# FACTORS EXPLAINING VARIATION IN SERUM DIOXIN CONCENTRATIONS FOR THE SPECIFIC CONGENERS IN THE FRENCH DIOXIN AND INCINERATORS STUDY

Zeghnoun A[1], Fréry N[1], Volatier JL[2], Falq G[1], Pascal M[1], Sarter H[1], Focant JF[3], Eppe G[3]

1. French Institute for Public Health Surveillance, 12 Rue du Val d'Osne, 94 415 St Maurice, France.
2. French Food Safety Agency, 27-31, avenue du Général Leclerc, 94701 Maison-Alfort Cedex, France
3. CART Mass Spectrometry Laboratory, Chemistry Department, University of Liège, Allée de la Chimie 3, B-6c Sart-Tilman, B-4000 Liège, Belgium

## Abstract

In the French Dioxin and Incinerators Study, serum analysis of dioxins, furans and PCBs were performed in 1030 adults randomly selected to identify the determinants of the body-burden of these compounds in the population living around waste incinerators. The data were analyzed for each congener separately. We found that many factors such as individual characteristics must be taken into account as confounding factors. For most congeners, the relationship between consumption of animal food products locally-produced and serum dioxin levels was more significant and stronger for people living around incinerators than for non-exposed people, particularly for 2,3,7,8 TCDD, 1,2,3,7,8 PCDD, 1,2,3,6,7,8 HCDD, 1,2,3,6,7,8 HCDF, 2,3,4,6,7,8 HCDF and PCB114.

## Introduction

The French Dioxin and Incinerators Study[1] was carried out in 8 areas in France around municipal solid waste incinerators to study whether serum dioxin levels were higher in people living in the vicinity of incinerators compared to referent people, and to investigate the factors that explain variations in serum dioxins, furans, and PCBs levels.

The distribution and the results of the regression analysis for the serum dioxin TEQ concentrations have been described elsewhere[2]. Our primary interest in this paper is: 1) to characterize the distribution of serum concentrations for each congeners, 2) and to identify factors that explain variations in serum concentrations for these congeners, particularly the consumption of animal food products locally-produced, since food is known to be the most important route of exposure.

## Materials and methods

The population study is composed of 1030 adults from 30 to 65 years selected through a stratified two stage random sampling. In each of the 8 study areas about 130 people living for at least 10 years around the incinerator, without occupational exposure, and for women without breastfeeding in the past 15 years were involved. Exposed people were defined as living in the impact area of the incinerator's plume and non-exposed people as living beyond 20 km of the incinerator and not exposed to known dioxins sources (referents). In each of the exposed or non-exposed study groups, the population studied was divided in two groups: 1) people eating home-grown or food produced locally (poultry, meat, eggs, milk, etc.), 2) and people not eating home-grown or locally-produced food.

The explanatory factors studied include physiological and socio-demographic factors (age, sex, BMI, recent changes in body weight, study level, socio-professional category, marital status, …), location or area of the incinerator, tobacco status (smokers, ex-smokers, non-smokers), environmental exposure factors (living in the exposed area under the plume or non-exposed area, urbanism (rural, suburb, urban), length of residency since the

incinerator installation, …), eating habits (background and locally-produced food diet), recreational activities with likely exposure to dioxins, furans, and PCBs etc.

Preliminary investigation indicated that serum congener concentrations were consistent with a log-normal distribution. We therefore used the log-transformation for each of the specific congeners. To assess the shape of the relationships between the log-transformed serum congener concentrations and the continuous explanatory factors, we used a spline regression with 3 degrees of freedom and/or analysed these factors as categorical variables.

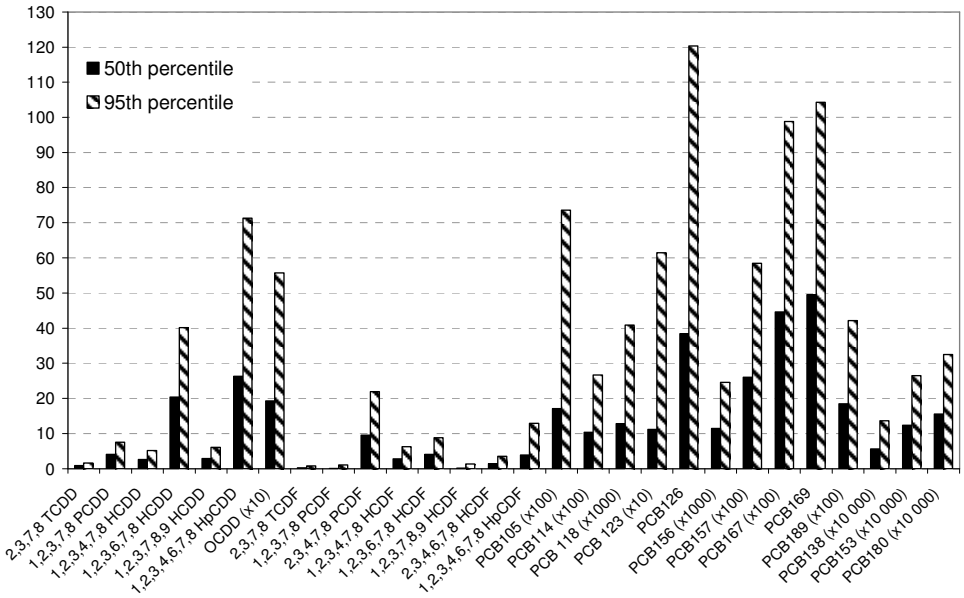
In spite of low limit of detection, several concentrations were not detected[3]. We therefore used regression model for censored data known as Tobit regression[4] to estimate the distribution of the different congeners and to determine factors that explain variation in serum dioxin congener levels. When the percentage of censored values is very small, we used the substitution method, as the method for treatment of censored data makes little difference in this case[5]. All models were adjusted for survey sampling weights.

