U.S. POPULATION LEVELS OF TOTAL TEQ (PCDDS, PCDFS, DIOXIN-LIKE PCBS) AND TOTAL PCBS (2003-2004)

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Introduction

We measured PCDD, PCDF, and PCB congeners in a statistically representative sampling of the U.S. population, aged 12 years and older. The samples were collected as part of the National Health and Nutrition Examination Survey (NHANES) 2003/2004, which is administered by the CDC's National Center for Health Statistics. We determined reference ranges for PCBs (38 congeners), PCDDs (7 congeners), and PCDFs (10 congeners). These data will be useful to epidemiologist, toxicologists, and risk assessors for establishing normal human background levels of these chemicals in the U.S. population.

Materials and Methods

The serum concentrations of PCDDs, PCDFs, and PCBs were determined by high resolution gas chromatography/isotope dilution high resolution mass spectrometry.[1,2] Results are given for the total population and by age group, sex, and race/ethnicity. For these analyses, race/ethnicity is categorized as Mexican Americans (MA), non-Hispanic blacks (NHB), and non-Hispanic whites (NHW). Data were analyzed using the statistical software packages Statistical Analysis System (SAS) and SUDAAN. For the multiple regression models, we adjusted the concentration mean by sex, age, and race and all possible two-way interactions to calculate the adjusted least square geometric mean (LSGM) concentrations. We compared the percentiles by examining whether the confidence intervals overlapped or not, although we recognized that this was a conservative method to reject the null hypothesis.[3] Concentrations less than the limit of detection (LOD) were assigned a value equal to the LOD divided by square root of 2.

Together with the PCDDs and PCDFs, certain PCB congeners, the coplanar (cPCBs) and mono-*ortho*-substituted (mPCBs), are often referred to as "dioxin-like" because they act through a similar mechanism of toxicity. To compare relative potency, each of the congeners in the four groups has been assigned a potency value (toxic equivalency factor, TEF) relative to 2,3,7,8-tetrachlorodibenzo-*p*-dioxin. Each TEF is multiplied by the respective congener concentration (in pg/g lipids) to give the congener WHO-toxic equivalency (TEQ); these are summed to give a total TEQ.[4] In 2005 the TEFs were reevaluated, and updated TEFs were published.[5] We report the total TEQ using both the 1998 and the 2005 TEF values using the method outlined previously by Patterson, et al.[6] We computed the sum of the 35 PCBs listed by Turner et al. (Dioxin-2008, this issue) on both a whole weight and lipid adjusted basis. Samples that had any missing data (not reportable for any quality control reason) for PCBs 118, 138+158, 153, 170, 180 and 187 were omitted.

Results and Discussion

In Table 1, we summarize the NHANES 2003-2004 total TEQ (PCDDs, PCDFs, Dioxin-like PCBs) for all persons age 12+ years in the U.S. population (1998 TEFs: 90th percentile 39.4 pg/g lipid, 95th percentile 49.1 pg/g lipid; 2005 TEFs: 90th percentile 30.9 pg/g lipid, 95th percentile 37.8 pg/g lipid) and the age group 20+ years (1998 TEFs: 90th percentile 41.1 pg/g lipid, 95th percentile 52.3 pg/g lipid; 2005 TEFs: 90th percentile 32.5 pg/g lipid, 95th percentile 39.9 pg/g lipid). The total TEQ levels are lower using the 2005 TEFs principally due to the much lower TEF values assigned to the mPCBs.[5] We have found a significant increase in total TEQ levels with age at both the 90th and 95th percentiles for all combined race/ethnicity and sex.

