TEQ Doses for CDD/Fs and PCBs General Population Exposure to Dioxin-Like Compounds in the United States During the 1990's

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Introduction

The United States (U.S.) Environmental Protection Agency's (EPA) draft *Dioxin Reassessment Document*[1] calculated an adult background dose of polychlorinated dibenzo-p-dioxins and dibenzofurans (CDD/Fs) in the United States to be 120 pg I-TEQ/day[1,2]. This calculation was derived by summing intake estimates resulting from diet, inhalation, and soil ingestion. Based on this dose, the Reassessment calculated an upper bound lifetime cancer risk of $2x10^{-4}$. Since 1994, significant improvement has occurred in the data on dioxin concentrations in food and food ingestion rates. This paper presents a summary of EPA's most recent calculations of CDD/F background dose, and also calculates a background dose of the dioxin-like coplanar or mono-ortho coplanar polychlorinated biphenyls (coplanar PCBs), using the 1998 WHO TEFs[3] (WHO_{98}) to calculate TEQs.

Procedures

Background dose was calculated as the product of the contact rate (e.g., inhalation rate, ingestion rate, etc.) for a given exposure medium (e.g., air, soil, foods, etc.) and the concentration of dioxin-like compounds in that medium. Contact rates were developed from EPA's revised Exposure Factors Handbook (EFH)[4] and data from the U.S. Department of Agriculture's Continuing Survey of Food Intake Among Individuals (CSFII)[5]. Most of the data used to support contact rates and media concentrations were collected in the 1990s. Consequently the dose estimates are thought to be most representative of the 1990s. EPA national surveys were used to determine the dioxin and PCB levels in milk, beef, pork and poultry (www.epa.gov/ncea/dei.htm). Results from these surveys were expressed on a lipid basis, and converted to a whole weight basis by assuming the following fat contents: milk - 0.032 (3.2%), beef - 0.19, pork - 0.15, and poultry - 0.15[6]. Whole weight CDD/F and PCB concentrations in dairy products were derived from concentrations in milk fat by assuming that the concentrations of CDD/Fs and coplanar PCBs were the same in dairy fat and milk fat. The dairy fat content assumption of 0.12 (12%) was derived from assumptions regarding dietary contributions and fat contents of various dairy products, including cheese (25%), yogurt (1.5%), and milk desserts and other dairy products (8.3%).[6] Freshwater fish concentrations were derived from the EPA National Bioaccumulation Survey.[7] Marine fish, shellfish, egg, vegetable fat, air and soil concentrations were not based on systematic surveys, but rather derived from values found in the general literature. Air and soil samples for CDD/Fs were selected to represent urban settings; air and soil data were not available on congener specific dioxin-like coplanar PCBs. All concentrations were averages. For food and air concentrations, averages were estimated by setting non-detects equal to one-half the detection limits (these values were not significantly different than using nondetects equal to zero). For soil concentrations, non-detects were set to zero, because congener-specific detection limits were not available for many of the studies. The table summarizes the adult contact rates, media levels and dose estimates. In addition to calculating adult doses, dose estimates were also made for three age groups of children based on age specific dietary patterns for 1-5 year olds, 6-11 year olds and 12-19 year olds.

Variability of dose across the general population was examined on the basis of distributions of total fat consumption. Most foods in the U.S. commercial food supply that contain animal fats are distributed on a nation-wide basis. Individuals will be exposed to a range of concentrations of dioxin-like compounds over time and their average food concentrations will approach the national average for any given food type. Therefore, it is expected that variability in long-term average exposures would more likely occur as a result of differences in long-term dietary patterns rather than variations in dioxin concentrations. Since concentrations of dioxin-like compounds in most meats are similar on a lipid basis, some understanding of the overall variability in dose can be gained from examining the variability in total fat consumption. In a U.S. regional heart study evaluating children's and young adults' consumption of animal fats, it was found that the 95% consumption rate (as represented by twice the standard deviation) of animal fats was roughly twice that of the mean, and that the 99% consumption rate (3 times the standard deviation) was about three times the mean.[8]

Results

1. The results reported here are based on WHO_{98} TEFs. These results were about 10% greater than the same results using the I-TEFs. An exception to the use of WHO_{98} TEFs was made to allow comparisons of the current estimates with EPA's dose estimates published in 1994. For these comparisons all values are calculated using I-TEFs.

2. The average total dose (CDD/F and PCB) was calculated to be 1.0 pg/kg-d for adults, 3.6 pg/kg-d for 1-5 year olds, 1.9 pg/kg-d for 6-11 year olds and 1.1 pg/kg-d for 12-19 year olds (WHO_{98} TEF).

3. Although the estimates made in 1994 and the ones made in this paper are both intended to represent the same time period, i.e. the 1990s, EPA's current average adult dose for CDD/Fs is lower than that estimated by EPA in the 1994 draft Reassessment. These estimated values have changed from 120 to 40 pg/d I-TEQs (1.7 to 0.57 pg/kg-d I-TEQs). These changes in estimates are due to lower food concentrations and consumption rates which were judged to be more representative than those used in the 1994 calculation. Therefore, the observed reductions should not be interpreted as implying a time trend. The 1994 estimates used some food concentration data collected in the 1980s when mean food concentrations may have been higher. This could have contributed to part of the difference between the 1994 and 1999 calculations. Higher detection limits in the earlier studies may have also contributed to the higher values. For dioxin-like coplanar PCBs, insufficient data were available to make a direct dietary estimate in 1994. The current PCB adult dose estimate is 0.35 pg/kg-d (WHO_{98} TEQs).

