DO RECENT CHANGES IN TEF VALUES HAVE A MAJOR IMPACT ON TEQ OF BIOLOGICAL SAMPLES?

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Introduction

The concept of "dioxin toxic equivalency factors" (TEFs) arose from a real life public health incident, the Binghamton, New York State Office Building (BSOB) electrical system fire where a large office building was contaminated in 1981with polychlorinated dibenzo-*p*-dioxins (PCDDs), dibenzofurans (PCDFs), and biphenyls (PCBs) from a transformer containing PCBs and tri- and tetra-chlorinated benzene. Cleanup criteria to be met were set by the New York State Health Department after reviewing the literature on these chemicals and conducting animal studies involving the mixture of the PCDDs and PCDFs found in the building and a simulated mixture prepared from chemical standards[1]. PCBs were not included in the TEF studies at that time. TEFs were derived to weight the measured levels of the PCDD and PCDF congeners present in a mixture as related to the most toxic dioxin congener, 2,3,7,8-TCDD, which was defined as having a TEF of 1.0. The measured concentration of each congener was multiplied by the TEF weighting factor. The total dioxin-like toxic equivalency, TEQ, of a mixture is the sum of these products.

It has become common to present data at scientific meetings and in journals in terms of the dioxin toxic equivalents rather than the measured levels of congeners. This is done in order to estimate the toxicity of the measured congeners. Since toxic equivalency factors, which are order of magniture consensus estimates of dioxin-like toxicity, change over time as new *in vivo*, *in vitro*, and epidemiology data as well as new interpretations are introduced, the question has arisen whether there are major differences among various TEFs and total TEQ. Presenting only measured congener levels would present a congener pattern reflecting the contamination source, but would not reflect toxicity.

We examine here recent human tissue data gathered for exposure assessment in different countries where, due to differences in congener patterns characteristic of background levels of exposure in the countries, we expected differing TEFs might lead to differently alter assessments of toxicity.

In order to depict the extent to which inferences of dioxin toxicity may have been influenced by the evolving re-evaluations of TEFs, we compare total TEQ values given for different sets of human tissue measurements by different sets of TEFs for PCDDs and PCDFs proposed by New York State, 1982[1], California 1983[2], the US EPA 1985[3], NATO and WHO 1988[4,5] (I-TEFs), and WHO 1998[6]. For PCBs our comparison is between Safe TEFs 1990[7], WHO 1994 TEFs[8], and the 1998 WHO TEFs.

Materials and Methods

Whole blood or serum was collected in chemically cleaned containers, frozen, and sent to WHO certified dioxin laboratories for analysis by high resolution gas chromatography-mass spectrometry[9]. The analytic methodology has been described previously[10].

Table 1. Different TEFs

A. PCDDs and PCDFs

	New York State 1982[1]	California 1983[2]	EPA 1985[3]	NATO (I-TEFs) 1988[4,5]	WHO 1998[6]
PCDDs					
2378 TCDD	1	1	1	1	1
12378 PeCDD	1	1	0.2	0.5	1
HxCDD*	0.033	1	0.04	0.1	0.1
1234678 HpCDD	0	1	0.001	0.01	0.01
OCDD	0	1	0	0.001	0.0001
PCDFs					
2378 TCDF	0.333	1	0.1	0.1	0.1
12378 PeCDF	0.333	1	0.1	0.05	0.05
23478 Pe CDF	0.333	1	0.01	0.5	0.5
HxCDF**	0.011	1	0.01	0.1	0.1
HpCDF***	0	1	0.001	0.01	0.01
OCDF	0	0	0	0.001	0.0001

