# Factors explaining variation in serum dioxin concentrations for the specific congeners in the French Dioxin and Incinerators Study

A. Zeghnoun[1], N. Fréry[1], J.L. Volatier[2], G. Falq[1], M. Pascal[1], H. Sarter[1], J.F. Focant[3], G. Eppe[3]

1/French Institute for Public Health Surveillance - 12, rue du Val d'Osne, 94415 Saint-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

## Introduction

### The French Dioxin and Incinerators Study

The FDIS study 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.

## Objective

Our primary interest in this work is:
- to characterize the distribution of serum concentrations for each congeners,
- 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.

## Methods

### Population
- **1030 adults from 30 to 65 years** were selected through a **stratified two stage random sampling**,
- **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 dioxin sources.

### Explanatory factors studied
They include:
- physiological and socio-demographic factors (age, sex, BMI, recent changes in body weight, study level, socio-professional category, marital status, …),
- 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, …), location or area of the incinerator,
- eating habits (background diet and locally-produced food diet),
- recreational activities with likely exposure to dioxins, furans, and PCBs etc.

### Statistical analysis
- Log-transformation was used for each of the specific congeners.
- A spline regression with 3 degrees of freedom and categorical variables were used to assess the shape of the relationships between the log-transformed serum congener concentrations and the continuous explanatory variables,
- Tobit regression model was used to determine factors that explain variation in serum dioxin congener levels.
- Interaction between the consumption of animal food products locally-produced and the exposure (living in exposed or non-exposed area) was introduced into the model 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 models were adjusted for survey sampling weights using Stata software.

## Results

### Median and 95th percentiles

The median and the 95th percentile for each of the 28 specific congeners are showed in the figure below (1,2,3,4,7,8,9 HpCDF, OCDF, PCB 77 and PCB 81 were not quantified with more than 96%<LOQ).
- For 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
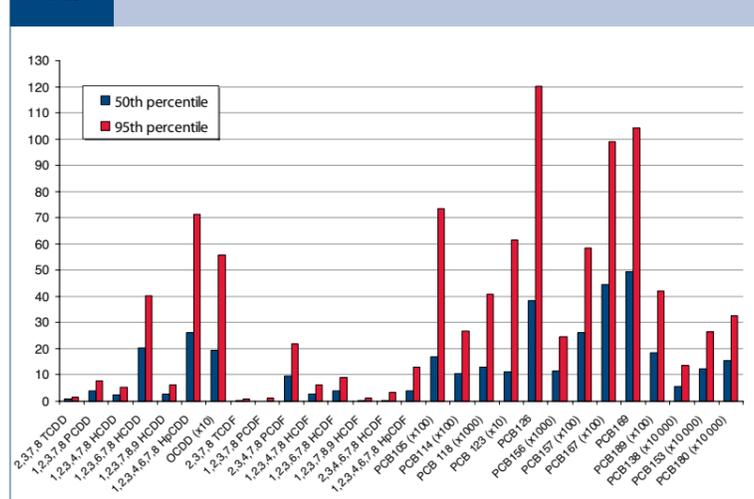
### Subject characteristics

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.

### Urbanism, chimney use and recreational activities

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 compared to 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, 1,2,3,7,8,9 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

| Exposure Area | Congener | % Increase | 95%CI lower | 95%CI upper | Congener | % Increase | 95%CI lower | 95%CI upper |
|---|---|---|---|---|---|---|---|---|
| **TABLE 1** | **Percentage increase in serum dioxin congener levels and 95% CI for an increase of 8 g/day of locally-produced animal lipids consumption** | | | | | | | |
| 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)*

### Background food consumption

Although background food consumption (i.e., bought at the supermarket, not locally produced) were marginally significant, we forced it into the model.

### Consumption of animal food products locally-produced

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 results for each of the specific congeners were usually similar to those for the serum dioxin TEQ analysis. 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.

## References

Fréry N, Volatier JL, Zeghnoun A, Falq G, Organohalogen compounds 2007, submitted.
Fréry N, Zeghnoun A, Sarter H, Volatier JL, Organohalogen Compounds 2007 submitted.
Pascal M, Eppe G, Zeghnoun A, Falq G, et al. Organohalogen Compounds 2007 submitted
Judge G, Griffiths WE, Hill RC, Lutkepohl H, et al. New York, John Wiley 1985.
Zeghnoun A, Pascal M, Fréry N, Sarter H, et al. Organohalogen Compounds 2007 submitted
Stata Reference Manual release 9. Stata Press 2006. SAS institute. SAS/STAT User's guide version 9. Cary, NC: SAS Institute Inc. 2004.
R Development Core Team (2006). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0.

## Acknowledgments

InVS
FRENCH INSTITUTE FOR PUBLIC HEALTH SURVEILLANCE

afssa

August 2007