign Neoplasms	1	0.32	309.5		46.3	1982.7
Diabetes Mellitus	3	2.18	136.8		44.8	413.8
Cerebrovascular Disease	17	8.70	195.3	**	124.6	306.3
All Heart Disease	50	54.44	91.8		74.1	113.9
Rheumatic Heart Disease	0	0.46	---		---	---
Ischemic Heart Disease	40	45.89	87.2		67.8	112.1
Chronic Endocard. Dis.; Other Myocard. Insuff.	2	2.52	79.4		20.2	312.2
Hypertension with Heart Disease	0	1.65	---		---	---
All Other Heart Disease	8	10.59	75.5		38.9	146.5
Hypertension w/o Heart Disease	0	0.40	---		---	---
Non-malignant Respiratory Disease	5	11.52	43.4	*	19.3	97.8
Influenza & Pneumonia	0	3.91	---		---	---
Bronchitis, Emphysema, Asthma	0	1.85	---		---	---
Bronchitis	0	0.31	---		---	---
Emphysema	0	1.41	---		---	---
Asthma	0	0.14	---		---	---
Other Non-malignant Respiratory Disease	5	6.03	82.9		35.3	194.7
Ulcer of Stomach & Duodenum	0	0.40	---		---	---
Cirrhosis of Liver	2	2.34	85.6		21.9	334.9
Nephritis & Nephrosis	1	0.79	126.5		18.0	887.9
All External Causes of Death	9	7.43	121.1		67.0	216.8
Accidents	6	4.54	132.2		61.9	282.3
Motor Vehicle Accidents	4	1.81	221.4		87.9	557.5
All Other Accidents	2	2.77	72.2		18.7	278.2
Suicides	3	1.79	167.8		56.3	500.1
Homicides & Other External Causes	0	1.11	---		---	---
All Other Causes of Death	14	14.41	97.2		59.2	159.5
Unknown Causes (In All Causes Category Only)	0					

* Significant at 5% Level; ** Significant at 1% Level

Table 18
Observed and Expected Deaths and Proportionate Mortality Ratios
by Department for All Malignant Neoplasms

	OBS	EXP	PMR	95% LOWER	UPPER
POTROOM	163	141.98	114.8*	100.7	130.9
CARBON	38	35.48	107.1	81.5	140.7
INGOT	44	44.33	99.3	76.9	128.1
MECH. MAINT.	117	108.00	108.3	92.7	126.6
ELECT. MAINT.	30	27.60	108.7	79.8	148.0
POWER	5	5.05	99.0	46.2	212.3

D. Selected Causes of Death

For those causes of death that were in excess or for which we have particular interest because of the Tripartite Study, we now present more detailed analysis.

(1) Kidney cancer - The PMR for kidney cancer for the total cohort is 158.1 based on 53 observed deaths and 33.52 expected. All cases of kidney cancer were in males and both white males and nonwhite males had an excess (PMR=157.5 and 257.8, respectively. Of the 53 employees with kidney cancer as a cause of death, 49 had more than 20 years employment. For those employees ever employed in the reduction process, the PMR is 200.1 based on 21 observed deaths and 10.5 expected and a corresponding 95% confidence interval of (131.7, 303.8). This compares to a PMR of 136.5 with a corresponding 95% confidence interval of (92.5, 201.4) for workers in nonreduction plants.

Further investigation within the reduction process indicates

that there is no particular area that appears to have a concentration of excess deaths (Table 19). The excess is not much affected when a PCMR is used instead of a PMR (Table 20). The investigation of kidney cancer by individual plant indicated no pattern for the excess although the distribution of only 53 observed deaths among 37 plants results in numbers too small to conclude that no clustering exists.

