ESTIMATION OF REFERENCE VALUES FOR DIOXIN, FURAN, AND PCB CONGENER CONCENTRATIONS FOR THE AUSTRALIAN POPULATION

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Introduction

Population-representative data for dioxin and PCB congener concentrations are available for the Australian population based on measurements in age- and gender-specific serum pools.[1] Such data provide a basis for characterizing the mean concentrations of these compounds in the population, but do not provide information on the inter-individual variation in serum concentrations that may exist in the population within an age- and gender-specific group. Such variation may occur due to inter-individual differences in long-term exposure levels or elimination rates. Reference values are estimates of upper percentiles (often the 95th percentile) of measured values in a defined population that can be used to evaluate data from individuals in the population in order to identify concentrations that are elevated, for example, from occupational exposures.[2] The objective of this analysis is to estimate reference values corresponding to the 95th percentile (RV_{95}s) for Australia on an age-specific basis for individual dioxin-like congeners based on measurements in serum pools from Toms and Mueller (2010).

Materials and methods

General approach. Data sets from populations in the United States are available to quantify both the central tendency and the range of concentrations in those populations, but the upper end limits of the normal range from those populations may not be directly applicable to Australians due to potential differences between these populations in current or historical exposure levels. However, these datasets may allow quantification of the degree of variation observed in upper-end quantiles (for example, the 95th or 99th percentiles) compared to the means in those populations. This degree of variation can then be applied to the Australian pooled sample concentrations to derive plausible estimates of the 95th percentile of typical concentrations in the Australian population for specific age groups (RV_{95}). These estimates of RV_{95} can be used to assess data from individual Australians to identify samples that may indicate unusual or elevated exposures, e.g. those occupationally exposed.

Datasets. Concentrations from pools constructed from Australian serum samples taken in 2008 and 2009 are available in Toms and Mueller (2010)[1]. Data sets that allow characterization of variation from population means for some congeners include data from the US National Health and Nutrition Examination Survey (NHANES) from samples collected in 2003 and 2004[3] as well as data from a large, population-representative study in Michigan, US, the University of Michigan Dioxin Exposure Study (UMDES 2009)[4]. This study collected large volumes of serum from each participant, allowing quantification of dioxin-like congeners in a much greater proportion of the sampled population than in the NHANES study. In each case, estimates of the degree of variation (upper percentile compared to mean) can only be made for those congeners and age or gender groups with sufficient rates of detection to allow quantification of both the population mean or median and the upper bound levels.

Scope. Evaluation of population variation and estimation of age-specific RV_{95} concentrations in the Australian population is presented here only for those congeners with quantified concentrations in the Australian pooled data reported by Toms and Mueller (2010)[1]. These are identified in Table 1.

Results and discussion

Variation analysis for US datasets. The ratios of the 95th percentiles to the means for each age group and congener from the two surveys are presented in Figures 1A and 1B. There appear to be trends with age for the ratio between the 95th percentile and mean values for most of the congeners, particularly as demonstrated in the UMDES dataset (Figure 1A)[4]. However, a rough estimate of a factor of increase between the mean and 95th

percentile appears to be appropriate for the included dioxin and furan congeners. The variability appears to be somewhat greater for PCB 126 and 169. For these congeners, an estimated ratio of approximately 3 appears to be appropriate.

Estimated age-specific RV_{95} concentrations for Australian 2008-2009 population data. Under the assumption that the degree of variation in congener concentrations in the Australian general population is roughly similar to those variations in the US samples (even if the actual magnitude is different), rough estimates of congener-specific RV_{95} concentrations in the Australian population can be made based on the results of the pooled samples. The mean age-specific concentration for each of the frequently-detected congeners in the Australian population was calculated by averaging the concentrations measured in each of the four age-specific pools. If the concentration of a congener in an individual pool was non-detected, we replaced the non-detected value with the reported limit of detection (LOD) divided by the square root of 2.[5] We assume that these average concentrations by age group represent estimates of the arithmetic mean concentration in the Australian population. Based on the patterns in the US datasets, we applied a factor of 2 to each congener age-specific pool result, except for PCBs 126 and 169, for which we applied a factor of 3, in order to estimate the age- and congener-specific 95th percentiles for the Australian population (Table 1). Based on the statistics from the US NHANES dataset, we applied a factor of 2 to the sum of the Australian pool data for the sum of the 13 selected congeners on a TEQ basis to estimate the 95th percentile of this sum on a TEQ basis.

