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Appraisal of the Potential Carcinogenic Properties
of
American Petroleum Products

Report of the Progress
in the
Epidemiological Studies
October 1955

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Cincinnati, Ohio

API 06517

Introduction

The planning for the epidemiological aspects of this project was begun in 1949. The objectives as finally defined by the Medical Advisory Committee are as follows:

1. To ascertain the incidence and prevalence of neoplastic disease among employees of the interested petroleum companies.
2. To compare these rates with those of the general population and other industrial groups.
3. To evaluate, employing epidemiological methods, housekeeping and hygienic arrangements directed toward eliminating or controlling exposure to possible irritants.
4. To advise, utilizing the results of these studies, possible improvements or modifications of present hygienic measures.

Among the various approaches to these goals are:

1. Historical Survey. Assembling and reviewing of the records of known cases in the files of the interested companies.
2. Current Case Registry. Establishing by mutual agreement a central file for receiving and tabulating reports of new cases as they occur among their employees.
3. Insurance Record Surveys. Employing the records of various health benefit plans to determine the incidence of neoplastic disease, not only in the refineries, but also in other industries located in the same general area and using the same labor pool.
4. Studies of Skin Changes. Comparing the incidence and prevalence of keratoses and/or similar hypertrophic lesions in groups of petroleum workers exposed.
5. Slack Wax Studies. Repeating the observations on employees exposed to possible unusual hazards due to their work in wax extraction processes.
6. Advisory Service. Furnishing epidemiological consultant service to aid in planning investigation and control programs for individual companies.
7. Literature Review Service. A literature review service was considered but later rejected. Critical abstracts of pertinent medical literature were to be prepared and circulated periodically to the members of the Medical Advisory Committee.

Only the first two have been implemented to date. The study of health insurance records has been held up until satisfactory relationships can be established. Field surveys were abandoned early because it was quite apparent that such studies must be carried out by the individual company. While the advice and help in the collection of records continues to be given on request, the literature review was never attempted.

Present Status of the Central Registry

Since late in 1950 until September 15, 1955, 1,877 reports have been received from sixteen companies. Twenty-nine have not been included in the various tabulations because the amount of information submitted is inadequate. The acceptable cases have been listed by year of onset and the reporting company number in Table 1a. (See last year's communication for company identification.)

Geographical coverage of the industry is now almost complete. An additional company has decided to participate and is planning to report current cases. Efforts are continuing to improve the accuracy of the reports; to include a larger number of employees in the reporting base (ten of the sixteen participating companies reported that they were recording cancer cases in approximately 120,000 employees); and to obtain the participation of all the major companies represented on the Medical Advisory Committee. Completeness of reporting is likewise a serious problem. From the 120,000 employees, only 185 cases were reported during the year 1954, a rate of approximately 150 per 100,000, or about 1/3 of the value found for the age group 50-54 in the Public Health Service Study. While the age distribution may account for some of this difference, it is obvious that a deficit is present.

At the start of this phase of the project, the information from the clinical and occupational record forms was coded and transferred to key sort cards sorted manually. Late in 1954 when it became evident that participation by a large segment of the industry was assured and the number of reports reached a point where the necessary manipulations became cumbersome, this method of tabulation was abandoned. Electronic methods utilizing IBM equipment were substituted. This change insures greater flexibility and permits the study of more variables in finer detail.

Throughout the first nine months of 1955, the work centered on the preparation of a new code; transferring the information to master tables; and finally punching the cards. Unfortunately, difficulties were encountered, some of which are still unresolved. Additional clerical assistance was assigned, but the task was not completed until September 1, 1955. As a consequence, no tabulations were prepared for the Buffalo Meeting, and only a few very basic summary tables are ready at this time although more complex analyses will be undertaken in the near future.

