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Problems and Perspective in Epidemiological Study of Occupational Health Hazards in the Rubber Industry

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An epidemiological analysis of the problems in the study of companies engaged in the manufacture of rubber products in different countries and in different time periods is given. Selected findings on cancer of gallbladder and biliary system, cancer of the lung, and tumors of the central nervous system among rubber workers are presented.

I believe it most appropriate to acknowledge at this conference, the remarkable scientific contributions and vision of Dr. Wilhelm C. Hueper who, for so many years, pioneered the study of occupational cancer and established the basis for the international concern on occupational and environmental cancer. Scientists all over the world are deeply indebted to him for his dedicated service to society.

The problems and perspectives of the study of any industry relate to the attitude, interest, and sense of social responsibility of the management of that industry or plant; and to the degree of awareness and understanding of the workers who unfortunately have not been informed of the hazards to which they were exposed. Further, the problems relate to the degree of responsibiilty exercised by the government for the protection of the industrial population and to the support provided by the government for the necessary resources for the identification and control of industrial health problems.

Past experience has taught us that, for the rubber industry as well as virtually all other industries, the absence of industrial medical surveillance systems and the absence of any environmental monitoring systems, the absence of any early warning detection system for current and delayed health effects among the workers, has created problems of recognition of health hazards, which have accumulated for decades.

Further, the absence of and inadequacy of experimental testing of chemicals prior to their use in the rubber industry, relative to chemicals tested, experimental design, lengths of exposure, and methods of exposure or even of testing chemicals under conditions of production, subject to heat, and in combination with other chemicals, all have compounded and delayed the problems of recognition of the potential health hazards among the workers.

What has not been properly recognized, too, is the generation of very large numbers of new chemicals during the work process and the interaction of these chemicals with other chemicals in the work environment, all of which have not been identified and, therefore, never studied individually or in combination for the toxic and carcinogenic effects. The permutations of numbers of chemicals that could evolve in the work environment, in so many combinations, is tremendous, and for these no toxicological or carcinogenic data are available.

In the present paper, I shall provide an overview relative to the epidemiological considerations, utilizing selections from a series of my own studies on the rubber industry to emphasize certain points for this conference. Virtually, every cancer site, as well as other major cancers, were studied and presented in the summary study (*1*). My analysis of the epidemiological problems was developed after reviewing the various types of studies conducted and the problems of interpretation of the findings of the studies in different countries and in the same country.

The future perspective relative to the rubber industry in the United States is more hopeful because of the constructive approach being developed between labor and management toward

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the resolution of industrial health problems, which began with the tripartite agreement between the International Union, the rubber companies, and the universities. I am pleased that the tripartite agreement which I helped to design has resulted in scientific advancements for the identification and control of occupational cancers and other health hazards in the rubber industry.

Epidemiological Considerations

It must be recognized that rubber companies have utilized several thousand chemical compounds in various combinations in association with the work processes during the past decades, and the continuous introduction of new chemicals, together with the markedly different working conditions at each plant, all contribute significantly to the diversity of each plant and the problems of epidemiological evaluation.

Further, the introduction of different chemicals in different time periods in different companies engaged in the manufacture and processing of rubber products with resultant different latent periods for the biological effects severely handicaps any simultaneous correlation analysis of processes of different companies.

The combination of these and other factors, operates to submerge the detection of the occupational cancers which may exist. Consequently, when similar observations of specific cancer sites or other biological effects are observed, utilizing the same methods and time periods among several rubber companies, these observations take on added significance. Within this context, however, there may be a tendency to discount observations from a single plant, or observations from different plants in which the excess may occur in different departments. This is unwise. The individual study may accurately reflect and indicate some of the potential problems, even though some may be missed.

For each individual plant there may be substantial differences inherent in the size and physical layout which bear on the uniqueness of the physical location of different processes and the handling of materials and chemicals. Further, the age and type of equipment and process and the presence or absence and degree of controls at different points in time provide for variation in each plant. Each company may vary further in the combination of use of the same and different chemicals in each of the processes or in different processes.

