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LONG-TERM MORTALITY STUDY OF VINYL CHLORIDE AND POLYVINYL CHLORIDE WORKERS IN A JAPANESE PLANT

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ABSTRACT

A group of 305 workers who were exposed to vinyl chloride for at least one year in the period 1949–1975 at a Japanese plant, and 273 workers in different occupations free from vinyl chloride exposure in the factory during the same period were traced to 99% and their health status was established in order to carry out a mortality study.

Twenty-seven deaths among the vinyl chloride workers and 42 deaths among the controls were observed, and expected deaths were calculated in order to compare the mortality for vinyl chloride workers with that for the general population and controls.

The observed malignancy deaths among the vinyl chloride workers exceeded the expected ones by 38%. No angiosarcoma and no liver malignancy were found. The observed death cases from liver cirrhosis were five times more numerous than the expected ones. This did not, however, suggest that the origin was related to vinyl chloride exposure in comparison with SMR among the controls.

Prevention of liver cirrhosis is considered as an important problem among all the workers in the factory.

In the past, workers engaged in vinyl chloride (VC) or polyvinyl chloride (PVC) manufacture have been exposed to VC as a result of working inside autoclaves or because of leaks occurring at various stages of the process. Workers in occupations involving exposure to VC have been found to have an increased risk of hemangiosarcoma[1,2,4] and suspected excess deaths from malignant neoplasms of multiple sites[8,10]. These facts have also been supported by experiments with rats[5].

The aim of this study was to assess the risk of VC exposure to VC or PVC workers in the period 1956–1975.

ENVIRONMENTAL STATUS OF THE PLANT

According to the history of the company, the VC and PVC plant has been in operation since 1949. The annual output of PVC (30 t in 1949) was increased to the amount of four figures in 1957, and then again to the amount of five figures in 1960.

In the course of the expansion of the PVC production, an environmental survey was made in 1958 using Kitagawa's detector tube method. The concentration of VC during the cleaning work inside the autoclaves was improved (below 250 ppm as maximal level since 1961). Before 1960 workers in PVC manufacture may have been transiently exposed to a considerably higher concentration of VC as a result of working inside autoclaves.

METHOD OF MORTALITY ANALYSIS

The study covers all 305 workers employed in the VC and PVC section, and 273 controls employed in other sections, in the period 1949–1975.

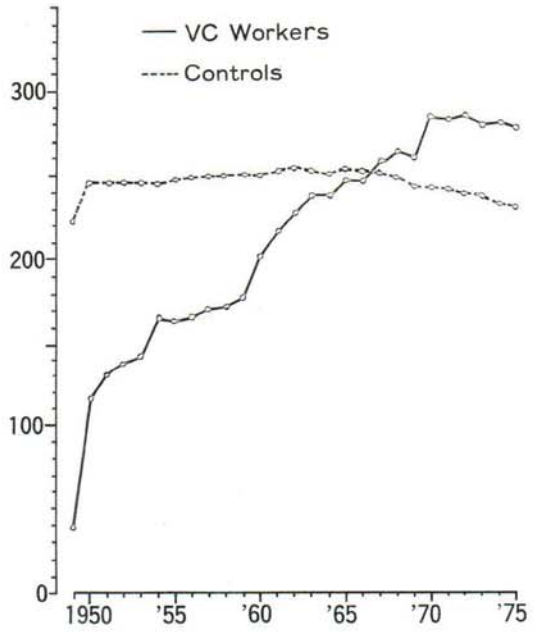

FIG. 1 – Number of VC workers and controls for each year since 1949.

Figure 1 shows changes in the number of VC workers and controls in the period 1949–1975. The number of controls was relatively constant in comparison with that of VC workers which continued increasing between 1949 and 1970. The total number for analysis was 4 777 VC workers and 4 929 controls in person years from 1956 till 1975.

Table 1 shows the major activity of the 305 VC workers, during employment. The majority of the VC workers were employed in the PVC or VC section, although about one tenth of the VC workers were employed in the plant's shipping department and laboratory.

TABLE 1
Major work activity of 305 VC workers during employment.

Type of work	Number
Reactor cleaning	148 (49%)
Other PVC production	73 (24%)
VC production	46 (15%)
Laboratory	28 (9%)
Shipping	10 (3%)
Total	305 (100%)

Data on the current status of the VC workers and controls are shown in Table 2. Over one half of the VC workers are currently employed in the PVC and VC section or elsewhere in the factory. The rest have retired from employment.

TABLE 2
Status of 305 VC workers and 273 controls.

Status	Interviewed and examined	Contact by phone or by mail	Deceased	Untraced	Total
All VC workers					305 (100%)
Working in the PVC or VC section or elsewhere	158				158 (52%)
Retired		120			120 (39%)
Deceased			26		26 (9%)
Untraced			1	0	1 (0.3%)
Controls					273 (100%)
Working outside the VC or PVC sections	102				102 (37%)
Retired		128			128 (47%)
Deceased			42		42 (15%)
Untraced				1	1 (0.4%)

Whenever a VC worker or a control individual died, a copy of the death certificate was obtained, or information on the cause of death was obtained from his family or his consultation doctor. With these sources, 27 deaths of VC workers and 42 deaths of controls were recorded and causes of deaths were identified for all but one.

The expected numbers were calculated on the basis of five years age/time/cause specific mortality rates for Japanese males and a five years age/time classified number of workers in person years. Statistical comparisons

between expected and observed death cases were made assuming a Poison distribution[9] with mean equal to the expected value. Then the SMRs for VC workers were calculated and adjusted with the SMRs for controls.