Table 19
Observed and Expected Deaths and Proportionate Mortality Ratios by Job Location for Kidney Cancer

	OBS	EXP	PMR	95% LOWER	UPPER
NONREDUCTION PLANT	25	18.32	136.5	92.5	201.4
REDUCTION PLANT	28	15.20	184.2**	128.1	265.0
NONREDUCTION PROCESS	11	7.05	156.1	87.0	280.0
REDUCTION PROCESS	17	8.11	209.7**	132.0	333.3
POTROOM	9	3.15	285.8**	153.4	532.5
CARBON	2	.75	265.2	70.3	1001.3
INGOT	2	.99	201.8	52.1	781.4
MECH. MAINTAIN.	4	2.48	161.1	61.2	423.7
ELECT. MAINTAIN.	0	.61	--	--	--
POWER	0	.11	--	--	--

Table 20
Observed and Expected Deaths and Proportionate Cancer Ratios
by Job Location for Kidney Cancer

	OBS	EXP	PMR	95% LOWER	UPPER
NONREDUCTION PLANT	25	19.25	129.9	88.2	191.1
REDUCTION PLANT	28	15.62	179.3**	125.0	257.2
NONREDUCTION PROCESS	11	6.60	166.6	93.5	296.9
REDUCTION PROCESS	17	9.01	188.6**	118.8	299.4
POTROOM	9	3.64	247.1**	132.4	461.2
CARBON	2	.84	237.9	63.1	897.5
INGOT	2	1.02	195.8	51.1	750.7
MECH. MAINTAIN.	4	2.74	146.2	55.8	382.7
ELECT. MAINTAIN.	0	.67	--	--	--
POWER	0	.10	--	--	--

(2) All other cancers - The PMR for the category "all other cancers" was 134.3 ($p<0.01$) with 164 observed deaths and 122.1 expected. The excess did not appear to be restricted to any particular race or sex. Of these, 138 were cancer of an unspecified site, 14 were cancer of multiple sites, and 12 were cancer of soft or connective tissue.

(3) Benign and unspecified neoplasms - The PMR for benign and unspecified neoplasms was 195.6 with a corresponding 95% confidence interval of (136.9, 279.5). The PMR was higher in the nonreduction plants than in the reduction plants (PMR=227.3, $p<0.01$) and PMR=154.7, respectively. The cases did not appear confined to any specific race or sex. The median age at death

for the 29 workers with this cause of death was 70.9. Of the 29 observed deaths, 2 were benign brain tumors and 10 were brain tumors of unspecified nature.

(4) Nephritis and nephrosis - The PMR for nephritis and nephrosis was 242.2 based on 85 observed deaths and 35.09 expected. The excess appeared in reduction as well as nonreduction processes and was not restricted to a specific sex or race group. This ICD classification is often a result of insufficient coding of the death certificate and a review of individual death certificates indicated "renal failure" as a frequent cause of death designated on the death certificates with this cause. Investigation of individual plants indicates that five plants accounted for 52 observed deaths when 13.95 were expected. These plants were both reduction and nonreduction plants.

(5) Cerebral vascular disease - The total cohort had approximately an 11% excess in cerebrovascular disease. This excess appeared restricted to white males where the PMR was 115.2 ($p<0.01$) based on 403 observed deaths and 349.8 expected and was higher in plants with a reduction process where the PMR was 135.3 ($p<0.01$) based on 151 observed deaths compared to a PMR of 98.9 for the remainder of the white male population. For reduction plant workers this represents 30 observed deaths in excess which is approximately the same as the deficit observed for the category "all heart disease". Although the excess occurs in reduction plants it is not confined to the reduction process. The white males who spent the majority of their time in a nonreduction process had a PMR of 132.1 ($p<0.01$) compared to

138.8 ($p<0.01$) for the white males spending the majority of their time in a reduction process.

(6) Respiratory cancer - The primary hypothesis in the Tripartite Study was to determine if there was an excess of lung cancer in the potroom and carbon departments of the reduction process. The overall SMR for lung cancer in that study was 96.4 with a corresponding 95% confidence interval of (83.2, 105.9). The corresponding SMR of the plants in the Tripartite Study which have been included in this study is 91.7 with a corresponding 95% confidence interval of (78.4, 106.5).