There is still the complex problem in intercompany comparisons of differences in production schedules, the volume of chemicals and how they are used and handled, of selection, retention, and separation of employees, and of retirement policies and requirements of life and sickness insurance coverage, etc., for each of the companies over the decades.

For these reasons, we believe that the evaluation of each individual plant, even with its own epidemiological limitations, has real significance. In contrast, strong caution is expressed relative to the averaging effect of the mortality experience of a series of rubber plants which when combined and viewed as a total may submerge the recognition of real excess risks which were detected in some of the individual plants in specific departments and processes.

We are particularly concerned about three fundamental aspects in the study of any industry which has been in existence for 60 years or so and has used such a substantial number of complex chemicals and undergone so many successive major changes in succeeding years.

The first concern in any epidemiological study is the year, or years, in which the cohort study is established—the prospective longitudinal study done retrospectively in time. The latent period for occupational concern may be very great indeed, as demonstrated in the case of the association of asbestos and mesothelioma, which may extend to 40 or 50 years. Consequently, recent cohorts which allow only for comparatively short latent periods have built-in limitations and may provide false negative findings.

Within this context, studies of employee cohorts of the 1930's, 1940's and 1950's, or in succeeding decades, in effect reflect the manufacturing processes and chemicals of prior years. It must be reemphasized that major changes have occurred in the rubber industry, in the chemicals and in the processes used, since the industry's inception. Consequently, carcinogenic exposures, even though not recognized, may have been lessened or discontinued by chance, not because of recognition of the hazard but as a result of evolution of the manufacturing process and changes in chemicals used. Conversely, there may be unrecognized carcinogenic chemicals introduced which cannot be detected epidemiologically until the number of years has elapsed to meet the requirements of the latent period for these chemicals.

Therefore, epidemiological studies of cohort populations in different decades may not be comparable; not only for the same company, but even more so for different companies. At least in studies of the same company, investigators can determine whether the carcinogenic risk persisted over different time periods, provided the employee populations are observed for the same number of years required for occupational cancer. This principle has been effectively applied by some investigators in determining whether risk of bladder cancer had been diminished in different time periods in the rubber industry.

Cohorts of current employees designated at a fixed point in time, reflect a mixture of those hired that year and the few years immediately prior to that date, and the survivor group who may have been employed 20, 30, or 35 years before.

For cancers which have long latent periods, the cohorts identified in the 1950's and 1960's would not necessarily detect the particular cancer site or excess risk unless there was, inherent in the cohort, a sufficiently large subcohort of employees who had been hired 20, 30 years or more before in that plant, in that particular department or process where the detection of risk was observed—in essence, if the subcohort of the early hired workers was very large and happened to be in departments or processes where the carcinogenic risk existed.

False negatives or misleading results may occur if investigators utilize total plant mortality rate as an estimate of risk, even though the dilution effect of the total population is well recognized.

A second concern is in the definition of the cohort, the composition, accuracy, and completeness of the data source, and the characterization of the population specified for inclusion in the study. This has a major bearing on the evaluation of findings conducted by different investigators of the same type of industry, in this case, the companies engaged in the manufacture of rubber products. It is already apparent that cohorts initiated in two different time decades, reflecting different prior occupational exposures, would, therefore, be observed for different lengths of years and would not be comparable, nor are cohorts identified by different criteria comparable (e.g., department process designation versus total employees or retired employees or those covered solely by life insurance).

There is a tendency in the use of life insurance data to assume a completeness of coverage of all employees under all conditions and all periods of time, which may not in fact exist. The insurance criteria for inclusion of employees into the system may change over time as may the applicability of such criteria to employees which may leave the company. It would not be appropriate, as occurred in the study of the chromate industry (*2*), to combine data from a series of rubber plants, all of which entered into insurance coverage at different years, had different numbers of years of actual coverage, and different years of observation since insurance coverage, and therefore different specific years and length of years in which death certificates would be available. Under this combination of limiting factors, comparative evaluation of the findings of specific causes of death for each of the companies would tend to limit and obscure the full extent of the findings.