* HxCDD: 123478, 123678, 123789 ** HxCDF: 123478, 123678, 234678, 123789

*** HpCDF: 1234678, 1234789

B. PCBs

		Safe 1990[1]	WHO 1994[2]	WHO 1998[3]
Coplanar PCBs				
77	33'44' TCB	0.01	0.0005	0.0001
126	33'44'5 PnCB	0.1	0.1	0.1
169	33'44'55' HxPCB	0.05	0.01	0.01
Mono-ortho PCBs				
105	233'44' PnCB	0.001	0.0001	0.0001
114	2344'5 PnCB	0.001	0.0005	0.0005
118	23'44'5 PnCB	0.001	0.0001	0.0001
123	233'44' PnCB	0.001	0.0001	0.0001
156	2344'5 PnCB	0.001	0.0005	0.0005
157	23'44'5 PnCB	0.001	0.0001	0.0005
167	2344'5 PnCB	0.001	0.0005	0.00001
189	23'44'5 PnCB	0.001	0.0001	0.0001
Di-ortho PCBs				
128	22'33'44' HxPCB	0.00002	0	0
138	22'344'5' HxPCB	0.00002	0	0
153	22'44'55' HxPCB	0.00002	0	0
170	22'33'44'5 HxPCB	0.00002	0.0001	0
180	22'344'55' HxPCB	0.00002	0.00001	0

Results and Discussion

The different sets of TEFs are shown in Table 1, A for PCDDs and PCDFs, and B for PCBs.

The data are presented in Figure 1 for dioxins in toxic equivalents and for dibenzofurans in Figure 2. Data shown are from our previous publications[11-14].

California 1983 TEFs, which are no longer used, give results much higher than the other TEFs, since all congeners except OCDF are rated unity: equally toxic with TCDD. The more modest differences in TEQ totals for New York 1982, EPA 1985, 1988 I-TEFs, and WHO 1998 TEFs were consistent across countries for dioxins and for dibenzofurans. In all cases, the 1998 WHO TEFs give a higher PCDD TEQ than the three earlier systems. Relative to I-TEFs, the increase is due to the changed TEF for 1,2,3,7,8-PnCDD from 0.5 to 1. Relative to NY State and 1985 EPA TEFs, the increase is due to higher TEFs for hexa- to octa-chlorinated PCDDs.

We conclude that there is relatively little difference in total PCDD/F toxic equivalents using most major TEF schemes. This suggests that representation of relative exposure and relative toxicity in human health studies using any of the major schemes for dioxins and dibenzofurans will lead to similar conclusions.

Table 2 presents, for the American blood analyses[12], mean TEQ for dioxins, dibenzofurans and coplanar, mono-ortho and di-ortho PCBs using the older Safe and NATO schemes and the WHO 1998 TEFs. PCDD TEQ is increased 21% with the new WHO TEFs, compared with the NATO I-TEFs. The PCDF TEQ is unaffected by the single changed TEF for OCDF.

TEQ for all PCBs is about three times higher with Safe's TEFs than with the two versions of WHO TEFs. Most of the disparity in total PCB TEQ is due to TEFs for mono-ortho PCBs, given an order of magnitude higher rating by Safe than by WHO. For WHO, the dropping of TEFs for di-ortho PCBs leads to a 5% decline in total TEQ for PCBs in 1998 compared with the 1994 TEFs.

Table 2. Mean TEQ Levels of Dioxins, Dibenzofurans, and PCBS in Blood of 50 Americans, Calculated with Different Sets of TEFs pg/g (ppt) lipid basis

TEFs:	NATO for PCDD/Fs; Safe 1990 for PCBs	NATO for PCDD/Fs; WHO 1994 for PCBs	WHO 1998
PCDDs	19.5	19.5	23.5
PCDFs	7.2	7.2	7.2
PCDD/Fs	26.7	26.7	30.7
PCBs: Coplanar	13.5	10.9	10.9
Mono-ortho	50.4	5.3	5.3
Di-ortho	2.3	0.9	0
PCBs	66.2	17.1	16.2
Total TEQ	92.9	43.8	46.9

This paper does not necessarily reflect official U.S.E.P.A. policy.

