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Cancer mortality in towns in the vicinity of incinerators and installations for the recovery or disposal of hazardous waste

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ABSTRACT

Background: Waste treatment plants release toxic emissions into the environment which affect neighboring towns.
Objectives: To investigate whether there might be excess cancer mortality in towns situated in the vicinity of Spanish-based incinerators and installations for the recovery or disposal of hazardous waste, according to the different categories of industrial activity.
Methods: An ecologic study was designed to examine municipal mortality due to 33 types of cancer, across the period 1997–2006. Population exposure to pollution was estimated on the basis of distance from town of residence to pollution source. Using Besag–York–Mollié (BYM) regression models with Integrated Nested Laplace approximations for Bayesian inference, and Mixed Poisson regression models, we assessed the risk of dying from cancer in a 5-kilometer zone around installations, analyzed the effect of category of industrial activity, and conducted individual analyses within a 50-kilometer radius of each installation.
Results: Excess cancer mortality (BYM model: relative risk, 95% credible interval) was detected in the total population residing in the vicinity of these installations as a whole (1.06, 1.04–1.09), and, principally, in the vicinity of incinerators (1.09, 1.01–1.18) and scrap metal/end-of-life vehicle handling facilities, in particular (1.04, 1.00–1.09). Special mention should be made of the results for tumors of the pleura (1.71, 1.34–2.14), stomach (1.18, 1.10–1.27), liver (1.18, 1.06–1.30), kidney (1.14, 1.04–1.23), ovary (1.14, 1.05–1.23), lung (1.10, 1.05–1.15), leukemia (1.10, 1.03–1.17), colon–rectum (1.08, 1.03–1.13) and bladder (1.08, 1.01–1.16) in the vicinity of all such installations.
Conclusions: Our results support the hypothesis of a statistically significant increase in the risk of dying from cancer in towns near incinerators and installations for the recovery or disposal of hazardous waste.

1. Introduction

Generation of waste by human activity is a matter of worldwide concern. Municipal incinerators and installations for the recovery or disposal of hazardous waste help address this problem but inevitably generate and release toxic emissions and effluents, such as dioxins – carcinogens recognized by the International Agency for Research on Cancer (IARC) (IARC, 1997) – into the environment, which then affect neighboring towns,.

Some studies have linked exposure to incinerator emissions, with adverse reproductive outcomes (Dummer et al., 2003), respiratory problems (Miyake et al., 2005) and cancer (Comba et al., 2003; Knox, 2000; Viel et al., 2008). With respect to treatment (elimination, disposal or recovery) of hazardous waste, which includes activities such as the recycling of scrap metal and end-of life vehicles (ELVs), re-refining of used oil, and physico/chemical treatment of waste, there are hardly any epidemiologic studies on these installations' health effects on the populations of nearby towns, even though they are known to release carcinogens, such as dioxins, arsenic, benzene, cadmium and chromium (Environmental Protection Agency, 2002; Landrigan et al., 1989). Accordingly, it would seem appropriate to ascertain whether residential proximity to these little-studied types of pollutant facilities might have an influence on the frequency of cancer.

Abbreviations: IARC, Agency for Research on Cancer; ELVs, End-of life vehicles; IPPC, Integrated Pollution Prevention and Control; E-PRTR, European Pollutant Release and Transfer Register; NSI, National Statistics Institute; PCBs, Polychlorinated biphenyls; RRs, Relative risks; 95% CrIs/CIs, 95% credible/confidence intervals; BYM, Besag, York and Mollié; INLAs, Integrated nested Laplace approximations; PAHs, Polycyclic aromatic hydrocarbons; NHL, Non-Hodgkin's lymphoma.

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In the case of pollution sources in Spain, the European Commission directives passed in 2002 afforded a new means of studying the consequences of industrial pollution: Integrated Pollution Prevention and Control (IPPC), governed both by Directive 96/61/CE (recently codified into Directive 2008/1/EC) and by Act 16/2002, which incorporates this Directive into the Spanish legal system, lays down that, to be able operate, industries covered by the regulation must obtain the Integrated Environmental Permit. This same enactment implemented the European Pollutant Release and Transfer Register (E-PRTR) in 2007, which makes it compulsory to declare all pollutant emissions to air, water and soil, that exceed the designated thresholds, and contains detailed information about the address and type of industrial activity in which the installations are involved. IPPC and E-PRTR records thus constitute an inventory of geo-located industries with environmental impact in Europe, which is a valuable resource for monitoring industrial pollution and, by extension, renders it possible for the association between residential proximity to such pollutant installations and health impacts, such as cancer, to be studied (Garcia-Perez et al., 2012; Lopez-Abente et al., 2012; Lopez-Cima et al., 2011).

In this context, this study sought to: (1) assess possible excess mortality attributable to 33 tumor sites among the Spanish population residing in the environs of incinerators and hazardous waste treatment plants governed by the IPPC Directive and E-PRTR Regulation; (2) analyze this risk according to the different categories of industrial activity, and for each installation individually; and, (3) perform the analysis for the population, both overall and broken down by sex, using different statistical approaches for the purpose.

