

COMMUNITY EXPOSURE STUDIES AND SMELTER WORKER MORTALITY STUDIES
AS RELATED TO A COPPER SMELTER

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A B S T R A C T

Studies in Tacoma, Washington, were conducted to investigate arsenic exposure in children living near a copper smelter and to test the Lee-Fraumeni hypothesis that copper smelter workers have increased incidence of respiratory cancer. Community exposure studies showed increased arsenic levels in hair and urine of children residing near the smelter. Urinary arsenic levels decreased as residential distance from the smelter increased. Younger children were found to have higher levels of urinary arsenic than older children. Worker mortality studies showed that smelter workers have increased mortality from respiratory cancer. No other causes of death showed a statistically significant excess mortality.

Since May, 1972, the Washington State Department of Social and Health Services Division, has been involved in studies on environmental contamination related to the American Smelting and Refining Company copper smelter in Ruston, Washington (adjoining Tacoma). The studies have been of 2 types: community exposure studies, and smelter worker mortality studies.

The community studies have been summarized in a recent publication.¹ Briefly, children who lived near the smelter were shown to have increased levels of arsenic in hair and urine. The urinary arsenic level decreased with distance of residence from the smelter stack, and house vacuum cleaner dust arsenic levels showed a similar distance relationship. Younger children showed higher average levels of urinary arsenic than older children, and urinary arsenic levels in young children living close to the smelter varied synchronously over a five week period.

Since this report, further analysis of urine and hair sampling from children living near the smelter revealed that:

1. No urinary mercury was detected in 45 samples (detection limit = 1.9 µg/l).
2. Urinary arsenic levels in 1974 sampling were essentially the same as those found in 1972 and 1973 (further sampling will be done in the summer of 1975 to assess the impact of environmental control steps currently being taken by the smelter).

3. Hair arsenic levels were seen to be lower than those done initially. Maximum levels of hair arsenic are now about 40 ppm, as compared with initial levels of 100 ppm. This difference is due to a change in the way the samples are handled before analysis. The initial samples were analyzed for arsenic without any pre-treatment. The current samples are washed to remove absorbed arsenic.
4. Hair samples, from 20 long-haired school girls (18 Ruston girls and 2 non-resident controls) for segmental analysis of heavy metal concentration, indicated the maximum concentrations as copper 164 ppm, lead 36 ppm, mercury 7.1 ppm, cadmium 43 ppm. Neither control showed any arsenic, antimony or cadmium. Results of the segmental analysis will be published later.
5. In the summer of 1974, the smelter was closed by a strike and during the strike, the average urinary arsenic level was .08 ppm for 18 specimens. After the strike, the average for 19 specimens from the same children was .16 ppm. Ten children were sampled twice during and twice after the strike. Eight of the 10 showed increased urinary arsenic excretion after the strike (1 stayed the same and 1 decreased). Since normal values of urinary arsenic are <.02 ppm, the elevated excretion of urinary arsenic seen during the strike means that children are exposed to arsenic from secondary sources (ingested or inhaled house dust) as well as from the smelter directly.

The smelter worker mortality study was based on occupational and cause-of-death information contained on death certificates in the Washington State Vital Statistics file. Three parallel studies focused on learning whether the Tacoma smelter employees showed increased mortality from respiratory cancer as reported by Lee and Fraumeni² for other smelters.

In the first study, applying U.S. mortality rates to published populations at risk at the smelter³ yielded 18 expected respiratory cancer deaths. Examination of all Pierce County, Washington (location of the smelter) resident male deaths in the years 1950-1971 due to respiratory cancer revealed 39 with stated employment at the smelter. The smelter employment records verified that all 39 men actually had been smelter employees. Another out-of-county case was discovered later.

Since there was an apparent discrepancy between the number of respiratory cancer cases reported in a smelter mortality study³ and that discovered through death certificates, a record overlap study was done with the cooperation of the smelter.

Table I, COMPARISON OF SOURCE OF ASCERTAINMENT
TACOMA SMELTER RECORDS *VERSUS* DEATH CERTIFICATES
RESPIRATORY CANCER DEATHS 1961-1972

Source of Ascertainment	Number of Deaths
Smelter Records only	1
Smelter Records and Death Certificates	18
Death Certificates only	<u>6</u>
Total	25

Table I shows that in the years 1961-1972, there were 25 respiratory cancer deaths in smelter employees. Eighteen cases were ascertained through both record sources; 6 on death certificates only, and 4 on smelter records only. The discrepancy resulted from the method used in the smelter study of ascribing deaths to immediate cause of death rather than to underlying cause.

