



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.

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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; INLA, 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 (García-Pérez 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.

2.3. Statistical analysis

Three types of analysis were performed to assess possible excess cancer mortality in towns lying near ("near") versus those lying far ("far") from incinerators and hazardous waste treatment installations, known as a "near vs. far" analysis. In all cases, a distance of 5 km was taken as the area of proximity ("exposure") to industrial installations, in line with the distance used by other studies on these types of installations (Federico et al., 2010; Knox, 2000; Leem et al., 2006):

- 1) in a first phase, we conducted a "near vs. far" analysis to estimate the relative risks (RRs) of towns situated at a distance of ≤ 5 km from incinerators and hazardous waste treatment installations as a whole. The variable, "exposure", was coded as: a) exposed or proximity area ("near"), consisting of towns lying at a distance of ≤ 5 km from any incinerator or hazardous waste treatment facility; b) intermediate area, consisting of towns lying at a distance of ≤ 5 km from any industrial installation other than incinerators or hazardous waste treatment facilities; and, c) unexposed area ("far"), consisting of towns having no (IPPC + E-PRTR)-registered industry within 5 km of their municipal centroid (reference group);
- 2) in a second analysis, we decided to stratify risk of analysis anterior according to the different categories of industrial activity. To this end, we created a variable of "exposure" in which the exposed area was stratified into the following groups: Group 1, made up of towns lying close (≤ 5 km) to one or more installations belonging to the category "Incineration"; Group 2, if the category was "Scrap metal + ELVs", and so on, until Group 9, if the category was "Wastes not otherwise specified"; and Group 10, made up of towns lying close to two or more installations belonging to different categories of activity ("multiple pollutant categories"). Intermediate and unexposed areas were defined as in the preceding phase; and,
- 3) lastly, bearing in mind that characteristics tend to vary from one incinerator or hazardous waste treatment facility to the next, we conducted separate "near vs. far" analyses of the individual installations, with the analysis being confined to an area of 50 km surrounding each such installation so as to have a local comparison group.

For all the above analyses, we used two statistical approaches based on log-linear models to estimate the RRs and their 95% credible/confidence intervals (95% CrIs/Cls), assuming that the number of deaths per stratum followed a Poisson distribution:

- a) a Bayesian conditional autoregressive model proposed by Besag, York and Mollié (BYM) (Besag et al., 1991), with explanatory variables:

$$O_i \sim \text{Poisson}(\mu_i), \text{ with } \mu_i = E_i \lambda_i$$

$$\log(\lambda_i) = \alpha \text{Expos}_i + \sum_j \beta_j \text{Soc}_{ij} + h_i + b_i \Rightarrow \log(\mu_i) =$$

$$\log(E_i) + \alpha \text{Expos}_i + \sum_j \beta_j \text{Soc}_{ij} + h_i + b_i$$

$$\text{Soc}_{ij} = ps_i + ill_i + far_i + unem_i + pph_i + inc_i$$

$$i = 1, \dots, 8098 \text{ towns}, \quad j = 1, \dots, 6 \text{ potential confounders}$$

$$\begin{aligned} h_i &\sim \text{Normal}(\theta, \tau_h) \\ b_i &\sim \text{Car.Normal}(\eta_i, \tau_b) \\ \tau_h &\sim \text{Gamma}(\alpha, \beta) \\ \tau_b &\sim \text{Gamma}(\gamma, \delta) \end{aligned}$$

- b) a mixed Poisson regression model (Gelman and Hill, 2007):

$$O_i \sim \text{Poisson}(\mu_i), \text{ with } \mu_i = E_i \lambda_i$$

$$\log(\lambda_i) = \alpha \text{Expos}_i + \sum_j \beta_j \text{Soc}_{ij} + p_i \Rightarrow \log(\mu_i) =$$

$$\log(E_i) + \alpha \text{Expos}_i + \sum_j \beta_j \text{Soc}_{ij} + p_i$$

$$\text{Soc}_{ij} = ps_i + ill_i + far_i + unem_i + pph_i + inc_i$$

$$i = 1, \dots, 8098 \text{ towns}, \quad j = 1, \dots, 6 \text{ potential confounders}$$

