A Retrospective Mortality Study of Workers in Three Major U.S. Refineries and Chemical Plants

Part II: Internal Comparisons by Geographic Site, Occupation, and Smoking History

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A cohort of 21,698 U.S. refinery and chemical plant workers was observed for eight years to determine if there were interplant or other variations in causes of mortality. Plant populations in three geographic locations were combined to develop an internal standard for comparing subgroups within the total cohort. At no one geographic site were consistently different rates for all major causes of death observed. The adjusted mortality rates for potentially exposed workers were slightly greater than those for nonexposed workers for most causes examined. Smokers incurred a higher risk of mortality from many causes of death when compared with nonsmokers, regardless of occupational category. After controlling for smoking, there remained a slight excess in mortality for potentially exposed as compared with nonexposed workers.

Mortality of cohorts of workers from three Exxon refineries and chemical plants in the United States was studied during the period 1970 through 1977. Comparisons with the mortality experience of the U.S. population have been reported separately[1]. This report details the results of the analysis that combined the three plant site populations into a single cohort to address the following objectives:

1. To develop an internal standard for comparing subgroups within the cohort.
2. To compare directly adjusted mortality rates among the three plant site populations using the internal comparison group as the standard.
3. To compare directly adjusted mortality rates in the total study population by (1) geographic site, (2) occupational categories, and (3) smoking history.

Materials and Methods

The study design, cohort definition, and data handling techniques were discussed in detail in our previous comparisons with the mortality experience of the U.S. population.[1] Work history summaries and smoking histories were used in the present analysis. Smoking histories have been documented in employee medical records since the mid-1960s, but consistency of detail varies by plant. The crude measure of "ever-smoked" was indicated by "Y" (yes), "N" (no), or "U" (unknown).

Work histories were summarized to derive the occupation at which each employee had spent the largest portion of his/her working time. Nine occupational categories were identified for analyses: official/manager, professional, technician, office worker/clerk, process operator, mechanical worker, unskilled laborer, service worker, and laboratory technician/field professional.

Comparisons used the total study population as the standard unless otherwise specified. Occupational categories based on employee records were classified into two groups based on their potential for daily exposure to petroleum, petrochemicals, and other related substances. Mechanical workers, process operators, unskilled laborers, service workers, and laboratory technician/field professionals were categorized as "potentially exposed" while officials/managers, professionals, technicians, and office workers/clerks were considered to be "nonexposed." Table 1 shows the occupational categories by job titles and by potential exposure grouping.

Directly adjusted death rates were calculated by multi-

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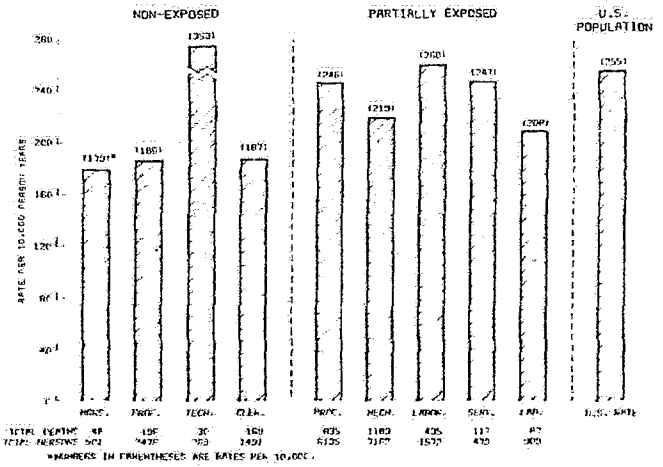

Fig. 1 — Directly adjusted mortality rates per 10,000 person-years, 1970 through 1977, for all causes of death, by occupation (704 employees, accounting for 98 deaths, could not be classified by occupation).