**Table 1a - NUMBER OF INDIVIDUALS WITH SINGLE NEOPLASMS
ACCORDING TO YEAR OF ONSET AS REPORTED BY 16 COMPANIES**

Company	Prior to 1950	1950	1951	1952	1953	1954	1955*	Total**
01								
02	3	2						5
03								
04								
05								
06	121	78	66	1				266
07	53	9	8	9	11	13		103
08	79	6	8					93
09	27	7	10	6	9	1		60
10		3		1	3	5	1	13
11	19	3	2	2				26
12	3	4	4	16	14	14	2	57
13								
14		7	11	11	18	20	10	77
15	2	2	2	5	4	12	1	28
16								
17	70	14	13	14	32	38	25	206
18	32	31	32	32	63	33	6	229
19	13	14	19	17	15	10	4	92
20								
21								
22								
23	231	39	24	8	12	9	4	327
24	26	9	9	17	11	25	1	98
25	76	26	14	13	19	17	3	168
Total	755	254	222	152	211	197	57	1,848*

***To September 15, 1955**

****Twenty-nine reports are not included because:**

- (a) four onsets were prior to employment in the petroleum industry;
- (b) eleven were totally inadequate and no more information was obtained;
- (c) three did not give a diagnosis;
- (d) eleven were not neoplasms as defined in this study.

Forty-two of the individual cases had multiple tumors.

Table 1b gives the number of individuals according to sex, race, and date of onset. It will be noted that 1,093, or 59% of the 1,848 acceptable reports, concern cases with onsets subsequent to January 1, 1950, the date arbitrarily chosen to separate historical from current records. This means that a reasonable number of new cases are at hand for further study.

It is noteworthy that 42 individuals were reported with two or three neoplasms. These cases are presented in Table 1c. In subsequent tabulations, the totals will include this group, counting each tumor as a separate occurrence. Some better method of including this group in the summaries will be sought during the coming year. In Table 2, therefore, the 1935 neoplasms are listed according to sex, race, and date of onset. Since the known colored group is such a small segment of the total, racial separation is also neglected in the following summary tables.

The first two of the simple summaries compares by sex and date of onset the relative frequency of different forms of cancer, both as to primary site and type, with the results of the 1947 Public Health Service Survey. It must be emphasized that these values are not incidence rates but represent the measurement of the frequency of one form of cancer by comparing the number of that form of cancer with the total number of all cases.

The distribution of tumors reported by the participating companies, both prior and subsequent to 1950 and both as to primary site and type of tumor, follow very closely the pattern found in the PHS Survey. A slight excess, 31.4% as compared to 28.7% of digestive system neoplasms, is noted among males with onsets prior to 1950. This difference is erased, and a smaller proportion is found in this category among the current cases. However, skin and soft tissue lesions are more frequent, 25.9% as to 19.3%, in the group with onsets subsequent to January 1, 1950. A higher proportion of non-glandular epithelial tumors were reported from both groups.

The question of age adjustment always enters the picture. In these particular comparisons, no effort has been made to take this into account. The error introduced by failure to consider this aspect is probably small, but it should be considered in the future.

Summary Tables 3 and 4 represent an attempt to relate the occupation of the patient in the petroleum industry with the primary site of the tumor. Summary Tables 5 and 6 are a similar attempt to ascertain the relationship of occupation to type. Unfortunately, for many of the occupational categories, the number of cases reported is too small to permit adequate analyses, and no reliance can be placed in the differences found. It is noteworthy, however, that these comparisons again show a relative

**TABLE 1b - NUMBER OF INDIVIDUALS WITH SINGLE NEOPLASMS
ACCORDING TO SEX, RACE, DATE OF ONSET, AND MALIGNANCY
AS REPORTED FROM 16 COMPANIES**

Sex	Race	Onset Prior to 1950			Onset Subsequent to 1950			Total		
		Malignant	Benign	Total	Malignant	Benign	Total	Malignant	Benign	Total
MALE	White	578	21	599	927	34	961	1,505	55	1,560
	Colored	17	1	18	17		17	34	1	35
	Not Given	80	23	103	51	5	56	131	28	159
	TOTAL	675	45	720	995	39	1,034	1,670	84	1,754
FEMALE	White	23		23	56		56	79		79
	Not Given	6	3	9	2	1	3	8	4	12
	TOTAL	29	3	32	58	1	59	87	4	91
Not Given		3		3				3		3*
Total Both Sexes		707	48	755	1,053	40	1,093	1,760	88	1,848

*These cases are not in subsequent tabulations.

