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# Short-Term Mortality and Cancer Incidence in Capacitor Manufacturing Workers Exposed to Polychlorinated Biphenyls (PCBs)

Per Gustavsson, MD, Christer Hogstedt, MD, and Christoffer Rappe, PhD

A cohort study of 142 male Swedish capacitor manufacturing workers was performed. PCB had been used as a dielectricum in power capacitors between 1960 and 1978. Mortality was investigated for the period 1965 to 1982 and cancer incidence from 1965 to 1980. Twenty-one deaths and seven cancers were observed, which was in agreement with the anticipated numbers calculated from national statistics. One person had developed two rare tumors, a slow growing mesenchymal tumor (desmoid) and a malignant lymphoma. The results cannot rule out the possibility of a carcinogenic risk from PCB exposure because of the small size of the cohort and relatively brief follow-up period, but they do not indicate any excess mortality or cancer incidence in this factory so far.

**Key words:** cancer incidence, capacitor workers, malignant lymphoma, mesenchymal tumor, mortality, PCB

## INTRODUCTION

PCB has been widely used as a capacitor dielectricum and has been prohibited in many countries due to ecological effects. A significant amount is still present in capacitors located in electrical power plants and transformer banks. These transformers and capacitors might represent a health hazard for electrical workers due to leakage of PCB. PCB fires have occurred, and highly toxic pyrolysis products such as dibenzofurans and dibenzodioxins have contaminated the sites.

PCB is carcinogenic in animal experiments and certain PCB isomers are mutagenic in bacterial test systems [McConnell, 1980]. PCB oil also contains small amounts of polychlorinated dibenzofurans. The health hazard for occupationally exposed workers is debated, as epidemiological studies have given contradictory results. A cohort study of Italian capacitor workers showed an increased frequency of malignancies [Bertazzi et al, 1982, 1984] while a U.S. cohort study was negative in this respect [Brown and Jones, 1981].

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## METHODS

We investigated the mortality and cancer incidence in a small cohort of Swedish workers engaged in the manufacturing of capacitors. Where PCB had been used between 1960 and 1978 as a capacitor dielectricum. The PCB oil was chlorinated to 42% and had been delivered from Monsanto and Prodelec companies. All male, Swedish workers employed for at least 6 months between 1965 and 1978 were identified from company records: 145 individuals had worked with filling, painting, testing, packaging, transport, and repair of capacitors. (The distribution of exposure times is shown in Table I.) Mean exposure time was 6.5 years. Sampling and analysis of airborne PCB were performed in 1973 and showed a level of  $0.1 \text{ mg/m}^3$ , which might indicate an intermediate air concentration, compared to other capacitor factories [Kimbrough, 1980]. Exposure levels may have been higher in the 1960s. PCB penetrates intact skin [Vos and Beems, 1979] and skin contamination had occurred for some of the workers. The presence of polychlorinated dibenzofurans in the PCB used in the factory was determined in a sample collected in 1978. The analytical method is based on column chromatography and HRGC-MS [Rappe et al, 1984]. The levels found in this sample were comparatively low (see Table II).

Vital status was determined by matching civil registration numbers with a computerized register of the living population at the National Insurance Authority. Individuals not found in this register were traced via death and burial books of the parishes. Death certificates coded for underlying cause of death were obtained from the Swedish National Central Bureau of Statistics. Cancer cases were identified from the National Cancer Registry. Follow-up was complete for all but three individuals who had emigrated and were excluded from the analysis. Expected numbers, standardized for sex, age-class, and calendar year, were calculated from national statistics.

TABLE I. Exposure Periods\*

Exposure time (years)	No. of indiv.	Cum. %
< 1	14	100
1-2	26	90
2-5	37	71
5-10	23	45
10-15	18	29
> 15	24	17

\*Mean exposure time = 6.5 yrs.