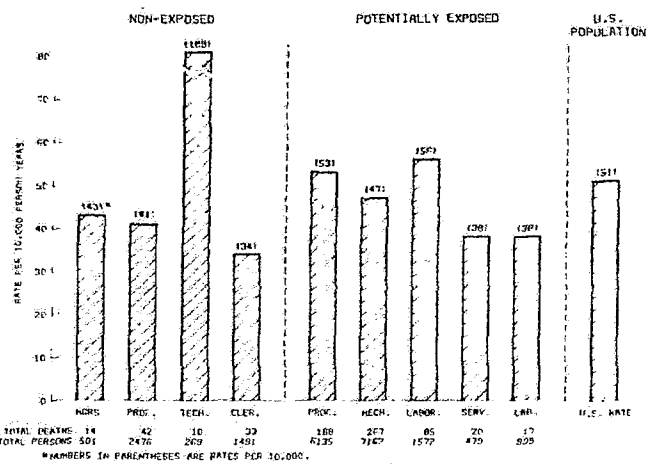

Fig. 2 — Directly adjusted mortality rates per 10,000 person-years, 1970 through 1977, for malignant neoplasms, by occupation (704 employees, accounting for 10 deaths due to malignant neoplasms, could not be classified by occupation).

plying each age-, sex-, race- and calendar year–specific death rate in the subgroup of interest (for example, smokers) by the number of person-years in the appropriate cell in the standard population (total cohort). The resulting numbers of expected deaths were then summed over all the cells and divided by the total number of person-years in the standard population. This quotient was multiplied by 10,000 to yield the directly adjusted rates per 10,000 person-years. Rates among subgroups could then be directly compared because the same population distribution was used in the standardization procedure.[2,3] The Mantel-Haenszel procedure, as implemented for life-table data with confounders, was used to test rate ratios for statistical significance.[4-6]

Results

The majority of employees were classified as mechanical workers (33%) or process operators (28%), followed by professionals (11%). Based on occupational category, 75% of the study population had potential for daily exposures to petroleum, petrochemicals, or other factors in the workplace (potentially exposed), 22% had little potential for exposure (nonexposed), and 3% had unknown potential (Table 2).

As shown in Table 3, smoking information was available for 70% of the study population. Fifty-one percent were known smokers and 19% had never smoked cigarettes.

Those occupational groups more likely to have potential occupational exposures generally had higher proportions of smokers. Professionals had the lowest percentage of smokers; however, they also had the highest proportion of subjects with "unknown" smoking histories (Table 4).

Comparison of Directly Adjusted Mortality Rates Among Cohorts at the Three Geographic Sites—Directly adjusted rates for selected causes of death for the three plant cohorts and for the U.S. population are shown on Table 5 if there were five or more observed cause-specific deaths at each of the three sites. No one geographic site cohort showed consistently different rates for all major causes of death.

Kidney cancer was the only cause of death whose rate was higher than that of the U.S. population for all three plant cohorts. Cancer mortality rates in Bayway/Bayonne were generally higher than those in other plants, although only slightly higher than the U.S. rates, particularly for cancer of the digestive organs (with the exception of pancreatic cancer) and respiratory system. The rate for cancer of the pancreas was higher in the Baton Rouge cohort.

Comparisons by Occupational Category—Mortality rates for potentially exposed workers were slightly greater than those for nonexposed workers for most causes shown, with the exception that there was a twofold greater increase in cancer of the prostate. For the category of all causes of death and for diseases of the circulatory system, the differences between the two groups were statistically significant. Mortality due to cancers of the brain/CNS was elevated considerably for workers classified as nonexposed to petroleum, petrochemicals, or other factors in the workplace. Most of the deaths from cancers of the bladder and kidney and from lymphosarcoma/reticulosarcoma and leukemia were in potentially exposed workers (Table 6).

The nonexposed technicians had the highest rates for all causes and for all malignant neoplasms (Fig. 1 and 2). Table 7 shows the directly adjusted mortality rates for selected cancers by specific occupation. No one occupational group had consistently higher rates than the others for specific causes of death. Process operators had the highest rates for cancers of the digestive organs, respiratory system, and kidney; these rates were also higher than those of the U.S. population. Mechanical workers had the highest pancreatic cancer rate; this was also higher than the U.S. rate.