with λ_i being the RR in town i , the number of observed deaths in town i for each cancer site (O_i) being the dependent variable, and the number of expected deaths in town i for each cancer site (E_i) being the offset, in both cases. All estimates for the variable of "exposure" (Expos_i) were adjusted for the following standardized, sociodemographic indicators (Soc_{ij}), chosen as potential confounders directly from the 1991 census for their availability at a municipal level and potential explanatory ability vis-à-vis certain geographic mortality patterns (Lopez-Abente et al., 2006): population size (ps_i) (categorized into three levels: 0–2000, 2000–10,000 and $\geq 10,000$ inhabitants); percentage illiteracy (ill_i), farmers (far_i) and unemployed ($unem_i$); average persons per household (pph_i); and mean income (inc_i) by the Spanish Market Yearbook, as a measure of income level (Ayuso Orejana et al., 1993). Their geographic patterns show the economic, demographic and social development of Spain, appreciating some spatial correspondence between illiteracy, unemployment and younger population areas. The variable of "exposure" and potential confounding covariates were fixed-effects terms in the models.

To enable the spatial autocorrelation problem (presence of geographic patterns in contiguous spatial data) to be assessed, this was estimated by applying Moran's I statistic to the Standardized Mortality Ratios (Bivand et al., 2008). The BYM Bayesian autoregressive model takes this problem into account, thanks to the inclusion of two random effects components, namely: a spatial term containing municipal contiguities (b_i); and the municipal heterogeneity term (h_i). Integrated nested Laplace approximations (INLAs) (Rue et al., 2009) were used as a tool for Bayesian inference. For this purpose, we used R-INLA (The R-INLA project, 2012), with the option of simplified Laplace estimation of the parameters. A total of 8098 towns were included, and the spatial data on municipal contiguities were obtained by processing the official NSI maps.

Furthermore, the mixed Poisson regression model includes province as a random effects term (p_i), to enable geographic variability and extra-Poisson dispersion to be taken into account and unexposed towns belonging to the same province to be considered as the reference group in each case, something that is justified by the geographic differences observed in mortality attributable to some tumors (Lopez-Abente et al., 2006).

Lastly, a residual analysis (based on deviance residuals) was performed to test the models.

3. Results

Fig. 1 depicts the geographic distribution of the 129 installations studied according to the different categories of industrial activity, together with their PRTR codes and year of commencement of operations. Supplementary data, Table 2 gives a detailed description of the type of activity undertaken by each installation and the pollutants emitted during the preceding decade. In all, the 129 installations released 525,428 t of toxic substances to air and 4984 t to water in 2007, including carcinogens such as arsenic (32 kg to air and 33 kg to water), chromium (81 kg to air and 80 kg to water) and polycyclic aromatic hydrocarbons (PAHs) (48 kg to air and 126 kg to water). More detailed information on emission amounts is provided in Supplementary data, Tables 3 and 4, which show the types of substances and amounts released by these installations to air and water, respectively.

