Environmental Health Perspectives
Vol. 17, pp. 167–170, 1976

Mortality and Cancer Morbidity in a Group of Swedish VCM and PCV Production Workers

by D. Byrén,* G. Engholm,† A. Englund,‡ and P. Westerholm**

The cohort of workers employed in a Swedish vinyl chloride/poly(vinyl chloride) plant since its start in the early 1940's has been followed for mortality and cancer morbidity patterns. Only 21 of the 771 persons could not be traced. Difficulties in establishing exposure levels at different work areas in the past makes an evaluation of dose-effect relationships impossible.

A four- to fivefold excess of pancreas/liver tumors was found, including two cases later classified as angiosarcomas of the liver. The number of brain tumors and suicide do not deviate significantly from expected. Cardiovascular and cerebrovascular diseases, on the other hand, differ significantly from the expected. The discrepancies between previous reports on VCM/PVC workers and this report are discussed. The possible etiology of the cardiovascular deaths is also discussed.

A review of known health effects of VCM and PVC has been published by Holmberg et al. (*1*).

Monson et al. (*2*) found a 50% excess of deaths due to all cancer in a proportional-mortality analysis of deaths among workers in two plants using vinyl chloride. The greatest excess was observed in liver, lung, and brain cancers. There was also a twofold excess of suicide.

A recent report by Duck et al. (*3*) on the age-standardized mortality rates for workers exposed to vinyl chloride did not show any excess of total or cause-specific mortality. One case of angiosarcoma of the liver was found.

Baxter and Fox (*4*) recently reported on the proportional mortality for deaths among male plastic workers in England and Wales (1970–1972). The only significant excess of deaths was found in stomach cancer and diseases of the urogenitary system. All cancer, cancer of the brain, and cancer of the liver did not differ from expected values.

Sweden has one factory producing VCM and PVC since the end of the World War II which is still in operation. Since the late sixties, a second plant has been producing these products as well. The cause-specific mortality and the reports of diagnosed cancers, which can be traced in a national registry of causes of deaths and a national cancer registry, respectively, have been analyzed for those ever employed in the first-mentioned factory.

Materials and Methods

In a cooperative effort of the governmental supervising agency (National Board of Occupational Safety and Health), the trade union, and the company, all persons ever employed in positions where exposure to VCM could occur were traced by the personnel files of the factory. Office staff was not included.

The persons were assigned to different working areas during different periods of time according to information in those files. On some occasions personal experience from former coworkers and foremen was of great help in this assignment to work areas.

* Kema Nord, 85013 Sundsvall, Sweden.

† Bygghülsan, Fack, S-10041, Stockholm, Sweden.

‡ Landsorganisation i Sverige, Barnhusgatan 18, S-105 53 Stockholm, Sweden.

** National Board of Occupational Safety and Health, Fack, S-10026, Stockholm, Sweden.

The level of exposure to VCM and PVC in the past was unknown, as measuring procedures were introduced very late. A semiquantitative grading of those work areas during different periods in time was performed according to experiences from factory chiefs, foremen, and co-workers.

It was known that episodes of unconsciousness had occurred among autoclave cleaners during the fifties, which indicates that exposures to VCM levels of at least 10,000–15,000 ppm had occurred. In a small study in 1971 of autoclave cleaners in the same factory, no cases of acroosteolyses were found, although some showed Raynaud's phenomenon.

The follow-up was performed primarily by use of the ID routine of the Swedish Central Bureau of Statistics. By this routine—which is run monthly—it is possible to obtain information about a defined group of identified persons by performing a record-linkage operation between a file containing the group and a population register containing information about all inhabitants in the country. This linking is based on the ten-digit social security number. At the time that this study was carried out, 771 persons were working or had earlier been working at the factory. Of these, 656 were found in the first follow-up to be alive, to have a correct social security number, and to still be living in the country.

The remaining 115 persons were traced by searching in registers in different counties. People who had died or emigrated could thereby be identified. Furthermore, in so doing, certain social security numbers were found to be incorrect and could be corrected. This was necessary for the identification of cancer cases in the group.

A further 21 persons, all foreigners, who had emigrated after a very short period of employment at the factory, were not traced further and were excluded from the group and study.