Comparisons by Smoking History—The following comparisons were based on smaller numbers of deaths, since smoking data were unavailable for 30% of the cohort. Rates were not calculated when the observed number of deaths was less than five. Mortality rates for selected causes of death, shown on Table 8, were compared for smokers (ever smoked) and nonsmokers (never smoked). Smokers

Table 1 — Occupational Group Definition

No Exposure	Potential Exposure	
A—Officials/managers	F—Process operators	H—Laborers
Buyers	Coke handlers/rollers	Handymen
Chiefs	Dock helpers/masters	Laborers
Department heads	Gaugers	Tankermen/deckhands
Directors	Plant trainees	Utilitymen
Managers	Process operators	Yardmasters/cleaners
Superintendents	Process technicians	J—Service workers
Supervisors	Receiving/shipping operators	Chauffeurs
B—Professionals/nonexposed	G—Mechanical workers	Chefs/cooks
Accountants	Auto mechanics	Firemen/Fire equipment Inspectors
Analysts	Boilermakers	Guards
Attorneys	Carpenters	Janitors/maids
Coordinators	Craftsmen	Storekeepers
Editors	Electricians	K—Laboratory Technicians/ Field Professionals
Engineers	Instrument men	Blenders/testers
Foremen/supervisors	Instrument technicians	Chemists
Nurses	Insulators	Gas testers
Physicians	Lead burners	Industrial hygienists
Planners	Linemen	Laboratory assistants
Scientific advisors	Machinists	Laboratory foremen
C—Technicians/nonexposed	Maintenance foremen	Laboratory supervisors
Cameramen	Maintenance/mechanical helpers	Laboratory technicians
Chainmen	Masons	Oil conservation inspectors
Computer technicians	Materials men	Refinery equipment inspectors
Data technicians	Measurement men	Research engineers
Designers	Mechanical asssistant/helpers	Research technicians
Draftsmen	Mechanical supervisors	Safety inspectors
Engineering technicians	Motorized equipment operators	X-ray technicians
Hospital/first-aid men	Oilers	
Surveyors	Painters	
E—Office/clerical	Pipe fitters	
Key-punch operators	Plumbers	
Office assistant/clerks	Railroadmen	
Office machine mechanics	Riggers	
Reproduction operators	Servicemen	
	Tinners	
	Trainees	
	Transportation operators	
	Warehousemen	
	Welders/burners	
	Wiremen/journeymen	

experienced a higher risk of death due to the majority of causes shown. Of these, the excess numbers of deaths due to smoking were statistically significant for all causes of death, diseases of the circulatory system, diseases of the respiratory system, diseases of the digestive system and for all malignant neoplasms. Smokers also experienced a higher rate of digestive organ cancers, but the increase was not statistically significant. Rates for pancreatic cancer, cancers of all genitourinary organs, and prostate cancer were slightly higher for those who had never smoked. Most of the deaths from cancers of the liver, respiratory system, bladder, kidney, lymphopoietic system and from leukemia occurred in smokers, but there were too few cases in the nonsmoker group to compare rates in these categories.

Rate ratios of "ever" to "never smoked" indicated about a twofold difference between smokers and nonsmokers for most causes of death in both exposure categories. In the potentially exposed group the differences between smokers and nonsmokers were statistically significant for all causes of death, for diseases of the circulatory system, and for malignant neoplasms. In the nonexposed group the excesses for smokers were statistically significant for all causes of death and for malignant neoplasms. The exception was for cancer of the pancreas, for which, among the potentially exposed workers, the rate was higher among

Table 2 — Distribution of Total Study Population by Occupational Category		
Occupational Category	**No.**	**%**
Potentially exposed	16,257	74.9
Process operators	6,135	28.3
Mechanical workers	7,162	33.0
Laborers	1,572	7.2
Service workers	479	2.2
Laboratory technicians/field professionals	909	4.2
Nonexposed	4,737	21.8
Officials/managers	501	2.3
Professionals	2,476	11.4
Technicians	269	1.2
Office/clerical	1,491	6.9
Unknown	704	3.2
Total	**21,698**	**99.9**

Table 3 — Distribution of Total Study Population by Smoking History		
Ever Smoked	**No.**	**%**
Yes	11,105	51.2
No	4,059	18.7
Unknown	6,534	30.1
Total	**21,698**	**100.0**

nonsmokers (Table 9). In this Table, comparisons cannot be made across all four exposure/smoking groups because the two different occupational subgroups, not the total population, were used as the standards. The death rates for all causes among the potentially exposed workers were only slightly higher than or about the same as those among the nonexposed for both smoking groups (Table 10). For smokers, the slight excesses remaining among the potentially exposed, compared with the nonexposed group, were statistically significant for all causes of death and for diseases of the circulatory system.

