Psychological Effects upon Exposure to Polyhalogenated Dibenzodioxins and Dibenzofurans

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Introduction

In contrast to the toxic effects of polyhalogenated dibenzodioxins and dibenzofurans little is known about psychological effects associated with these compounds. Polyhalogenated dioxins and furans are generated by combustion (pyrolysis) of chlorinated and/or brominated organic compounds, e.g., plastics or flame retardants. Such materials are used in the building industry. A case-control study was performed in a facility in which construction materials are tested for their flame resistence. In this study psychological effects, medical parameters and concentrations of polyhalogenated dibenzodioxins and dibenzofurans have been examined.

Material and Methods

Thirty workers exposed to combustion products from flame resistence tests of building materials and 30 non-exposed controls from the same facility matched for age, gender, length of employment at the facility, and occupational qualification, were interviewed for their medical and detailed occupational history. All subjects were examined by two psychologists for possible neurobehavioural effects using tests for mental performance, i.e., simple reaction time, vigilance by colour word interference, memory span, digit symbol coding, and a vocabulary test (1). Neurobehavioural symptoms (2), individual sensitivity to chemical and environmental stimuli (3), and trait anxiety (4) were asked for by using questionnaires.

All subjects were also physically examined by two physicians. Routine laboratory parameters, e.g., red and white blood cell counts, liver enzymes (GGT, GOT, GPT) and serum creatinine were determined using standard tests (Boehringer, Mannheim, Germany). Blood concentrations of lead, chromium and cadmium were determined from 5 ml EDTA blood samples (potassium-EDTA-monovettes, Sarstedt, Nuembrecht, Germany) by electrothermal atomic absorption spectrometry with Zeeman background compensation. The detection limits were 10 µg/l for lead, 0.7 µg/l for chromium and 1.0 µg/l for cadmium. From 10 persons, presumably exposed to polychlorinated dibenzodioxins (PCDDs) and dibenzofurans (PCDFs) along to their exposure to combustion fumes, 100 ml blood samples were drawn from the cubital vein to determine concentrations of PCDFs and PCDDs in the blood fat. These blood samples were immediately frozen and stored at -20° C until processing.

For exposure assessment airborne deposits on ceilings, walls, and hoods suspected to be contaminated with combustion products were obtained. Analyses of the organic compounds were performed by GfA, Muenster-Roxel, Germany. PCDFs, PCDDs, PBDFs, and PBDDs were determined by high resolution gas chromatography/high resolution mass spectrometry, according to standard methods (5,6). Polycyclic aromatic hydrocarbons were analyzed by high resolution gas chromatography/flame ionisation detection. Samples were drawn from an old facility which had been closed for several years before sampling, and from the present facility as well.

Results and Discussion

In the old facility deposits from 9 different sites were analyzed for PCDDs and PCDFs. The concentrations found were between 0.016 µg/kg and 38.5 µg/kg (TE, according to NATO/CCMS 1988). The concentrations in the deposits at 5 sites of the actual working facility were between 0.13 µg/kg and 67.09 µg/kg (TE, according to NATO/CCMS 1988).

The concentrations of polybrominated dibenzofurans (PBDFs) drawn from 2 sites (a shaft of a ventilator in the closed facility and from the bars of a skylight in the new facility) were extremely high (Table 1).

Tabl. 1: Concentrations of PBDFs and PBDDs from a shaft of a ventilator (sample 1) and from a barred window at a ceiling (sample 2) (nd = not detectable)

	sample 1	sample 2		sample 1	sample 2
PBDF	µg/kg	µg/kg	PBDD	µg/kg	µg/kg
Σ mono BDF	0.4	0.8	Σ mono BDD	nd	nd
Σ di BDF	14.5	45.1	Σ di BDD	nd	nd
Σ tri BDF	269	489	Σ tri BDD	nd	nd
Σ tetra BDF	2,850	1,190	Σ tetra BDD	nd	nd
Σ penta BDF	6,910	1,420	Σ penta BDD	18.3	nd
Σ hexa BDF	4,620	1,330	Σ hexa BDD	nd	nd
Σ mono-hexa BDF	14,660	4,470	Σ mono-hexa BDD	18.3	nd

The concentrations of mixed brominated and chlorinated dibenzofurans (P(BC)DFs) and dibenzodioxins (P(BC)DDs) were much lower compared to the concentrations of PBDFs and PBDDs. The sum of all mixed congeners (furans) determined was 4,790 µg/kg in sample 1 and 1,410 µg/kg in sample 2. P(BC)DDs were not detected in both samples.

