RISK MODELING FOR RESIDENTS LIVED NEAR A TCDD-CONTAMINATED DUMPSITE

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Introduction

Worldwide distribution of persistent organic pollutants may result in potential long-term health effects of general public. Especially in newly developed industrial countries such as Taiwan, unsupervised dumping and inappropriate handling have resulted in numerous toxic waste sites. Some of them are contaminated with Dioxin-like compounds. In this work, potential health risk of residents live near a PCDD/PCDFs-contaminated dumpsite was estimated by combining measured serum levels of exposed population and the dose-response relationships from previous epidemiology studies.

Methods and Materials

Serum samples were obtained from fifty subjects, who lived near a known pentacholophenol and PCDD/PCDF contamination site located in southern Taiwan[1]. Their residences are also in the downwind zone of a municipal waste incinerator (MWI), which was not yet in operation when the serum samples were collected.

Preparation and analysis of serum samples were following the method developed by Chang et al. (1993)[2]; solid phase extraction and clean-up were used. Seventeen PCDD/PCDFs were analyzed by HRGC/HRMS with Rtx-5MS column following USEPA Method 1613B. Lipid contents of serum samples were also determined. The serum levels of PCDD/PCDFs were expressed as pg/g-lipid.

Potential health risk was modeled using excess deaths from cancer as an indicator. The formula for excess risk of cancer attributable to PCDD/PCDFs exposure can be expressed as follows[3]:

$$D=O-E=E\times(b/100)\times X \quad (1)$$

where D is the excess deaths from cancer; O is the observed deaths; E is the expected deaths; X is the body burden of PCDD/PCDFs, which was obtained in the above analysis; and b is the slope, which can be obtained based on findings of epidemiological study; it can be calculated as:

$$(SMR_e\times 100-ED_u)/(C_e-C_u) \quad (2)$$

SMR_e is the standard mortality rate (SMR) of the exposed group; ED_u is the expected deaths of the reference group, assumed to be 100; C_e is the serum level of the exposed group and C_u is the

serum level of the reference group. The SMR of cancers and serum levels of PCDD/PCDFs were obtained from previous epidemiological studies.

Fingerhut et al (1991)[4] reported that SMR of all cancers were 1.15 for workers exposed to TCDD (mean serum TCDD level was 233 pg/g-lipid). And the SMR of all cancers for subgroup, subjects with exposure longer than 1 year, was 1.46; the mean serum TCDD level was 418 pg/g-lipid. The reference group had serum levels around 7 pg/g-lipid. In another epidemiological study[5], the SMR of all cancers of workers in the high TCDD exposed group was 1.78 (mean serum level was 296 pg/g-lipid TCDD). The SMRs of all cancers of workers in the low and medium TCDD exposed groups were 1.20 and 1.45, respectively, the mean serum TCDD level of those workers was 83 pg/g-lipid TCDD. The serum levels of the reference group was assumed to be 7-20 pg/g-lipid, which is the background level for unexposed general public[6].

The slope factors calculated based on the above data were different among studies. Therefore, Latin Hypercube simulation was used to calculate the possible b values and also compute the risk distribution. Latin Hypercube simulation is a method similar to Monte Carlo simulation, they both can consider the variation of input variables to obtain a risk distribution instead of a single risk estimate. Latin Hypercube simulation has the advantage of obtaining a stable estimation with fewer simulation iterations than Monte Carlo simulation[7]. Different distributions of the slope factor can be substituted into risk model to obtain a distribution of risk estimates.

Results and Discussion

The average total PCDDs/PCDFs concentration in the fifty blood samples was found to be 9.6 pg/mL-serum (range 3.0 ~ 42.3 pg/mL-serum). When the concentration was expressed in international toxic equivalents (I-TEQs), the average total PCDDs/PCDFs concentration in the blood samples was found to be 0.28 pg-TEQ/mL-serum (range 0.11 ~ 0.56 pg-TEQ/mL-serum). When the concentration was expressed on a lipid-adjusted basis, the average total PCDDs/PCDFs concentration in the blood samples was found to be 1620 pg/g-lipid (range 480 ~ 5930 pg/g-lipid), or 47.3 pg-TEQ/g-lipid (range 13.5 ~ 104 pg-TEQ/g-lipid, SD 22.4 pg/g-lipid).

Based on equation (1) and (2), the risk modeling was conducted for eight different scenarios. The input distribution of different scenarios is listed in Table 1. The results of risk modeling are listed in Table 2.

Excess cancer deaths estimated based on dose-response relationship from Fingerhut et al[4] were all below 10. The excess death estimates according to high-exposed subgroup were slightly more than the estimates from the whole worker cohort (scenarios 1 & 2). In addition, the serum levels of the reference group in the study of Manz[5] was not measured but assumed. However, the risk estimates were not sensitive to this assumption. Whether the serum level is 7 pg/g-lipid, as in Fingerhut et al[4], or 7-20 pg/g-lipid, as in general unexposed group, the excess cancer deaths were very similar to each other (scenarios 5 & 7, scenarios 6 & 8). Furthermore, since the serum TCDD levels of exposed group was lower and the SMR was higher in the study of Manz[5], the estimated cancer deaths based on the dose-response relationship of Manz[5] were higher than those based on Fingerhut et al[4], (scenarios 5 & 7 vs. scenarios 6 & 8).

Based on the above simulation, the 95 percentile of potential excess cancer death of local residents who live near a dumpsite was from 6 to 44 in a population of 100. In other words, in the

worst case, the estimated SMR of this exposed population was from 1.06 to 1.44. In view of the likely operation of the near-by municipal waste incinerator in the near future, the aggravated body burdens and potential health effects of those citizens warrant further monitoring.

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Table 1 Distribution of input variables of risk model

Scenario	1	2	3	4	5	6	7	8
SMRe*100	146	115	146	115	178	120-145[a]	178	120-145[a]
EDu	100	100	100	100	100	100	100	100
Ce (pg/g-lipid)	418	233	418	233	296	83	296	83
Cu (pg/g-lipid)	7	7	7-20[a]	7-20[a]	7	7	7-20[a]	7-20[a]
X (pg-TEQ/g-lipid)	47.30 (22.4)[b]	47.30 (22.4)[b]	47.30 (22.4)[b]	47.30 (22.4)[b]	47.30 (22.4)[b]	47.30 (22.4)[b]	47.30 (22.4)[b]	47.30 (22.4)[b]

PS. 1. Number in parenthesis is standard deviation;

2. a: uniform distribution; b: lognormal distribution

Table 2 Estimated excess cancer deaths based on measured serum levels of 50 residents

Scenario	1	2	3	4	5	6	7	8
Mean	5.3	3.1	5.4	3.2	12.8	20.3	13.1	22.2
Mode	3.9	2.6	5.2	2.9	9.3	15.1	10.3	12.3
Medium	4.8	2.8	4.9	2.9	11.5	17.8	11.8	19.6
5%	2.3	1.4	2.3	1.4	5.5	7.6	5.7	8.5
95%	10.0	5.9	10.2	6.1	24.1	40.8	24.7	44.4