Discussion

The majority of this cohort were mechanical workers or process operators during the major portion of their employment periods. Smoking histories were available for 70% of the population. Those groups more likely to have occupational exposures generally had higher proportions of smokers as well.

Mortality rates for digestive and respiratory cancers were higher in the New Jersey cohort. The conspicuously high rate of pancreatic cancer in the Louisiana cohort may explain the increased pancreatic cancer risk observed in the total study population.[1] Local, state, and county mortality data show similar patterns of cancer excesses for these geographic sites.[7] The kidney cancer rate was the only one found to be higher than that of the U.S. population consistently across the three plants. However, the magnitude of increase was small and not statistically significant. Additional analyses would be required to determine if these (cancer rate) differences represent true geographic variations or differences among plant processes. Detailed comparisons with state and local rates might provide more insight, and further analyses by plant processes at the three sites may be of academic interest; however, considering the low realtive risks observed, additional geographic analyses may not be justified.

Occupational groups were examined by comparing potentially exposed workers with nonexposed workers. The definition of occupational category was based on job titles and not on specific processes or chemical agents at the work sites. Misclassification may have occurred as employees were assigned to an occupational category based

Table 4 — Distribution of Occupational Categories by Smoking History, 1970 Through 1977							
	Ever Smoked		**Never Smoked**		**Unknown**		**Total**
Occupational Categories	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**
Nonexposed							
Officials/managers	255	50.9	100	20.0	146	29.1	**501**
Professionals	797	32.2	566	22.9	1,113	45.0	**2,476**
Technicians	144	53.5	66	24.5	59	21.9	**269**
Office/clerical	638	42.8	409	27.4	444	29.8	**1,491**
Subtotal	**1,834**	**38.7**	**1,141**	**24.1**	**1,762**	**37.2**	**4,737**
Potentially exposed							
Process operators	3,368	54.9	1,032	16.8	1,735	28.3	**6,135**
Mechanical workers	4,080	57.0	1,313	18.3	1,769	24.7	**7,162**
Laborers	835	53.1	182	11.6	555	35.3	**1,572**
Service workers	241	50.3	59	12.3	179	37.4	**479**
Laboratory technicians/field professionals	505	55.6	213	23.4	191	21.0	**909**
Subtotal	**9,029**	**55.5**	**2,799**	**17.2**	**4,429**	**27.2**	**16,257**
Unknown	242	34.4	119	16.9	343	48.7	704
Grand Total	**11,105**	**51.2**	**4,059**	**18.7**	**6,534**	**30.1**	**21,698**

Table 5 — Directly Adjusted* Mortality Rates per 10,000 Person-Years for Deaths Due to Selected Causes in the Baton Rouge, Baytown, and Bayway/Bayonne Cohorts and the U.S. Population, 1970 Through 1977

Cause of death†	Death Rate: Baton Rouge Observed No.	Baton Rouge Rate	Baytown Observed No.	Baytown Rate	Bayway/Bayonne Observed No.	Bayway/Bayonne Rate	U.S. Rate	Highest Rate Ratio‡
All causes of death (000-999)	1,205	238.9	784	238.7	1,209	239.2	255.3	0.9
All malignant neoplasms (140-209)	249	47.5	158	46.6	259	55.6	51.2	1.1
All digestive organs (150-159)	73	13.5	39	14.7	84	17.9	14.2	1.3
Stomach (151)	11	1.5	6	1.8	16	2.7	2.5	1.1
Large intestine (153)	24	4.5	11	5.8	32	6.7	5.0	1.3
Pancreas (157)	23	4.7	10	3.3	9	1.9	2.8	1.7
All respiratory system (160-163)	79	15.3	54	14.6	84	19.1	16.8	1.1
Lung (162)	78	15.2	54	14.6	77	17.7	16.0	1.1
All genitourinary organs (180-189)	39	7.8	20	4.9	41	7.3	9.0	0.9
Kidney (189)	9	1.7	6	1.2	7	1.6	1.1	1.5
All lymphopoietic (200-209)	25	4.9	16	4.0	14	3.5	4.5	1.1
Endocrine/nutritional/metabolic diseases (240-279)	18	3.4	9	7.9	32	6.9	4.6	1.7
Diseases of circulatory system (390-458)	729	147.4	455	140.6	762	142.3	143.8	1.0
Diseases of respiratory system (460-519)	66	13.5	48	17.3	50	8.4	18.5	0.9
Diseases of digestive system (520-577)	34	6.6	25	6.2	34	7.3	9.5	0.8
Diseases of genitourinary system (580-629)	25	5.1	10	3.0	16	3.2	3.7	1.4
Symptoms/senility/ill-defined (780-796)	8	1.5	17	4.7	17	5.1	3.2	1.6
All external causes (E800-E999)	52	9.2	38	8.9	21	5.0	14.3	0.6
Total No. of person-years§	56,012.0		46,192.6		35,525.8			
Total No. of employees‖	8,662		7,322		5,776			
Total No. of deaths	1,205		784		1,209			