For this study the PMR for lung cancer shows a slight excess. The PMR for lung cancer for employees in the reduction process is 124.3 with a corresponding confidence interval of (107.3, 144.0). This compares to a PMR of 108.9 for workers in plants with no reduction process and a PMR of 81.3 ($p<0.05$) for workers in a reduction plant that spent the majority of their time in a nonreduction process. Further investigation was conducted by department within the reduction process (Table 21). Workers spending the majority of their time in the potroom, carbon or ingot department all have excesses of 20%-30% that are not statistically significant. Workers spending the majority of time in mechanical maintenance have a significantly elevated PMR of 136.3 ($p<0.05$).

When the risk is estimated using a proportionate cancer mortality ratio (Table 22), the risk is slightly increased for employees in the nonreduction process of the reduction plant (PCMR=87.9) and decreased for employees in the reduction process

(PCMR=111.9). Neither of these is significantly different from 100. The only significant excess using the PCMR occurs for maintenance workers where the PCMR is 125.7 with a corresponding 95% confidence interval of (101.6, 155.6).

Table 21
Observed and Expected Deaths and Proportionate Mortality Ratios by Job Location for Cancer of Bronchus, Trachea and Lung

	OBS	EXP	PMR	95% LOWER	UPPER
NONREDUCTION PLANT	310	284.73	108.9	97.9	121.0
REDUCTION PLANT	248	238.24	104.1	92.5	117.1
NONREDUCTION PROCESS	89	109.53	81.3*	66.7	98.9
REDUCTION PROCESS	159	127.95	124.3**	107.3	144.0
POTROOM	62	50.77	122.1	96.5	154.5
CARBON	16	12.44	128.6	80.9	204.5
INGOT	19	15.13	125.6	82.0	192.4
MECH. MAINTAIN.	53	38.34	136.3*	107.2	178.3
ELECT. MAINTAIN.	8	9.53	83.9	43.5	162.0
POWER	1	1.69	59.2	9.4	372.4

The observed and expected deaths and PMRs are shown for each plant in Table 23. There was a statistically significant excess. at both the Mobile and Vancouver plants (PMR=161.2 and 154.4, respectively). Two other plants with Soderberg processes, had excesses greater than 40% that failed to achieve statistical significance. When we restricted analysis within each plant to employees with reduction experience, the PMR for Vancouver was 162.4 ($p<0.01$), for Point Comfort was 164.6 ($p<0.05$) and for Warrick was 161.8 (not statistically significant).

Table 22
Observed and Expected Deaths and Proportionate Cancer Mortality Ratios by Job Location for Bronchus, Trachea and Lung

	OBS	EXP	PCMR	95% LOWER	UPPER
NONREDUCTION PLANT	310	300.93	103.0	94.2	112.7
REDUCTION PLANT	248	243.32	101.9	92.3	112.6
NONREDUCTION PROCESS	89	101.23	87.9	74.4	103.9
REDUCTION PROCESS	159	142.09	111.9	98.6	126.6
POTROOM	62	59.27	104.6	85.9	127.4
CARBON	16	13.09	122.2	82.6	180.8
INGOT	19	15.70	121.0	84.7	172.9
MECH. MAINTAIN.	53	42.15	125.7*	101.6	155.6
ELECT. MAINTAIN.	8	10.39	77.0	44.3	133.8
POWER	1	1.50	66.5	13.6	324.5

The PCMRs for the Point Comfort and Vancouver plants were also significant (151.9, $p<0.01$ and 143.2, $p<0.05$, respectively). The PCMR for Warrick was 112.0.

