THE FRENCH DIOXIN AND INCINERATORS STUDY: METHOD OF THE STUDY

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Abstract

The French Dioxin and Incinerators Study was carried out by the French Institute for Public Health Surveillance and the French Food Safety Agency in 8 different areas in France around municipal solid wastes incinerators. The population study was made up of adults who had been living for at least 10 years in the study area, not occupationally exposed to dioxins and for women with no breastfeeding. The individuals were selected through a random sampling and were provided 200 ml blood serum samples as well as their personal characteristics, eating habits, occupational and environmental exposure through a face to face interview. Exposure was assessed by serum concentrations of dioxins, furans and PCBs. The main goal of the study was to investigate whether living around incinerators was associated with elevated blood dioxins, furans and PCBs levels. To respond to this question, several statistical methods were used including univariate and multivariate analyses. All analyses were adjusted for survey sampling weights and used methods taken in to account the presence of non-detects.

Introduction

Dioxins and furans are organic compounds resulting mainly from human activities such as waste incineration. They accumulate in the food chain. France is the European country with the highest number of wastes incinerators (123 units operating in 2003, 300 in 1998) but is amongst the few countries that do not have any data on dioxin levels in the general population (except in maternal milk). The French Dioxin and Incinerators Study was carried out in response to the concern of the French population which wants to know whether living in the vicinity of wastes incinerators can influence their serum dioxin levels.

The objectives of the study are:

1) to measure dioxin levels in serum samples collected in the populations living around various types of municipal solid waste incinerators,
2) and to evaluate the contribution of the dioxins contained in locally-produced food products to these serum levels, since food is known to be the most important route of exposure.

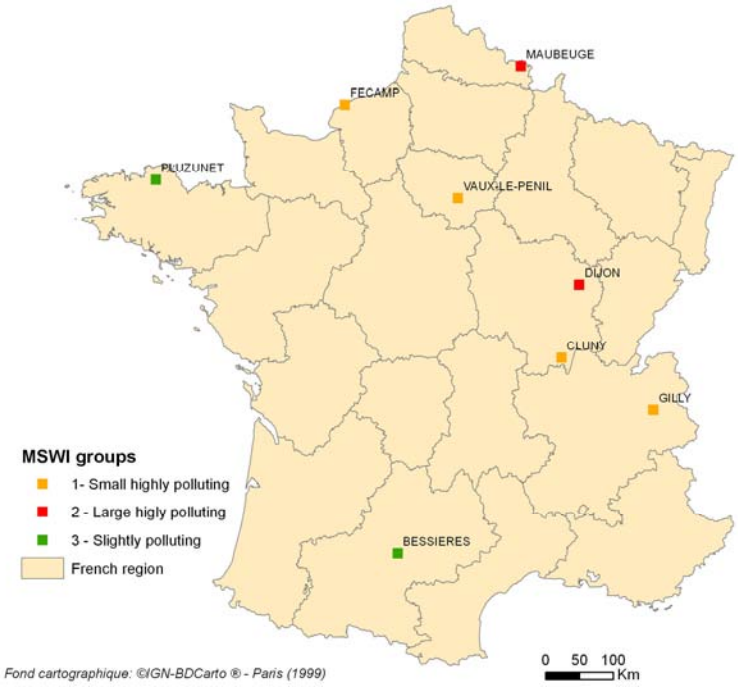
Material and Methods

The population study

The French Dioxin and Incinerators Study was carried out by the National Institute for Health Surveillance and the French Food Safety Agency in 8 different areas in France around municipal solid wastes incinerators. The population study was made up of 1030 adults between the ages of 30 and 65. The individuals were selected through a stratified two stages random sampling and were provided blood serum samples for dioxins, furans and PCBs measurement[1]. In each of the 8 areas (Cluny, Fécamp, Gilly sur Isère, Vaux-le-Pénil, Maubeuge, Dijon,

Pluzunet, Bessières) 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 not exposed people as living beyond 20 km of the incinerator and not exposed to known dioxins sources (referents). In each of the exposed or not exposed study groups, the population studied was divided in two groups:

1) people eating home-grown or food produced locally (poultry, meat, eggs, milk, fruit and vegetables…),
2) and people not eating home-grown or locally-produced food.



The municipal solid wastes incinerators

Three categories of municipal solid wastes incinerators were considered:

1) four small incinerators (<6 tons per hour) and highly polluting ones (> 10 ng/Nm3; some data > 500 ng/Nm3),
2) two large incinerators (≥ 6 tons per hour) and highly polluting ones,
3) two large incinerators and slightly polluting ones, which have respected environmental directive (< 0,1 ng/Nm3).

The study areas around each of these incinerators were defined using a threshold applied to the surface deposit accumulated over several years. The deposits were estimated through a modeling of atmospheric dispersion of the municipal solid wastes incinerators plume.