* Rates for the three plant cohorts and the U.S. population were directly adjusted for age, sex, race, and calendar year using the total study population as the standard population

† International Classification of Diseases (ICDA), eighth revision codes shown in parentheses

‡ Ratio of the highest plant mortality rate to the U.S. rate

§ The sum of person-years for the Baton Rouge, Baytown, and Bayway/Bayonne cohorts is slightly greater (27.8 person-years, or 0.02% of the total person-years) than that for the total study population, owing to rounding

‖ An employee may have been at more than one plant during this observation period

on where they had spent the largest portion of their working time. It is impossible to determine accurately the magnitude of misclassification, effects of which tend to dilute any real difference.[8] Furthermore, the use of complete work histories for analyses requires more extensive methodological development. The mortality rates tended to be higher among potentially exposed workers than among nonexposed workers but the differences were minimal. One exception was the nonexposed technicians, who had the highest rates for all causes and for all malignant neoplasms. This occupational group represented 1.2% of the total population and only 0.9% of the deaths (N=269; number of deaths, 30). Since these rates are based on a very small number of deaths and since the list of main jobs included in this occupational group does not suggest areas with occupational exposure problems, the relatively higher rates among the nonexposed technicians cannot be interpreted further. Other exceptions included the respiratory and digestive system disease rates and the brain/CNS cancer rate, which were higher for nonexposed workers. The brain/CNS result does not support the recent finding in the Texas Gulf Coast study, in which the proportion of brain cancer deaths was higher than expected among refinery and petrochemical workers who were union members.[9] No one occupational subgroup had consistently higher mortality rates for all causes of death examined. However, rates were found to be generally lower for managers, professionals, and clerical workers.

Smokers generally had higher mortality rates than nonsmokers, with the exception of deaths from cancers of the pancreas, genitourinary organs, and prostate. However, these observations were based on small numbers and interpretations should be made with caution. Smoking history explained most of the differences observed be-

Table 6 — Observed Number of Deaths and Directly Adjusted* Mortality Rates per 10,000 Person-Years for Selected Causes of Death, by Occupational Categories, 1970 through 1977

Cause of Death‡	Occupational Category†				
	Potentially Exposed		Nonexposed		
	Observed No.	Rate	Observed No.	Rate	RR§
All causes (000-999)	2,657	236.1	443	189.1	1.2**
All malignant neoplasms (140-209)	557	49.8	99	41.0	1.2
All digestive organs (150-159)	167	14.6	25	10.7	1.4
Liver/gallbladder/bile ducts (155-156)	14	1.2	0	. . .	. . .
Pancreas (157)	35	3.0	7	2.8	1.1
All respiratory system (160-163)	185	16.7	29	12.3	1.4
Lung (162)	177	16.0	29	12.3	1.3
All genitourinary organs (180-189)	87	7.7	11	4.8	1.6
Prostate (185)	50	4.4	5	2.3	1.9
Bladder (188)	16	1.4	3	. . .	. . .
Kidney (189)	18	1.6	3	. . .	. . .
Brain/CNS (191-192)	8	0.7	7	2.8	0.3
All Lymphopoietic (200-209)	45	4.4	9	3.8	1.2
Lymphosarcoma/reticulosarcoma (200)	10	0.9	3	. . .	. . .
Leukemia (204-207)	15	1.7	4	. . .	. . .
Diseases of circulatory system (390-458)	1,640	145.6	250	106.6	1.4**
Diseases of respiratory system (460-519)	124	10.8	32	14.7	0.7
Diseases of digestive system (520-577)	66	5.8	19	7.5	0.8
Diseases of genitourinary system (580-629)	47	4.0	3	. . .	. . .
Total No. of person-years	103,360.1		30,354.7		
Total No. of employees	16,257		4,737		
Total No. of deaths	2,657		443		