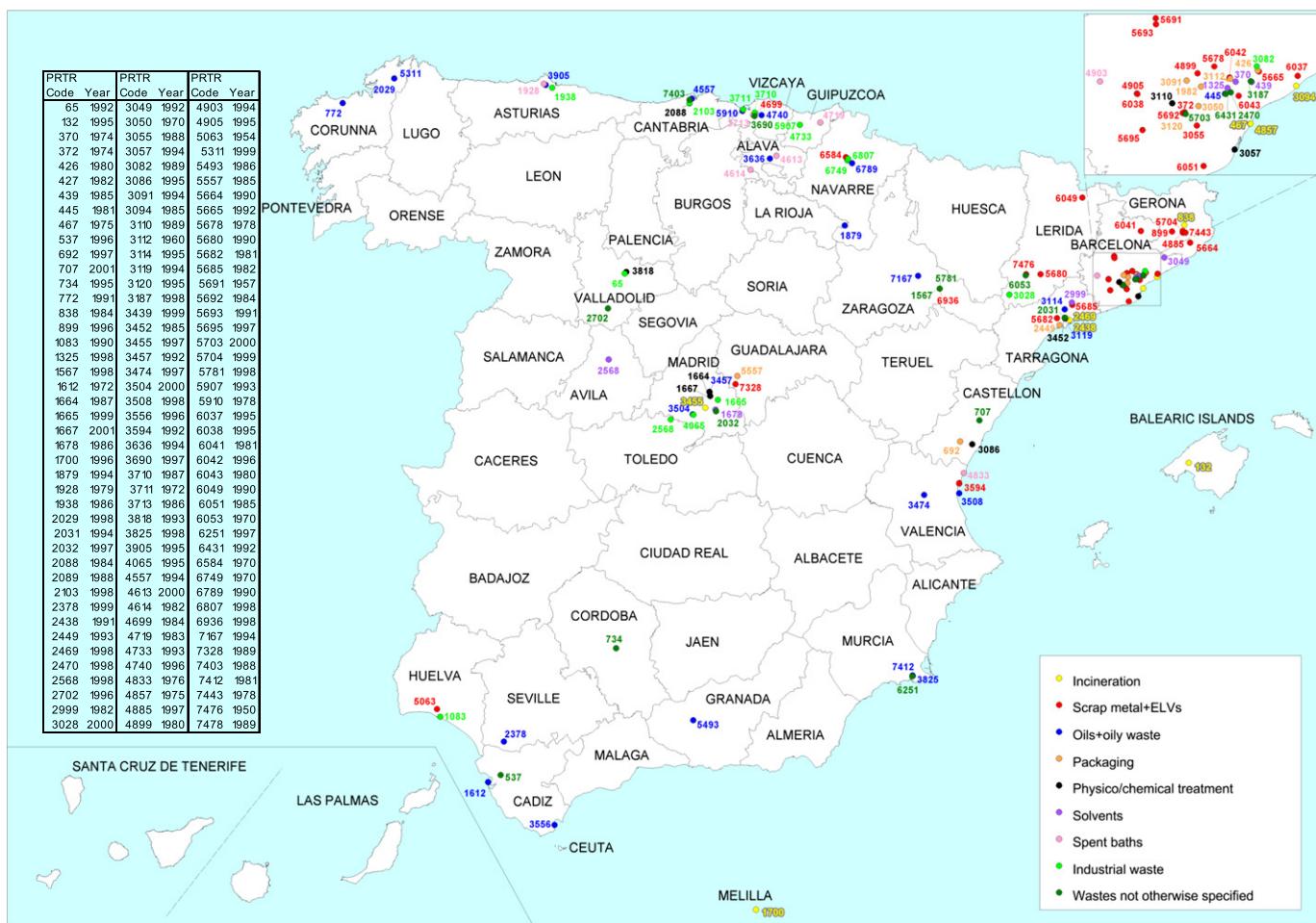


Fig. 1. Geographic distribution of Spanish-based incinerators and hazardous waste treatment installations.

Table 1 shows the RRs and 95% CrIs/CIs for cancers proving to be statistically significant in towns situated at ≤ 5 km from incinerators and hazardous waste treatment installations, estimated using BYM and Poisson mixed regression models and Moran's I test for spatial autocorrelation. Overall, excess cancer mortality was present in both sexes, with the two models displaying identical RRs, which were higher in men (RR = 1.08) than in women (RR = 1.03). In the case of specific tumors, the estimates yielded by both models were largely similar in general (slightly higher and significant in the mixed model in tumors of the oral cavity and pharynx, esophagus and non-Hodgkin's lymphoma (NHL), and somewhat higher in the BYM model in renal cancer). Some cancers – such as all cancers combined (in men and women) or malignant tumors of the stomach (in men and women) and lung, bladder, oral cavity and pharynx, colon–rectum, and liver (in men) – displayed a statistically significant spatial autocorrelation, and it thus seemed appropriate to use the BYM model in order to take this spatial autocorrelation into account. Based on this model, statistically significant RRs appeared for tumors of the stomach, liver, pleura and kidney (in men and women), colon–rectum, lung, bladder, gallbladder and leukemia (in men), and brain and ovary (in women). In these results, note should be taken of the high excess risk for cancer of the pleura (RR = 1.84 in men and RR = 1.52 in women). With respect to leukemias and brain cancer in the under-15- and under-25 age groups, statistically significant excess risks were not in evidence (see Supplementary data, Table 5, which shows the RR of dying from leukemia and brain cancer among the under-15 and under-25 age groups in towns situated at

≤ 5 km from incinerators and hazardous waste treatment installations, estimated using BYM models).