Table 1c - NUMBER OF INDIVIDUALS WITH MULTIPLE NEOPLASMS ACCORDING TO SEX, RACE, DATE OF ONSET, AND MALIGNANCY AS REPORTED FROM 16 COMPANIES

Sex	Race	Onset Prior to 1950					Onset Subsequent to 1950				
		Three Malign	Two Malign	One Benign One Malign	Two Benign	Total	Three Malign	Two Malign	One Benign One Malign	Two Benign	Total
MALE	White	2	14	1		17	1	14	2	1	18
	Colored		1			1					
	Not Given		1	2	2	5					
	Total	2	16	3	2	23	1	14	2	1	18
FEMALE	White							1			1
Total Both Sexes		2	16	3	2	23	1	15	2	1	19

Table 2 - NUMBER OF NEOPLASMS ACCORDING TO SEX, RACE, DATE OF ONSET,
AND MALIGNANCY AS REPORTED FROM 16 COMPANIES

Sex	Race	Onset Prior to 1950			Onset Subsequent to 1950			Total Neoplasms Reported*		
		Malignant	Benign	Total	Malignant	Benign	Total	Malignant	Benign	Total
MALE	White	613	22	635	960	38	998	1,573	60	1,633
	Colored	19	1	20	17		17	36	1	37
	Not Given	84	29	113	51	5	56	135	34	169
	TOTAL	716	52	768	1,028	43	1,071	1,744	95	1,839
FEMALE	White	23		23	58		58	81		81
	Not Given	6	3	9	2	1	3	8	4	12
	TOTAL	29	3	32	60	1	61	89	4	93
Not Given		3		3				3		3**
Total Both Sexes		748	55	803	1,088	44	1,132	1,836	99	1,935

*In 1,919 individuals reported to September 15, 1955.

**These cases are not included in subsequent tabulations.

increase in frequency of neoplasms of the skin and soft tissues and of a non-glandular epithelial type.

Summation

It is planned to continue these studies following essentially the original plan. Now that the information can be tabulated readily by electronic devices, many further analyses are possible and will be undertaken.

The epidemiological investigations developed slowly for several good and sufficient reasons. The first was that certain of the companies have no centralized medical department to collect the necessary data, past or future. Even with medical departments, some found it difficult to participate because (a) the department is new and has no past records; or (b) the record system in use does not permit easy location of the clinical records of the case. Another is that this was a precedent-breaking departure from usual relationships. Companies and physicians are reporting voluntarily to an unofficial central agency. Physicians have always rebelled against even the official requirement of reporting of communicable disease cases. This makes it more difficult to secure cooperation on a voluntary basis. An occasional management is still wary and is waiting to see what happens.

The cooperation obtained and the progress made in view of these many difficulties is significant although, as yet, little reliance can be placed on the results. As the project grows and matures and more of the current cases are found and reported, worthwhile comparisons will be forthcoming. Further, as the recognition of the need of such studies crystallizes, other and different approaches may become feasible.

