

Mortality and Cancer Incidence Among PVC-Processing Workers in Sweden

Ingvar Lundberg, MD, Annika Gustavsson, BSc, Bo Holmberg, PhD,
Gustavo Molina, MD, and Peter Westerholm, MD

The mortality pattern and the cancer incidence were investigated among 717 men who had been employed for at least 3 months during 1964-1974 in three Swedish PVC-processing plants. The mortality was followed 1964-1986 and the cancer incidence 1964-1984. Expected figures were calculated from Swedish national rates.

Among Swedish citizens, the observed mortality and cancer incidence was close to the expected in most diagnoses. Among immigrants, mostly from Finland, there was a marked excess of circulatory deaths. This finding was probably due to the higher incidence of coronary mortality in Finland compared to Sweden.

In the whole cohort, five cases of malignant melanoma had occurred as compared to 1.5 expected (SMR = 3.4, 95% confidence limit 1.1-7.9). This may be due to chance but merits further investigation since an increased incidence of malignant melanoma has previously been found among Norwegian PVC-manufacturing workers.

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INTRODUCTION

The association between exposure to vinyl chloride monomer (VCM) and liver angiosarcoma among PVC-manufacturing workers has been established through a number of epidemiological studies [IARC, 1987]. The large majority of the angiosarcomas have occurred among workers with VCM exposures of several hundreds of ppm and more [Wu et al., 1989; Simonato et al., 1991]. No other form of cancer has been consistently reported among VCM-exposed workers [Doll, 1988].

The PVC-processing industry has had a lower VCM exposure than the VCM- and PVC-manufacturing industry [Holm et al., 1982] and has been the subject of few

Department of Occupational Health, Karolinska Hospital, Stockholm, Sweden (I.L.).

Department of Occupational Medicine, National Institute and Occupational Health, Solna, Sweden (A.G., P.W.).

Department of Occupational Toxicology, National Institute of Occupational Health, Solna, Sweden (B.H.).

School of Medicine, University of Concepcion, Concepcion, Chile (G.M.).

Address reprint requests to Ingvar Lundberg, Department of Occupational Health, Karolinska Hospital, S-171 84 Stockholm, Sweden.

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epidemiological studies. In the mid 1970s, a cohort was established of PVC-processing workers in Sweden. The intentions were to study the mortality and cancer incidence pattern among PVC processing workers as well as to examine any possible effects of exposure to low levels of VCM. The cohort was followed in the register of causes of death and in the cancer incidence register until 1976. An increased risk of ischemic heart disease was found but no excess of any type of cancer [Molina et al., 1981]. We have now made a new follow-up concerning causes of death and cancer incidence among the cohort members in three of the four factories included in the original cohort. The results of a follow-up of the workers in the fourth factory has been published [Hagmar et al., 1990].

MATERIALS AND METHODS

Exposure

PVC pipes, tubes, and filaments as well as sheetings for food packaging, cars, wallpaper, etc. were produced in the three factories.

The work activities of the cohort members were classified in three categories according to potential VCM exposure. The group with "high" exposure consisted of employees at the mixing departments of the factories. In these departments, the PVC powder, the basic raw material in the production, was mixed with other ingredients in the plastic at high temperature. Other departments in which the plastic was heated were classified as having "intermediate" exposure, while the remaining departments were classified as having "low" exposure. Individuals were assigned to the highest exposure category in which they had worked for at least 1 year.

The 8-hour time-weighted average VCM exposure in the mixing departments never exceeded 10 ppm during the period before 1975, and was much lower after that. In the other departments it was below 5 ppm before 1975 and below 1 ppm after that [Bruder and Stråby, 1976; Holm et al., 1982]. The workers were also exposed to different phthalates used as plasticizers, but there was no attempt to quantify this exposure. Asbestos was never used in the processing in the three factories.

Study Group

The cohort comprised all male workers who had been employed for at least 3 months during the period 1964–1974 in three PVC-processing factories in the southern part of Sweden; 717 workers met these inclusion criteria. Of these, 519 had been Swedish citizens at least since 1977 (Swedes) and 198 were foreign citizens or had become Swedish citizens after 1977 (immigrants). Of the cohort, 67% had "low," 23% had "intermediate," and 10% had "high" VCM exposure; 46% of the cohort had been employed for at least 5 years.

