PROBABILISTIC INTAKE ASSESSMENT AND BODY BURDEN ESTIMATION OF DIOXIN-LIKE SUBSTANCES IN BACKGROUND CONDITIONS AND DURING THE BELGIAN 1999 FOOD CONTAMINATION EPISODE.

Bernard Vrijens[1,4], Stefaan De Henauw[2], Koen Dewettinck[3], Sarah Srebrnik[4], Willem Talloen[4], Leo Goeyens[4], Guy De Backer[2], Jan Willems[1]

[1] Heymans Institute of Pharmacology, Ghent University, Belgium;
[2] Department of Public Health, Ghent University, Belgium;
[3] Department of Food Technology, Ghent University, Belgium;
[4] Department of Pharmaco-Bromatology, Scientific Institute of Public Health, J. Wytsmanstraat 14, 1050-Brussels, Belgium.

Introduction

The Belgian "dioxin" incident (February 1999), which was actually a dramatic PCB incident, involved livestock feed as a route of contamination. Subsequently enhanced PCB and dioxin concentrations in the human food chain led to a wide-spread public concern about adverse health effects.

The present study aimed at detailed analyses of food consumption data for Belgian adolescents and of background as well as incident-related food contaminations with PCDDs. PCDFs. and dioxin-like PCBs. This was completed with a probabilistic intake assessment of dioxin-like substances and a body burden estimation.

Methodology

Fat concentrations in the different food items as well as relative contributions of fat species (milk, egg, pork, beef, chicken, sheep, horse, fish and vegetable) were determined from a 7 day food record of 341 14 to 18 year old adolescents, carried out in 1997. This resulted in a three dimensional database $X_{v,i,t}$ presenting the amount of fat consumed (g), for each combination of fat species (v), subject (i) and time (t). The BACK PCDD/F and dioxin-like PCB concentrations in food items were derived from Belgian and Dutch data. Incident-related PCDD/F and non-dioxin-like PCB concentrations were obtained from the data base of the Belgian Ministry of Agriculture. The human food contaminations that were most representative for the incident were used.

During the crisis event two major sampling programs were installed: (1) samples taken within the framework of the incident specific or sanitary (SANI) program, designed for incident fingerprinting and (2) samples taken for background (BACK) contamination study.

For each subject i, the average daily intake (DI_i) of dioxin-like contaminants through food consumption is obtained from equation

$DI_i = Y_i/bw_i$;

whereby Y_i is the subject average daily dose (in pg TEQ) and bw_i the corresponding body weight (in kg). The subject specific average daily dose is derived from the combination of individual food consumption data and concentrations of the dioxin-like contaminants according to equation (1):

$$Y_i = \sum_v \sum_t [(X_{v,i,t} C^S_{v,i,t})\delta_{v,i,t} + (X_{v,i,t} C^B_{v,i,t})(1-\delta_{v,i,t})] \ / T \qquad (1),$$

whereby $X_{v,i,t}$ represents the amount (g) of fat from origin v, consumed by subject i, at day t ($t = 1,...,T$), $\delta_{v,i,t}$ a binary variable determining whether the particular food item is issued from a SANI production unit ($\delta = 1$) or not ($\delta = 0$) and $C_{v,i,t}$ the concentration of the dioxin-like contaminant expressed in pg TEQm(/UTEQ/g fat. The erscript S or B indicates whether the contamination stems fron SANI production units or BACK contamination. Since items from SANI productions were not uniformly distributed across the population, the intersubject variability in the percentage of items consumed from a SANI production unit was modelled according to a unimodal, right skewed, beta distribution $B(b_1,b_2)$ for each contaminated fat species.

The probabilistic exposure estimations, according to this model, were assessed through Monte Carlo simulations (Cullen, 1999). The simulation separates variation among the different subjects in each subgroup, from uncertainty due to uncertainties in the incident input parameters. According to the procedure, different models are run consecutively, each using different values for the vector of input parameters (S-Plus 2000 software, Professional release 1, Math Soft Inc).

The body burden (*bb*, pg or ng TEQ/kg bw) was calculated according to equation (2)

$$bb(t) = bb(t-1)\, e^{-k_e} + f\,DI \qquad (2)$$

with $k_e = \ln 2/t½$, DI the daily intake, f the fraction of the dose absorbed and $t½$ the elimination half life. The TCDD values for f (0.5) and $t½$ (7.5 years) were applied to the whole of the congeners that contribute to the total TEQ intake (WHO-ECEH-IPCS, 2000).

Results

Non-dioxin-like PCB congener profile analysis of SANI and BACK samples confirmed that there was only one single PCB sources at their origin. The 1999 Belgian dioxin-incident has to be seen as a common contamination, accidentally concentrated in time and space.

Table 1 summarises the simulated daily BACK intakes and the simulated daily intakes during the 4 month dioxin-incident period.

Table 2 summarises the body burden calculated at age 16 in BACK conditions and at the end of a 4 month dioxin-incident period.

Comments and conclusions

The main source of BACK daily intakes of PCDDs, PCDFs and dioxin-like PCBs in Belgian adolescents appeared to be milk, fish becomes important at the higher percentiles of intake (data not shown). During the dioxin-incident, moderate intake increases were due to moderately increased contaminations of chicken, egg, pork and beef. At the highest percentiles, chicken took the place of fish as the major source. At the end of the dioxin-incident some increase in body burden had taken place. Even in a worst case situation, body burdens remained below those values, that are accompanied by increased incidence of adverse effects in the animal experiment.

It is, therefore, unlikely that the 1999 incident would have a dramatic impact on public health, but it can not be disregarded that some subgroups who were intensively exposed to contaminated food (eg. farmers consuming own contaminated production) and/or subjects most sensible to dioxins (eg. women pregnant at or shortly after the incident and with a direct and repetitive access to highly contaminated chickens) would develop adverse health effects.

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References
Cullen AC, Frey HC. Probabilistic Techniques in Exposure Assessment. New York and London : Plenum Press; 1999.
WHO-ECEH-IPCS. Consultation on assessment of the health risks of dioxins; re-evaluation of the tolerable daily intake (TDI): Executive Summary. Food Additives and Contaminants 2000;17:223-240.

Table 1: daily intake of the sum of PCDD, PCDF and dioxin-like PCB (pg TEQ/kg bw/d) via food in different percentiles of the adolescent population in BACK conditions and during the Belgian dioxin incident (based on 7 day food survey). For the incident period the most likely intake (at median uncertainty) as well as the lower (5%) and upper (95%) bound uncertainty are given.

Percentile	Background	Incident simulation 5% uncertainty	Incident simulation median uncertainty	Incident simulation 95% uncertainty
1	0.68	0.72	0.78	1.24
3	0.93	1.02	1.10	1.84
5	1.15	1.28	1.39	2.11
25	1.85	2.05	2.20	4.46
50	2.53	2.78	2.98	8.49
75	3.30	3.65	4.02	16.91
95	6.52	7.17	8.46	47.23
97	7.47	8.39	10.53	58.04
99	9.65	11.26	19.58	94.62

Table 2: starting body burdens and body burdens at the end of the incident in the adolescents for different percentiles and at two incident levels of uncertainty.

Estimated body burden at age 16 (ng TEQ/kg bw)			
Population distribution	BACK body burden	Body burden at end of dioxin-incident	
		at median uncertainty	at 95% uncertainty
50th percentile	3.854	3.880	4.207
75th percentile	5.027	5.069	5.834
95th percentile	9.931	10.046	12.346
97th percentile	11.378	11.560	14.378
99th percentile	14.699	15.288	19.739