

## Chlorinated Dioxin and Dibenzofuran Levels in Plasma of Sawmill Workers Exposed to Chlorophenol-Containing Anti-Stain Agents

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### 1. Introduction

The use of chlorophenols as preservatives against blue-staining fungi ceased in Finland at the end of the 1980s. Previously they had been used extensively since the 1930s, the main commercial product being the Finnish Ky-5 formulation. Contaminants detected in the latter include polychlorinated dibenzo-*p*-dioxins (PCDD) and dibenzofurans (PCDF), polychlorinated phenoxyphenols, diphenylethers, and anisoles <sup>1,2)</sup>. In a recent study, we showed that the urinary concentrations of chlorophenols in sawmill workers were of the same level as in the general population. Thus no current exposure occurred, *e.g.*, via a contaminated work environment<sup>3)</sup>. In the present paper, we report the levels of 2,3,7,8-substituted PCDDs and PCDFs in the plasma of sawmill workers and in nonexposed controls from the same sawmills.

### 2. Materials and methods

#### 2.1 Study groups

Fifty-seven workers participated in the study at three sawmills (A, B, and C) located in eastern and southern parts of Finland. Chlorophenols were last used in 1988 in sawmills A and B and in 1984 in sawmill C. The duration of employment for exposed workers during the period when chlorophenols were used was 9 years or more in sawmills A and B. The corresponding period in sawmill C was more than 13 years for all exposed workers except two who had potential exposure periods of 3 years and 1 year, respectively. The controls worked in the same sawmills, but their work did not involve contact with the chlorophenol formulation. All subjects were interviewed about their nutritional and smoking habits. Informed consent was obtained from the participants and the design of the study was approved by the Ethics Committee of the Finnish Institute of Occupational Health.

#### 2.2 Analysis of blood samples

Venous blood was collected in heparinized glass bottles. The plasma was separated by centrifugation and the sample was immediately frozen until further treatment. The lipid content of the plasma was determined enzymatically<sup>4)</sup>. Each plasma sample was spiked with <sup>13</sup>C-labeled 2,3,7,8-substituted internal standards and extracted with organic solvents, followed by sulfuric acid treatment and washes with deionized water. The extract was then subjected to a three-column cleanup procedure using the FMS (Fluid Management Systems, Inc.) fully automated Dioxin-Prep<sup>TM</sup> System<sup>5)</sup>. This method uses disposable pre-packed silica, alumina, and carbon columns made of Teflon<sup>TM</sup>. The final

extract was quantified by high-resolution gas chromatography / high-resolution mass spectrometry utilizing the isotope dilution technique. The blood plasma concentrations were reported as lipid-adjusted (pg/g) and as international toxic equivalents (pg I-TEQ/g).

### 3. Results and discussion

The concentrations obtained for 2,3,7,8-substituted PCDDs/PCDFs in the blood of the workers at three sawmills are presented in Table 1.

**Table 1.** Chlorinated dibenzodioxin and dibenzofuran levels (lipid-adjusted) in the blood of sawmill workers

Congener	Sawmill A Mean (pg/g)		Sawmill B Mean (pg/g)		Sawmill C Mean (pg/g)	
	Exposed workers	Controls	Exposed workers	Controls	Exposed workers	Controls
	n=15	n=5	n=12	n=5	n=12	n=8
2,3,7,8-TCDD	2.4	2.5	7.2	4.4	5.0	4.6
1,2,3,7,8-PnCDD	11	9.6	29	19	20	20
1,2,3,4,7,8-HxCDD	2.5	nd (0.3)	nd (0.3)	nd (0.3)	11	5.2
1,2,3,6,7,8-HxCDD	115	100	168	97	203	155
1,2,3,7,8,9-HxCDD	12	5.9	12	8.3	17	9.5
1,2,3,4,6,7,8-HpCDD	77	63	93	90	114	70
OCDD	522	466	473	804	591	473
2,3,7,8-TCDF	1.7	1.0	3.3	1.4	2.7	1.6
1,2,3,7,8-PnCDF	1.9	0.6	1.6	1.7	1.2	1.0
2,3,4,7,8-PnCDF	29	39	39	38	39	48
1,2,3,4,7,8-HxCDF	14	9.7	14	8.7	18	9.2
1,2,3,6,7,8-HxCDF	nq	nq	nq	nq	nq	nq
1,2,3,7,8,9-HxCDF	5.4	1.0	2.6	1.1	4.0	1.6
2,3,4,6,7,8-HxCDF	5.6	3.0	4.8	3.6	7.5	4.1
1,2,3,4,6,7,8-HpCDF	224	43	99	48	148	44
1,2,3,4,7,8,9-HpCDF	nd (0.3)	nd (0.3)	nd (0.3)	nd (0.3)	nd (0.3)	nd (0.3)
OCDF	nr	nr	nr	nr	nr	nr
Total PCDDs	742	647	782	1023	961	737
Total PCDFs	282	97	164	103	220	110
Total PCDDs/PCDFs	1024	744	946	1126	1181	847

n = number of participants; nd = not detected (detection limit in parenthesis); nq = not quantified; nr = not reported.