* Rates were adjusted for age, sex, race, and calendar year using the total study population as the standard population; rates were not included w the observed number of deaths was less than five

† For 704 subjects, accounting for 98 deaths, a category could not be assigned because of missing data

‡ *ICDA*, eighth revision codes shown in parentheses

§ Rate ratio (RR): ratio of rates of potentially exposed subjects to those of nonexposed subjects; statistical significance at $p<.05$ is indicated by **

tween the occupational groups. Smokers incurred a higher risk of mortality from most causes of death when compared with nonsmokers, regardless of occupational category. In the nonexposed category, technicians who had the highest death rates for malignant neoplasms also had the highest percentage of smokers, while the professionals with the lowest death rates also had the lowest percentage of known smokers. In the potentially exposed category, the distribution of smokers was similar and the death rates were also similar among the five occupational categories. It appears that differences in death rates across occupational subgroups could be explained to great extent by differences in smoking history. Other studies have shown that cigarette consumption is higher among blue-collar workers as compared with white-collar workers.[10] Since the majority of the potentially exposed workers in our study could be classified as blue-collar workers, our results are consistent with these findings. There remains a slight excess in mortality for potentially exposed as compared with nonexposed workers allowing for smoking differences. However, the data on which this report is based do not allow further conclusions to be drawn because the numbers of deaths are too small in occupation-and smoking-specific subgroups to permit further analysis. With smoking histories unavailable for 30% of the study pc ulation, it is not possible to separate out completely t effects of smoking from potential effects of a specific cupation. The exposed and nonexposed groups also m have varied with respect to other socioeconomic fact that could be related to mortality outcome. Expansion this cohort over time and across other similar worker pc ulations may help us to identify the possible effects such confounders as educational level, family history, etary intake, alcoholic consumption, and other presen unknown factors that may become apparent in the futu

Summary

A cohort of 21,698 U.S. refinery and chemical pl workers was observed for eight years to determine if th were interplant variations in causes of mortality. Mortal outcomes were analyzed by geographic site, by occu tional subgroups, and by smoking history. Mortality fr cancer of the pancreas was highest in the Baton Rou cohort, while mortality from digestive and respiratory c cers was highest in the Bayway Bayonne cohort. The interplant variations in mortality were consistent with kno geographic variations. Only kidney cancer rates were c sistently higher than those of the U.S. population for

Table 7 — Observed Number of Deaths and Directly Adjusted* Mortality Rates per 10,000 Person-Years for Selected Malignant Neoplasms by Occupation, 1970 through 1977

	Occupation Group†									
	Nonexposed				Potentially Exposed					
e of Death‡	Officials Managers (N=501)	Professionals (N=2,476)	Technicians (N=269)	Office/ Clerical (N=1,491)	Process Operators (N=6,135)	Mechanical Workers (N=7,162)	Laborers (N=1,572)	Service Workers (N=479)	Laboratory Technicians/ Field Professionals (N=909)	U.S. Rate
rgan cancer	16.1	11.0	. . .	6.7	18.3	12.4	16.1	13.4	. . .	14.2
))	(5)§	(12)	(2)	(6)	(56)	(70)	(31)	(7)	(3)	
eatic cancer (157)	. .	. .	. . .	. .	2.6	3.2	0.5	. . .	. . .	2.8
	(3)	(2)	(1)	(1)	(10)	(18)	(6)	(0)	(1)	
r system	. .	11.9	. . .	15.0	19.4	15.8	17.0	11.2	18.6	16.8
160-163)	(2)	(12)	(2)	(13)	(55)	(90)	(26)	(5)	(9)	
cancer (162)	. .	11.9	. . .	15.0	18.9	15.1	16.4	. . .	18.6	16.0
	(2)	(12)	(2)	(13)	(53)	(86)	(25)	(4)	(9)	
icer (189)	. .	. .	. .	. .	1.8	1.6	. .	. .	. .	1.1
	(0)	(0)	(1)	(2)	(7)	(9)	(2)	(0)	(0)	
cancer	. .	. .	. .	. .	. .	1.1	. .	. .	. .	1.0
2)	(1)	(3)	(2)	(1)	(2)	(6)	(0)	(0)	(0)	
(204-207)	. .	. .	. .	. .	. .	1.6	. .	. .	. .	1.9
	(0)	(2)	(1)	(1)	(2)	(9)	(1)	(2)	(1)	