Figure 1. Comparison of Dioxin TEQ levels in pooled blood samples for TEFS adopted by New York State 1982, California 1983, EPA 1985, NATO-WHO 1988, and WHO 1998 pg/g (ppt) lipid basis

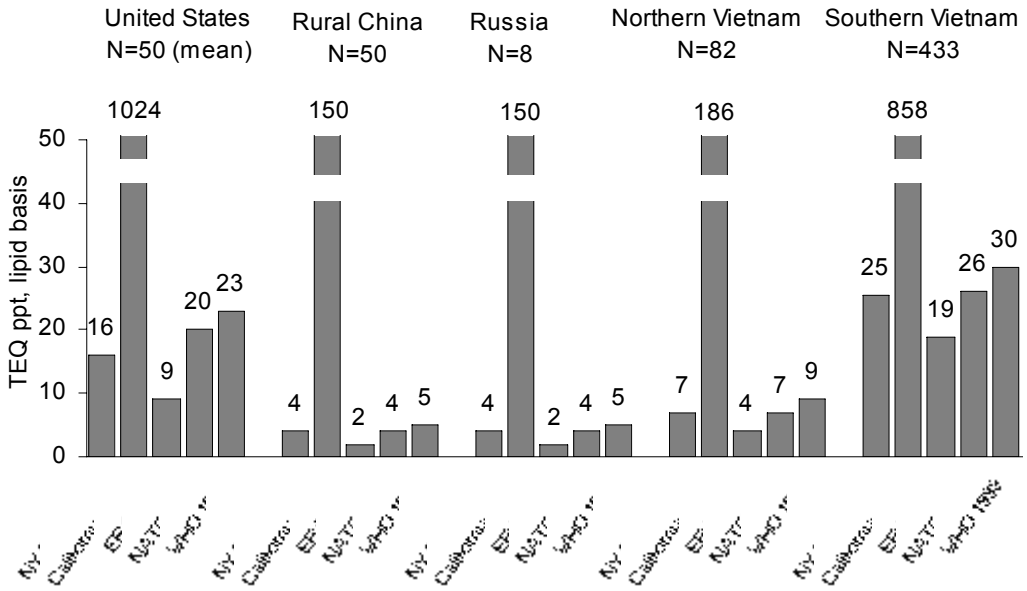
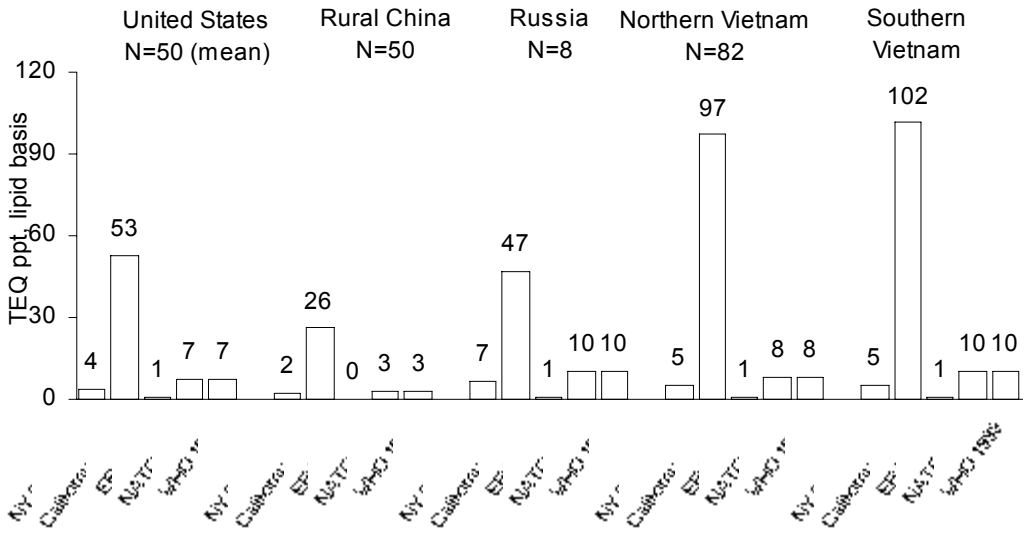


Figure 2. Comparison of Dibenzofuran TEQ levels for Different TEFs pg/g (ppt) lipid



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