Method

The cohort members were followed during the period 1964–1986 for causes of death and during the period 1964–1984 for cancer incidence in the Swedish national cancer register. The observed numbers of deaths and cancers were compared to the expected, calculated by multiplication of the person-years observed within 5-year age categories during every calendar year of the study period with the cause- and gender-specific national death and cancer incidence rates, and by adding the fractional contributions. The 95% confidence limits were calculated for the quotient between

TABLE I. Observed and Expected Mortality Among the Swedish Workers in Three PVC-Processing Plants in Sweden*

ICD 8 no.	Cause of death	Obs	Exp	Obs/exp	95% CI
1-999	All causes	105	103.1	1.0	0.8-1.2
140-209	All cancers	23	24.2	1.0	0.6-1.4
155	Liver	0	0.6	0	0.0-6.1
162	Lung	3	4.6	0.7	0.1-1.9
172	Malignant melanoma	3	0.5	6.3	1.3-18
390-458	Circulatory diseases	49	51.7	1.0	0.7-1.3
410-414	Ischemic heart disease	38	37.2	1.0	0.7-1.4
460-519	Respiratory diseases	6	5.2	1.2	0.4-2.5
800-999	Violent deaths	15	10.6	1.4	0.8-2.3

*At least 3 months of employment during 1964-74 was required for cohort membership.

observed and expected numbers, based on a Poisson distribution. The Epilin computer program was used for the calculations [Anjou et al., 1981].

RESULTS

Causes of Death, and Cancer Incidence, Among Swedes

Among the Swedish workers, 105 had died compared to 103 expected (Table I). The number of deaths in the major disease groups were also close to the expected. Three men had died from malignant melanoma compared to 0.5 expected from national rates. There was no excess risk for other forms of cancer. There was no increase in mortality in any diagnosis with increasing duration of employment, increasing VCM exposure category, or increasing time since first exposure. The differences in mortality between the three factories were small.

The incidence of all cancer diagnoses, apart from melanoma, was close to the expected (Table II). The three cases of melanoma observed in the death register could also be found in the cancer register. There was no increase of any form of cancer with increasing duration of employment, increasing VCM exposure category, or increasing time since first employment.

Causes of Death, and Cancer Incidence, Among Immigrants

The immigrants showed an increased mortality compared to Swedish males, particularly from ischemic heart disease (Table III). However, the increased mortality was evenly distributed over different strata according to duration of employment, VCM exposure, and time since first employment. One immigrant had died from malignant melanoma.

Among the immigrants, ten cases of cancer had been reported to the cancer register. Two of these cases were malignant melanomas as compared to 0.3 cases expected based on Swedish national rates. Both these immigrants came from Nordic countries.

Malignant Melanoma

There were five cases of malignant melanoma found in the cancer register in the whole cohort; 1.5 cases were expected from the Swedish general male population without any requirement concerning time since first employment (observed/expected

TABLE II. Observed and Expected Cancer Incidence Among the Swedish Workers With and Without a Requirement for at Least 10 Years Between First Employment in PVC-Processing Plant and Diagnosis

ICD 7 no.	Cancer localization	No latency		10 years latency	
		Obs	Exp	Obs	Exp
140-209	All cancers	33	35.6	22	25.7
155	Liver	0	0.9	0	0.7
162	Lung	3	4.1	3	3.0
190	Malignant melanoma	3	1.2	3	0.7

TABLE III. Observed and Expected Mortality Among Immigrant Workers in Three PVC-Processing Plants in Sweden^a

ICD 8 no.	Cause of death	Obs	Exp	Obs/Exp	95% CI
1-999	All causes	30	16.0	1.9	1.3-2.7
140-209	All cancers	5	3.5	1.4	0.5-3.4
155	Liver	0	0.1	0	0.0-44
162	Lung	0	0.7	0	0.0-5.6
172	Malignant melanoma	1	0.1	7.7	0.2-43
390-458	Circulatory diseases	15	6.1	2.5	1.4-4.1
410-414	Ischemic heart disease	13	4.4	3.0	1.6-5.1

^aAt least 3 months of employment during 1964-74 was required for cohort membership.

= 3.4; 95% confidence limits = 1.1-7.9). Similarly, four workers had died due to this tumor versus 0.6 expected (observed/expected = 6.6; 95% confidence limits = 1.8-17).

The melanomas were diagnosed 9-17 years after the start of employment. They had occurred in all three factories. Two of the melanomas were found among workers in the "intermediate" exposure category, and three among workers in the "low" exposure category. Two of the workers with melanoma had been employed in the factories under study for only about 1 year. The melanomas were localized to widely different parts of the body.