**Summary Table 1 - MALIGNANT NEOPLASMS
ACCORDING TO SEX, DATE OF ONSET, AND SITE OF TUMOR**

Site	Male	Female									
		USA* 1947	Prior to 1950		Subsequent to 1950		USA* 1947	Prior to 1950		Subsequent to 1950	
			No.	%	No.	%		No.	%	No.	%
Buccal Cavity 00-0X	6.9	55	7.7	77	7.5	2.2	0	0.0	0	0.0	
Digest. Sys. and Perit. 10-1X	28.7	225	31.4	273	26.6	19.8	7	24.1	7	11.7	
Respiratory System 20-2X	12.6	87	12.2	153	14.9	2.3	3	10.3	0	0.0	
Breast 30	0.2	0	0.0	2	0.2	22.0	8	27.6	22	36.7	
Genital Organs 40-4X	10.4	58	8.1	76	7.4	25.5	2	6.9	19	31.7	
Urinary System 50-55	6.9	40	5.6	60	5.8	3.1	0	0.0	2	3.3	
Skin and Soft Tissue 60-6X	19.3	139	19.4	266	25.9	13.1	4	13.8	6	10.0	
Bones 70-75	0.8	16	2.2	7	0.7	0.5	3	10.3	0	0.0	
Brain 76-78	2.7	17	2.4	18	1.8	1.9	0	0.0	1	1.7	
Lymph. and Hem. System 80-8Y	6.7	36	5.0	52	5.1	4.2	0	0.0	1	1.7	
Other Sites 90-9X	4.8	43	6.0	44	4.3	5.4	2	6.9	2	3.3	
Total	100.0	716	100.0	1,028	100.0	100.0	29	100.0	60	100.0	

*From "Morbidity from Cancer in the United States," Public Health Monograph No. 29, U.S.P.H.S.

**Summary Table 2 - MALIGNANT NEOPLASMS
ACCORDING TO SEX, DATE OF ONSET, AND TYPE OF TUMOR**

Type of Tumor	USA* 1947	Male				USA* 1947	Female			
		Prior to 1950		Subsequent to 1950			Prior to 1950		Subsequent to 1950	
		No.	%	No.	%		No.	%	No.	%
Gland. Epith. 00-09	22.4	114	15.9	161	15.7	31.1	7	24.1	22	36.7
Non-Gland. Epith. 11-19	60.1	484	67.6	703	68.4	54.7	17	58.6	31	51.7
Leukemia 20-29	2.9	12	1.7	13	1.3	1.7	1	3.4	0	0.0
Lymphoma 30-39	3.8	29	4.1	41	4.0	2.4	0	0.0	1	1.7
Nervous Tissues 40-49	2.0	5	0.7	14	1.4	1.4	0	0.0	1	1.7
Vascular Tissues 50-59	0.2	1	0.1	2	0.2	0.2	0	0.0	0	0.0
Muscle 66-69	0.2	0	0.0	1	0.1	0.4	0	0.0	0	0.0
Non-Epith. Tissues 70-79	2.0	18	2.5	20	1.9	1.6	1	3.4	1	1.7
Embry. and Mixed Tissues 80-89	1.5	14	2.0	16	1.6	1.3	0	0.0	0	0.0
Not Classified 97-99	4.8	39	5.4	57	5.5	5.0	3	10.3	4	6.7
Total	100.0	716	100.0	1,028	100.0	100.0	29	100.0	60	100.0

*From "Morbidity from Cancer in the United States," Public Health Monograph No. 29, U.S.P.H.S.

**Summary Table 3 - PERCENTILE DISTRIBUTION OF MALIGNANT NEOPLASMS
IN MALES WITH ONSETS PRIOR TO JANUARY 1, 1950,
ACCORDING TO SITE OF TUMOR AND PETROLEUM OCCUPATION
AS COMPARED TO THE UNITED STATES' EXPERIENCE**