s were adjusted for age, sex, race, and calendar year using the total study population as the standard population; rates were not calculated when observed number of deaths was less than five
e were 704 missing work histories; of these, 98 were for decedents
l, eighth revision codes shown in parentheses
ber of deaths shown in parentheses

ible 8 — Observed Number of Deaths and Directly Adjusted* Mortality Rates per 10,000 Person-Years for Selected Causes of Death, by Smoking History, 1970 through 1977

Cause of Death†	Ever Smoked		Never Smoked		Rate‡ Ratio
	Observed No.	Rate	Observed No.	Rate	
l causes (000-999)	1,566	254.9	208	131.5	1.9**
All malignant neoplasms (140-209)	377	57.1	43	24.5	2.3**
All digestive organs (150-159)	96	14.5	17	9.2	1.6
Liver/gallbladder/bile ducts (155-156)	10	1.3	2	. . .	. . .
Pancreas (157)	24	3.7	7	4.4	0.8
All respiratory system (160-163)	146	22.2	4	. . .	. . .
Lung (162)	142	21.6	3	. . .	. . .
All genitourinary organs (180-189)	44	7.4	12	8.4	0.9
Prostate (185)	22	4.1	10	7.3	0.6
Bladder (188)	7	1.2	. . .	. . .	. . .
Kidney (189)	15	2.1	1	. . .	. . .
Brain/CNS (191-192)	9	1.9	3	. . .	. . .
All lymphopoietic (200-209)	31	4.2	4	. .	. .
Lymphosarcoma/reticulosarcoma (200)	7	1.0	2	. . .	. . .
Leukemia (204-207)	12	1.6	1	. . .	. . .
Diseases of circulatory system (390-458)	908	153.1	134	92.0	1.7**
Diseases of respiratory system (460-519)	77	13.2	7	3.8	3.5**
Diseases of digestive system (520-577)	52	7.6	7	3.4	2.2**
Diseases of genitourinary system (580-629)	19	3.8	7	4.0	1.0**
Total No. of person-years	74,362.7		26,418.3		
Total No. of employees	11,105		4,059		
Total No. of deaths	1,566		208		

ates were adjusted for age, sex, race, and calendar year using the total study population as the standard population; rates were not calculated when ne observed number of deaths was less than five
DA, eighth revision codes shown in parentheses
atio of rates for those who ever smoked to those who never smoked; statistical significance at $p<.05$ is indicated by a double asterisk

Table 9 — Directly Adjusted* Mortality Rates per 10,000 Person-Years for Deaths Due to Selected Causes, by Occupational Category and Smoking History

Causes of Death‡	Occupational Category†					
	Potentially Exposed			Nonexposed		
	Ever Smoked	Never Smoked	Rate§ Ratio	Ever Smoked	Never Smoked	Rate§ Ratio
All causes of death (000-999)	279.7	142.6	2.0**	180.2	99.6	1.8**
Diseases of circulatory system (390-458)	169.0	100.6	1.7**	104.0	66.5	1.6
Malignant neoplasms (140-209)	62.1	26.2	2.4**	42.6	19.4	2.2**
Digestive organs (150-159)	16.0	10.0	1.6	9.9	. . .	. . .
Respiratory system (160-163)	24.2	. . .	. . .	16.7	. . .	. . .
Pancreas (157)	3.9	4.8	0.8	3.0	. . .	. . .
Kidney (189)	2.3	. . .	. . .	. . .	. . .	. . .
Brain (191)	. . .	1.0	. . .	. . .	. . .	. . .
Leukemia (204-207)	1.8	. . .	. . .	. . .	. . .	. . .
Total No. of Person-years		103,360.1			30,354.7	
Total No. of employees		16,257			4,737	
Total No. of deaths		2,658			443	