In Tables 2 and 3, the unadjusted GM total PCB concentration for all age, sex, and race/ethnicity in the U.S. population for 2003-2004 is 0.820 ng/g whole-weight (95% confidence interval: 0.782-0.863 ng/g whole-weight) and 134.4 ng/g lipid (95% confidence interval: 128.9-140.0 ng/g lipid). The 95th percentile of the total PCB concentration for all age, sex, and race/ethnicity in the U.S. population for 2003-2004 is 3.531 ng/g whole-weight (95% confidence interval: 3.234-3.916 ng/g whole-weight) and 530.7 ng/g lipid (95% confidence interval: 498.4-570.2 ng/g lipid). The GM and the 50th, 75th, 90th, and 95th percentile levels for total PCBs all increased significantly with age (Tables 2 and 3). There was no difference in total PCB levels for males and females. MA had significantly lower GM levels of total PCBs as well as significantly lower 50th, 75th, 90th, and 95th percentile levels than NHW and NHB. There was no difference in the levels for NHW and NHB.

The LSGM of the sum of 35 PCBs for males (140.2 ng/g lipid) was higher ($p = 0.0004$) than that for females (129.6 ng/g lipid). We also found a significant interaction between race-ethnicity and age-group ($p = 0.0001$). The LSGMs for NHB aged 40-59 and aged 60+ years were higher than those for NHW in corresponding age groups ($p < 0.0079$ and $p < 0.0001$, respectively), but in the aged 12- 19 and aged 20-39 years, the LSGMs for NHB aged 12-19 and aged 20-39 years were not significantly different ($p = 0.537$ and $p = 0.879$, respectively). The LSGMs for NHB and for NHW were higher than those for MA in all age groups ($p \leq 0.0001$ in all groups). The LSGMs for the total PCBs increased with age as evidenced by all age groups differing significantly from one another in each race-ethnicity group ($p < 0.0001$ for all groups except for MA and for the 12-19 vs 20-39 years age groups, where $p = 0.0012$).

Table 1. Total TEQ (PCDD, PCDF, cPCB, mPCB) in pg/g lipid at the 90th and 95th percentiles by age group for all sex and race/ethnicity in the U.S. population 2003-2004.

Age Group Years	*Percentiles*	*TEQ (1998)*	*95%CI*	*TEQ (2005)*	*95%CI*	*N*
All 12+	90th	39.4	37.0-43.1	30.9	28.2-33.9	1796
	95th	49.1	46.2-57.1	37.8	35.3-43.4	
All 20+	90th	41.1	38.2-46.1	32.5	29.2-35.7	1237
	95th	52.3	47.1-59.8	39.9	36.6-45.7	
12-19	90th	14.2	13.4-14.9	12.1	10.9-13.0	559
	95th	15.8	14.5-18.4	14.0	12.4-15.9	
20-39	90th	19.4	17.5-20.9	16.2	14.5-17.7	440
	95th	23.2	20.6-25.2	18.7	16.9-20.1	
40-59	90th	35.1	32.3-39.2	28.2	23.7-32.6	367
	95th	40.5	34.5-64.0	32.0	28.0-45.3	
60+	90th	63.3	57.3-71.2	49.7	41.5-58.6	430
	95th	84.1	66.7-99.0	63.2	50.9-75.1	

References

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Table 2. The unadjusted GMs, selected percentiles and their associated 95 % confidence intervals of the sum of 35 whole weight PCBs in ng/g for NHANES 2003-2004 by Race/Ethnicity, Sex and Age.