Principal Pet. Occupation Site	USA* 1947	Produc- tion 01-09	Refining							Trans- port 80-89	Market and Exec. 90-98	Others 99
			Cracking 20-29	Lub. and Grease 30-35	Paraffin 36-39	Str. Run 40-49	Spec. Prod. 50-59	Mainten- ance 60-69	Others 70-79			
Buccal Cavity 00-0X	6.9	5.2	12.5	12.5	0.0	15.4	23.1	7.7	6.9	12.3	6.8	0.0
Digest. Sys. and Perit. 10-1X	28.7	28.6	37.5	37.5	33.3	23.1	15.4	31.6	34.6	31.6	30.8	20.0
Respiratory System 20-2X	12.6	18.2	18.8	12.5	4.8	7.7	38.5	8.6	13.2	10.5	12.0	10.0
Breast 30	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Genital Organs 40-4X	10.4	2.6	0.0	12.5	38.1	15.4	0.0	8.6	5.7	14.0	6.0	20.0
Urinary System 50-55	6.9	3.9	6.3	12.5	0.0	7.7	7.7	4.8	3.1	5.3	10.5	10.0
Skin and Soft Tissue 60-6X	19.3	23.4	25.0	12.5	14.3	30.8	15.4	22.5	20.1	12.3	13.5	30.0
Bones 70-75	0.8	3.9	0.0	0.0	4.8	0.0	0.0	2.9	1.9	0.0	2.3	0.0
Brain 76-78	2.7	1.3	0.0	0.0	4.8	0.0	0.0	1.9	2.5	3.5	3.8	0.0
Lymph. and Hem. System 80-8Y	6.7	2.6	0.0	0.0	0.0	0.0	0.0	7.2	5.7	5.3	5.3	0.0
Other Sites 90-9X	4.8	10.4	0.0	0.0	0.0	0.0	0.0	4.3	6.3	5.3	9.0	10.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

*From "Morbidity from Cancer in the United States," Public Health Monograph No. 29, U.S.P.H.S.

**Summary Table 4 - PERCENTILE DISTRIBUTION OF MALIGNANT NEOPLASMS
IN MALES WITH ONSETS SUBSEQUENT TO JANUARY 1, 1950,
ACCORDING TO SITE OF TUMOR AND PETROLEUM OCCUPATION
AS COMPARED TO THE UNITED STATES' EXPERIENCE**

Principal Pet. Occupation Site	USA* 1947	Produc- tion 01-09	Refining							Trans- port 80-89	Market and Exec. 90-98	Others 99
			Cracking 20-29	Lub. and Grease 30-35	Paraffin 36-39	Str. Run 40-49	Spec. Prod. 50-59	Mainten- ance 60-69	Others 70-79			
Buccal Cavity 00-0X	6.9	6.3	2.7	15.0	5.6	10.5	12.5	7.4	9.8	6.8	7.1	0.0
Digest. Sys. and Perit. 10-1X	28.7	15.1	35.1	5.0	22.2	31.6	25.0	29.6	29.4	24.8	29.0	24.0
Respiratory System 20-2X	12.6	16.7	8.1	25.0	11.1	10.5	37.5	14.8	9.8	19.7	15.2	24.0
Breast 30	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0
Genital Organs 40-4X	10.4	7.1	5.4	0.0	27.8	0.0	0.0	7.4	5.4	14.5	6.2	4.0
Urinary System 50-55	6.9	6.3	5.4	15.0	11.1	10.5	0.0	6.5	3.9	3.4	5.4	16.0
Skin and Soft Tissue 60-6X	19.3	36.5	29.7	40.0	22.2	31.6	25.0	24.3	28.4	21.4	19.6	24.0
Bones 70-75	0.8	0.8	2.7	0.0	0.0	0.0	0.0	0.0	0.5	1.7	0.9	0.0
Brain 76-78	2.7	0.8	2.7	0.0	0.0	0.0	0.0	1.3	2.5	1.7	2.7	0.0
Lymph. and Hem. System 80-8Y	6.7	6.3	2.7	0.0	0.0	0.0	0.0	5.2	7.4	3.4	4.9	4.0
Other Sites 90-9X	4.8	4.0	5.4	0.0	0.0	5.3	0.0	2.6	2.9	2.6	8.9	4.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

*From "Morbidity from Cancer in the United States," Public Health Monograph No. 29, U.S.P.H.S.