Table 23
Observed and Expected Deaths and Proportionate Mortality Ratios for Lung Cancer by Plant

Plant	OBS	EXP	PMR	95% LOWER	95% UPPER
ADDY	3	.71	--	--	--
ANDERSON	1	.11	--	--	--
ALCOA	8	7.47	107.2	55.5	206.8
BADIN	12	12.19	98.5	57.5	168.7
BAUXITE	13	12.29	105.8	63.1	177.3
BRIDGEPORT	4	1.94	--	--	--
BUFFALO	0	.16	--	--	--
CHICAGO	3	2.45	--	--	--
CHILLICOTHE	6	4.87	123.2	57.8	262.6
CLEVELAND	42	36.63	114.7	86.0	152.8
CORONA	0	1.08	--	--	--
CRESSONA	23	23.53	97.8	66.5	143.8
DAVENPORT	29	23.39	124.0	88.0	174.8
DETROIT	2	4.39	--	--	--
EAST ST. LOUIS	5	7.99	62.6	27.1	144.5
EDGEWATER	17	18.26	93.1	59.0	146.8
EDISON	11	8.17	134.6	76.9	235.7
FORT MEADE	0	.31	--	--	--
FRANKLIN	2	1.95	--	--	--
LAFAYETTE	21	30.36	69.2	46.2	103.6
LANCASTER	5	2.69	185.5	81.8	420.8
LEBANON	2	.85	--	--	--
LOGANS FERRY	3	1.60	--	--	--
MARSHALL	3	1.09	--	--	--
MASSENA	47	53.08	88.5	67.5	116.1
MOBILE	22	13.65	161.2*	108.8	238.7
NEW KENSINGTON	54	52.96	102.0	79.0	131.5
POINT COMFORT	25	17.42	143.5	99.4	207.3
RICHMOND	4	5.94	67.3	26.7	170.0
ROCKDALE	5	9.58	52.2	23.1	117.7
ROSICLARE	5	2.45	204.4	89.9	464.8
TENNESSEE	107	109.3	97.9	81.7	117.2
TIFFON	1	.72	--	--	--
VANCOUVER	27	17.49	154.4*	108.3	220.1
VERNON	21	16.75	125.4	83.6	188.1
WARRICK	16	11.10	144.2	91.0	228.4
WENTACHEE	9	8.07	111.5	60.1	207.0

(7) Cancer of the Lymphatic and Haematopoietic Cancer - The PMR for the total cohort for lymphatic and haematopoietic cancer was 113.6 with a 95% confidence interval of (96.8, 133.2). The PMR for workers in nonreduction plants was 100.2 compared to a PMR of 130.2 ($p<0.05$) for workers in reduction plants. Within the reduction plants, those workers spending the majority of their time in a nonreduction process had a higher PMR than those in a reduction process [PMR=140.1, $p<0.05$ and PMR=122.1 (not significant), respectively]. The PCMR was 146.7 ($p<0.05$) for workers in the nonreduction process and 111.3 for workers in the reduction process. Analysis based on majority of time in individual departments yielded no statistically significant results. Potroom workers had a PMR of 144.9 with a 95% confidence interval of (90.8, 231.3) and electrical maintenance workers had a PMR of 217.3 with a corresponding 95% confidence interval of (93.3, 506.3). The only individual plant with a significant excess was Tennessee which had a PMR of 172.1 ($p<0.01$. The PMR for leukemia in the total cohort was 102.0. The PMR for those in reduction plants was 117.4 compared to 89.8 for those in nonreduction plants. The number of deaths was small on which to do an analysis by department. However, 8 of the 15 deaths occurred in the potroom with a subsequent PMR of 168.3 based on 8 observed deaths and 4.75 expected with a corresponding 95% confidence interval of (85.1, 333.0). The only individual plant with a significant excess was Edgewater with a PMR of 260.7 ($p<0.05$).

(8) Pancreatic cancer - In this study, the PMRs for

pancreatic cancer did not show a significant excess for either reduction plant workers or workers spending the majority of their time in the potrooms (PMR=103.2 and 87.2). This compares to an SMR of 134.8 for workers in the potrooms of the Tripartite Study. The significant finding of the Tripartite Study was for potroom workers with more than 15 years employment, where the excess was more than twofold. With the data available in the present study a risk for longterm employees could not be obtained.

