

DIOXINS, DIBENZOFURANS AND DIOXIN-LIKE PCBS IN BLOOD OF AMERICANS

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Objective: Dioxins (PCDDs), dibenzofurans (PCDFs), coplanar, mono-ortho and di-ortho polychlorinated biphenyls (PCBs) were measured in individual analyses of blood from fifty adult residents of the state of Michigan. The mean levels from these fifty and a pooled blood bank sample (N=5) from the general population of Missouri are compared with individual blood samples from two chemical plant workers with potential exposure to dioxins and two residents of Michigan who had previously been found to have elevated blood PCB levels from consuming fish.

Methods: One unit (450mL) of whole blood was collected from each of the individuals and pooled blood was obtained from a Kansas City blood bank (N=5). Analytic methodology consisted of gas chromatography and mass spectroscopy (GC-MS), previously described in detail.^{1,2} Analyses were performed at Midwest Research Institute under the supervision of J. Stanley and K. Boggess.³ This laboratory has been "certified" for competency by the World Health Organization in interlaboratory validation tests for dioxins, dibenzofurans and PCBs in human milk and blood.⁴

Results: The congener-specific results are shown on Table I. Both of the comparison groups, the pooled blood from Missouri and the individual analyses from Michigan, have relatively high levels of PCBs. The Michigan data are from 50 Vietnam veterans (six individuals with elevated TCDD were excluded from the average for TCDD, making N=44 for TCDD while for all of the other congeners, N=50). Patients 1 and 2 are both paper and pulp plant workers who were diagnosed and treated for Non-Hodgkins lymphoma and had no other known exposure to dioxins. Patient 1 shows an elevation of 2,3,7,8-TCDD, Patient 2, shows no elevation of 2,3,7,8-TCDD or 2,3,7,8-TCDF, the

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congeners characteristic of paper and pulp bleaching. Patients 3 and 4 had PCBs levels much higher than the comparison groups, presumably due to their higher than normal consumption of fish contaminated with PCBs. One of the Michigan residents, Patient 4, also has an elevation of some dioxin congeners when compared with the control group, from an unknown source. Table II shows estimated dioxin toxic equivalents (TEqs) using USEPA dioxin toxicity factors (TEFs) for PCDD/Fs⁵ and Safe's suggested factors for PCBs.⁶

Conclusions: In the Michigan residents, Missouri pool, and chemical workers who had no known special exposure to PCBs, high levels of coplanar, mono-ortho and di-ortho PCBs were detected in whole blood.⁷ If proposed estimates of dioxin-like toxicity⁶ are correct, the PCBs are contributing substantially to total dioxin toxicity in Americans. Using these proposed estimates of PCB dioxin toxicity, and adding the dioxin toxic equivalents from coplanar, mono-ortho and di-ortho PCBs may produce up to a three-fold increase in total dioxin toxic equivalents beyond that from dioxins and dibenzofurans alone in the general population. Accurate exposure assessment should include measurement of these PCBs to reflect possible human toxic effects. However, PCB toxicity may be lower than these proposed estimates, based on new toxicity data.

References:

- 1 USEPA. PCDDs and PCDFs by HRGC/HRMS, SW-846 EPA method 8290. *USEPA* 1990;1B.
- 2 Dewailly E, Tremblay-Rousseau H, Carrier G, Groulx S, Gingrass S, Boggess K, Stanley JS, Weber JP. PCDFs and PCBs in human milk of women exposed to a PCB fire and of women from the general population of the province of Quebec - Canada. *Organohalogen Compounds, Eco-Infirma Press, Bayreuth, Germany* 1990;1:227-230.
- 3 Boggess KE, Stanley JS. *Analysis of human blood and semen samples for PCDDs, PCDFs, and PCBs in support of the State of Michigan Vietnam Veteran Agent Orange Study, Report Nos: 9829-A and 9940-A.* Kansas City, MO: Midwest Research Institute, 1993.
- 4 World Health Organization. *Levels of PCBs, PCDDs and PCDFs in human milk and blood: Second round of quality control studies - Environment and Health in Europe #37.* Denmark: FADL Publishers, 1991;1-76.
- 5 USEPA. *Interim procedures for estimating risks associated with exposures to mixtures of chlorinated dibenzo-p-dioxins and dibenzofurans (CDDs and CDFs) and 1989 update.* Springfield, VA 22161 PB90-145756: U.S. Department of Commerce, National Technical Information Service, 1989.
- 6 Safe S. Polychlorinated biphenyls (PCBs), dibenzo-p-dioxins (PCDDs), dibenzofurans (PCDFs), and related compounds: environmental and mechanistic considerations which support the development of toxic equivalency factors (TEFs). *CRC Critical Reviews In Toxicology* 1990;21:51-88.