TABLE II. Levels of Dibenzofurans (DBF) in the PCB-oil, 1978

Isomer	Level (ppb)
Trichloro-DBF (tot)	700
Tetrachloro-DBF (tot)	630
Tetrachloro-DBF (2,3,7,8-)	53
Pentachloro-DBF (tot)	35
Hexachloro-DBF (tot)	ND

## RESULTS

There were the Cancer Regis and cancers corre of exposure to er 13 years (Table I in the cohort had up. The power of for the relative r could exclude a level of 5% (two A subgroup (ers) was analyze ty or cancer inci tumors were loc 5 years had deve lymphoma, both mas and soft tis chlorinated phen cally related to F more benign t occurrence of th noteworthy. The specimens by an

TABLE III. Obser Age\*

Total deaths
Cancer deaths
Circulatory disease
Ischemic heart disease
Respiratory disease
Other causes of death
Total cancer incidence

RR, relative risk; c.i.

TABLE IV. Latency

Latency time (years)*
5
10
15
20

Median latency with RR, relative risk.

## RESULTS

There were 21 deaths in the period 1965 to 1982 and seven cancers reported to the Cancer Registry between 1965 and 1980 (Table III). Observed numbers of deaths and cancers correspond well with those expected. The latency time — time from start of exposure to end of follow-up—ranges from 4 to 22 years, with a median value of 13 years (Table IV). As can be seen from this Table, 65% (92/142) of the members in the cohort had a latency of at least 10 years from start of exposure to end of follow-up. The power of the study is determined by the upper limit of the confidence interval for the relative risk, eg, with a latency requirement of at least 10 years, the study could exclude a relative risk for total mortality greater than 1.75, with a significance level of 5% (two-sided).

A subgroup of 19 individuals with higher exposure (capacitor fillers and repairers) was analyzed separately, but there was no tendency towards an increased mortality or cancer incidence in this subgroup. There were two lung cancer cases; the other tumors were localized to single sites. One individual with intermediate exposure for 5 years had developed a slow growing mesenchymal tumor (desmoid) and a malignant lymphoma, both occurring 10 years after beginning of exposure. Malignant lymphomas and soft tissues sarcomas have been found in excess in workers exposed to chlorinated phenoxy acid herbicides and chlorophenols, compounds that are chemically related to PCB [Hardell, 1981]. Although the observed soft tissue tumor was of a more benign type than those reported in association with herbicide exposure, the occurrence of these relatively rare tumors in one individual in this small group is noteworthy. The pathological diagnosis was confirmed by review of histological specimens by an independent pathologist.

TABLE III. Observed and Expected Numbers of Deaths and Cancers, Computed up to 80 Years of Age\*

	Observed	Expected	RR	95% c.i.
Total deaths	21	22.12	0.95	0.58-1.45
Cancer deaths	7	5.39	1.30	0.52-2.67
Circulatory diseases	8	11.40	0.70	0.30-1.38
Ischemic heart disease	6	8.38	0.72	0.26-1.55
Respiratory diseases	2	0.96	2.08	0.25-7.50
Other causes of death	4	4.37	0.91	0.24-2.34
Total cancer incidence	7	7.58	0.92	0.37-1.90

\*RR, relative risk; c.i., confidence interval.

TABLE IV. Latency Periods

Latency time (years) <sup>a</sup>	No. of indiv.	Mortality		95% conf. interv. (RR) <sup>b</sup>
		Observed	Expected	
1	142	21	22.1	0.58-1.45
5	135	21	20.5	0.60-1.55
10	92	17	15.5	0.63-1.75
15	56	12	9.2	0.67-2.27
20	39	4	2.9	0.37-3.52

<sup>a</sup>Median latency was 13 years.

<sup>b</sup>RR, relative risk.

## CONCLUSIONS

The conclusions must be tempered due to the small size of the cohort and the short time of follow-up, but the results do not indicate any excess mortality or cancer incidence in this factory so far. The confidence interval for the relative risk indicates that risk excesses over 1.5 are improbable with regard to total mortality, and 1.9 with regard to cancer incidence. Since this cohort contains individuals with different exposure levels (assessed from job titles), an analysis purely by exposure time would be misleading; the alternative is an analysis by job title. Both analyses were actually performed and did not give any further information. The exposure data in this study are too limited and the group is too small to warrant a more extensive dose-response analysis. We have therefore chosen to include, in addition to the overall results, only the findings for the most heavily exposed group — capacitor fillers and repairers. Naturally, the group will be followed in the future.

## ACKNOWLEDGMENTS

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