**Summary Table 5 - PERCENTILE DISTRIBUTION OF MALIGNANT NEOPLASMS IN MALES
WITH ONSETS PRIOR TO JANUARY 1, 1950, ACCORDING TO TYPE OF NEOPLASM
AND PETROLEUM OCCUPATION AS COMPARED TO THE UNITED STATES' EXPERIENCE**

Principal Pet. Occupation Type of Neoplasm	USA* 1947	Produc- tion 01-09	Refining							Transport 80-89	Market and Exec. 90-98	Others 99
			Crack- ing 20-29	Lub. and Grease 30-35	Paraffin 36-39	Str. Run 40-49	Spec. Prod. 50-59	Main- tenance 60-69	Others 70-79			
Gland. Epith. 00-09	22.4	5.2	6.3	12.5	23.8	23.1	30.8	18.7	15.7	17.5	13.5	40.0
Non-Gland. Epith 11-19	60.1	83.1	87.5	75.0	66.7	61.5	69.2	59.8	64.8	64.9	73.7	60.0
Leukemia 20-29	2.9	1.3	0.0	0.0	0.0	0.0	0.0	1.4	3.1	1.8	1.5	0.0
Lymphoma 30-39	3.8	2.6	0.0	0.0	0.0	7.7	0.0	6.2	4.4	3.5	3.0	0.0
Nervous Tissues 40-49	2.0	0.0	0.0	0.0	4.8	0.0	0.0	0.5	0.0	1.8	1.5	0.0
Vascular Tissues 50-59	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0
Muscle 66-69	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Non-Epith. Tissues 70-79	2.0	1.3	0.0	12.5	0.0	0.0	0.0	1.9	4.4	3.5	2.3	0.0
Embry. and Mixed Tissues 80-89	1.5	2.6	0.0	0.0	0.0	0.0	0.0	1.9	0.6	5.3	3.0	0.0
Not Class. 97-99	4.8	3.9	6.3	0.0	4.8	7.7	0.0	9.6	6.3	1.8	1.5	0.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

*From "Morbidity from Cancer in the United States," Public Health Monograph No. 29, U. S. P. H. S.

**Summary Table 6 - PERCENTILE DISTRIBUTION OF MALIGNANT NEOPLASMS IN MALES
WITH ONSETS SUBSEQUENT TO JANUARY 1, 1950, ACCORDING TO TYPE OF NEOPLASM
AND PETROLEUM OCCUPATION AS COMPARED TO THE UNITED STATES' EXPERIENCE**

Principal Pet. Occupation	USA* 1947	Produc- tion 01-09	R e f i n i n g							Transport 80-89	Market and Exec. 90-98	Others 99
Type of Neoplasm			Crack- ing 20-29	Lub. and Grease 30-35	Paraffin 36-39	Str. Run 40-49	Spec. Prod. 50-59	Main- tenance 60-69	Others 70-79			
Gland Epith. 00-09	22.4	7.9	27.0	10.0	22.2	21.1	25.0	14.3	12.3	25.6	15.2	28.0
Non-Gland Epith. 11-19	60.1	75.4	56.8	85.0	72.2	63.2	75.0	65.2	71.6	64.1	68.3	60.0
Leukemia 20-29	2.9	1.6	0.0	0.0	0.0	0.0	0.0	1.7	1.5	0.0	1.3	4.0
Lymphoma 30-39	3.8	6.3	2.7	0.0	0.0	0.0	0.0	3.5	5.9	3.4	3.6	0.0
Nervous Tissues 40-49	2.0	0.8	0.0	0.0	0.0	0.0	0.0	0.9	2.0	0.9	2.2	4.0
Vascular Tissues 50-59	0.2	0.8	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0
Muscle 66-69	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0
Non-Epith. Tissues 70-79	2.0	0.8	5.4	0.0	5.6	5.3	0.0	3.9	1.0	1.7	0.9	0.0
Embry. and Mixed Tissues 80-89	1.5	1.6	0.0	0.0	0.0	0.0	0.0	1.3	1.5	1.7	2.7	0.0
Not Class. 97-99	4.8	4.8	8.1	5.0	0.0	10.5	0.0	8.7	4.4	2.6	5.4	4.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

*From "Morbidity from Cancer in the United States," Public Health Monograph No. 29, U.S.P.H.S.