RESULTS AND COMMENT

Tables 3 and 4 show observed and expected deaths and SMRs for VC workers and controls. The observed deaths from all causes almost agree with the

TABLE 3
Observed and expected deaths from 1956 to 1975, among vinyl chloride workers.

I.C.D.	Cause of death	Observed	Expected	SMR-1
	All deaths	27	26.5	101
140-209	All malignant neoplasms	8	5.8	138
151	Stomach neoplasms	4	2.7	148
155, 197.7, 197.8	Liver neoplasms	0	0.6	0
	Other malignant neoplasms*	4	2.5	160
571	Cirrhosis of liver	5	1.0	500
430-438	Cerebrovascular disease	5	5.1	98
393-398, 410-414, 420-429	Heart disease	3	2.6	115
E810-823, E800-807, E825-949	Accidents	2	3.7	54
E950-959	Suicide	1	1.2	83
	All other disease	3	6.8	44

* Site of cancers: Oesophagus 2, Biliary passage 1, Lung 1

TABLE 4
Observed and expected deaths from 1956 to 1975, among controls.

I.C.D.	Cause of death	Observed	Expected	SMR-2
	All deaths	42	42.1	100
140-209	All malignant neoplasms	9	9.9	91
151	Stomach neoplasms	6	4.6	130
155, 197.7, 197.8	Liver neoplasms	0	1.0	
	Other malignant neoplasms*	3	4.3	70
571	Cirrhosis of liver	6	1.4	429
430-438	Cerebrovascular disease	13	9.7	134
393-398, 410-414, 420-429	Heart disease	4	4.4	91
E810-823, E800-807, E825-949	Accidents	4	3.7	108
E950-959	Suicide	1	1.3	77
	All other disease	5	11.1	45

* Site of cancers: Rectum 2, Leukemia 1

expected deaths among VC workers, although deaths from malignant neoplasms exceed the expected ones by 38%, while four times excess deaths from liver cirrhosis are observed among VC workers, but without statistical significance.

Angiosarcoma and hepatic malignant neoplasm were observed neither among the VC workers nor the controls. Five deaths due to liver cirrhosis and one death from extrahepatic biliary malignant neoplasm described in Table 3 were traced and verified by specialists of the Government's Committee for the VC Problem. Observed deaths from liver cirrhosis among the controls also exceeded the expected ones 3.29 times.

In order to assess mortality among the VC workers in relation to that among the controls, SMRs among the VC workers were adjusted on the basis of SMRs among the controls (Table 5). The adjusted SMR for malignant neoplasms is 52% higher than that of the controls. The adjusted SMR for liver cirrhosis does not suggest that its origin is related to VC exposure, although the incidence of liver cirrhosis in the factory is higher than that among the Japanese general population.

TABLE 5
Adjusted SMRs among VC workers based on control SMRs.

I.C.D.	Cause of death	SMR-1	SMR-2	Adjusted*
	All	101	100	101
140-209	All malignant neoplasms	138	91	152
151	Stomach neoplasms	148	130	114
155, 197.7, 197.8	Liver neoplasms	0	0	0
	Other malignant neoplasms	160	70	229
571	Cirrhosis of liver	500	429	117
430-438	Cerebrovascular disease	98	134	73
393-398, 410-414, 420-429	Heart disease	115	91	126
E810-823, E800-807, E825-949	Accidents	54	108	50
E950-959	Suicide	83	77	108
	All other disease	44	45	98

* Adjusted = (SMR-1/SMR-2) × 100

Table 6 shows the distribution of the number of deaths from all causes, malignant neoplasms and liver cirrhosis according to five years age groups for VC workers and controls. The distribution does not move towards younger persons among the VC workers in comparison with the controls.

There is disagreement among authors as regards VC exposure as the origin of cancer in multiple sites[3,6,7,8,10]. Tabershaw and co-workers[10] reported that in humans VC might be associated with cancer of multiple sites. Ott and co-workers[8] in their epidemiological study also concluded that observed malignancy deaths exceeded expected ones among workers in the high exposure category.

TABLE 6
Distribution of deaths by age groups among VC workers and controls.

Age groups (years)	All causes		Malignant neoplasms		Liver cirrhosis	
	VC workers	Controls	VC workers	Controls	VC workers	Controls
30–34	1	2	0	0	0	1
35–39	2	4	0	2	0	0
40–44	3	2	1	2	1	0
45–49	1	7	0	2	1	1
50–54	6	8	3	0	0	0
55–59	5	5	1	1	2	1
60–64	4	6	3	1	0	2
65–69	4	6	0	1	1	1
70–74	1	2	0	0	0	0
Total	27	42	8	9	5	6

However, Fox and co-workers[3] denied the hypothesis that cancers other than those of the liver are associated with exposure to VC.

In this study the number of VC workers is not large enough for statistical evaluation so that SMR concerning malignant neoplasms will not be evaluated.

No reports on liver cirrhosis related to VC exposure are found in epidemiological studies, and liver cirrhosis among VC workers may not be associated with VC exposure.

CONCLUSIONS

A long-term mortality study among VC workers in one of Japan's oldest VC plant was carried out controlling different types of workers in the factory.

The observed deaths from malignant neoplasms exceeded the expected ones by 38% among VC workers, but, without statistical significance. No angiosarcoma and no deaths due to liver malignant neoplasms were established.

Death incidence from liver cirrhosis was five times greater than expected deaths, but this did not suggest that the origin was related with VC exposure if adjusted with SMR among controls.

Prevention of liver cirrhosis is regarded as an important problem among the workers of the factory.

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