* Rates were adjusted for age, sex, race, and calendar year using the occupational subgroup as the standard population; rates were not calculated the observed number of deaths was less than five
† For 704 subjects, accounting for 98 deaths, a category could not be assigned because of missing data
‡ *ICDA* eighth revision codes shown in parentheses
§ Ratio of ever to never smoked; statistical significance at $p<.05$ is indicated by a double asterisk

Table 10 — Directly Adjusted* Mortality Rates per 10,000 Person-Years for Deaths Due to Selected Causes, by Smoking Histo and Occupational Category†

Cause of Death‡	Ever Smoked			Never Smoked		
	Potentially Exposed	Nonexposed	Rate§ Ratio	Potentially Exposed	Nonexposed	Rate Rati
All causes of death (000-999)	256.8 (1,321)¶	214.2 (210)	1.2**	128.9 (158)	125.9 (43)	1.0
Diseases of circulatory System (390-458)	158.7 (783)	115.7 (111)	1.4**	88.2 (103)	83.6 (26)	1.1
Malignant neoplasms (140-209)	58.0 (321)	48.7 (52)	1.2	25.9 (34)	21.7 (8)	1.2
Digestive organs (150-159)	14.4 (83)	12.0 (11)	1.2	9.7 (14)	. . . (2)	. . .
Respiratory system (160-163)	24.4 (129)	14.0 (16)	1.7	. . . (3)	. . . (1)	. . .
Pancreas (157)	3.4 (19)	3.4 (5)	1.0	4.8 (6)	. . . (1)	. . .
Kidney (189)	2.1 (13)	. . . (2)	. . .	. . . (1)	. . . (0)	. . .
Brain (191)	. . . (4)	3.0 (5)	. . .	. . . (2)	. . . (1)	. . .
Leukemia (204-207)	1.5 (10)	. . . (1)	. . .	. . . (1)	. . . (0)	. . .
Total No. of person-years	74,362.7			26,418.3		
Total No. of employees	11,105			4,059		
Total No. of deaths	1,566			208		

* Rates were adjusted for age, sex, race, and calendar year using the total study population as the standard population; rates were not accountin 98 deaths, calculated when the observed number of deaths was less than five
† For 704 subjects, a category could not be assigned because of missing data
‡ *ICDA*, eighth revision codes shown in parentheses
§ Ratio of rates of potentially exposed workers who ever smoked to those of nonexposed workers who ever smoked; statistical significance at $p<.$ indicated by a double asterisk
‖ Ratio of rates of potentially exposed workers who never smoked to those of nonexposed workers who never smoked
¶ Number of deaths shown in parentheses

three plant sites. Variations in mortality were observed by occupation and smoking history. This study could not completely discriminate between the effects of smoking and the possible contributory effect of occupation on mortality outcome. However, substantially higher death rates among smokers as compared with nonsmokers persisted regardless of occupational classification and, indeed, contributed more to observed differences than did occupation.

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Broker for Medical Services

Those who see occupational medicine in the vanguard of the new national strategy of health promotion and disease prevention worry that industry-sponsored health care is a diversion that may duplicate and undercut the existing health infrastructure. Others doubt that companies can do an adequate job of employee health protection — their unique responsibility — when they dilute this mission with primary care services generally available in the community.

Most companies currently stand on a middle ground; their medical departments serve a brokering function. They maintain collegial ties with a far-flung outside medical network, screening employees and referring them for needed care, and following up afterwards. They informally monitor quality of referred care by consultations and by watching the forms that come through from outside practitioners for disability and other insurance claims.

As this brokerage function evolves, a company medical department can be more aggressive in managing situations that could compromise health. The company's attitude is communicated to outside medical providers and the medical department becomes more activist and anticipatory — thus, more strategic — in its outlook.

—From "Is There a Doctor In-House?" by Diana C. Walsh in *Harvard Business Review*, July/August, 1984.