Third is the problem of utilization of appropriate controls. The general U.S. population is frequently used to derive the expected rates, even though investigators know that the industrial working population (the total plant actuarial) life experience may be 40% better than that of the general population (*3*) which includes the sick, the disabled, and those unable to work.

The resulting higher expected rate derived from the general population narrows the difference between the observed and the expected, and therefore limits the degree of recognition which may occur for a particular cancer site. In some instances the detection or recognition may be completely submerged. The reason given for the use of the U.S. population as a control is one of convenience. This does little, however, to correct the impression which evolves from such studies—that the observed rate was only twice that of the general population or even less than the general population, which may be misleading in terms of determining the degree of real biological effects.

We have utilized, wherever possible, internal controls—the comparison of employee groups within the same plant. In this method all the employees are subjected to the same selective influences and procedures and events at the company of preemployment and periodic medical examinations, of employment and separation practices, of insurance policy requirements and policy changes, of shifts and requirements in production, of reasons for termination, of medical care in the community, and of residence in the area, all of which may at least be brought within the boundaries of comparability.

For this purpose the internal cohort comparisons are made of the employees of each department group, compared with the balance of the company, i.e., all employees in all other departments minus the observed department.

I should like to emphasize this approach, the *utilization of the balance of the company to* derive the expected rates. My series of tables on lung cancer will illustrate this major point. The use of this approach will detect higher risk groups that would not be noted utilizing the total population as comparison.

Internal comparisons of employee groups alone, although effective, still require a further refinement—the characterization of the employee cohorts of the respective departments by date of hire and duration of employment. This has considerable bearing on the sensitivity of detection of the excess in specific cancer sites. Duration of employment data lessens still further the dilution factor. Duration resource data were not available to us.

Another major consideration is the necessity of review of the pathology reports and microscopic slides of the various cancer sites that were observed in an epidemiological study. This will be illustrated with the findings relative to cancer of the gall blader and biliary system. It is not enough to cite the cause of death, e.g., a particular cancer; there should be verification of the specific cancer site.

The problem has been the reluctance to do this, because it could not be done for the controls when the general population was used for this purpose. However, if as was done in our studies, the follow-up on the histological diagnosis is carried out uniformly for the entire cohort, then, both the study population and the internal controls would have the same criteria of histological identification.

In the ultimate analysis, the objective, once the excess risk process or department has been established for each cancer site, is to identify the specific chemicals or combinations of chemicals, in each department or process which may be the etiological factors.

In previous studies (*4, 5*) representing the first epidemiological considerations of the rubber industry, we identified a number of cancer sites for which excess mortality rates occurred, and the present study is a continuation of the study of biological effects among workers in the rubber industry.

Malignant Neoplasm of Gallbladder and Bile Ducts

Table 1 shows the continuation of the study of cancer of the gallbladder and bile ducts among rubber workers. There were 30 deaths due to cancer of gallbladder and bile ducts for males and females.

The findings have emphasized the importance of repeated efforts to obtain hospital and pathology reports which have changed the diagnosis as to precise site of origin of the cancer in some instances. However, such data are not always available. As shown in the footnote of Table 1, three cases were excluded because pathology information on follow-up revealed, for example, cancer of pancreas or of liver.

For comparative purposes, the estimated frequency of the anatomical designation for this rare cancer site was derived from the total of autopsies cited by Edmondson (*6, 7*) utilizing the Los Angeles County Hospital autopsy series. We had calculated (*5*) the ratio for cancer of the ampulla of Vater to total autopsies as 1:2333; for the common bile duct as 1:4600; and for the gallbladder 1:275 (there is considerable difference of opinion among pathologists to the effect that cancer of the gallbladder may occur in 1:500 or 1:1000 autopsies); for cholangioma, 1:1293 autopsies. Regardless of the eventual agreed-upon ratios, there is no doubt that these cancers are very rare, and this designation is sufficient for our purpose. In viewing Table 1, it must be emphasized that the published ratio for these anatomically designated parts of the biliary system relate to the total autopsy and not to total deaths.