The analyses of the above table, including the two regression models and spatial autocorrelation test, were performed separately for each tumor (see Supplementary data, Tables 6 and 7, which show the RR of dying from cancer in towns situated at ≤ 5 km from incinerators and hazardous waste treatment installations as a whole – estimated using BYM models – and Moran's I p-values for spatial autocorrelation analyses, respectively). In the residual analysis of the BYM model for all tumors under study, the graphs plotting deviance residuals against distance to the nearest installation displayed an apparently random scatter pattern, consistent with a well-fitted model (see Supplementary data, Fig. 1).

Table 2 shows the RRs and 95% CrIs estimated with BYM models for cancers that yielded statistically significant results in the analysis of risk stratified by category of industrial activity. For all cancers combined, statistically significant excess risks were observed in the environs of multiple pollutant categories (men and women), incinerators and installations for the recycling of scrap metal + ELVs (total population), and installations for the regeneration of spent baths (men), though in no case were these higher than 10%. Insofar as the remaining tumors were concerned, attention should be drawn to the significant excess risks found for the following (we have highlighted the highest statistically significant RRs for each tumor): stomach and colorectal cancers in men, in the vicinity of packaging recycling industries (RRs = 1.53 and 1.29, respectively); cancers of the liver and ovary in women, in

Table 1

Relative risk of dying from cancers with significant results in towns situated at ≤ 5 km from incinerators and hazardous waste treatment installations as a whole, estimated using BYM and Poisson mixed regression models, and Moran's I test for spatial autocorrelation. Significant results are in bold.

	T ^a	Obs ^b	Exp ^c	BYM model		Mixed model		Moran's I test p-Value
				RR ^d	95%CI ^e	RR ^d	95%CI ^f	
All cancers^g								
Total	163	91,708	85,109.6	1.06	1.04–1.09	1.06	1.05–1.07	0.0001
Men	163	58,275	53,071.8	1.08	1.05–1.11	1.08	1.07–1.10	0.0001
Women	163	33,433	32,037.8	1.03	1.01–1.06	1.03	1.01–1.04	0.0006
Oral and pharyngeal cancer								
Total	163	2482	2178.7	1.04	0.95–1.14	1.11	1.05–1.19	0.0039
Men	163	2056	1804.5	1.03	0.94–1.13	1.11	1.04–1.19	0.0031
Women	163	426	374.2	1.09	0.94–1.26	1.07	0.93–1.24	0.4660
Esophageal cancer								
Total	163	1960	1733.3	0.99	0.90–1.09	1.07	1.00–1.15	0.0725
