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CANCER EXPERIENCE OF WORKERS EMPLOYED IN THE STEEL AND ALUMINUM INDUSTRIES

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Our purpose in preparing this presentation was two-fold. First, we wanted to call attention to the reported high risk of various cancers within certain sections of the steel and aluminum industries. Second, we wanted to use this material to point out the need for systematic industry-wide studies of aluminum and other industries which might hopefully lead to the identification of previously unrecognized occupational carcinogens.

In recent years, much attention has been given to the study of cancer due to occupational exposures, and a great variety of agents in the industrial environment have been implicated as human carcinogens (Table 1). We are all now aware, for example, of the lung cancers and mesotheliomas that result from asbestos exposure; the bladder cancers induced by exposure to beta-nepthylamine, benzidine and other aromatic amines; and the angiosarcomas of the liver due to vinyl chloride exposure, to name only a few. Unfortunately, millions of workers have been needlessly exposed to these agents and consequently many have suffered and died from occupational cancers, because of the long delay between the first introduction of agents into the workplace, the first suspicion of cancer hazard, and the systematic development of evidence

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considered necessary to demonstrate the carcinogenicity of such agents. A more detailed discussion of this delay period and alternative approaches to early identification of occupational carcinogens is given elsewhere.[1-2] Of particular interest to the present discussion is the long delay between the first observation of human cancers induced by combustion products of bituminous coal and the development of evidence describing the cancer risks among men employed at coke plants in the steel industry - a period of two hundred years.

In 1962, the United States Public Health Service, in collaboration with the Department of Biostatistics, University of Pittsburgh School of Public Health and three major steel firms, initiated a study to analyze the mortality experience of men employed in the steel industry in 1953. The purpose of this study was to determine whether particular patterns of mortality among workers employed at certain trades or at certain work processes might provide leads to causative agents for occupational diseases. The methodological approaches to this study and many of the findings have been presented in a series of papers published in the Journal of Occupational Medicine.[3-12]

Using detailed work histories going back to original employment with the steel firms, it was possible to determine cause-specific rates of mortality for more than 60 work areas within the industry, and for a great variety of trades. As shown in Table II, unusual patterns of site specific cancer have been noted for several work areas. Because of the unusually high lung cancer risk observed among coke plant workers and the variety of cancer sites in excess for men employed in this area, more detailed analysis of this experience was undertaken. As seen in Table III, the greatest risk is noted for those with longest exposure, and those employed where exposure to emissions is greatest (topside). The United States Department of Labor has now proposed a standard to protect workers from these emissions. The detailed evidence indicating the high risk of specific cancers among men employed at the coke plant, and the demonstration of a relationship between level of exposure to coke oven emissions, and the level of disease response was crucial in reaching this decision

As noted previously, the initial evidence suggesting that carcinogenic agents are produced during the carbonization or combustion of bituminous coal was presented by Percivall Pott in 1775. Since that time, a great amount of information indicating excess cancer of several sites among workers in other coal combustion or carbonization occupations has been noted and, in fact, a report of official statistics from England and Wales for the years 1921 - 1938 showed an excess lung cancer mortality for gas producermen, chimney sweeps, and several categories of gas works employees.[13] The excess indicated for gas stokers and coke oven chargers was approximately three-fold. Although many of us might agree that such a high level of risk would be sufficient evidence for initiation of controls by standard setting agencies, workers have continued to be exposed to carcinogens in these environments and have suffered and died from a variety of cancers while we awaited the more definitive studies of defined cohorts.

In trying to assess the extent of the cancer problem in the aluminum industry, we find the same situation as we noted for gas workers and coke oven workers thirty years ago. That is, review of death certificates shows that persons employed in the industry are at high risk of developing cancer. Furthermore, men employed in certain work areas with exposures related to those at the coke plant appear to be at greatest risk.

During the electrolytic reduction of alumina to aluminum a variety of toxic substances are released which may contaminate the workroom air. Among these substances, hydrogen fluoride, fluori fume, and dust and carbon monoxide are potential contaminants whose biological effects are recognized. In addition, coal tar pitch volatiles are also released in the process, either in the anode preparation area for pre-baked anodes, or in the pot lines where Soderberg self-baking cells are used.

Investigators from the Soviet Union[14-15] have reported a significantly higher mortality for all cancers and for specific sites such as lung, bronchi and pleura, and have reported an increased incidence of skin cancer among workers in the aluminum "electrolyzer shops" in comparison with the general population in the same cities. Unfortunately, neither of these studies is sufficiently documented to allow firm conclusions.

Milham[16] has reported an increase in proportionate mortality from total cancer, cancer of the pancreas, respiratory system, and malignant lymphomas among aluminum workers in Washington State (Table IV). He suggests that the simultaneous increase in pancreatic cancer and lymphoma among aluminum millworkers, not seen in other occupational groups, may be related to coal tar pitch volatiles rather than to metal exposures.