For each of the comparisons in both the cohorts, and from the supplementary union deaths, the specific type of cancer is shown.

In the summary by anatomical site for the cases in which this could be determined in the total series, there were three cancers of ampulla of Vater, six of the common bile duct, 13 cancers of the gallbladder, and two designated cholangioma and six bile ducts.

This repeated consistency of the observation in prospective studies and in retrospective stud-

Table 1. Distribution of deaths due to malignant neoplasm of gallbladder and bile ducts among males and females employed by companies manufacturing rubber products.

Company	Cohort	Number of cases		All deaths		All cancers		No. of autopsies (all causes)	Cases autopsied	Cases biopsied	Comments
		M	F	M	F	M	F				
1	Cohort 1938–39 followed to 1968	4	—	552	41	103	11	148	2	2	2 ampulla of Vater 2 gallbladder
2	Cohort 1950 followed to 1972	1	—	1312	59	282	13	355	—	—	1 bile duct
	Union data [a]	4	2	1584	195	410	70	392	1	2	3 bile ducts, 1 gallbladder, 2 common bile duct
3	Cohort 1949 followed to 1972	1	1	336	60	74	18	98	—	—	1 cholangioma 1 gallbladder
4	Cohort 1937–38 followed to 1972	2[b]	—	663	36	95	13	113	1	1	1 common bile duct, gallbladder
	Union data [a]	1	—	214	16	53	4	28	—	—	1 gallbladder
5	Cohort 1937–38 followed to 1972	1	—	59	35	14	9	29	—	—	ampulla of Vater
10		6	—	1523	104	249	44	396	3	3	5 gallbladder, 1 common bile duct
12		4	—	1082	34	184	11	255	3	1	1 cholangioma, 1 bile duct, 2 common bile duct
18		1	—	72	5	11	4	20	1	—	1 gallbladder
26		2[c]	—	580	37	104	14	150[d]	—	2	1 gallbladder, 1 bile duct
	Total	27	3	7977	622	1579	211	1984	11	12	

[a] Additional data (nonduplication of cohort data).

[b] Does not include a case of cancer of ampulla of Vater on death certificate which was found on autopsy to be cancer of pancreas.

[c] Does not include two cases of cancer of the bile duct as recorded on the death certificate, autopsies reported: one as adenocarcinoma of liver (hepatoma) and the other as primary hepatoma.

[d] Estimated.

ies in different rubber companies of rare cancer sites with such frequency, together with the determination that chemicals capable of causing cancer of gallbladder and biliary system were used in the processes of the rubber industry in the early years (*5*), establishes an occupational relationship.

Malignant Neoplasm of Lung

Company 2

Table 2 shows that within the major departments pertaining to manufacturing processes, a higher mortality rate occurred for the curing department for each of the age groups when compared with the balance of the company. For age group 35+, the mortality rate was 167 vs. 94.

Two other departments (nonprocess) (Table 2) also showed a marked excess in mortality rates over the balance of the company. For the machine maintenance and tire shop, the excess rate occurred in each age group and was highest in ages 35+ (176 vs. 93). For the craftsmen the rates were highest in ages 65+ (603 vs. 284) for the balance of the company.

Table 3 shows the mortality rate by combination of risk departments. When the curing department is compared against the balance of the company in which the high risk nonprocess departments are removed (machine maintenance and tire shop, machine shop, and craftsmen) then the excess for the curing department becomes even more marked.

Company 3

Table 4 shows that an excess in mortality rates occurs for the tire and tube building departments and for the curing department. In the curing department, the rate for ages 25–64 was over four times the balance of the company (149 vs. 34). (For this age group the curing department in company 2 had a mortality rate twice the balance of the company).

Company 4

Table 5 shows an excess occurs in the tire and tube building departments for ages 65+ (305 vs. 159) and a consistent excess occurs in the curing department for all age groups.