The sampling and recruitment

In order to be eligible for participation in the survey, population was first contacted by phone after obtaining their contact details from voter lists. Then, populations from each 8 areas were sampled using a two-stage probability sample design, stratified by area of exposure (exposed area or not) and by type of locally-produced

food consumption (eating or not locally-produced food). In the first stage, households were sampled using probabilities proportional to the size of the household. The second stage sampled people using a simple random sampling. The random sample included a single eligible adult in each household. Stratification allowed to over-sample certain consumer profiles in order to study them with a sufficient power. This over-sampling is compensated in the statistical analysis using survey design weights. Each subject who was sampled was asked to complete informed consent documents and was asked to participate in an interview and blood draw close to their home (about 200 ml of blood under fasting conditions in the morning).

Questionnaires

Individual characteristics, eating habits, occupational and environmental exposure data were collected through a interview. They will be used to assess the impact of the main risk factors for dioxin impregnation. The physiological and socio-demographic factors include age, sex, body mass index, recent changes in body weight, study level, socio-professional category, marital status, tobacco status (smokers, ex-smokers, non smokers), grams of tobacco smoked, occupational exposure.

The originality of this study lies in its relatively detailed analysis of locally-produced food consumption[2]. Food intake was quantified by a validated food frequency and portions questionnaire detailed for the food vectors for animal lipids, which are also the food vectors for dioxins. There were 3 questionnaires:

1) the first on the general diet involving 109 frequencies of consumption of food products combined with several items on portions (food groups: meat (beef, pork, poultry,…), fish, sea shell and shellfish, eggs, milk and dairy products, oils and fats, vegetables (leafy, roots), fruit, starchy food,
2) the second on locally-produced food diet (132 items: frequency, portion, duration per year, etc),
3) and the third on production of cattle, poultry, eggs, milk in the area of the plume.

Results of the food consumption were expressed in grams per day of food products or in grams per day of lipids in the food products for food from animal origin.

The environmental factors studied were the length of residency since the incinerator installation, accumulated deposit at the residence measured by the dispersion models, living or not in the exposed area (under the plume), urbanism (rural, suburb, city), type and date of the household, vegetable garden (yes/no, duration of exposure to the plume, use of ashes to fertilize), barbecue, type of heating, burning, exposure to a fire, leisure, number of minutes per week in a vehicle.

Biomarkers

Exposure was assessed by serum concentrations of the 17 classical dioxins (PCDDs) and furans (PCDFs), 12 DL-PCBs and 4 marker PCBs (IUPAC 118, 138, 153, 180). A fast automated extraction and clean-up procedure was used for low-level analysis. Samples were analyzed by GC–HRMS on the lipid fraction of serum[3]. The total lipids content was measured by enzymatic summation method. Concentrations of dioxins, furans and PCBs are expressed in pg WHO-TEq per gram of lipids. Toxicological analysis of lead in blood and cadmium in urine were also performed.

Data quality

During the study, several procedures were developed to insure the data quality of the serum analyses at low concentrations[4]. Internal, external and blind quality controls were implemented to assess the performances at the various levels of concentrations found in the population. Two definitions of the limit of quantification (LOQ) were computed. One was based on the EU dioxin directive 2004/44/EC. The second took into account the levels of congeners found in the procedure blank, to define a more restrictive LOQ. The difference between these two definitions can be as large as one or two orders of magnitude for some congeners. However, the LOQ are still low enough to allow the quantification of the majority of the samples.

Statistical Analysis

To investigate whether living around the incinerator was associated with elevated blood dioxins, furans and PCBs levels, several statistical methods (univariate descriptive and multivariate analyses) were used.
The population study was selected through a stratified two stages random sampling. Therefore, sampling weights were usually used to adjust statistical analysis results. However, the results of the weighted and unweighted regression models were compared in most analyses to check their sensitivity to the over/under sampling of certain consumer profiles.

Preliminary investigation indicated that serum dioxins, furans and PCBs levels were consistent with a log-normal distribution. We therefore used the log-transformation for the dioxin TEQ as well as for each of the 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[4]. We therefore used regression model for censored data known as Tobit regression model[5] to estimate the distribution of serum dioxin congener concentrations and to determine factors that explain variations in serum concentrations. In this model, we make a distinction between left-censored data when values are less than the LOD and interval censored data when values are between the LOD and the LOQ. When the percentage of censored values is small, we used the substitution method, as the method for treatment of censored data makes little difference in this case[6]. Taking into consideration that laboratories usually make a distinction between LOD and LOQ, the method used substitute by LOD/2 when the censored value fall between 0 and LOD, and substitute by (LOD+LOQ)/2 when the censored value fall between LOD and LOQ. All statistical analyses were completed using stata[7], SAS[8] and R[9].

Acknowledgments

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