Regression models were also fit to determine if the levels of serum dioxin congener increase with an increase in the consumption of animal food products locally-produced. Additionally, the interaction between the consumption of animal food products locally-produced and the exposure (living in exposed or non-exposed area) was used to determine if the relationship between levels of serum concentrations and the consumption of animal food products locally-produced was significantly different in exposed and non-exposed area. All statistical analyses were completed using stata[6], SAS[7] and R[8].

## Results

Figure 1 shows the median and the 95$^{th}$ percentile for each of the 28 specific congeners (1,2,3,4,7,8,9 HpCDF, OCDF, PCB 77 and PCB 81 were not quantified with more than 96%<LOQ). Concerning the PCDDs, the median ranged from 0.9 pg/g lipids for 2,3,7,8 TCDD to 192.6 pg/g lipids for OCDD. For PCDFs, it ranged from 0.1 pg/g lipids for 1,2,3,7,8 PCDF to 9.6 pg/g lipids for 2,3,4,7,8 PCDF. For PCBs, it ranged from 38.4 pg/g lipids for PCB 126 to 155 146 pg/g lipids for PCB 180.

Figure 1- Median and 95$^{th}$ percentile for each of the specific congeners in pg/g lipids*




* Example: OCDD(x10) means that the levels of OCDD must be multiplied by 10 (median about 200 pg/g lipids),…

Table 1- Percentage increase in serum dioxin congener levels and 95% CI for an increase of 8 g/day of the consumption of lipids from local animals

| Exposure status | Congener | % Increase | 95%CI lower | 95%CI upper | Congener | % Increase | 95%CI lower | 95%CI upper |
|---|---|---|---|---|---|---|---|---|
| Non-exposed | 2,3,7,8 TCDD | -0.4% | -4.4% | 3.7% | PCB105 | 1.5% | -3.7% | 7.0% |
| Exposed | | **11.9%** | **6.3%** | **17.8%** | | 3.7% | -2.0% | 9.7% |
| Non-exposed | 1,2,3,7,8 PCDD | 1.8% | -1.5% | 5.3% | PCB114 | -2.2% | -6.2% | 2.0% |
| Exposed | | **8.3%** | **4.9%** | **11.8%** | | 4.7% | -0.1% | 9.7% |
| Non-exposed | 1,2,3,4,7,8 HCDD | 2.2% | -0.5% | 5.0% | PCB118 | 1.6% | -3.6% | 7.0% |
| Exposed | | **5.2%** | **2.2%** | **8.4%** | | 2.6% | -2.6% | 8.0% |
| Non-exposed | 1,2,3,6,7,8 HCDD | 1.6% | -1.1% | 4.4% | PCB123 | **13.7%** | **1.1%** | **27.9%** |
| Exposed | | **5.5%** | **2.7%** | **8.5%** | | -4.1% | -15.2% | 8.6% |
| Non-exposed | 1,2,3,7,8,9 HCDD | 0.2% | -3.3% | 3.7% | PCB156 | 2.5% | -1.3% | 6.4% |
| Exposed | | **4.2%** | **1.2%** | **7.3%** | | **7.7%** | **2.3%** | **13.5%** |
| Non-exposed | 1,2,3,4,6,7,8 HpCDD | -0.3% | -6.7% | 6.6% | PCB157 | 1.9% | -1.0% | 4.8% |
| Exposed | | 1.5% | -1.7% | 4.8% | | **7.4%** | **1.0%** | **14.1%** |
| Non-exposed | OCDD | -3.5% | -9.9% | 3.4% | PCB167 | 4.0% | 0.0% | 8.1% |
| Exposed | | -0.4% | -3.5% | 2.8% | | 4.3% | -0.2% | 9.0% |
| Non-exposed | 2,3,7,8 TCDF | 0.5% | -5.0% | 6.3% | PCB169 | **5.1%** | **1.9%** | **8.4%** |
| Exposed | | 2.6% | -5.5% | 11.3% | | **8.3%** | **5.0%** | **11.6%** |
| Non-exposed | 1,2,3,7,8 PCDF | -0.6% | -14.9% | 16.1% | PCB189 | 5.0% | -1.2% | 11.6% |
| Exposed | | -0.8% | -12.3% | 12.4% | | **7.8%** | **4.5%** | **11.3%** |
| Non-exposed | 2,3,4,7,8 PCDF | **3.1%** | **0.2%** | **6.0%** | PCB138 | 1.7% | -2.7% | 6.2% |
| Exposed | | **6.8%** | **3.5%** | **10.2%** | | **6.0%** | **1.3%** | **11.0%** |
| Non-exposed | 1,2,3,4,7,8 HCDF | **2.9%** | **0.0%** | **5.8%** | PCB153 | 2.0% | -2.1% | 6.4% |
| Exposed | | **6.9%** | **3.2%** | **10.7%** | | **6.0%** | **2.3%** | **9.8%** |
| Non-exposed | 1,2,3,6,7,8 HCDF | 2.8% | -0.2% | 5.8% | PCB180 | 4.1% | -1.6% | 10.0% |
| Exposed | | **8.0%** | **3.9%** | **12.3%** | | **6.7%** | **3.6%** | **9.9%** |
| Non-exposed | 1,2,3,7,8,9 HCDF | -5.3% | -15.1% | 5.6% | | | | |
| Exposed | | 3.5% | -4.9% | 12.7% | | | | |
| Non-exposed | 2,3,4,6,7,8 HCDF | 1.7% | -2.9% | 6.6% | | | | |
| Exposed | | **9.5%** | **4.4%** | **14.9%** | | | | |
| Non-exposed | 1,2,3,4,6,7,8 HpCDF | 2.4% | -4.0% | 9.3% | | | | |
| Exposed | | **10.1%** | **4.6%** | **15.8%** | | | | |

