Levels of PCDD/F and other chlorinated hydrocarbons in the blood of fire-fighters - results of an epidemiological study

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Abstract

A prospective cross-sectional study was performed from 1989 to 1992 in the urban area of Düsseldorf, Northrhine-Westfalia, Germany. The main interest of the study was to find out, if fire-fighting leads to an elevated body burden of PCDD/F.

The total number of the participants being 250, three age-matched groups of male workers were formed: active fire-fighters (I), firemen without relevant contact to fire (II), and administration employees (III). Blood levels of PCDD/F and various other organochlorine compounds were determined; haematological, biochemical and immunological analyses of the blood, physical examination, extensive medical history and psychodiagnostics were performed.

Results: No significant differences were found between the blood levels of PCDD/F in the 3 groups (mean values; group I: 44,7 pg/g; II: 42,6 pg/g; III: 43,5 pg/g; $p=0,61$; ANOVA). However, significant differences were observed in the concentrations of Pentachlorophenol (mean values; group I: 13 µg/l; II: 17 µg/l; III: 7 µg/l; $p<0,01$), Polychlorinated Biphenyls (Sum of PCB 138, 153 and 180; I: 2042 ng/l; II: 2130 ng/l; III: 1508 ng/l; $p<0,01$), γ-Hexachlorcyclohexane (I: 39 ng/l; II: 23 ng/l: III: 25 ng/l; $p<0,01$) and DDE/DDT (I: 2402 ng/l; II: 2326 ng/l; III: 2022 ng/l; $p=0,04$).

A marked age-related increase of the blood concentrations of PCDD/F - TEFs (Toxicity Equivalent Factors-NATO/CCMS), HCB, β-HCH, PCB and DDE/DDT was found, whereas PCP did not show any age-dependent tendency.

Introduction

It is widely accepted, that nutrition contributes the major part to the body burden of PCDD/F in the general population [1,2]. In occupationally exposed persons, inhalation and dermal contact may become important pathways for the intake of PCDD/F too.
As revealed by former investigations[3], the PCDD/F-content of soot produced by routine fire incidents ranges from a few hundred to several thousands of Nanogram/m^2. It was assumed that fire-fighters risk taking up larger amounts of PCDD/F than the normal population, especially via inhalation of contaminated smoke.
Dermal absorption of TCDD is estimated to be very low[4], nevertheless, recent analyses of fire-fighter's clothing[5] gave rise to the suspicion that even the dermal route could be of some importance.

The main objective of the study was to find out, if fire-fighting leads to an elevated body burden of PCDD/F.

Experimental design

The investigation was conceived as a prospective cross-sectional study. Three groups of differently exposed persons were compared in order to test the hypothesis that fire-fighting results in elevated blood levels of PCDD/F. The main distinguishing feature between the groups was the extent of their occupational contact to fires, burning substances and soot.

Group I (exposed *fire-fighters*) consisted of active fire-fighters, who were involved in fire-fighting almost every working day;
group II (*firemen control group*) was formed by firemen, who mainly performed control functions in airports or in a harbour and did not have relevant contact to fires in the last 15 years; training and working hours were similiar to group I;
group III (*comparison group*) was composed of persons, who worked as administration employees and have not been exposed to fires at all, nor had similiar working conditions as groups I and II.

The groups were formed of male volunteers, who worked for

* a busy urban fire-brigade (Düsseldorf),
* airport fire-brigades (Düsseldorf, Köln/Bonn) or a fireboat in the harbour Düsseldorf and
* the municipal authorities of Düsseldorf, respectively.

In certain cases, the occupational history revealed that volunteers of the airport- or harbour-fire-brigades, who were originally assigned to the control group, had worked as fire-fighters in urban areas in the last 15 years. They did not fulfill the criteria for one of the originally designed groups. This fact led to the formation of a fourth group, labeled "without

classification", which is not listed in the following tables. Statistical data referring to the whole study population, however, do include the members of all groups.

A list of all parameters investigated is presented in table 1.