Men	163	1710	1504.0	1.01	0.91–1.11	1.08	1.00–1.16	0.0979
Women	163	250	229.4	0.92	0.74–1.13	1.02	0.84–1.24	0.7441
Stomach cancer								
Total	163	6123	5646.0	1.18	1.10–1.27	1.07	1.03–1.11	0.0001
Men	163	3822	3461.8	1.18	1.09–1.28	1.09	1.04–1.15	0.0073
Women	163	2301	2184.3	1.16	1.06–1.27	1.04	0.98–1.11	0.0049
Colorectal cancer								
Total	163	12,265	11367.2	1.08	1.03–1.13	1.06	1.03–1.09	0.0004
Men	163	7084	6343.6	1.12	1.06–1.18	1.08	1.04–1.12	0.0131
Women	163	5181	5023.6	1.04	0.98–1.10	1.03	0.99–1.08	0.6319
Liver cancer								
Total	163	2929	2310.4	1.18	1.06–1.30	1.23	1.15–1.31	0.0012
Men	163	2075	1678.6	1.17	1.05–1.30	1.22	1.13–1.31	0.0014
Women	163	854	631.8	1.20	1.02–1.40	1.24	1.10–1.40	0.8100
Gallbladder cancer								
Total	163	1339	1262.6	1.10	0.99–1.21	1.10	1.01–1.19	0.2574
Men	163	511	432.5	1.26	1.08–1.45	1.23	1.07–1.41	0.5436
Women	163	828	830.1	1.02	0.90–1.15	1.04	0.94–1.15	0.6723
Lung cancer								
Total	163	19,214	17,394.4	1.10	1.05–1.15	1.10	1.07–1.12	0.0001
Men	163	17,156	15,336.5	1.12	1.06–1.18	1.12	1.10–1.15	0.0001
Women	163	2058	2057.8	0.92	0.84–1.00	0.91	0.85–0.97	0.9473
Pleural cancer								
Total	163	394	206.8	1.71	1.34–2.14	1.74	1.44–2.11	0.1093
Men	163	284	147.0	1.84	1.39–2.40	1.86	1.48–2.34	0.0688
Women	163	110	59.7	1.52	1.04–2.14	1.51	1.07–2.14	0.8281
Skin cancer								
Total	163	354	424.0	1.11	0.93–1.31	1.10	0.94–1.27	0.3792
Men	163	209	226.5	1.23	0.99–1.50	1.26	1.03–1.53	0.4815
Women	163	145	197.5	0.97	0.75–1.23	0.88	0.70–1.10	0.2312
Ovarian cancer								
Women	163	1852	1770.0	1.14	1.05–1.23	1.12	1.05–1.21	0.8134
Bladder cancer								
Total	163	4131	3809.9	1.08	1.01–1.16	1.07	1.02–1.12	0.0140
Men	163	3419	3138.4	1.10	1.02–1.18	1.09	1.03–1.14	0.0092
Women	163	712	671.5	1.02	0.91–1.15	1.02	0.91–1.13	0.7499
Renal cancer								
Total	163	1918	1651.3	1.14	1.04–1.23	1.07	1.00–1.15	0.6497
Men	163	1268	1094.0	1.12	1.02–1.24	1.07	0.98–1.17	0.4631
Women	163	650	557.4	1.16	1.02–1.31	1.11	0.99–1.26	0.9937
Brain cancer								
Total	163	2380	2245.9	1.04	0.97–1.12	1.03	0.97–1.10	0.9354
Men	163	1285	1248.8	1.00	0.91–1.09	1.00	0.92–1.08	0.1687
Women	163	1095	997.0	1.11	1.00–1.22	1.10	1.00–1.20	0.2573
Non-Hodgkin's lymphoma								
Total	163	2396	2240.2	1.02	0.94–1.11	1.09	1.02–1.16	0.3802
Men	163	1274	1171.1	1.07	0.97–1.19	1.12	1.03–1.22	0.7342
Women	163	1122	1069.1	0.96	0.87–1.07	1.03	0.94–1.13	0.1000
Leukemia								
Total	237	5378	4947.1	1.10	1.03–1.17	1.06	1.01–1.11	0.6310
Men	237	2956	2713.8	1.12	1.04–1.21	1.09	1.02–1.16	0.1279
Women	237	2422	2233.4	1.07	0.98–1.17	1.04	0.97–1.20	0.2602

