

## Total TEQ Reference Range (PCDDs, PCDFs, cPCBs, mono-PCBs) for the U.S. Population 2001-2002

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### Introduction

Polychlorinated dibenzo-p-dioxins (PCDDs) and dibenzofurans (PCDFs) are chemicals that are produced as contaminants or byproducts. Polychlorinated biphenyls are chemicals that were used as electrical insulating and heat-exchange fluids. Together with the PCDDs and PCDFs, certain PCB congeners, the coplanar (cPCBs) and mono-ortho-substituted (mPCBs) PCBs, are often referred to as “dioxin-like” because they act through a similar mechanism. The general population is exposed to these chemicals as mixtures primarily through the ingestion of high-fat foods, such as dairy products, eggs, and animal fats, and some fish and wildlife. To compare potency, each of the congeners in the four groups has been assigned a potency value relative to TCDD (toxic equivalency factor, TEF). The TEF values are multiplied by the respective congener concentration to give the congener WHO-toxic equivalency (TEQ) and these are summed to give a total TEQ.<sup>1</sup> Thus, the dioxin-like toxicity contribution of each chemical class can be compared.

We report population-based concentrations of the total TEQ (stratified by age, sex, and race/ethnicity) for a statistically designed sample of the civilian, noninstitutionalized U.S. population. The samples were collected as part of the National Health and Nutrition Examination Survey (NHANES) 2001/2002, which is administered by the CDC's National Center for Health Statistics.

### Materials and Methods

The NHANES protocol includes a home interview followed by a standardized physical examination in a mobile center. All selected individuals were asked to complete a questionnaire. As part of the examination component, blood is obtained by venipuncture. PCDDs, PCDFs, and PCBs were measured in serum by high resolution gas chromatography/isotope dilution high resolution mass spectrometry (HRGC/IDHRMS)<sup>2,3</sup> from a random one-third subsample of people aged 20 years and older in 2001 and 2002. Results are given for the total population and also by age group, gender, and race/ethnicity. For these analyses, race/ethnicity is categorized as Mexican American (MA), non-Hispanic black (NHB), and non-Hispanic white (NHW). Other race/ethnic groups are included in estimates that are based on the entire population sample.

Because the NHANES sample design is complex, statistical sample weights must be used to adjust for the unequal probability of selection into the survey. Sample weights also are used to adjust for possible bias resulting from nonresponse and are post-stratified to U.S. Census Bureau estimates of the U.S. population. Data were analyzed using the statistical software package Statistical Analysis System (SAS) (SAS Institute Inc. 2002) and the statistical software package SUDAAN (SUDAAN Release 8.0, 2001). SUDAAN uses sample weights and calculates variance estimates that account for the complex survey design.

Because of the small serum sample size which resulted in a significant number of non-detects for certain congeners, we also prepared pools from the NHANES 2001/2002 samples. We analyzed 51 pools with 34 people per pool (total of 1,734 people) using 0.75 mL of serum per person. The pools were stratified by age, gender, and race/ethnicity. This pooling strategy provided a total of 25.5g of serum for each pool and we used 3g for PBDEs, PCBs, Persistent Pesticides; 22g for PCDDs, PCDFs, cPCBs, PCNs; and 0.5g for the total lipid measurements. These pools, however, are unweighted and not representative of the U.S. population. Variability of the estimates using these pools cannot be estimated.

### Results and Discussion

Table 1 lists for NHANES 2001/2002 the 90<sup>th</sup> and 95<sup>th</sup> percentiles along with their 95% confidence intervals for the 20+ year age group by sex, race/ethnicity, total TEQ, PCDD TEQ, PCDF TEQ, cPCB TEQ, and mPCB TEQ. The reference range 95<sup>th</sup> percentiles for the 20+ year olds total TEQ are plotted in Figure 1. It is clear that at the 95<sup>th</sup> percentile the total TEQ varies by race/ethnicity. Mexican Americans have significantly lower levels than both non-Hispanic whites and non-Hispanic blacks. About 80 to 90% of the total TEQ can be estimated from seven of the congeners, namely 2378-TCDD, 12378-PeCDD, 123678-HxCDD, 23478-PeCDF, PCB-126, PCB-118, PCB-156. The percent contribution to the total TEQ for the 2001/2002 U.S. reference range at the 95<sup>th</sup> percentile (n=1549) for

the 20+ year olds is 44% PCDDs, 24% mPCBs, 17% PCDFs, and 15% for cPCBs. This percent contribution is similar to what we found for the 1999/2000 data.<sup>4</sup>

Since for the NHANES 2001/2002 pools, a number of categories contained more than one pool, we were able to get a measure of the variability within these categories. The means and ranges of the TEQ estimate for the sum of the PCDDs, PCDFs, and cPCBs by age group, race/ethnicity, and gender are shown in Figure 2. It is clear from the results in Figure 2 that TEQ levels varied dramatically with age. The older age groups had consistently higher TEQ levels than the younger age groups. In addition, within most age groups, females had higher levels than males for all race/ethnicity groups. The exception to this was found in the youngest age group studied (12-19 years), where the TEQ levels in males were higher than the levels in females for each race/ethnicity group.