For the persons who could not be ascertained to be alive, cause and time of death were searched for in the registers of Causes of Death at the Swedish Central Bureau of Statistics. This register contains information of all deaths in the country. It is based on death certificates. Cases of cancer were identified by search in the cancer register of the Swedish Medical Board to which all new cancer cases have been reported since 1958.

Results and Discussion

The number of deaths up to October 1974 was 58, and the number of cancer cases recorded during the time from January 1, 1958 until December 31, 1971 was 11. In the analysis of observed cancer incidence and observed mortality, the material was divided into subgroups by class of exposure (total time of employment) and time of latency (time between first employment and end of follow-up) in the analysis of cancer incidence and in the analysis of mortality are in the range of 6,300 and 12,000, respectively.

Table 1. Distribution of employees by time of exposure and time of latency.

Time of exposure, yr	No. of employees showing various latency times		
	0–4 yr	5–9 yr	≥10 yr
<1	97	101	179
1–3	42	34	68
3–5	10	9	28
5–10	0	33	37
>10	0	0	112
	149	177	424

The observed cancer incidence and the observed mortality in the study group were compared with expected numbers derived from information concerning 1969 about the population of Sweden. Information of cancer incidence (*5*) and information on death causes were taken from the literature (*6*).

This information has been used for computation of one-year risks of different groups of age. These measures of risks have been used for computation of expected frequencies. Comparison between observed and expected frequencies was made in terms of measures of SMR type. The analysis of significance of prevailing differences between observed and expected frequencies was performed by computations of probabilities of Poisson distribution.

Naturally, such exposure-level gradings which are not based on objective measurements are subject to potential classification errors. This is quite natural, and the uncertainty of such criteria has to be kept in mind when discussing results based on them. Due to the low number of persons employed, significant devia-

tions of observed numbers from the expected age-standardized numbers are seldom found except in the total group. The mentioned uncertainty in exposure levels in addition to the low numbers of persons in subgroups makes it impossible to discern any dose–response pattern. Subgroups exposed for longer periods or with longer time of latency sometimes appear with significant deviations from the expected figures. Frequently, increasing length of exposure and latency time leads to decreasing observed SMR's which might be explained by increased influence of selection.

Whether all people ever employed under working conditions have been adequately included into the cohort is difficult to assess. Information about persons who have earlier been employed in jobs implying exposure to VCM was to some extent based on information elicited from memories of foremen and former employees. Naturally such information may be subject to bias. Such a possibility is hard to exclude with certainty. The decreasing SMR's with increasing time of exposure and time of latency might reflect incompleteness in the collection of individuals who—in terms of exposure—are qualified for inclusion into the cohort. However, all possible efforts have been undertaken jointly by the company and the unions and no more persons can be recollected.

The excess of cancers of the liver and pancreas taken as a common group increases with time of latency. On the other hand, the excess in cardiovascular (ICD 410-438) and cerebrovascular (ICD 430-438) deaths is found only in the total group (Tables 2 and 3).

The difference in numbers of cancers between the Register of Causes of Death and the Cancer Registry is entirely due to the different lengths of time of observation offered by the two registers. Interestingly enough, the excess of cancers of liver and pancreas is four- to fivefold in both. These two sites are considered together, as there seems to be some overlapping in reporting. The two earlier reported cases of angiosarcoma of the liver are included among those four, although this specific diagnosis was never made in the original reports but only after reevaluation. Thus, these rare tumors were primarily classified as one pancreatic cancer and one liver cancer. No additional cases of this diagnosis have been discovered so far.*

The two cases of cancer of the brain represent an excess but they do not deviate significantly from the expected number. One of them was a young man with less than a year of employment when the diagnosis was made. The excess of lung cancers was not statistically significant.

The number of deaths by accidents and suicide was extremely close to the expected numbers. As suicide is a diagnosis consistently reported in Sweden in comparison with the reporting rate in many other countries, it can be concluded that suicide is not more common among VCM-exposed Swedes.

* On March 20, 1976 a third man died at the age of 65 of a hemangiosarcoma of the liver. He was employed as an autoclave operator from 1947 to 1968, when he left the company. Since 1973 he had been the recipient of a sick pension due to coronary heart disease. The tumor disease was asymptomatic until one month prior to his death.

Table 2. Morbidity and mortality for total employee group.