Table 6 shows the rates by subcohorts. For the tire and tube building departments, two of

Table 2. Number of deaths and age-adjusted mortality rates per 100,000 population by age at death due to malignant neoplasm of lung (162–163) for selected departments of company 2, compared with the balance of the company.[a,b]

Departments	25–64 yr	65+ yr	35+ yr	Balance of company 25–64 yr	Balance of company 65+ yr	Balance of company 35+ yr
Compounding, mill and calender						
No.	2	3	5	35	33	67
Rate	15	207	61	39	323	107
Tire and tube building						
No.	1	2	3	36	34	69
Rate	5	472	107	45	306	108
Curing						
No.	8	7	15	29	29	57
Rate	77	385	167	33	293	94
Machine maintenance and tire shop						
No.	8	5	13	29	31	59
Rate	86	387	176	33	290	93
Craftsmen[c]						
No.	4	6	10	33	30	62
Rate	55	603	189	36	284	95

[a] White males employed by company 2 manufacturing rubber products. Cohort 1950 followed to mid-1972. Seniority List as of 1950. Includes dates of hire through 1950.

[b] Categories of International Classification of Diseases (*8*).

[c] Electricians, elevator mechanics, carpenters, pipefitters and plumbers, blacksmiths, printers and glazers, riggers.

Table 3. Number of deaths and age-adjusted mortality rates per 100,000 population by age at death due to malignant neoplasm of lung (162–163) for combined departments of company 2, compared with the balance of the company.[a, b]

Departments	25–64 yr	65+ yr	35+ yr	Balance of company 25–64 yr	Balance of company 65+ yr	Balance of company 35+ yr
Curing						
No.	8	7	15	29	29	57
Rate	77	385	167	33	293	94
				(All Depts.)—(Curing) (Machine Maint. & Tire Shop)		
Curing						
No.	8	7	15	21	24	44
Rate	77	385	167	28	268	82
				(All Depts.)—(Curing) (Machine Maint. & Tire Shop) (Craftsmen)[c]		
Curing						
No.	8	7	15	17	18	34
Rate	77	385	167	25	229	71
Tire and tube building + curing						
No.	9	9	18	28	27	54
Rate	90	379	115	40	289	99

[a] White males employed by company 2 manufacturing rubber products. Cohort 1950 followed to mid-1972. Seniority List as of 1950. Includes dates of hire through 1950.

[b] Categories of International Classification of Diseases (*8*).

[c] Electricians, elevator mechanics, carpenters, pipefitters & plumbers, blacksmiths, printers and glazers, riggers.

Table 4. Number of deaths and age-adjusted mortality rates per 100,000 population by age at death due to malignant neoplasm of lung (162–163) for selected departments of company 3, compared with the balance of the company.[a,b]

Departments	25–64 yr	65+ yr	35+ yr	Balance of company 25–64 yr	Balance of company 65+ yr	Balance of company 35+ yr
Compounding, mill and calender						
No.	2	1	3	11	6	17
Rate	28	124	57	49	238	105
Tire and tube building						
No.	5	2	7	8	5	13
Rate	68	295	138	37	188	81
Curing						
No.	4	—	4	9	7	16
Rate	149	—	161	34	220	84

[a] White males employed by company 3 manufacturing rubber products. Cohort 1949 followed to mid-1972. Seniority List as of 1949. Includes all dates of hire from 1920 through 1949.

[b] Categories of International Classification of Diseases (*8*).

Table 5. Number of deaths and age-adjusted mortality rates per 100,000 population by age of death due to malignant neoplasm of lung (162–163) for selected departments of company 4, compared with the balance of the company.[a,b]

				Balance of company		
Departments	25–64 yr	65+ yr	35+ yr	25–64 yr	65+ yr	35+ yr
Compounding, mill and calender						
No.	—	—	—	9	7	16
Rate	—	—	—	39	232	92
Tire and tube building						
No.	2	3	5	7	4	11
Rate	29	305	97	36	159	74
Curing						
No.	5	3	8	4	4	8
Rate	97	769	271	20	135	50

[a] White males employed by company 4 manufacturing rubber products. Cohort 1939 followed to mid-1972. Seniority List as of 1942. Includes dates of hire from 1913 through 1939.