#### References

1. Van den Berg M, Birnbaum L, Bosveld ATC, Toxic Equivalency Factors (TEFs) for PCBs, PCDDs, and PCDFs for Humans and Wildlife. *Environmental Health Perspectives* 106: 775-792 (1998).
2. Patterson D.G. Jr., Hampton L., Lapeza C.R. Jr., High-Resolution Gas Chromatographic/High-Resolution Mass Spectrometric Analysis of Human Serum on a Whole-Weight and Lipid Basis for 2,3,7,8-TCDD. *Anal. Chem.* 59: 2000-2005 (1987).
3. Turner W., DiPietro E., Lapeza C., Green V., Gill J., Patterson, D.G. , Jr. A Fast Universal Automated Cleanup System for the Isotope-Dilution High-Resolution Mass Spectrometric Analysis of PCDDs, PCDFs, Coplanar PCBs, PCB Congeners, Persistent Pesticides from the Same Serum Sample. *Organohalogen Compounds* 31: 26-31 (1997).
4. Needham L, Barr D, Caudill SA, Pirkle JL, Turner W, Osterloh J, Jones R, Sampson, E.J., Concentrations of environmental chemicals associated with neurodevelopmental effects in U.S. population. *Neurotoxicology* online 11 January 2005.

**Table 1. NHANES 2001 & 2002**

**TEQs: Replace Results Below Detection Limit with LOD/ $\sqrt{2}$**

Analyte	File	VAR	TEQ	L95	U95	n_actual
TEQ_AII	ALL	P90	49.4	45.4	56.4	1549
TEQ_AII	ALL	P95	65.3	59.6	71.5	1549
TEQ_AII	FEMALE	P90	52.9	46.6	59.5	825
TEQ_AII	FEMALE	P95	68.7	61.6	81.2	825
TEQ_AII	MA	P90	28.3	24.9	33.7	321
TEQ_AII	MA	P95	38.3	31.1	45.7	321
TEQ_AII	MALE	P90	47.8	38.8	56.7	724
TEQ_AII	MALE	P95	61.4	52.8	72.1	724
TEQ_AII	NHB	P90	57.1	45.7	71.7	286
TEQ_AII	NHB	P95	80.8	60.8	100	286
TEQ_AII	NHW	P90	53.6	47.0	59.4	833
TEQ_AII	NHW	P95	67.7	62.5	77.6	833
TEQ_PCDD	ALL	P90	22.3	19.1	27.8	1549
TEQ_PCDD	ALL	P95	30.9	27.5	38.9	1549
TEQ_PCDD	FEMALE	P90	23.7	19.6	28.6	825
TEQ_PCDD	FEMALE	P95	32.7	27.5	41.5	825
IEQ_PCDD	MA	P90	12.4	10.8	15.6	321
TEQ_PCDD	MA	P95	17.7	14.5	21.3	321

