DIOXIN EXPOSURE AND CANCER INCIDENCE IN VICINITY TO MUNICIPAL SOLID WASTE INCINERATORS IN FRANCE

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Abstract

To evaluate the health impact for population living in the vicinity of a municipal solid waste incinerator (MSWI), we conducted a retrospective ecological study on the cancer incidence around sixteen MSWIs in France. The general cancer registries of the study zone provided the morbidity data. The modelled dioxin (2,3,7,8 TCDD) ground-level dispersion was used as marker of a global exposure to MSWI. The home address at the time of diagnosis was used to locate each case of cancer. Urbanization, socio-economic deprivation, exposure to air pollution from traffic and from other industries were took into account as potential confounding factors. All collected data were implemented in a geographical information system in order to estimate, at the IRIS level, cancer incidences, exposure to MSWI emissions and to confounding factors. Through a log-linear Poisson regression associated with a Bayesian hierarchical analysis, we analyzed the relationship between exposure to MSWI emissions and cancer incidences. The analysis of our data shows a positive association between exposure to incinerators in the 70s' and 80s' and the incidence of different cancers during the period 1990-1999. However, this ecological study does not allow to establish any causal relationship; it only provides further arguments in favor of this link.

Introduction

Incineration is one of the most used waste disposal methods in Europe. The scientific literature already showed, in occupational context, an excess of risk of certain cancers associated with strong exposures to incineration pollutants [1-5]. However, few studies have been carried out to evaluate the health impact of a long-term exposure at low dose of pollutants as it is the case for population living in the vicinity of municipal solid waste incinerator (MSWI) [6-10].

Materials and Methods

To estimate in France the association between cancer incidence and the past exposure to MSWI emissions, we conducted an ecological study. It was carried out in four "*departments*" (administrative subdivision of a Region in France), chosen according to statistical power and feasibility criteria, divided into 2,272 IRIS. An IRIS is the smallest administrative and demographic units of around 2,000 inhabitants, for which different socio-economical and demographic data are available. Sixteen MSWI functioned in these four "*departments*" before 1990. Cases of cancer were these collected by the cancer registries of these four French "*departments*". Incidence rates were estimated for all cancers and selected subtypes (liver, breast, soft-tissue sarcoma, leukemia and non-Hodgkin lymphoma) from 1990 to 1999 in adults aged over 14 years old. During the study period, 135,000 cases of primary cancer were identified among 25,000,000 person-years. Between the exposure period and the data collection phase, we took into account a latency period of 5 years for hematological cancers and 10 years for solid cancers. The dioxin (2,3,7,8 TCDD) exposure was identified as surrogate marker of the global exposure to MSWI. This exposure variable, defined as a ground-level dioxin concentration expressed in I-TEQ WHO $\mu g/m^2$/year, was obtained through a cumulative function taking into account the modelled ground-level dioxin deposit, a 10 year environmental half-life decrease and the exposure duration.

Because no data concerning dioxin emission levels are available for the period before 1997, the 1970-1980 mean level of dioxin emission have been retrospectively estimated, for each MSWI, by an expert panel ; estimates were based on technical characteristics of these facilities and their over time evolution (global incineration capacity, type of combustion, clearance and filtration processes). Exposure status of each statistical unit to stack emissions of dioxin from MSWI was estimated by a dispersion model (ADMS3). Inputs of this second-generation Gaussian model were meteorological hourly data (representative of 2 years of the study period for wind speed, wind direction and temperatures), surface topography and obstacle descriptions, stack characteristics and dioxin emission level from the MSWI. The modelling area covered about 15 to 20 kilometers around the incinerator stack. Urbanization, socio-economic deprivation, exposure to air pollution from traffic and other industries were considered as confounding factors. The home address at the time of diagnosis was used to locate each case of cancer in a specific IRIS.

All collected data were implemented in a geographical information system (GIS) in order to estimate, at the IRIS level, cancer incidences, exposure to MSWI emissions and exposure to confounding factors. A log-linear Poisson regression was performed to analyze the relationship between exposure to MSWI emissions and cancer incidences. A Bayesian hierarchical analysis took into account over dispersion and spatial correlation. Relative risks of cancer were calculated by comparing the risk for people living in an exposed IRIS, defined as the 90^{th} percentile of the IRIS exposure distribution, to the risk for people living in a weakly exposed IRIS, defined as the 2.5^{th} percentile of the exposure distribution.

Results and discussion

Exposure to MSWI

23% of the 2,272 IRIS involved in the study was exposed to at least one incinerator. The distribution of exposed IRIS was asymmetric: many IRIS were weakly exposed whereas few of them were highly exposed. The numerical values of exposure to dioxin at some relevant percentiles of the distribution are presented in table 1. A 100 factor separates the two endpoints of the exposure distribution chosen to calculate the relative risks (90^{th} percentile vs. 2.5^{th} percentile).

Table 1: IRIS distribution according to the ground-level dioxin concentration.

IRIS distribution	**Ground-level dioxin concentration** (I-TEQ WHO µg/m^2/year)
Percentile 0	2.04e^{-05}
Percentile 2.5	1.25e^{-04}
Percentile 5	2.30e^{-04}
Percentile 50	4.25e^{-03}
Percentile 75	8.89e^{-03}
Percentile 90	1.78e^{-02}

The figure 1 gives an illustration of the interest to use a refined dispersion model, especially in mountainous areas like the "*département*" of Isère where the shape of the plume is very dependant of the local topography and winds.