TABLE 1. List of the included parameters

Blood analyses of chlorinated hydrocarbons	haematology / biochemistry / immunology	history, psychodiagnostics
Polychlorinated Dibenzo-p-Dioxins / Dibenzo-Furans (PCDD/F) - volumen and lipid basis Hexachlorobenzene (HCB) Polychlorinated Biphenyls (PCB 153, PCB 138, PCB 180) Pentachlorophenol (PCP) DDE/DDT α-, β-, γ-Hexachlorcyclohexane (HCH)	Red cell count, Haemoglobin concentration, MCV, Platelets, White cell count, Neutrophils, Lymphocytes, Monocytes, Eosinophils, Basophils, CD4/CD8-Lymphocytes, ALT, γ-GT, Uric acid, Triglycerides, Cholesterol, Phospholipids, Thyroxine, TSH, Vitamin A, Vitamin E	extensive medical history (illnesses, physical complaints, drug history, previous occupations, occupational or private use of toxic substances, nutrition habits etc.) psychodiagnostics (d2-Test, Benton-Test) physical examination

Results

A summary of the demographic data of the study population is given in table 2. The mean body weight in the control group is remarkably (about 4 kg) higher than in other groups.
Mean blood levels of the 2,3,7,8-substituted PCDD/F congeners are presented in figure 1, statistical data are given for the TEF (NATO/CCMS) in table 3.
Results of the blood analyses of the other chlorinated hydrocarbons (DDT, PCB, PCP, HCB, HCH) are presented in table 4. The blood levels of PCB (Sum of PCB138, 153, 180) ranged from 320 to 5600 ng/l, being appreciable lower in the comparison group than in the 2 collectives of firemen. The same applies to DDE/DDT, which ranged from 190 to 7800 ng/l.
The firemen control group had higher blood concentrations of PCP than the exposed fire-fighters (mean values; I: 13,2 µg/l; II: 17,4 µg/l; III: 7,2 µg/l; $p<0,01$; ANOVA*). The exposed fire-fighters had the highest blood level of γ-HCH (mean values; I: 38,8 ng/l; II: 22,8 ng/l; III: 24,8 ng/l; $p<0,01$).
There is a marked age-dependent increase of the TEF-levels in all groups (figure 2). An increase of the HCB- and PCB-levels with growing age is also demonstrated in figure 3 and figure 4. The same applies to the blood levels of DDE/DDT and β-HCH.

* analysis of variance

TABLE 2. Demographic data. Mean values, standard deviations (in brackets).

group	N	age [years]	body-mass-index [kg/m^2]	height [cm]	body weight [kg]
fire-fighters	80	42,9 (10,25)	25,6 (2,18)	177,7 (6,05)	80,8 (8,15)
firemen control group	72	43,6 (10,38)	26,8 (2,47)	177,6 (5,74)	84,6 (8,88)
comparison group	86	44,1 (10,09)	25,3 (3,11)	177,0 (6,33)	79,3 (10,85)

FIGURE 1. Mean TEF blood levels of the 2,3,7,8-substituted congeners in the groups. Lipid basis.