As part of a general occupational mortality study, proportional mortality rates were computed for detailed causes of death in smelter workers. This method uses all other male deaths in the State as controls. Table II shows, again, that smelter workers have increased mortality from respiratory cancer. No other causes of death showed a statistically significant excess mortality.

In summary, this work supports the Lee-Fraumeni study and the hypothesis that workers in copper smelters have an increased incidence of respiratory cancer. This study cannot speak directly to the question of etiology, but the smelter worker population affords a unique opportunity to examine the whole question of arsenical carcinogenesis in man.

TABLE II
PROPORTIONATE MORTALITY RATIOS, WHITE MALE DEATHS IN WASHINGTON STATE, 1950-1971
435 SMELTER WORKERS, HEAT TREATERS, ANNEALERS, TEMPERERS

CAUSE OF DEATH		ICD #	AGE AT DEATH																
			1950 1960	1951 1971	1950 1971	20- 64	20- 24	25- 29	30- 34	35- 39	40- 44	45- 49	50- 54	55- 59	60- 64	65- 69	70- 74	75- 79	80+
Malignant Neoplasm Respiratory System		160 OBS	23	30	53	27	0	0	0	2	2	2	4	7	10	11	8	6	1
		165 EXP	12	21	32	15	0	0	0	0	1	1	3	5	6	7	5	3	2
		PMR	197*	146*	164*	176	0	0	0	R	R	162	154	143	181	165	157	179	58
Nose, Middle Ear, Accessory Sinuses		160 OBS	1	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0
		EXP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		PMR	R	0	R	0	0	0	0	0	0	0	0	0	0	R	0	0	0
Larynx		161 OBS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		EXP	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
		PMR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bronchus, Trachea, Lung (Primary)		152 OBS	13	23	36	21	-	-	-	2	2	2	3	6	6	7	4	3	1
		EXP	7	15	22	11	0	0	0	0	0	1	2	4	4	5	4	2	1
		PMR	178*	152*	161*	196	0	0	0	R	R	R	164	168	164	155	105	133	90
Bronchus and Lung		162.1 OBS	7	23	30	19	0	0	0	2	2	1	3	6	5	4	3	3	1
		EXP	4	15	19	8	0	0	0	0	0	1	1	3	3	4	3	2	1
		PMR	197	153*	162*	226	0	0	0	R	R	R	248	202	170	111	88	145	95
Pleura		162.2 OBS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		EXP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		PMR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lung, Unspecified Primary- Secondary		163 OBS	8	7	15	6	0	0	0	0	0	0	1	1	4	3	4	2	0
		EXP	3	4	8	4	0	0	0	0	0	0	1	1	2	2	1	1	0
		PMR	245*	159	195*	165	0	0	0	0	0	0	R	99	262	170	R	R	0
Thoracic Organs Secondary		165 OBS	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0
		EXP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		PMR	R	0	R	0	0	0	0	0	0	0	0	0	0	0	0	R	0

CONTINUED

TABLE II CONTINUED

CAUSE OF DEATH	ICD #	AGE AT DEATH																
		1950 1960	1951 1971	1950 1971	20- 64	20- 24	25- 29	30- 34	35- 39	40- 44	45- 49	50- 54	55- 59	60- 64	65- 69	70- 74	75- 79	80+
Malignant Neoplasm Prostate	177	OBS	9	5	14	3	0	0	0	0	0	0	1	2	3	4	1	5
		EXP	6	8	14	2	0	0	0	0	0	0	0	1	2	3	3	4
		PMR	151	62	100	187	0	0	0	0	0	0	R	198	135	69	30	125
Testis	178	OBS	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	1
		EXP	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
		PMR	0	R	R	0	0	0	0	0	0	0	0	0	0	0	0	R
Other Male Genital Organs	179	OBS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		EXP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		PMR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Kidney	180	OBS	2	2	4	3	0	0	0	0	0	1	1	1	0	0	1	0
		EXP	1	2	3	1	0	0	0	0	0	0	0	0	1	0	0	0
		PMR	146	118	130	210	0	0	0	0	0	R	R	R	0	0	R	0
Bladder and Other Urinary Organs	181	OBS	0	1	1	1	0	0	0	0	0	0	1	0	0	0	0	0
		EXP	2	3	5	1	0	0	0	0	0	0	0	1	1	1	1	1
		PMR	0	34	20	80	0	0	0	0	0	0	R	0	0	0	0	0
Malignant Melanoma of Skin	190	OBS	1	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0
		EXP	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
		PMR	R	0	R	R	0	0	0	R	0	0	0	0	0	0	0	0

*Statistically Significant at 5 percent

PMR - R Expected Value less than 1

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