The National Institute for Occupational Safety and Health has recently conducted environmental surveys of aluminum reduction facilities in East and Northwest United States monitoring for coal tar pitch volatiles and a variety of other potentially hazardous substances.[17] These surveys included reduction plants using pre-baked anodes, the vertical pin Soderberg Anodes, and horizontal pin Soderberg anodes. The findings indicate that the concentration of coal tar pitch volatiles (CTPV) as measured by the benzene soluble fraction technique, were almost all elevated above the current OSHA standard of 0.2mg/M^3 CTPV for an 8 hour time-weighted average. The levels were highest in the Soderberg potrooms, presumably because the pitch is heated and "baked off" the anode in these potrooms. In contrast, the lowest measurements were in the potrooms using pre-baked anodes. This type of carbon anode already has the pitch "baked off" before use in the reduction area. Table V provides a review of these surveys.

In a 1976 study of chronic respiratory disease among aluminum reduction workers, sputum cytology was utilized to determine the degree of abnormal cells in the respiratory tract as an early indication of cancer.[18] Because of certain limitations of that study, the authors were unwilling to draw any conclusions regarding the carcinogenic risks among the study group, as compared to matched controls. However, review of the results from that study leads us to conclude that the evidence of potential carcinogenic risk for potroom workers is certainly quite consistent with the previously mentioned mortality observations. When consideration is given to the sputum cytology classification of moderate atypia or higher, a significant ($p < .01$) difference is observed between the study group (30/390) and the control group (5/195). Moreover, when consideration is restricted to cases of suspicious and positive cancer, there are 6/390 meeting such criteria in the study group, compared to 0/193 in the control group. It also should be noted that the control group in this study had a greater exposure to known carcinogens according to prior work history, so that differences in cancer risks are underestimated. Other studies on workers exposed to recognized pulmonary carcinogens have used sputum cytology and demonstrated its validity as an early indicator of cancer.[19, 20]

CONCLUSION

Available evidence from three independent sources strongly suggests an increased cancer risk at one or more sites for aluminum reduction workers, and we have been unable to identify any negative reports on this question. Furthermore, it has been noted that these workers, like the coke oven workers, are exposed to coal tar pitch volatiles, many of whose constituents are recognized to be carcinogenic. While some would conclude that this is sufficient evidence to initiate action for control of the aluminum reduction environment, others would argue that more detailed study should be undertaken before such decisions are made. The situation you may note is analogous to what we observed in the 1930's with the coke oven workers. It would be most unfortunate if we were to wait another forty years before addressing this problem.

At the same time, it must be recognized that agencies of government demand more extensive evidence of excess cancer risk before setting standards for control of such work environments. That being the case, we would strongly suggest to these agencies that in-depth epidemiological cohort studies of aluminum-industry workers be initiated as speedily as possible.

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TABLE I

Non-Cutaneous Cancers of Occupational Origin
By Agent, Occupation and Site

Agent	First Report of Unusual Disease Patterns	Occupations	Sites
I. Coal combustion products	1775	Gas Retort workers Coke oven workers Producer gas men	Lung, urinary bladder, kidney
II. Aromatic amines	1895		
Benzidine beta-Naphthylamine 4-Aminobiphenyl		Dyestuffs manufacturers Rubber workers Cable makers	Urinary bladder, kidney
III. Metals			
Arsenic	1822	Pesticide formulators Copper smelter workers Sheep dip workers Vineyard workers	Lung, liver, lymphoma
Chromium		Producers & processors Pigment makers	Lung
Nickel		Nickel smelters, mixers and roasters	Lung, nasal sinuses
Cadmium			Prostate
IV. Asbestos	1935	Asbestos products makers Insulation workers Miners & millers Shipyard workers	Lung, pleural & peritoneal mesothelioma, digestive tract
V. Ionizing radiation			
X-rays Radon	1531	Radiologists Uranium miners Uranium millers Radium dial painters.	Leukemia Lung Lymphomas Bone
VI. Other			
Bis (chloromethyl) ether		Producers & handlers	Lung
Isopropyl oil		Producers	Lung, larynx, nasal cavity
Mustard gas		Producers	Lung
Vinyl chloride		Polyvinyl chloride producers	Liver, brain, lung, lymphona

TABLE II

Observed And Expected Deaths and Relative Risks
By Cancer Sites For Workers Employed Five or More Years In Specified Work Areas
Allegheny County Steelworkers, 1953 - 1966+