4. The changes from the 1994 draft to the current paper for relative contributions from various CDD/F exposure pathways are presented below (calculated using I-TEFs):

- beef, dairy products and milk collectively: 66% declined to 46%
- fish: 7% increased to 29%

The current analysis for the relative contribution from various pathways for total CDD/F and coplanar PCBs (calculated using I-TEFs) are as follows: beef, dairy products and milk collectively: 43% and fish: 22%.

5. Background TEQ doses for CDD/Fs and coplanar PCBs among younger children, as expected, were lower, on a pg/day basis, but higher, on a pg/kg/day basis. The average dose for children aged 1-5 was 3.6 times higher than the average adult dose on a body weight basis. This

ratio decreases with age such that the average dose for 12-19 year olds is the same as adults.

6. As with previous analyses, food intake was found to account for over 95% of the total dose of CDD/Fs. For younger children, exposure to dioxin-like compounds in milk and dairy products accounted for a larger portion of the total dose than in older children and adults in which meat products accounted for a higher percentage of the total dose. For example, milk and dairy products accounted for over 60% of the total CDD/F dose among 1 to 5 year old children, but only 25% in adults.

7. The estimate of exposure from breast milk in 1994[1] was 60 pg CDD/F TEQ/kg-d, based on a 750 g breast milk consumption/day, a 10 kg body weight over an approximate year of breast feeding, a breast milk fat concentration of 20 pg/kg and fat content of 4% . Current information suggests that these continue to be appropriate estimates for the CDD/Fs in the U.S. Because PCB TEQ concentrations in breast milk are similar to those of CDD/Fs, adding the PCB dose from breast milk intake approximately doubles the total TEQ dose to infants.

8. Based on the distribution of total fat consumption alone, it is inferred that the variability in TEQ doses for CDD/Fs and coplanar PCBs in the general population is about two times the mean for the 95^{th} percentile and about three times the mean for the 99^{th} percentile. This use of fat consumption data to estimate dose variability is likely to result in under estimates for two reasons. First, non-dietary pathways of exposure exist. Second, fat consumption alone does not capture the full range of variability. Although dioxin levels in lipids are similar across most meats, some are discernibly higher (e.g., freshwater fish). Therefore diets high in these foods could result in doses which exceed the variability derived from differences in total fat consumption alone.

Discussion

Improvements in both dioxin concentration data and food consumption rates have resulted in significant reductions in the uncertainty associated with estimates of dioxin general population exposure. As with previous estimates, the commercial food supply remains the principal route of exposure to dioxin-like compounds for the general population. In this most recent analysis, fish and shellfish have gained a more prominent proportional role in total exposure; however, they are also the area of greatest uncertainty. Systematic surveys of commercial beef, pork, poultry, and milk production do not show significant regional variations in dioxin concentration; however, the majority of the production of these food is concentrated in a limited number of states. Consequently, most of the dioxin that contributes to general population exposure is associated with agricultural production from only a limited portion of the country.

References

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Adult Contact Rates and Background Doses of Dioxin-like Compounds.

Exposure Route	Contact Rate	Dioxins and Furans		Coplanar PCBs		Total Intake (pg/kg-d)
		TEQ Conc.	Intake (pg/kg-d)	TEQ Conc.	Intake (pg/kg-d)	
Soil Ingestion	50 mg/d	12 pg/g	0.0085	NA	NA	0.0085
Freshwater Fish	6 g/d	1.2 pg/g	0.13	1.2 pg/g	0.11	0.24
Marine Fish	12.5 g/d	0.36 pg/g	0.064	0.25 pg/g	0.045	0.11
Marine Shellfish	1.6 g/d	0.79 pg/g	0.018	0.042 pg/g	0.0096	0
Inhalation	13.3 m^3/d	0.12 pg/m^3	0.023	NA	NA	0.023
Milk	175 g/d	0.031 pg/g	0.078	0.016 pg/g	0.040	0.12
Dairy	55 g/d	0.12 pg/g	0.094	0.058 pg/g	0.046	0.14
Eggs	0.24 g/kg-d	0.032 pg/g	0.0077	0.10 pg/g	0.024	0.032
Beef	0.67 g/kg-d	0.20 pg/g	0.13	0.094 pg/g	0.063	0.19
Pork	0.22 g/kg-d	0.22 pg/g	0.048	0.009 pg/g	0.0020	0.05
Poultry	0.49 g/kg-d	0.11 pg/g	0.054	0.044 pg/g	0.022	0.076
Vegetable Fat	17 g/d	0.056 pg/g	0.014	0.037 pg/g	0.0090	0.023
Water	1.4 L/d	0.0005 pg/L	0.000011	NA	NA	0.000011
TOTAL			**0.65 (45 pg/d)**		**0.35 (25 pg/d)**	