[b] Categories of International Classification of Diseases (*8*).

Table 6. Number of deaths and age-adjusted mortality rates per 100,000 population by age at death due to malignant neoplasm of lung (162–163) for selected departments of company 4, compared with the balance of the company.[a,b]

				Balance of company		
Departments	25–64 yr	65+ yr	35+ yr	25–64 yr	65+ yr	35+ yr
Subcohort 1913–1919						
Compounding, mill, and calender						
No.	—	—	—	1	2	3
Rate	—	—	—	120	836	311
Tire and tube building						
No.	—	2	2	1	—	1
Rate	—	2139	462	191	—	206
Curing						
No.	—	—	—	1	2	3
Rate	—	—	—	126	822	313
Subcohort 1920–1929						
Compounding, mill, and calender						
No.	—	—	—	6	3	9
Rate	—	—	—	43	150	79
Tire and tube building						
No.	—	—	—	6	3	9
Rate	—	—	—	46	157	84
Curing						
No.	5	3	8	1	—	1
Rate	136	970	356	8	—	9

[a] White males employed by company 4 manufacturing rubber products. Cohort 1939 followed to mid-1972. Seniority List as of 1942. Includes dates of hire from 1913 through 1939.

[b] Categories of International Classification of Diseases (*8*).

the three cases occurred among those employed 1913–1919. The most notable observation occurred for the curing department. All eight cases of lung cancer in the curing department, as detected in the initial screening comparison of the company, had been employed during the 1920–1929 subcohort, with corresponding increase in rate (356 vs. 9) for ages 35+, whereas the rates for the plant cohort were 271 vs. 50 for the balance of the company. The mortality rates for the curing department of company 4 were greater than for companies 2 and 3.

Malignant Neoplasm of Brain and Other Parts of Nervous System, Benign Neoplasm of Brain and Other Parts of Nervous System, and Neoplasm of Unspecified Nature of Brain and Other Parts of Nervous System

In a demographic study of cancer and other tumors of the brain and central nervous system in which all deaths (1944–1952) for the state of Ohio were classified by degree of confirmation, it was determined that white male resi-

Table 7. Industry comparisons of employment in 1939 in agriculture, construction, and manufacturing industries in Ohio by years of employment.[a]

Industry[b]	No. of deceased employed first quarter 1939	Rate per 100,000 males aged 20–59 in 1939[c]		
		Employees first quarter 1939	Period of employment through 1939	
			≧ 4 yr	≧ 8 yr
Total[d]	934	61.48	—	—
Total (excluding miscellaneous and unspecified industries)	794	52.74	40.34	31.63
Agriculture	74	42.87	41.02	35.93
Construction	48	55.56	42.37	35.34
Manufacturing	300	51.48	38.14	27.45
Durable goods	219	52.56	37.28	25.14
Primary metal industries	63	52.82	44.24	31.71
Fabricated metal industries	24	33.80	21.21	13.89
Machinery except electrical	41	55.18	38.77	24.06
Electrical machinery	27	90.34	64.59	47.28
Transportation equipment	35	76.75	45.72	23.87
Other durable goods	29	38.39	23.92	18.89
Nondurable goods	81	49.14	40.53	33.26
Food and kindred products	14	39.55	32.17	17.33
Rubber	27	63.02	58.69	58.69
Paper and allied products	11	72.51	55.05	46.79
Other nondurable goods	29	40.71	32.41	24.59
All other industries	372	56.50	42.21	33.91

[a] White male residents of Ohio, 25–64 years of age, who died of tumors of the central nervous system, 1944–1952.

[b] Data limited to industries with 10 or more employees in the first quarter, 1939 in the group of Ohio male residents dying of tumors of the central nervous system, 1944–1952.

[c] Rates were computed on the basis of the 1940 Census population and age adjusted on the basis of the total population of continental United States in 1950. Separate population data were not available by duration of employment for each industry.