E. Analysis by Plant

Mortality for each of the 62 selected causes of death was done for each of the 37 study plants. Such analysis must be interpreted with caution since by random chance alone some plants would be expected to deviate from the average value. In addition, many of the plants did not have sufficient numbers for an individual analysis. Because of these limitations, we view the results as preliminary and any plants that are identified should be given consideration for a more detailed study (if feasible) in a second phase.

Table 24 summarizes the observed, expected deaths and Proportionate Mortality Ratios by plant. Of the 29 plants with sufficient sample size to compute a PMR, 14 had a PMR less than 100 and 15 had a PMR greater than 100. Four plants had a statistically significant excess, but one was based on only 5 observed deaths. One plant had a borderline excess of PMR=130.5 with a corresponding 95% confidence interval of (99.9, 170.4).

Numbers were often too small to do an analysis of individual plants for many of the specific cancers. Nevertheless, in reviewing the results from those plants we note the following

Table 24
Observed and Expected Deaths and Proportionate Mortality Ratios for All Malignant Neoplasms by Plant

Plant	OBS	EXP	PMR	95% LOWER	95% UPPER
ADDY	5	2.00	250.6*	123.2	509.9
ANDERSON	1	.37	--	--	--
ALCOA	21	22.02	95.3	66.1	137.6
BADIN	40	37.11	107.8	82.5	140.7
BAUXITE	34	36.16	94.0	70.4	125.5
BRIDGEPORT	12	7.04	170.5*	103.7	280.3
BUFFALO	0	.91	--	--	--
CHICAGO	5	7.06	70.8	33.5	149.4
CHILLICOTHE	16	14.98	106.8	70.8	161.0
CLEVELAND	138	110.16	125.3**	108.6	144.6
CORONA	1	2.85	--	--	--
CRESSONA	64	62.75	102.0	82.8	125.6
DAVENPORT	85	64.20	132.4**	110.5	158.6
DETROIT	14	16.17	86.6	54.6	137.3
EAST ST. LOUIS	28	29.04	96.4	69.5	133.9
EDGEWATER	60	61.07	98.2	78.7	122.6
EDISON	30	24.75	121.2	89.1	165.0
FORT MEADE	1	.88	--	--	--
FRANKLIN	5	5.85	85.4	40.4	180.5
LAFAYETTE	78	87.57	89.1	73.6	107.8
LANCASTER	7	7.83	89.4	47.4	168.3
LEBANON	3	2.16	--	--	--
LOGANS FERRY	5	4.36	104.7	54.5	24.7
MARSHALL	3	2.78	--	--	--
MASSENA	148	152.68	96.4	84.4	111.4
MOBILE	45	38.58	116.6	90.8	149.8
NEW KENSINGTON	160	168.55	94.9	83.0	108.6
POINT COMFORT	45	45.95	97.9	76.5	125.4
RICHMOND	19	19.81	95.9	65.6	140.1
ROCKDALE	23	26.44	87.0	61.4	123.2
ROSICLARE	10	7.78	128.5	74.7	220.9
TENNESSEE	330	323.35	102.1	93.0	112.0
TIFFON	4	2.33	--	--	--
VANCOUVER	52	49.27	105.8	83.6	133.2
VERNON	52	51.06	101.8	80.6	128.7
WARRICK	39	29.89	130.5	99.9	170.4
WENTACHEE	22	22.55	97.6	68.3	139.5

neoplasms which were in excess at particular plants:

(1) The Cleveland plant had PMRs of 280.5 for stomach cancer (based on 12 observed deaths, $p<0.01$), 298.8 for cancer of

the rectum (based on six observed deaths, $p<0.05$) and 464.7 for cancer of the breast (based on 4 observed deaths, $p<0.01$).