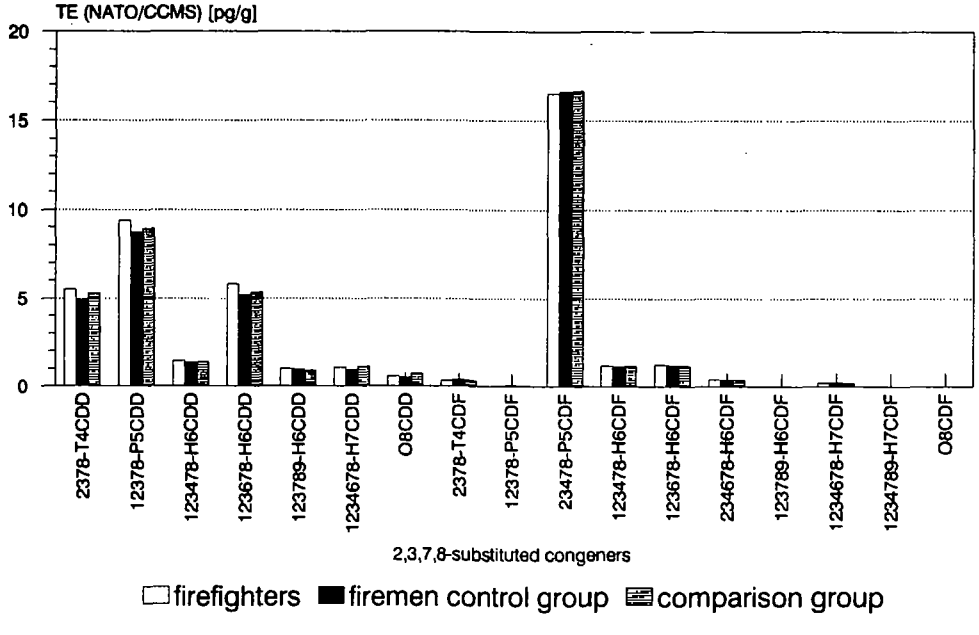


TABLE 3.* TEF blood levels in different groups

		TEF (NATO/CCMS)	TEF (NATO/CCMS)
unit		[pg/l] volumen	[pg/g] lipid
fire-fighters	mean	277,0	44,7
n=70	Std	98,4	13,5
	5°/ile	124,6	23,01
	Median	272,7	42,86
	95°/ile	418,1	67,69
control group	mean	270,9	42,6
n=69	Std	100,9	14,4
	5°/ile	127,1	24,60
	Median	263,0	41,21
	95°/ile	446,0	67,35
comparison group	mean	277,6	43,5
n=86	Std	137,9	15,3
	5°/ile	137,2	24,40
	Median	250,8	42,54
	95°/ile	516,7	66,83
total	mean	274,2	43,6
n=235	Std	114,3	14,4
	5°/ile	130,2	24,27
	Median	256,0	41,94
	95°/ile	454,3	67,35

* 5°/ile = 5%-percentile,
95°/ile = 95%-percentile,
Std = standard deviation;
"total" includes 10 participants without classification.

** Note: Scatter diagram of the TEF-blood levels (logarithmic scale, non-logarithmic labels) vs. age. Regression line and 95%-confidence regions (dotted lines) are plotted.

FIGURE 2.** Plots of TEF vs. age in different groups

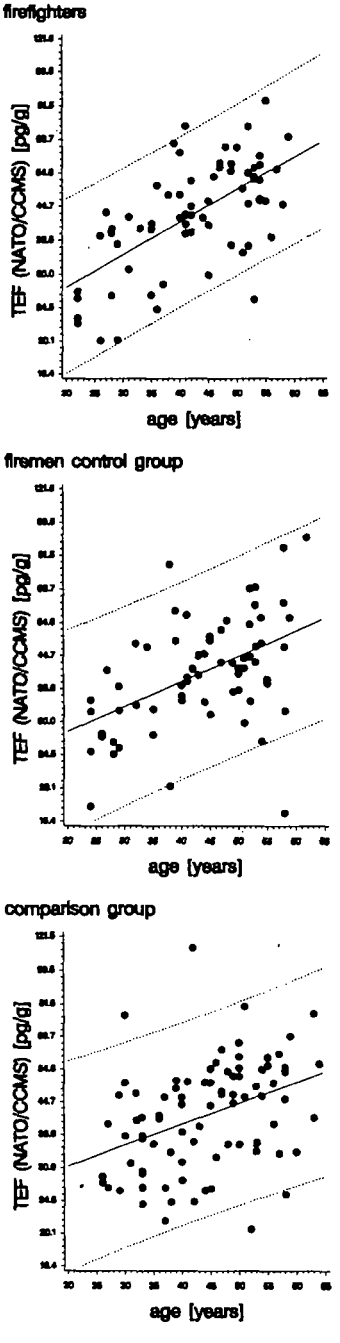


TABLE 4.* Blood levels of PCB, HCB, DDE/DDT, HCH, PCP.
Mean values, 5%-Percentile - 95%-Percentile (in brackets)