2. Materials and methods

We designed an ecologic study to evaluate the association between cancer mortality and proximity to incinerators and hazardous waste treatment plants at a municipal level (8098 Spanish towns), during the period 1997–2006. Separate analyses were performed for the overall population and for each sex.

2.1. Mortality data

Observed municipal mortality data were drawn from the records of the National Statistics Institute (NSI) for the study period, and corresponded to deaths due to 33 types of malignant tumors (see Supplementary data, Table 1, which shows the list of tumors analyzed and their codes as per the International Classification of Diseases—9th and 10th Revisions). Expected cases were calculated by taking the specific rates for Spain as a whole, broken down by age group (18 groups: 0–4, …, 80–84 years, and 85 years and over), sex, and five-year period (1997–2001, 2002–2006), and multiplying these by the person-years for each town, broken down by the same strata. Person-years for each quinquennium were calculated by multiplying the respective populations by 5 (with data corresponding to 1999 and 2004 being taken as the estimator of the population at the midpoint of the study period). In addition, we specifically analyzed leukemias and brain cancer in subjects under ages 15 and 25 years, since these were the most frequent tumors in adolescents and young adults in our data.

2.2. Industrial pollution exposure data

Population exposure to industrial pollution was estimated by taking the distance from the centroid of town of residence to the industrial facility. We used the industrial database (industries governed by IPPC and facilities pertaining to industrial activities not subject to IPPC but included in the E-PRTR) provided by the Spanish Ministry for Agriculture, Food & Environment in 2007. Bearing in mind the minimum induction periods for the tumors targeted for study, generally 10 years for solid tumors and 1 year for leukemias (United Nations Scientific Committee on the Effects of Atomic Radiation, 2006), two industry databases were used:

a) for the study of leukemias, we selected the 129 installations corresponding to IPPC categories 5.1 (installations for the recovery or disposal of hazardous waste with a capacity exceeding 10 t per day) and 5.2 (installations for the incineration of municipal waste with a capacity exceeding 3 t per hour), which came into operation prior to 2002 (1 year before the mid-year of the study period), denominated "pre-2002 installations"; and,
b) for the remaining tumors, we selected the 67 installations corresponding to IPPC categories 5.1 and 5.2 which came into operation prior to 1993 (10 years before the mid-year of the study period), denominated "pre-1993 installations".

The date (year) of commencement of the respective industrial activities was provided by the industries themselves.

Each of the installations was classified into one of the following 9 categories of industrial activities, according to the type of waste involved and treatment applied:

1. "*Incineration*": incineration of solid urban (municipal) and special waste (9 pre-2002 and 5 pre-1993 installations);
2. "*Scrap metal + ELVs*": scrapping/decontamination of ELVs, and recycling of scrap metal (ferrous and non-ferrous products) and electric/electronic equipment (32 pre-2002 and 23 pre-1993 installations);
3. "*Oils + Oily waste*": treatment of used oil, oily marine pollutant (MARPOL) waste and decontamination of equipment contaminated by polychlorinated biphenyls (PCBs) (24 pre-2002 and 8 pre-1993 installations);
4. "*Packaging*": recycling of metallic and plastic industrial packaging (9 pre-2002 and 5 pre-1993 installations);
5. "*Solvents*": recovery of used solvents (7 pre-2002 and 5 pre-1993 installations);
6. "*Spent baths*": regeneration of spent acid pickling and basic baths and hydrochloric acid used in metal descaling (7 pre-2002 and 5 pre-1993 installations);
7. "*Physico/chemical treatment*": physico/chemical treatment of waste not included in the above sections (8 pre-2002 and 4 pre-1993 installations);
8. "*Industrial waste*": treatment of industrial waste not included in the above sections, such as recovery of wastes from the iron and steel industry (15 pre-2002 and 7 pre-1993 installations); and,
9. "*Wastes not otherwise specified*": treatment of waste not included in any of the above sections, such as medical wastes, lead acid batteries, photochemical wastes, or textile wastes (18 pre-2002 and 5 pre-1993 installations). This category also included installations that treated different types of waste or applied several different treatment processes.

Owing to the presence of errors in the initial location of industries, the geographic coordinates of the industrial locations recorded in the IPPC + E-PRTR 2007 database were previously validated: every single address was thoroughly checked using Google Earth (with the street-view application), the Spanish Agricultural Plots Geographic Information System (which includes orthophotos and topographic maps showing the names of the industries) (Ministerio de Agricultura Alimentación y Medio Ambiente, 2012), the Google Maps server and the "Yellow pages" web page (which allow for a search of addresses and companies), and the web pages of the industries themselves, to ensure that location of the industrial facility was exactly where it should be. 25% of the incinerators and hazardous waste treatment installation coordinates were corrected at a distance of 4471 m or more from the original location in the IPPC + E-PRTR database.