TABLE I: PCDDS, PCDFS, AND PCBs IN BLOOD OF FOUR INDIVIDUALS COMPARED WITH GENERAL POPULATION CONTROLS

	Missouri*	Michigan#	Patient 1	Patient 2	Patient 3	Patient 4
2,3,7,8-TCDD	3.4	3.8	13.2	4.0	7.4	19.2
1,2,3,7,8-PeCDD	7.1	9.3	15.1	ND(7.0)	16.7	29.7
1,2,3,4,7,8-HxCDD	+	9.8	23.1	8.3	14.8	24.1
1,2,3,6,7,8-HxCDD	67.5	72.1	118.0	64.1	87.1	156.0
1,2,3,7,8,9-HxCDD	13.4	11.9	21.0	10.2	15.0	23.6
1,2,3,4,6,7,8-HpCDD	155.0	118.6	219.0	125.0	179.0	314.0
OCDD	1208.0	793.9	1670.0	829.0	782.0	1800.0
2,3,7,8-TCDF	3.19	2.3	3.0	ND(2.3)	2.6	5.3
1,2,3,7,8-PeCDF	ND(2.1)	1.2	ND(1.9)	ND(2.5)	ND(1.9)	2.0
2,3,4,7,8-PeCDF	7.0	8.8	16.2	7.6	20.6	38.2
1,2,3,4,7,8-HxCDF	9.4	10.6	16.2	9.6	ND(15.8)	25.4
1,2,3,6,7,8-HxCDF	6.04	6.9	13.1	ND(8.0)	ND(13.2)	17.3
2,3,4,6,7,8-HxCDF	ND(5.7)	2.8	5.2	ND(4.6)	ND(6.2)	8.3
1,2,3,7,8,9-HxCDF	ND(5.7)	2.8	ND(5.0)	ND(4.6)	ND(5.0)	ND(4.1)
1,2,3,4,6,7,8-HpCDF	20.2	19.6	23.2	25.3	24.3	48.0
1,2,3,4,7,8,9-HpCDF	ND(6.7)	3.1	7.6	ND(5.4)	8.9	6.4
OCDF	ND(16.7)	9.3	31.9	15.6	24.6	21.6
Tetra PCB #77	34.2	78.6	248.0	10.5	936.0	1550.0
Penta PCB #126	49.8	104.4	526.0	28.1	1880.0	2490.0
Hexa PCB #169	29.9	45.8	78.4	8.3	299.0	413.0
Mono-ortho						
#28 2,4,4'-Tri PCB	10148	7170	3900	1700	2720	24300
#74 2,4,4',5'-Tetra PCB	7602	14330	15700	8350	56100	81500
#105 2,3,3',4,4'-Penta PCB	3200	6928	5190	2720	28700	64700
#118 2,3',4,4',5'-Penta PCB	11346	16213	21200	10700	94200	135000
#156 2,3,3',4,4',5'-Hexa PCB	4202	5988	10000	5940	39000	38200
Di-ortho						
#99 2,2',4,4',5'-Penta PCB	5328	11361	7530	6150	25000	61400
#128 2,2',3,3',4,4'-Hexa PCB	1200	2104	2720	1330	15200	18500
#138 2,2',3,4,4',5'-Hexa PCB	14784	26297	26300	14000	98200	15200
#153 2,2',4,4',5,5'-Hexa PCB	23666	40055	39100	21200	132000	180000
#170 2,2',3,3',4,4',5'-Hexa PCB	4260	6620	6280	4920	37300	50200
#180 2,2',3,4,4',5,5'-Hepta PCB	12728	19034	42000	16800	115000	103000
#183 2,2',3,4,4',5,6'-Hepta PCB	1402	2534	5930	2620	19200	28700
#185 2,2',3,4,5,5',6'-Hepta PCB	852	1284	1960	1070	14400	24700
#187 2,2',3,4',5,5',6'-Hepta PCB	3588	7378	17600	3990	51100	65900
TOTAL PCDDs	1,454	1,019	2,079	1,044	1,102	2,367
TOTAL PCDFs	64	67	120	72	102	175
TOTAL PCDD/Fs	1,518	1,086	2,199	1,116	1,204	2,542
TOTAL COPLANARs	114	229	852	47	3,115	4,453
TOTAL MONO-ORTHOs	36,498	50,629	55,990	29,410	220,720	343,700
TOTAL DI-ORTHOs	67,808	116,667	149,420	72,080	507,400	547,600
TOTAL PCBs	104,420	167,525	206,262	101,537	731,235	895,753
GRAND TOTAL	105,938	168,611	208,461	102,653	732,439	898,295

+ 1,2,3,4,7,8/1,2,3,6,7,8-HxCDD is sum of both. * Pool, N=5. # TCDD is mean of 44 individual analyses, all other congeners are mean of 50

TABLE II: DIOXIN TOXIC EQUIVALENTS IN FOUR INDIVIDUALS' BLOOD COMPARED WITH GENERAL POPULATION CONTROLS
(ppt, lipid)