	Geometric mean	***Selected percentile*** *(95% confidence interval)*				***Sample size***
	(95% Confidence interval)	***50th***	***75th***	***90th***	***95th***	
Total	*0.820 (0.782-0.863)*	*0.825 (0.761-0.909)*	*1.625 (1.502-1.745)*	*2.638 (2.478-2.810)*	*3.531 (3.234-3.916)*	*1866*
Age Group						
12-29 years	*0.275 (0.258-0.293)*	*0.263 (0.239-0.286)*	*0.395 (0.365-0.430)*	*0.557 (0.489-0.634)*	*0.654 (0.570-0.778)*	*585*
20-39 years	*0.470 (0.442-0.500)*	*0.454 (0.405-0.496)*	*0.646 (0.594-0.715)*	*1.031 (0.857-1.301)*	*1.466 (1.214-1.946)*	*452*
40-59 years	*1.206 (1.105-1.316)*	*1.151 (1.026-1.279)*	*1.661 (1.458-2.026)*	*2.478 (2.103-3.037)*	*3.221 (2.638-4.433)*	*383*
60+ years	*2.271 (2.145-2.404)*	*2.167 (2.073-2.278)*	*3.051 (2.827-3.272)*	*4.311 (3.965-5.115)*	*5.912 (4.921-7.676)*	*446*
Sex						
Males	*0.835 (0.788-0.884)*	*0.814 (0.736-0.916)*	*1.615 (1.493-1.714)*	*2.543 (2.411-2.764)*	*3.432 (2.956-4.264)*	*928*
Females	*0.806 (0.753-0.863)*	*0.824 (0.734-0.931)*	*1.648 (1.464-1.837)*	*2.724 (2.426-3.034)*	*3.564 (3.246-4.170)*	*938*
Race/ethicity						
Non-Hispanic Whites	*0.880 (0.822-0.942)*	*0.917 (0.807-1.030)*	*1.683 (1.566-1.806)*	*2.638 (2.444-2.877)*	*3.443 (3.079-3.790)*	*873*
Non-Hispanic Blacks	*0.884 (0.728-0.978)*	*0.771 (0.570-0.907)*	*1.786 (1.262-2.285)*	*3.854 (2.690-5.151)*	*6.518 (4.253-8.392)*	*453*
Mexican Americans	*0.434 (0.368-0.512)*	*0.375 (0.329-0.454)*	*0.687 (0.513-0.960)*	*1.311 (1.015-1.629)*	*2.001 (1.494-2.426)*	*420*

Table 3. The unadjusted GMs, selected percentiles and their associated 95 % confidence intervals of the sum of 35 PCBs in ng/g lipid for NHANES 2003-2004 by Race/Ethnicity, Sex and Age.

	Geometric mean	**Selected percentile** (95% confidence interval)				**Sample size**
	(95 % Confidence interval)	**50th**	**75th**	**90th**	**95th**	
Total	134.4 (128.9-140.0)	131.8 (121.8-145.5)	245.6 (230.7-260.9)	409.0 (374.0-436-5)	530.7 (498.4-570.2)	1866
Age Group						
12-29 years	54.4 (50.5-58.6)	51.2 (48.2-56.1)	77.7 (74.6-82.4)	109.0 (104.9-127.0)	139.0 (110.8-164.3)	585
20-39 years	79.2 (74.6-84.1)	75.4 (71.2-81.7)	109.8 (102.0-119.8)	157.8 (141.1-183.7)	226.5 (170.6-300.5)	452
40-59 years	186.4 (171.5-202.5)	174.4 (159.9-201.9)	254.4 (227.0-292.1)	375.2 (307.5-444.2)	470.7 (373.5-650.9)	383
60+ years	347.3 (323.1-373.2)	334.5 (308.7-351.8)	470.6 (433.3-503.3)	688.9 (577.7-796.1)	929.4 (752.2-1167.9)	446
Sex						
Males	135.2 (128.6-142.0)	127.2 (118.0-141.2)	241.2 (223.4-265.4)	409.0 (358.0-455.1)	540.1 (475.3-650.0)	928
Females	133.6 (126.4-141.3)	137.9 (123.6-151.7)	253.7 (230.7-264.0)	410.1 (366.3-444.2)	522.2 (472.1-570.2)	938
Race/ethnicity						
Non-Hispanic Whites	142.7 (134.2-151.9)	143.2 (130.8-155.7)	255.6 (237.0-275.2)	406.0 (363.9-433.8)	508.8 (461.8-539.2)	873
Non-Hispanic Blacks	148.3 (129.0-170.5)	135.4 (109.0-160.9)	284.5 (209.8-379.0)	604.6 (454.4-830.6)	984.3 (631.1-1426.9)	453
Mexican Americans	71.2 (61.0-83.1)	61.7 (53.7-73.2)	109.8 (76.6-148.3)	188.2 (155.8-220.3)	245.1 (192.7-323.9)	420