The significance of the levels found depends on the definition of the normal background concentration. Schecter *et al.*<sup>6)</sup> have published data on human blood from various general

populations, and Patterson *et al.*<sup>7)</sup> and Beck *et al.*<sup>8)</sup> on adipose tissue of nonexposed individuals. Generally, a good correlation has been reported between concentrations in adipose tissue and whole blood; and by inference plasma can be used to estimate dioxin body burden.

For all isomers, the lipid-adjusted levels in the controls were within the range of PCDD/PCDF background concentration in human fat<sup>8)</sup>. The same was true for the exposed workers with the exception of the 1,2,3,4,6,7,8-HpCDF isomer, the concentration of which was 2 to 5 times higher among the exposed workers than among the controls. The total PCDD/PCDF levels found in the exposed workers at sawmills A and C (1024 pg/g and 1181 pg/g) were about 40 % higher than among the controls (744 pg/g and 846 pg/g). On the other hand, the total concentration measured in exposed workers at sawmill B (946 pg/g) was about 16 % lower than among the controls (1126 pg/g).

The results were tested using a multivariate analysis of covariance to determine whether there was a significant association between work involving contact with chlorophenols and the lipid-adjusted concentrations of the 2,3,7,8-substituted PCDDs/PCDFs. The effects of nutritional and smoking habits as well as duration of employment, age, and body mass index were considered in the analysis.

When examining the specific isomers occurring as contaminants in the commercial chlorophenol formulation, *i.e.*, 1,2,3,6,7,8-HxCDD, 1,2,3,4,6,7,8-HpCDD, and 1,2,3,4,6,7,8-HpCDF, the mean concentration of the 1,2,3,6,7,8-HxCDD isomer in controls was found to be significantly higher in sawmill C than in sawmills A and B. The concentrations of the other two isomers did not differ among the three sawmills.

In sawmill A, only the concentration of the 1,2,3,4,6,7,8-HpCDF isomer was higher among the exposed workers than among the controls ( $p < 0.01$ ). In sawmill B, also the concentration of the 1,2,3,6,7,8-HxCDD was higher ( $p < 0.01$ ) among the exposed workers than among the controls. In sawmill C, the same pattern as in sawmill A was observed, *i.e.*, only the 1,2,3,4,6,7,8-HpCDF level was higher ( $p < 0.001$ ) among the exposed workers than among the controls.

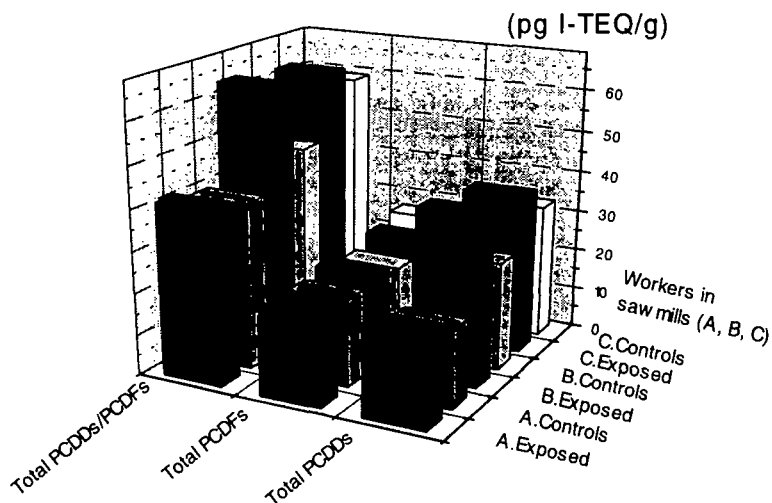
When the PCDD/PCDF levels were expressed in toxic equivalents (pg I-TEQ/g lipid-adjusted, Figure 1), no significant differences were found between the exposed workers and the controls in any of the sawmills. Still, there was a distinct difference among the three sawmills in the levels measured in the exposed workers the lowest levels (42 pg -I-TEQ/g) being found in sawmill A. The levels in exposed workers at sawmills B and C were about 50 % higher than those found in sawmill A. The contribution of PCDD to the total body burden was on average 60 %.

The PCDD/PCDF pg I-TEQ levels found in the present study were generally of the same order of magnitude as those in our previous investigation on pulp and paper mill workers<sup>9)</sup>, the mean value for exposed workers being 60 pg I-TEQ/g and for controls 50 pg I-TEQ/g.

## 4. Conclusions

The results for individual isomers measured in the sawmill workers imply an association between PCDD/PCDF blood plasma concentrations and past exposure to chlorophenols. However, the total toxic equivalent concentrations did not differ significantly between the workers and their respective controls, although differences in levels were observed among the mills.

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**Figure 1.** Total PCDDs/PCDFs in the blood of sawmill workers (pg I-TEQ/g lipid-adjusted).

## 5. References

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