The estimated age- and congener- specific upper percentiles from this exercise can be used to evaluate measured serum concentrations of dioxin-like compounds in individuals in the Australian population to provide an indication of whether the measurements suggest elevated exposures above the range expected to occur in the general population. The RV_{95} values presented here are not rigorous, statistically-derived values, but rather should serve as general guidelines for evaluation of individual serum data for persons in the Australian population.

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Table 1: Congener- and age-specific averages for the Australian population (from Toms and Mueller 2010) and estimated population 95th percentiles (based on analyses presented herein) for selected congeners, pg/g TEQ (WHO 2005[6]).

Congener	Age Group	Avg., Australian 08-09 pools	Estimated 95th percentile
TCDD	16 to 30	0.31	0.62
	31 to 45	0.33	0.67
	46 to 60	0.54	1.08
	61+	1.28	2.55
1,2,3,7,8-PeCDD	16 to 30	1.30	2.60
	31 to 45	1.50	3.00
	46 to 60	2.60	5.20

Congener	Age Group	Avg., Australian 08-09 pools	Estimated 95th percentile
	61+	3.90	7.80
1,2,3,4,7,8-HxCDD	16 to 30	0.04	0.08
	31 to 45	0.06	0.11
	46 to 60	0.16	0.31
	61+	0.29	0.59
1,2,3,6,7,8-HxCDD	16 to 30	0.28	0.57
	31 to 45	0.60	1.21
	46 to 60	1.09	2.18
	61+	1.90	3.80
1,2,3,7,8,9-HxCDD	16 to 30	0.12	0.25
	31 to 45	0.13	0.26
	46 to 60	0.20	0.40
	61+	0.39	0.78
1,2,3,4,6,7,8-HpCDD	16 to 30	0.11	0.23
	31 to 45	0.15	0.30
	46 to 60	0.19	0.39
	61+	0.28	0.55
OCDD	16 to 30	0.05	0.10
	31 to 45	0.07	0.15
	46 to 60	0.08	0.15
	61+	0.11	0.21
2,3,4,7,8-PeCDF	16 to 30	0.52	1.04
	31 to 45	0.65	1.31
	46 to 60	0.87	1.74
	61+	1.45	2.90
1,2,3,4,7,8-HxCDF	16 to 30	0.08	0.16
	31 to 45	0.05	0.10
	46 to 60	0.09	0.18
	61+	0.17	0.35
1,2,3,6,7,8-HxCDF	16 to 30	0.07	0.14
	31 to 45	0.07	0.15
	46 to 60	0.12	0.23
	61+	0.24	0.48
1,2,3,4,6,7,8-HpCDF	16 to 30	0.05	0.09
	31 to 45	0.04	0.08
	46 to 60	0.03	0.06
	61+	0.03	0.07
PCB 126	16 to 30	0.67	2.00
	31 to 45	0.87	2.62
	46 to 60	1.16	3.47
	61+	2.10	6.29
PCB 169	16 to 30	0.13	0.26
	31 to 45	0.21	0.41
	46 to 60	0.35	0.69
	61+	0.63	1.25
Summed TEQ (13 congeners)	16 to 30	3.73	7.5
	31 to 45	4.74	9.5
	46 to 60	7.45	14.9
	61+	12.74	25.5

Figure 1: Ratios of 95th percentiles to mean values by age group and congener from the UMDES (top) and NHANES (bottom) surveys.