	TEFs	Missouri*	Michigan#	Patient 1	Patient 2	Patient 3	Patient 4
2,3,7,8-TCDD	1.0	3.4	3.8	13.2	4.0	7.4	19.2
1,2,3,7,8-PeCDD	0.5	3.5	4.6	7.6	1.8	8.4	14.9
1,2,3,4,7,8-HxCDD	0.1	+	0.7	2.3	0.8	1.5	2.4
1,2,3,6,7,8-HxCDD	0.1	6.8	7.2	11.8	6.4	8.7	15.6
1,2,3,7,8,9-HxCDD	0.1	1.3	1.2	2.1	1.0	1.5	2.4
1,2,3,4,6,7,8-HpCDD	0.01	1.6	1.2	2.2	1.3	1.8	3.1
OCDD	0.001	1.2	0.8	1.7	0.8	0.8	1.8
2,3,7,8-TCDF	0.1	0.3	0.2	0.3	0.1	0.3	0.5
1,2,3,7,8-PeCDF	0.05	0.1	0.1	0.1	0.1	0.1	0.1
2,3,4,7,8-PeCDF	0.5	3.5	4.4	8.1	3.8	10.3	19.1
1,2,3,4,7,8-HxCDF	0.1	0.9	1.1	1.6	1.0	0.8	2.5
1,2,3,6,7,8-HxCDF	0.1	0.6	0.6	1.3	0.4	0.7	1.7
2,3,4,6,7,8-HxCDF	0.1	0.3	0.3	0.5	0.2	0.3	0.8
1,2,3,7,8,9-HxCDF	0.1	0.3	0.3	0.3	0.2	0.3	0.2
1,2,3,4,6,7,8-HpCDF	0.01	0.2	0.2	0.2	0.3	0.2	0.5
1,2,3,4,7,8,9-HpCDF	0.01	0.3	0.03	0.1	0.03	0.1	0.06
OCDF	0.001	0.01	0.01	0.03	0.02	0.02	0.02
Tetra PCB #77	0.01	0.3	0.8	2.5	0.1	9.4	15.5
Penta PCB #126	0.1	5.0	10.4	52.6	2.8	188.0	249.0
Hexa PCB #169	0.05	1.5	2.3	3.9	0.4	15.0	20.7
Mono-ortho							
#28 2,4,4'-Tri PCB	0.001	10.2	7.0	3.9	1.7	2.7	24.3
#74 2,4,4',5-Tetra PCB	0.001	7.6	14.3	15.7	8.4	56.1	81.5
#105 2,3,3',4,4'-Penta PCB	0.001	3.2	6.9	5.2	2.7	28.7	64.7
#118 2,3',4,4',5-Penta PCB	0.001	11.4	16.2	21.2	10.7	94.2	135.0
#156 2,3,3',4,4',5-Hexa PCB	0.001	4.2	6.0	10.0	5.9	39.0	38.2
Di-ortho							
#99 2,2',4,4',5-Penta PCB	0.00002	0.1	0.2	0.2	0.1	0.5	1.2
#128 2,2',3,3',4,4'-Hexa PCB	0.00002	0.02	0.04	0.1	0.03	0.3	0.4
#138 2,2',3,4,4',5-Hexa PCB	0.00002	0.3	0.5	0.5	0.3	2.0	0.3
#153 2,2',4,4',5,5'-Hexa PCB	0.00002	0.5	0.8	0.8	0.4	2.6	3.6
#170 2,2',3,3',4,4',5-Hexa PCB	0.00002	0.1	0.1	0.1	0.1	0.8	1.0
#180 2,2',3,4,4',5,5'-Hepta PCB	0.00002	0.3	0.4	0.8	0.3	2.3	2.1
#183 2,2',3,4,4',5',6-Hepta PCB	0.00002	0.03	0.1	0.1	0.05	0.4	0.6
#185 2,2',3,4,5,5',6-Hepta PCB	0.00002	0.02	0.03	0.04	0.02	0.3	0.5
#187 2,2',3,4',5,5',6-Hepta PCB	0.00002	0.1	0.2	0.4	0.08	1.0	1.3
TOTAL PCDD TE _q		18	20	41	16	30	59
TOTAL PCDF TE _q		7	7	13	6	13	26
TOTAL PCDD/F TE _q		25	27	54	22	43	85
TOTAL COPLANAR TE _q		7	14	59	3	212	285
TOTAL MONO-ORTHO TE _q		37	50	56	29	221	344
TOTAL DI-ORTHO TE _q		1	2	3	1	10	11
TOTAL PCB TE _q		45	66	118	33	443	640
GRAND TOTAL TE _q		70	93	172	55	486	725

+ 1,2,3,4,7,8/1,2,3,6,7,8-HxCDD is sum of both. * Pool, N=5. # TCDD is mean of 44 individual analyses, all other congeners are mean of 50.