TEQ_PCDD	MALE	P90	21.4	15.9	28.9	724
TEQ_PCDD	MALE	P95	30.3	24.6	37.6	724
TEQ_PCDD	NHB	P90	25.9	21.1	34.4	286
TEQ_PCDD	NHB	P95	41.7	25.9	50.3	286
TEQ_PCDD	NHW	P90	24.1	19.5	28.7	833
TEQ_PCDD	NHW	P95	33.1	28.7	39.9	833
TEQ_PCDF	ALL	P90	9.28	8.18	10.9	1549
TEQ_PCDF	ALL	P95	11.8	10.4	14.1	1549
TEQ_PCDF	FEMALE	P90	9.43	8.28	10.9	825
TEQ_PCDF	FEMALE	P95	11.5	10.7	13.1	825
TEQ_PCDF	MA	P90	5.49	4.40	6.43	321
TEQ_PCDF	MA	P95	6.91	5.83	7.71	321
TEQ_PCDF	MALE	P90	9.29	7.70	11.4	724
TEQ_PCDF	MALE	P95	11.9	9.44	14.9	724
TEQ_PCDF	NHB	P90	9.26	7.63	11.2	286
TEQ_PCDF	NHB	P95	12.9	9.91	15.4	286
TEQ_PCDF	NHW	P90	9.98	8.47	11.5	833
TEQ_PCDF	NHW	P95	12.4	11.0	14.3	833
TEQ_mono_ortho	ALL	P90	13.3	12.0	14.9	1549
TEQ_mono_ortho	ALL	P95	16.5	15.0	19.4	1549
TEQ_mono_ortho	FEMALE	P90	14.6	12.6	15.7	825
TEQ_mono_ortho	FEMALE	P95	17.0	15.6	20.0	825
TEQ_mono_ortho	MA	P90	8.60	7.74	9.66	321
TEQ_mono_ortho	MA	P95	10.2	9.29	11.8	321
TEQ_mono_ortho	MALE	P90	12.3	10.5	15.1	724
TEQ_mono_ortho	MALE	P95	15.8	13.1	19.5	724
TEQ_mono_ortho	NHB	P90	16.2	13.0	18.4	286
TEQ_mono_ortho	NHB	P95	22.0	16.1	30.9	286
TEQ_mono_ortho	NHW	P90	14.3	12.1	15.4	833
TEQ_mono_ortho	NHW	P95	17.0	15.0	20.4	833
TEQ_non_ortho	ALL	P90	6.41	5.85	7.09	1549
TEQ_non_ortho	ALL	P95	9.93	8.58	11.0	1549
TEQ_non_ortho	FEMALE	P90	7.50	6.80	8.64	825
TEQ_non_ortho	FEMALE	P95	11.3	9.67	12.3	825
TEQ_						

non_ortho						
TEQ_ non_ortho	MA	P90	4.38	3.82	5.11	321
TEQ_ non_ortho	MA	P95	6.17	5.05	8.72	321
TEQ_ non_ortho	MALE	P90	5.30	4.40	5.96	724
TEQ_ non_ortho	MALE	P95	6.77	5.91	9.29	724
TEQ_ non_ortho	NHB	P90	6.80	5.61	10.2	286
TEQ_ non_ortho	NHB	P95	11.3	7.42	13.3	286
TEQ_ non_ortho	NHW	P90	6.70	5.89	7.57	833
TEQ_ non_ortho	NHW	P95	10.2	8.48	11.8	833

Figure 1. NHANES 2001/2002 U.S. Reference Range 95<sup>th</sup> Percentiles for 20+ Year Olds Total TEQ (95% Confidence Intervals) for PCDDs, PCDFs, cPCBs, and mPCBs

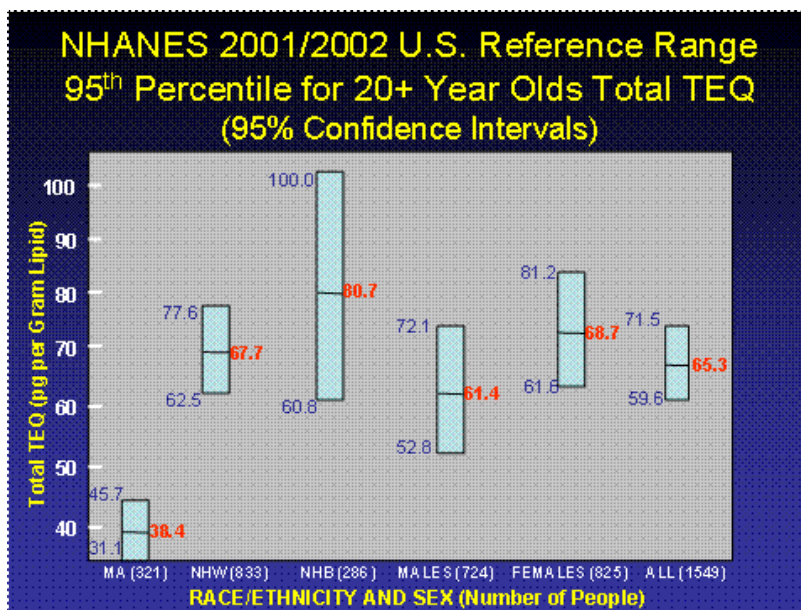


Figure 2. Mean and Range of TEQ ( PCDDs, PCDFs, cPCBs) by Age Group, Race and Sex in NHANES 2001/2002 Serum Pools (number of pools per category in parentheses)