(2) The Cressona plant had a PMR of 247.4 for stomach cancer (based on five deaths, $p<0.05$), 261.9 for kidney cancer (based on four deaths, $p<0.05$), and 530.4 for melanoma (based on four deaths, $p<0.01$).

(3) The Davenport plant had a PMR of 177.0 for all digestive cancers (based on 27 observed deaths, $p<0.01$). The PCMR was not significantly elevated for this cause.

(4) The Edgewater plant had a PMR of 260.7 for leukemia (based on six observed deaths, $p<0.05$).

(5) The Massena plant had a PMR of 283.2 for lymphosarcoma (based on 4 observed deaths, $p<0.05$).

(6) The Mobile plant had a PMR of 161.2 ($p<0.05$) for lung cancer. The PCMR was 135.3.

(7) The Tennessee (Alc) plant had a PMR of 172.1 (based on 46 observed deaths, $p<0.01$) for cancer of the lymphatic and haematopoietic tissue.

(8) The Vancouver plant had a PMR of 154.4 for lung cancer (based on 27 observed deaths, $p<0.05$) and a PMR of 356.1 (based on 4 observed deaths, $p<0.05$) for kidney cancer.

Summary

Conclusions from this study must be drawn more cautiously than was necessary for the Tripartite Study because of the inherent limitations of the PMR study design as well as the less specific job classification used in the present study. Furthermore, the large number of estimates of risk that were computed will result in a larger number of false positive findings than can be inferred from the p-values. Conversely, the small number of workers available for many of the estimates of risk precludes any strong statements in regard to those findings that were negative. With these limitations stated, we now summarize the findings we feel are most important. Consistent with the study objectives, we have given most attention in our summary to malignant neoplasms.

The PMR for malignant neoplasms for the total study population was 103.7 and was not significantly different from the total U.S. population. The only specific cancer site which was significantly elevated was kidney cancer with a PMR of 158.1 and a corresponding 95% confidence interval of (121.2, 206.3). The nonspecific disease categories of benign and unspecified neoplasms, nephritis and nephrosis and "all other malignant neoplasms" were elevated and appeared to result from lack of complete specification of cause of death on the certificate. The only other disease category that was elevated for the total cohort was cerebral vascular disease with a PMR of 111.4 ($p<0.05$) and this was accompanied by a deficit in ischemic heart disease (PMR=85.2, $p<0.01$).

The analysis by work area yielded the following:

(1) For the combined group of workers in nonreduction plants the PMR for all malignant neoplasms was 105.2. The only statistically significant excesses occurred for nonspecific disease categories (i.e., nephritis, benign and unspecified neoplasms, all other cancers). Analysis by race indicated that whites had an excess of colon cancer and nonwhites had an excess of stomach, liver and lymphatic cancer.

(2) For the 1320 workers in a reduction plant who spent the majority of their time in a nonreduction process, the PMR for all malignant neoplasms was 93.6. The only specific neoplastic site with a significant elevation was cancer of the lymphatic and haematopoietic tissue (PMR=140, $p<0.05$).

(3) Workers with the majority of their employment in the reduction process had a PMR of 109.5 ($p<0.05$) for all malignant neoplasms. These workers had a PMR of 124.3 for lung cancer ($p<0.01$) and a PMR of 209.2 for kidney cancer ($p<0.01$). When a PCMR was computed, the estimate of risk for lung cancer was a nonsignificant 111.9 but remained significant for kidney cancer (PCMR=188.6, $p<0.01$). The workers spending the majority of their time in the reduction process had a significant excess for two of the study plants. Neither of these plants had an excess in the Tripartite Study. Workers spending the majority of their time in mechanical maintenance also had an excess of lung cancer.

(4) Although workers in reduction plants had a significantly elevated PMR of 130.2 ($p<0.05$), for cancer of the lymphatic and haematopoietic tissue it was greater in workers in the reduction plant spending the majority of their time in a

nonreduction process (PMR=140.1, $p<0.05$). No individual department had a statistically significant excess, although the small number of observed deaths when analyzed by department makes the results inconclusive.