Bold characters correspond to statistically significant parameters ($p<0.05$)

The regression analysis results indicated that subject characteristics (age, gender, BMI, recent change in body weight, smoking status and the current socio-professional category) and location of the incinerator were important factors explaining variations in serum dioxin congener concentrations. Therefore, theses factors were forced into all subsequent models. Other factors such as urbanism, chimney use, recreational activities with likely exposure to dioxins were also significant factors ($p<0.05$). Serum dioxin congener levels were slightly higher:

- in rural zone than in suburban or urban zone for 1,2,3,7,8 PCDD, 1,2,3,4,7,8 HCDD, 1,2,3,6,7,8 HCDD, 1,2,3,7,8,9 HCDD, OCDD, 2,3,4,6,7,8 HCDF, 1,2,3,4,6,7,8 HpCDF and PCB169
- for people using chimney for 1,2,3,7,8PCDD, 1,2,3,6,7,8 HCDD, OCDD, 1,2,3,4,6,7,8 HpCDF, PCB169
- for people doing recreational activities with likely exposure to dioxins for 2,3,7,8 TCDD, 1,2,3,7,8 PCDD, 1,2,3,4,7,8 HCDD, 1,2,3,6,7,8 HCDD, 1,2,3,7,8,9 HCDD, 1,2,3,4,6,7,8 HpCDD, OCDD,

2,3,4,7,8 PCDF, 1,2,3,4,7,8 HCDF, 1,2,3,6,7,8 HCDF, 2,3,4,6,7,8 HCDF, 1,2,3,4,6,7,8 HpCDF, PCB114, PCB156, PCB157, PCB169, PCB189, PCB180

Although background food consumption (i.e., bought at the supermarket, not locally produced) was marginally significant, we forced it into the model. Living in the exposed area was not a significant factor explaining variations of serum dioxin congener levels. However, living in the exposed area and consuming animal food products locally-produced was a determinant factor (table 1). The relationship between the consumption of animal food products locally-produced and serum dioxin levels was more significant and stronger for people living around incinerators than for non-exposed people (table 1). Moreover, this relationship was significantly different between exposed and non-exposed people for 2,3,7,8 TCDD, 1,2,3,7,8 PCDD, 1,2,3,6,7,8 HCDD, 1,2,3,6,7,8 HCDF, 2,3,4,6,7,8 HCDF and PCB114. For example, an increase of 8 grams per day of the consumption of animal food products locally-produced increased 2,3,7,8 TCDD serum concentrations by 11.9% (95%CI: 6.3-17.8%) for exposed people whereas increase was not observed for non-exposed people.

## Conclusion

The resulting analysis for each of the specific congeners was in general similar to the results of the serum dioxin TEQ analysis[2]. Individual characteristics, urbanism, chimney use, recreational activities with likely exposure to dioxins and the background food consumption were important confounding factors determining current serum dioxin congener levels. We therefore, took into account these factors in the regression models before to study other factors related to exposure to the incinerators.

For most congeners, the relationship between consumption of animal food products locally-produced and serum dioxin levels was more significant and stronger for people living around incinerators than for non-exposed people, particularly for 2,3,7,8 TCDD, 1,2,3,7,8 PCDD, 1,2,3,6,7,8 HCDD, 1,2,3,6,7,8 HCDF, 2,3,4,6,7,8 HCDF and PCB114.

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