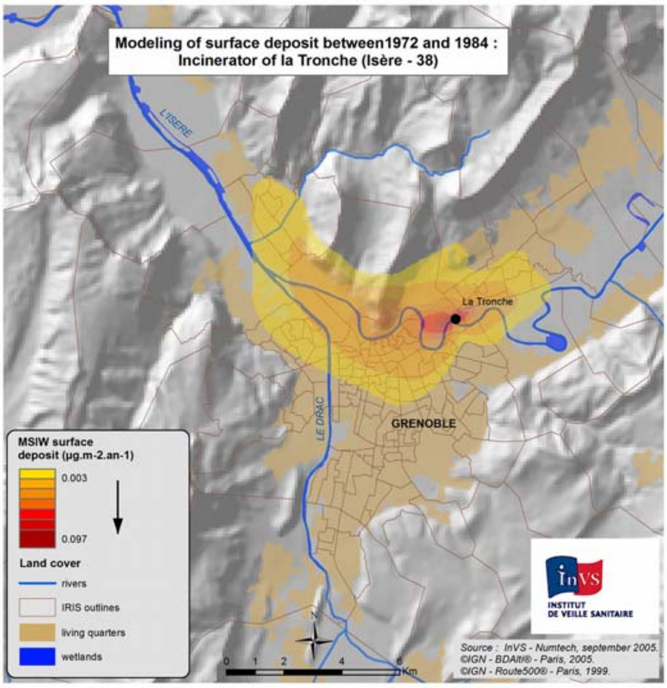

Figure 1: Modeling of exposure to the MSWI of La Tronche, Isère (France).

<u>Relative risk of cancer</u>

In table 2, we present the relative risks (RR) of different cancer incidences estimated as the ratio between the risk in a highly exposed and a low level exposed IRIS. N represents the number of cases for each localization of cancer.

Table 2: Relative risk between people living in a highly exposed IRIS (90^{th} percentile of the exposure distribution) and people living in a weakly exposed IRIS (2.5^{th} percentile).

Localization of cancer	**Relative Risk**	**95% CI**	***p-value***	**N**
Breast cancer in women	1.09	(1.03-1.16)	*< 0.01*	18,824
All cancers in women	1.06	(1.01-1.12)	*< 0.05*	59,076
Non Hodgkin's lymphoma	1.12	(1.00-1.25)	*< 0.05*	3,974
Liver cancer	1.16	(0.99-1.37)	*< 0.1*	2,784
Soft tissue sarcoma	1.22	(0.98-1.51)	*< 0.1*	655
Myeloma	1.16	(0.97-1.40)	*0.1*	1,700
Chronic lymphoid leukaemia	1.13	(0.91-1.39)	*> 0.1*	1,262
Acute leukaemia	1.04	(0.86-1.25)	*> 0.1*	1,238
All cancers in men	1.03	(0.97-1.09)	*> 0.1*	76,047

Our data show positive relationships between dioxin exposure in the 70s' and 80s' and the incidence for different types of cancers during the period 1990-1999. In women, we observe a statistically significant RR of 1.06, meaning an excess of relative risk of 6 %, for all cancer localizations, and an 1.09 RR for breast cancer, meaning an excess of relative risk of 9 %. In both sexes, our data show a statistically significant RR of 1.12 for Non Hodgkin's lymphoma, corresponding to an excess of relative risk of 12 %. We also observe a positive relationship close to a statistical significance (p-value=0.07) between dioxin exposure and liver cancer as well as soft tissues sarcoma incidence. No other statistical relationship was observed with other types of cancer.

Even, the excess risk of cancer have been already evoked for population living in the vicinity of MSWI in previous environmental health studies [6-11], our data confirm these results as well as the specific cancer impact in the female population.

This is one of the most important sample sized multicentric population-based study designed in the environmental health domain to detect small cancer incidence differences in relation to variations of dioxin exposures. The high data quality, provided by the four registries of cancer, definitely contributed to product strongly valid cancer incidence indicators. This study was improved upon the sophisticated methods for modelling ground-level concentrations exposures. The state-of-the-art method used for spatial analysis and the inclusion of the principal confounding factors quoted in the literature as the main incidence cancer modifiers, are also major strengths of this work.

However, our methodology also had limitations. Mainly, our work presents the inherent limits of any ecological study where the exposure is measured at the community level instead at the individual level. Thus, we couldn't have any information about different potential individual risk factors such as the residential history, dietary habits information, alcohol consumption and occupational exposure. Furthermore, although we can reasonably make the assumption these individual features are not related to the exposure status, this ecological design does not allow establishing a causal relationship. It only provides further arguments in favour of such a link. The relatively short latency time periods used in this study, between exposure and data collection, can also be discussed. Our choice was done for operational reasons. Longer latency time periods would have only increase the already shown statistical relationships. It is important to note that the dioxin ground deposition has been used as a marker of the global air pollution emitted by the MSWIs which in fact includes numerous other pollutants: polycyclic aromatic hydrocarbons, heavy metals, particles. Thus, the statistical relationships shown in this study express only a link between cancer incidence and a global exposure to rejects of MSWI without any possibility to identify which are the putative pollutants. Finally, this study refers to a past environmental situation. These results can not be transposed to the current context in France where the MSWIs generated pollution is controlled for several years.

We conclude that our study shows a significant relationship between exposure to incinerators in the 70s' and 80s' and the incidence of different cancers during the period 1990-1999 in areas classified as highly exposed to dioxin from MSWIs. The excess of risk of cancer is essentially observed in the female population for all types of cancer together and breast cancers as well as, for both genders, the non Hodgkin's lymphoma. Our data confirm the results of previous studies and gives further arguments in favour of a specific cancer impact of MSWI emissions in the female population.

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