DISCUSSION

Mortality Differences Between Swedes and Immigrants

The immigrant workers, who mainly came from Finland, showed increased mortality compared to Swedish males. Most immigrants were young. Less than 6% of the person-years under observation among the immigrants belonged to the age groups above 60. Between 20 and 60 years of age, the death rates for all causes were around 1.5 times higher in Finland than in Sweden during the follow-up period. For ischemic heart disease, the death rates were 2-3 times higher than among Swedish males [Central Statistical Office of Finland, 1964-1986]. The observed deaths among the immigrants were therefore probably close to what should have been expected if the Finnish male population had constituted the reference category. Thus, it seems likely that the increased mortality from ischemic heart disease among the immigrants was not due to work environment exposures.

Comparison With Previous Investigations

The mortality and cancer incidence has been followed in another Swedish PVC-processing factory [Hagmar et al., 1990]. In this factory deaths from, as well as incidence of, all cancers combined was increased compared to regional rates. There was also an increased mortality from, and incidence of, respiratory tract tumors that tended to increase with increasing asbestos exposure. There was no relation between the estimated individual cumulative VCM exposure and the risk of respiratory cancers and there was no case of hemangiosarcoma of the liver.

A multicenter study on cancer risks among European VCM-exposed workers showed excess risk for liver angiosarcoma and no other tumor [Simonato et al., 1991]. A recent review on VCM carcinogenicity concluded that VCM does not cause other tumors than liver angiosarcoma, with the possible exception of lung cancer after very heavy long-term exposures [Doll, 1988].

Our study is too small to exclude excess risks of most diseases, and particularly of relatively uncommon diseases such as cancers at individual sites, associated with low-level exposure to VCM. The fact that we did not find any excess risk for most cancer diagnoses must therefore not be interpreted as an evidence of lack of effect but rather as inconclusive results. Yet, together with our studies performed in the PVC-processing industry, our study could possibly contribute to the knowledge on this issue. However, that asbestos was not used in the processing is compatible with the finding of no increased risk of lung cancer in the three plants investigated.

Malignant Melanoma

During the follow-up period, the age-standardized incidence of melanoma was somewhat higher in the regions where the investigated factories were located than in the general Swedish male population. On the other hand, the incidence of melanoma is somewhat lower among Swedish blue collar workers than among Swedish males [Vågerö and Persson, 1986]. The reported incidence of melanoma in the other Nordic countries is not higher than the incidence in Sweden. We did not try to estimate the influence of these contradictory tendencies on the expected value, but it appears that the studied cohort shows some excess of melanoma.

Exposure to sunlight is an important cause of melanoma. However, the cohort members should not have been more exposed to sunlight than other sectors of the population. There are no established risk factors for malignant melanoma in the occupational environment, but exposure to polychlorinated biphenyls [Bahn et al., 1976], laboratory work [Aquavella et al., 1982; Austin et al., 1981; Thomas and Decouflé, 1979], oil refinery work [Rushton and Alderson, 1981; Thomas et al., 1980], and work with exposure to electricity as well as work in the electronics industry [Olin et al., 1985; Sorohan et al., 1985; Vågerö et al., 1985] have been observed to be associated with melanoma in some studies. Such exposures were uncommon in the factories studied.

An increased incidence of melanoma was also detected in a Norwegian factory for PVC production [Storetvedt Heldaas et al., 1987]. The authors implicated VCM as the cause of the melanomas. In our study, VCM is an unlikely cause of the melanomas detected since the tumors occurred among workers in departments with very low VCM exposure. However, the Norwegian finding may support a role for some exposure associated with PVC handling in the etiology of melanoma. On the

other hand, the short employment duration of two of the melanoma cases in our study, as well as the localization of the melanomas to different parts of the body, does not immediately support a common occupational etiology.

CONCLUSIONS

The mortality and cancer incidence patterns among the Swedish PVC-processing workers was close to the expected. The immigrants, mainly from Finland, showed excess ischemic heart disease as compared to Swedish national rates. This was probably due to population characteristics, rather than to occupational exposures, as the incidence of this disease is higher in Finland than in Sweden. An excess incidence of malignant melanoma was detected among Swedish as well as immigrant workers, based on five cases. This finding may be due to chance but deserves further investigation since excess melanomas have also been detected in workers at a Norwegian plant for PVC production.

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