(5) Analysis by plant is limited by small numbers and a further increase in the expected false positives due to the larger number of estimates of risk. Overall, 14 plants had a PMR for "all malignant neoplasms" below 100, 15 plants were above, and 8 had less than 5 observed deaths from neoplasms. Of plants with greater than 5 observed deaths for "all malignant neoplasms", three had a statistically significant excess and one had borderline significance. Eight of the plants had at least one specific site that showed a statistically significant excess. We could identify no consistent pattern in site-specific cancers among plants with similar processes, although such inferences are clearly limited by small numbers and lack of more detailed job classifications in plants with multiple processes.

References

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2. Marsh GM, Preininger M: OCMAP: A user-oriented occupational cohort mortality analysis program. American Statistician 34: 245-246, 1980.

3. Wong O, DeCoufle P: Methodological issues involving the standardized mortality ratio and proportionate mortality ratio in occupational studies. Journal of Occupational Medicine 24:299-304, 1982.

Appendix

Distribution of causes of death using 4 digit ICD codes

ICD	Freq.	ICD	Freq.	ICD	Freq.
88	1	1562	1	2008	4
119	3	1569	1	2019	7
189	1	1570	5	2020	1
310	1	1579	69	2021	1
360	1	1590	3	2024	1
381	3	1599	1	2028	41
384	7	1619	7	2030	25
388	1	1625	1	2040	5
389	54	1629	557	2041	8
419	1	1639	2	2049	2
498	1	1640	1	2050	17
499	1	1701	1	2051	6
539	1	1706	1	2080	9
543	1	1709	1	2081	1
703	2	1712	1	2089	7
1159	2	1713	1	2159	1
1169	1	1716	1	2169	1
1175	1	1719	9	2251	1
1179	2	1722	1	2252	1
1350	1	1725	2	2302	1
1363	2	1727	1	2373	1
1369	1	1729	15	2384	1
1409	1	1734	1	2387	4
1419	2	1749	13	2389	2
1449	1	1790	2	2390	2
1459	2	1809	1	2391	1
1460	2	1820	1	2395	1
1469	1	1830	4	2396	10
1479	3	1850	147	2398	1
1481	1	1869	1	2399	1
1490	5	1874	2	2429	1
1505	2	1889	47	2449	1
1509	17	1890	48	2500	72
1510	3	1891	1	2501	2
1519	56	1892	4	2502	2
1522	2	1899	1	2503	6
1529	1	1909	1	2504	1
1531	1	1910	1	2505	1
1532	2	1913	2	2506	6
1533	4	1916	1	2507	1
1534	2	1919	20	2509	1
1536	5	1930	1	2535	1
1539	152	1940	2	2554	1
1540	6	1946	1	2558	1
1541	24	1950	1	2599	1
1550	12	1990	14	2639	3
1551	2	1991	136	2651	1
1552	8	2000	5	2733	1

Table (continued)