Site	I.C.D. List Numbers	Work Area	Observed	Expected	Relative Risk
All Cancers	140-205	Coke Plant	119	91.9	1.51**
Digestive Organs	150-159	Stainless Annealing	6	2.3	2.80*
Esophagus	150	Open Hearth	13	6.6	2.41*
Stomach	151	Blast Furnace	17	12.3	1.45
Large Intestine	153	Coke Plant	12	7.8	1.77
Rectum	154	Machine Shop	6	2.5	2.55
Respiratory System	160-164	Coke Plant	45	34.9	1.81**
		Mason Department	17	11.0	1.57
		Blacksmith Shop	8	3.8	2.16
		Machine Shop	24	16.6	1.48
Genito-Urinary Organs	177-181	Coke Plant	17	10.4	2.01*
		Janitors	7	3.4	2.28
Prostate	177	Janitors	6	2.3	3.11*
Kidney	180	Coke Plant	6	1.5	15.20**
Leukemia & Lymphoma	200-205	Heat Treating & Forging	5	2.2	2.87

\+ Source: Carol K. Redmond, 1975. Comparative Cause-Specific Mortality Patterns by Work Area within the Steel Industry. U. S. Department of Health, Education and Welfare, Public Health Service, CDC, NIOSH, HEW Publication No. (NIOSH) 75-157.

* Significant at 5% level.
** Significant at 1% level.

Observed And Expected Deaths And Relative Risks
By Cancer Site For Coke Plant Workers Employed Five Or More Years In Selected Work Areas
Allegheny County, 1953 - 1970

Site	I.C.D. List Numbers	Work Area	Observed	Expected	Relative Risk
All Cancers	140-205	Coke Plant	568	525.6	1.11*
		Coke Oven	313	279.5	1.15*
		Full Topside	35	11.0	3.70**
		Part Topside	26	16.7	1.59*
		Side Only	40	34.7	1.17
		Non-oven	65	51.6	1.28
Respiratory System	160-164	Coke Oven	54	21.9	3.02**
		Full Topside	25	3.6	9.19**
		Part Topside	12	5.4	2.29**
		Side Only	17	10.0	1.79*
		Non-oven	14	15.6	0.90
Genito-Urinary Organs	177-181	Coke Oven	16	9.2	1.85*
		Full Topside	3	1.6	--
		Part Topside	6	2.0	3.14*
		Side Only	7	5.4	1.33
		Non-oven	8	6.4	1.26

* Significant of 5% level
** Significant of 1% level
-- Less than 5 deaths

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TABLE I7

Proportionate Mortality Ratios (PMR's)

White male deaths in Washington State, 1950-1971

	ALUMINUM WORKERS		DEATHS	
CAUSE OF DEATH	I.C.D. NUMBER*	OBS.	EXP.	PMR
All Malignant Neoplasms	140 - 204	129	103	126**
Cancer of Esophagus	150	5	2	232
Cancer of Pancreas	157	13	6	204**
Cancer of Respiratory System	160 - 165	40	31	128
Cancer of Testis	178	3	1	251
Cancer of Brain	193	6	4	155
Malignant Lymphoma	200, 202	10	4	250**
Hodgkin's Disease	201	4	2	164

* I.C.D. = International Classification of Diseases, 7th Revision

** $p \leq .05$

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TABLE V

Comparison of Time Weighted Average (TWA) Pitch Volatile Results in Aluminum Reduction Facilities in the Eastern United States Versus Those in the Northwestern United States

ype of Plant & Job Type	Eastern Facilities Number of Samples	Eastern Facilities Concentration, mg/m^3	Northwestern Facilities Number of Samples	Northwestern Facilities Concentration, mg/m^3
re-Baked				
Potrooms				
Potman	3	0.2	13	0.2
Tappers/anode setters	3	0.5	34	0.1-0.5
Pot reliner	1	0.3	29	0.4
arbon Plant				
Ball mill opr.	1	2.4	3	0.2
Press opr.	1	2.9	6	0.1
Mixer opr.	1	0.6	3	0.3
ertical Pin oderberg				
Potrooms				
Potman	10	2.2	5	0.3
Tapper	5	12.0	10	0.3
Pin Setter	5	2.5-7.5	40	1.1
arbon Plant				
Mixer Operator	1	2.6	2	< 0.1
orizontal in Soderberg				
otrooms				
Potman	4	4.5	42	0.5
Flex raisers	1	18.5	10	0.3
Pin pullers	2	1.5	4	0.4
Channel hangers	1	3.5	4	0.5
Tappers	4	2.0-3.4	5	0.3
Pot reliners	1	8.3	5	0.1

ter: Shuler, P.J. and Bierbaum, P.J.: 1974 Environmental Surveys of Aluminum Reduction Plants. U. S. Department of Health, Education and Welfare, Public Health Service, National Institute for Occupational Safety and Health, HEW Publication Number (NIOSH) 74-101, page 26