There were no statistically significant differences in the results of physical examinations, vital capacity, Tiffeneau's test, hemoglobin, red and white blood counts, liver enzymes (GGT, GOT, GPT), creatinine, and blood concentrations of lead, chromium and cadmium between the presumably exposed and the control group. The mean values were within the normal ranges.

The PCDF/PCDD concentrations in blood fat of 10 workers with the highest occupational exposure to combustion products were between 13.1 and 16.9 pg/g (TE, according to NATO/CCMS 1988).
The results of the deposit analyses provided evidence for considerable potential exposure to polyhalogenated dibenzodioxins and dibenzofurans at the working places. It is noteworthy that the combustion of building materials leads to higher amounts of polybrominated rather than the polyhalogenated congeners, dependent on the parent materials.
The blood fat concentrations of PCDFs and PCDDs of the 10 workers with the highest occupational exposure to combustion products were within normal findings. This is probably due to the fact that the main uptake of PCDDs and PCDFs occurs via food ingestion whilst the uptake by inhalation is very low. This finding is not inconsistent with the elevated concentrations of PCDDs and PCDFs in the deposits.
The investigations of mental performance of the subjects did not reveal significant differences between cases and controls. In these tests, verbal intelligence (vocabulary) was statistically controlled. The investigation of neurobehavioural symptoms (six scales) showed a tendency towards higher frequencies of symptoms among the cases which is not statistically significant. However, if the score for „sensitivity" was used to distinguish between groups of lower and higher sensitivity (separated by the mean) the frequency of symptoms increased with this factor of sensitivity (multivariate, df 6/68, $F = 2.17$, $p = 0.056$). This holds true for the scales of psychovegetative lability, neurological symptoms, difficulties of concentration and irritations.
In another step, the score for „anxiety" was used to form the groups of lower and higher trait anxiety (separarted by the mean); the frequency of neurobehavioural symptoms increased with trait anxiety (multivariate, df 6/68, $F = 10.8$, $p = 0.0001$), independent of the risk of exposure to combustion products (Figure 1).

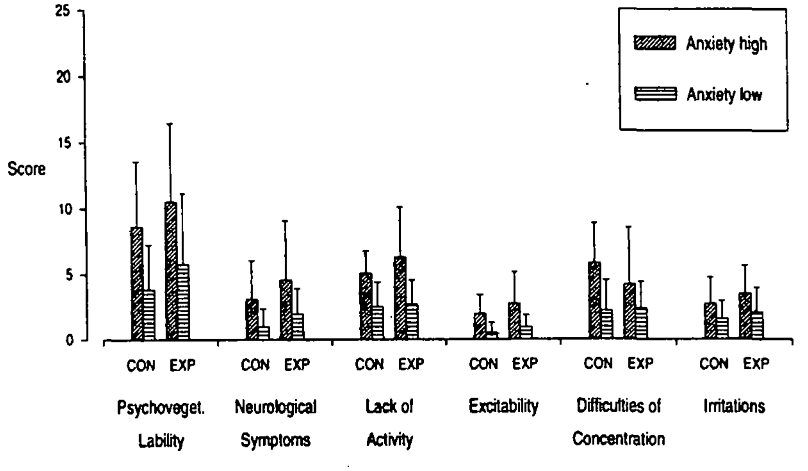

Fig. 1: Means and standard deviations of neurobehavioural symptoms determined by use of a questionnaire. The subjects were grouped according to their trait anxiety into subgroups with low and high trait anxiety. CON: controls, EXP: exposed

In all scales, the difference of scores between „controls" and „exposed" can be neglected whereas the difference between groups of high and low trait anxiety is obvious.
The results of these psychological investigations show that individual differences in determinants of personality strongly influence the complaints. In cases of subjective and presumed exposure conditions, with expectations about possible exposure effects, the personality determinants of the subjects explain more variance of the symptoms reported than the exposure does. These results suggest that errors in interpretation of reports of subjective symptoms are likely to occur when personality characteristics are not properly taken into account.

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