Distribution of causes of death using 4 digit ICD codes

ICD	Freq.	ICD	Freq.	ICD	Freq.
1560	4	2001	6	2738	1
1561	2	2002	1	2754	1
2761	1	4049	4	4402	3
2762	2	4100	1017	4409	65
2765	4	4109	16	4410	4
2773	2	4110	11	4411	1
2780	1	4120	9	4412	1
2793	1	4130	1	4413	41
2810	1	4140	617	4414	3
2848	2	4141	1	4415	7
2849	2	4148	14	4416	3
2859	1	4149	203	4429	1
2866	2	4151	36	4439	8
2888	2	4160	3	4440	1
2898	1	4169	5	4449	5
2899	1	4210	3	4472	1
2900	4	4239	1	4479	1
2901	2	4240	5	4512	1
2910	1	4241	23	4519	2
3030	1	4249	6	4539	1
3089	1	4254	67	4549	1
3109	5	4255	2	4560	4
3229	1	4271	1	4578	1
3239	2	4273	3	4589	3
3240	1	4274	4	4590	5
3310	19	4275	164	4599	1
3312	1	4278	1	4660	1
3314	2	4279	19	4787	1
3319	2	4280	80	4809	1
3320	16	4281	2	4810	4
3334	3	4284	4	4820	3
3352	12	4289	14	4823	1
3400	3	4290	2	4824	1
3418	1	4291	1	4828	1
3419	1	4292	150	4829	1
3429	2	4299	4	4830	1
3481	3	4300	6	4850	35
3483	1	4301	5	4860	103
3485	1	4310	46	4870	1
3489	1	4321	6	4878	1
3561	1	4329	5	4900	3
3570	2	4330	1	4912	6
3760	1	4331	4	4919	1
3940	2	4340	49	4920	54
3941	1	4341	2	4939	9
3949	5	4349	27	4940	1
3959	1	4360	275	4960	141

Table (continued)

Distribution of causes of death using 4 digit ICD codes

ICD	Freq.	ICD	Freq.	ICD	Freq.
3980	1	4370	16	5000	18
3989	4	4371	1	5010	1
4019	11	4378	1	5020	1
4029	48	4379	15	5050	1
4039	12	4380	7	5064	1
5070	17	5715	34	8120	9
5109	3	5718	2	8121	1
5118	1	5719	3	8122	3
5119	4	5722	1	8129	16
5120	4	5724	3	8130	4
5130	3	5728	19	8147	6
5140	6	5733	4	8150	2
5150	13	5739	2	8159	2
5163	1	5742	2	8169	2
5168	2	5743	1	8190	7
5183	1	5750	3	8191	2
5184	2	5751	1	8192	3
5185	3	5754	1	8199	16
5188	9	5761	3	8209	1
5199	1	5770	5	8219	1
5301	1	5771	1	8220	1
5304	1	5789	11	8249	1
5309	1	5809	1	8259	1
5314	4	5829	4	8261	1
5315	2	5838	1	8300	1
5319	1	5839	2	8309	1
5324	2	5845	1	8329	1
5325	2	5849	12	8480	1
5326	1	5850	19	8682	1
5329	1	5860	45	8689	3
5334	6	5900	1	8698	1
5335	2	5901	2	8781	1
5339	1	5908	3	8782	2
5369	1	5920	1	8789	1
5400	1	5938	1	8799	5
5409	1	5939	4	8809	7
5532	2	5959	1	8810	4
5539	1	5990	25	8811	1
5560	1	6019	1	8820	1
5570	8	6029	1	8839	1
5579	1	6821	1	8849	2
5580	1	6829	1	8870	1
5601	1	6861	1	8880	10
5602	1	6954	1	8902	4
5608	1	7070	6	8903	2
5609	5	7101	1	8909	4
5621	5	7802	2	8920	1
5660	1	7855	6	8939	1

Table (continued)

Distribution of causes of death using 4 digit ICD codes

ICD	Freq.	ICD	Freq.	ICD	Freq.
5679	1	7860	1	9000	1
5698	4	7970	2	9053	1
5699	1	7981	5	9068	1
5710	1	7982	44	9102	1
5712	13	7991	41	9108	3
5713	2	7999	62	9110	4
5714	1	8109	2	9120	2
9138	1	9251	1	9571	1
9190	5	9289	15	9600	1
9192	1	9323	1	9651	1
9198	2	9345	1	9652	1
9199	2	9520	4	9654	7
9220	1	9530	5	9660	2
9221	1	9538	1	9689	2
9222	1	9540	1	9821	4
9229	5	9550	4	9830	1
9239	1	9551	4	9851	1
9240	1	9552	2	9854	2
9250	1	9554	52	9947	1

Aluminum W kers:Tripart Study
Propos Sept. 30, 1991