	Observed frequency	Expected frequency	SMR	p (one-tailed)
Mortality registry				
Brain cancer	2	0.33	612	0.043
Lung cancer	3	1.78	168	0.26
Cancer of liver/pancreas	4	0.97	413	0.017
Circulatory diseases (total)	28	18.26	153	0.02
Cerebrovascular diseases	6	3.02	198	0.086
Myocardial infarction	15	9.15	164	0.046
Cerebral hemorrhage	5	1.48	338	0.018
Morbidity registry				
Lung cancer	3	1.30	231	0.14
Cancer of liver/pancreas	2	0.48	416	0.086

Table 3. Some mortality results concerning groups with different times of latency.

	Time of latency		
	0	>5 yr	>10 yr
Cancer of liver/pancreas			
Observed	4	4	4
Expected	0.97	0.84	0.68
SMR	413	474	589
p	0.017	0.011	0.005
Circulatory diseases			
Observed	28	25	18
Expected	18.26	16.08	13.11
SMR	153	155	137
p	0.020	0.024	0.12
Myocardial infarction			
Observed	15	13	8
Expected	9.15	8.07	6.56
SMR	164	161	122
p	0.046	0.067	0.34
Cerebrovascular diseases			
Observed	6	6	4
Expected	3.02	2.65	2.15
SMR	198	226	186
p	0.086	0.053	0.17
Cerebral hemorrhage			
Observed	5	5	5
Expected	1.48	1.29	1.04
SMR	338	388	288
p	0.018	0.010	0.09

The most interesting observation, in our view, is the excess of cardiovascular and cerebrovascular deaths, with a total of 28 found aginst 18.3 expected (SMR = 153). The highest excess is found in the cerebrovascular group and above all in cerebral hemorrhage. There is also an excess of myocardial infarctions, but this observation is limited to the total group. As increased exposure time or longer time of latency do not lead to increase in excess, it is hard to say whether the disease pattern observed is due to the exposure or due to different selection processes in the employment of the workers. The finding that the excess can be observed only in persons with short-term exposures in itself suggests that selection phenomena can more probably be involved as an explanation. It is to be emphasized, however, that this can in no way be regarded as conclusive, and it is our feeling that in view of known biological properties of VCM, any observation relevant to the cardiovascular system after exposure to VCM should be shown and openly discussed. Analogously, great caution should be exercised in discarding possibilities concerning such effects. The expected numbers are calculated from national rates and do not take into account geographic variations. The observed geographical area does not to our knowledge represent an extreme in this respect. Duck et al. (*3*) found an SMR of 143 for this group of diseases, but they have not made any comment in their report.

The excess of vascular deaths is an interesting observation, as other disorders observed in VCM-exposed workers like acroosteolysis, Raynaud's phenomenon, and angiosarcomas also occur in vessels. The findings of two aneurysmus of the aorta in this small group of persons (a 6–8-fold excess) adds importance to this observation. Cardiovascular effects have been reported for other industrial substances like carbon disulfide (*7*). However, nothing is known about smoking habits and other known determinants of chronic degenerative cardiovascular disease such as heredity, food habits, obesity, or physical activity in the studied population. No increased prevalence of arterial hypertension was observed in the presently employed group of workers. We have not found any other aspect showing arterial hypertension in excess among VCM workers.

REFERENCES

1. Holmberg, B., and Molina, G., The industrial toxicology of vinyl chloride—a review, Work Environ. Health 11: 138 (1974).
2. Monson, R. R., et al. Proportional mortality among vinyl chloride workers. Lancet 1974: 397 (Aug. 17, 1974).
3. Duck, B. W., et al. Mortality study of workers in a polyvinyl-chloride production plant. Lancet 1975: (Dec. 13, 1975).
4. Baxter, P. J., and Fox, A. J., Angiosarcoma of the liver in PVC fabricators. Lancet 1976: 245 (Jan. 31, 1976).
5. Cancer Incidence in Sweden 1969, National Board of Health and Welfare (the Cancer Registry) Stockholm.
6. Dödsorsaker 1969 och 1970. National Central Bureau of Statistics, Sweden.
7. Tolonen, M., et al, A follow-up study of coronary heart disease in viscose rayon workers exposed to carbon disulphide. Brit. J. Ind. Med. 32: 1 (1975).