[d] Approximately 15% of the total was employed in miscellaneous or unreported industries and no data were computed on the length of employment of this group. On the other hand, only about 1% of the population used as a basis for computing rates was in the miscellaneous or unreported industry group.

Table 8. Number of deaths and age-adjusted mortality rates per 100,000 population by age at death due to malignant neoplasm of brain and other parts of nervous system (193) for selected departments of company 3, compared with the balance of the company.[a,b]

Departments	25–64 yr	65+ yr	35+ yr	Balance of company 25–64 yr	Balance of company 65+ yr	Balance of company 35+ yr
Tire and tube building						
No.	2	1	3	1	2	3
Rate	25	179	66	4	69	20
Miscellaneous						
No.	—	2[c]	2	3	1	4
Rate	—	137	30	14	58	27

[a] White males employed by company 3 manufacturing rubber products. Cohort 1949 followed to mid-1972. Seniority List as of 1949. Includes dates of hire from 1920 through 1949.

[b] Categories of International Classification of Diseases (*8*).

[c] Control laboratory and pipefitters.

dents of Summit County (the center of the major rubber companies) had a significantly higher rate than expected.

A similar comparison of Summit County rubber workers confined to histologically confirmed cancers of the central nervous system showed a significantly higher rate than expected.

Table 7 shows the age-adjusted mortality rate for 934 deaths due to cancer and tumors of the central nervous system which occurred during the period 1944–1952 according to industry classification and duration of employment. Data on prior employment in industry were obtained from multiple sources.

In the comparison for those employed 4 yr or more in the designated industry in 1939, the highest death rate occurred in the electrical machinery category (64.59 per 100,000), then rubber (58.69) and paper and allied products (55.05). When the duration is 8 yr or more in that industry, then the rate for the rubber industry is highest (58.69), then electrical machinery (47.28), and paper and allied products (46.79). Table 7 also illustrates that death rates by industry for a single point in time may change extensively when further refined by duration of employment.

For company 3 (Table 8), three (50%) of the six cancers of the brain (193) for the entire company occurred in the tire and tube building departments with a resultant excess over the balance of the company (25 vs. 4 for ages 25–64 and 66 vs. 20 for age 35+). The two deaths which occurred in the miscellaneous departments were classified as control laboratory and pipefitter.

In the intercompany comparisons for categories 19, 223, and 237 of the International Classification of Diseases (*8*), there was an excess in the tire and tube building departments for companies 2, 3, and 4 and for the curing department in companies 2 and 4. Stock preparation and machine maintenance and tire shop in company 2 showed marked excess over the balance.

REFERENCES

1. Mancuso, T. F. Epidemiological investigation of occupational cancers in the rubber industry. In The New Multinational Health Hazards, C. Levinson, Ed., ICF, 1975, pp. 80–136.
2. Public Health Service, Division of Occupational Health. Health of workers in chromate producing industry. Public Health Service, No. 192, 1953.
3. Myers, R. J. Mortality of workers insured under OASDI. Social Security Bull. 24: 11 (1961).
4. Mancuso, T. F., Ciocco, A., and El-Attar, A. A. An epidemiological approach to the rubber industry—a study based on departmental experience. J. Occup. Med. 10: 213 (1968).
5. Mancuso, T. F., and Brennan, M. J. Epidemiological considerations of cancer of the gallbladder, bile ducts and salivary glands in the rubber industry. J. Occup. Med. 12: 333 (1970).
6. Edmondson, H. A. Tumors of the gallbladder and extrahepatic bile ducts. Atlas of Tumor Pathology, Section VII, Fascicle 26, Armed Forces Institute of Pathology, GPO, Washington, D. C., 1967.
7. Edmondson, H. A. Tumors of the liver and intrahepatic bile ducts. Atlas of Tumor Pathology, Section VII, Fascicle 25, Armed Forces Institute of Pathology, GPO, Washington, D.C., 1957.
8. International Classification of Diseases, 7th Revision, World Health Organization.