	[unit]	firefighters	firemen control group	comparison group	total
		n=80	n=72	n=86	n=250
PCB 138	[ng/l]	717,0 (310-1450)	752,5 (340-1300)	539,2 (240-1000)	657,0 (250-1300)
PCB 153	[ng/l]	868,0 (380-1700)	889,3 (390-1500)	641,7 (280-1200)	784,4 (290-1500)
PCB 180	[ng/l]	457,3 (170-805)	487,8 (190-940)	327,2 (140-630)	416,4 (150-800)
HCB	[ng/l]	1520,1 (340-3100)	1450,8 (360-2700)	1457,2 (350-3000)	1464,8 (350-2900)
DDE/DDT	[ng/l]	2402,3 (760-5300)	2325,7 (740-4300)	2022,0 (560-4900)	2224,0 (610-5000)
α-HCH	[ng/l]	4,0 (n.d.-8)	4,0 (2-7)	4,8 (2-9)	4,3 (2-8)
β-HCH	[ng/l]	332,2 (100-625)	332,0 (120-610)	374,1 (120-840)	344,5 (110-700)
γ-HCH	[ng/l]	38,8 (7,5-110)	22,8 (3-93)	24,8 (4-77)	30,1 (5-100)
PCP	[µg/l]	13,2 (3,5-31,5)	17,4 (7-36)	7,2 (3-12)	12,5 (3-31)

FIGURE 3: Plot of HCB-levels vs. age**

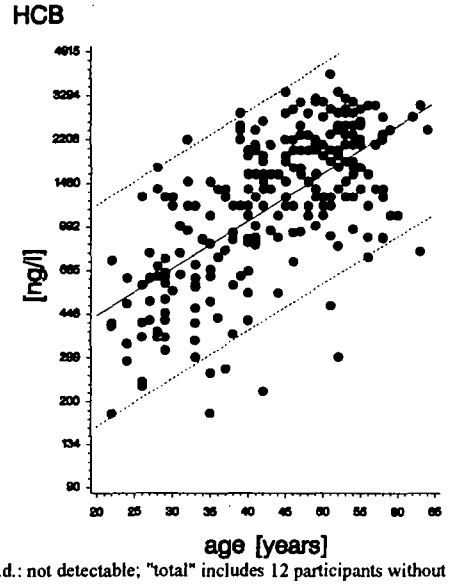
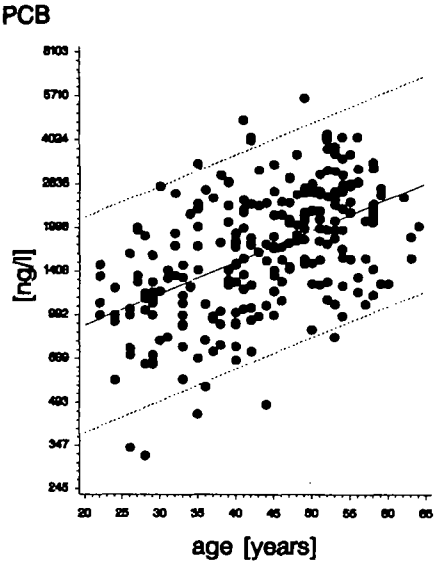


FIGURE 4. Plot of PCB-levels vs. age**



* n.d.: not detectable; "total" includes 12 participants without classification.

** Note: Scatter diagrams of the HCB and PCB (PCB138+PCB153+PCB180)-blood levels (logarithmic scale, non-logarithmic labels) vs. age. Regression line and 95%-confidence regions (dotted lines) are plotted.

Discussion

The active fire-fighters did not show significantly elevated blood levels of PCDD/F when compared to their less-exposed colleagues or the administration employees (p=0,61; ANOVA).
Only if nutrition data, age and BMI (body-mass-index) as confounding factors are included into the regression analysis, a group-dependent effect on the TEF-levels can be demonstrated. Following the statistical model, a fire-fighter, 50 years of age, is estimated to have an about 4,5pg/g higher blood level of TEF (lipid basis) than participants of the other groups (same age). It ist noteworthy that these results can only be observed, when a statistical standardization of the data concerning nutrition has been performed.

The highest mean PCP-level was found in the control group, who did not have relevant contact to fires. Analyses of protective clothing material worn by the airport-firemen revealed, that elevated PCP-levels could, at least partially, be explained by the use of PCP-treated leather clothing.

Although a thorough investigation into the working conditions of the fire-fighters has been performed, including analyses of indoor air and fire-fighter's equipment, a reason for the elevated γ-HCH-, DDE/DDT and PCB-blood concentrations has not yet been found.

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