^a Number of towns situated at ≤ 5 km from incinerators and hazardous waste treatment installations as a whole.

^b Observed deaths.

^c Expected deaths.

^d RRs adjusted for population size, percentage illiteracy, farmers and unemployed persons, average persons per household, and mean income.

^e 95% credible interval.

^f 95% confidence interval.

^g Sum of the 33 types of cancer analyzed.

areas surrounding installations for the regeneration of spent baths (RRs = 1.55 and 1.29, respectively); cancers of the gallbladder, lung and pleura in men living near incinerators (RRs = 1.43, 1.19 and 1.98,

respectively); skin cancer in men, in the vicinity of solvent treatment installations (RR = 3.30); Hodgkin's lymphoma and kidney cancer in men, in the areas around physico/chemical treatment installations

Table 2

Relative risk of dying from cancers with significant results in towns situated at a distance of 5 km or less from incinerators and hazardous waste treatment installations as a whole, estimated using BYM models and shown with a breakdown by category of industrial activity. Significant results are in bold.

T ^a	Total			Men			Women			
	Obs ^b	RR ^c	95%CrI ^d	Obs	RR ^c	95%CrI ^d	Obs	RR ^c	95%CrI ^d	
All cancers^e										
Incineration	12	13,051	1.09	1.01–1.18	8385	1.09	0.99–1.19	4666	1.06	0.98–1.14
Scrap metal + ELVs	52	11,981	1.04	1.00–1.09	7668	1.06	1.00–1.12	4313	1.03	0.98–1.08
Oil + oily waste	7	8277	1.08	0.99–1.18	5214	1.09	0.99–1.21	3063	1.07	0.98–1.16
Packaging	2	2471	1.09	0.97–1.22	1591	1.13	0.98–1.29	880	1.02	0.91–1.14
Solvents	6	1108	0.97	0.87–1.08	693	0.98	0.87–1.11	415	0.95	0.84–1.08
Spent baths	15	12412	1.06	0.98–1.14	7833	1.09	1.00–1.18	4579	1.03	0.95–1.11
Physico/chemical treatment	5	369	1.11	0.97–1.26	230	1.08	0.92–1.27	139	1.15	0.95–1.37
Industrial waste	7	8261	1.07	0.98–1.17	5166	1.09	0.99–1.21	3095	1.01	0.92–1.11
Wastes not otherwise specified	1	144	0.98	0.74–1.26	93	0.99	0.71–1.33	51	0.98	0.70–1.31
Multiple pollutant categories	56	33,634	1.08	1.04–1.13	21402	1.10	1.05–1.15	12232	1.04	1.00–1.09
Stomach cancer										
Incineration	12	801	1.21	0.98–1.47	492	1.11	0.89–1.36	309	1.38	1.09–1.72
Scrap metal + ELVs	52	794	1.14	1.00–1.29	508	1.17	1.01–1.34	286	1.11	0.94–1.31
Oil + oily waste	7	522	1.22	0.97–1.51	326	1.30	1.01–1.64	196	1.10	0.83–1.42
Packaging	2	193	1.38	1.02–1.82	134	1.53	1.20–2.04	59	1.08	0.76–1.49
Solvents	6	76	1.10	0.79–1.47	50	1.15	0.79–1.60	26	1.01	0.63–1.50
Spent baths	15	842	1.23	1.00–1.48	523	1.20	0.97–1.48	319	1.20	0.96–1.49
Physico/chemical treatment	5	17	0.90	0.50–1.41	15	1.24	0.67–1.99	2	0.35	0.06–0.94
Industrial waste	7	700	1.33	1.05–1.67	407	1.22	0.94–1.55	293	1.33	1.03–1.68
Wastes not otherwise specified	1	10	1.25	0.52–2.41	7	1.47	0.53–3.01	3	1.01	0.22–2.51
Multiple pollutant categories	56	2168	1.17	1.05–1.29	1360	1.14	1.01–1.28	808	1.17	1.03–1.33
Colorectal cancer										
Incineration	12	1645	1.07	0.95–1.20	933	1.08	0.94–1.24	712	1.04	0.91–1.18
Scrap metal + ELVs	52	1583	1.05	0.97–1.14	894	1.09	0.98–1.19	689	1.04	0.93–1.14
Oil + oily waste	7	1072	1.09	0.95–1.25	576	1.09	0.92–1.27	496	1.12	0.95–1.31
Packaging	2	347	1.16	0.97–1.37	215	1.29	1.05–1.55	132	0.99	0.79–1.22
Solvents	6	148	1.05	0.85–1.27	85	1.10	0.85–1.39	63	0.99	0.74–1.28
Spent baths	15	1763	1.11	0.99–1.25	1045	1.20	1.05–1.37	718	1.04	0.90–1.20
Physico/chemical treatment	5	43	1.03	0.73–1.37	20	0.84	0.51–1.26	23	1.31	0.82–1.91
Industrial waste	7	1201	1.11	0.96–1.28	710	1.15	0.97–1.34	491	1.05	0.88–1.23
Wastes not otherwise specified	1	15	0.90	0.48–1.49	9	0.93	0.41–1.69	6	0.92	0.34–1.81
Multiple pollutant categories	56	4448	1.09	1.02–1.16	2597	1.13	1.04–1.21	1851	1.03	0.95–1.12
Liver cancer										
Incineration	12	521	1.26	0.96–1.63	375	1.28	0.97–1.66	146	1.28	0.87–1.81
Scrap metal + ELVs	52	364	1.08	0.90–1.29	273	1.13	0.92–1.36	91	0.97	0.71–1.29
Oil + oily waste	7	290	1.19	0.85–1.60	181	1.14	0.80–1.56	109	1.43	0.88–2.18
Packaging	2	80	1.24	0.83–1.78	59	1.28	0.85–1.85	21	1.14	0.60–1.93
Solvents	6	43	1.17	0.76–1.70	30	1.19	0.74–1.79	13	1.37	0.66–2.42
Spent baths	15	326	1.43	1.09–1.83	240	1.30	0.98–1.68	86	1.55	1.01–2.25
Physico/chemical treatment	5	11	1.52	0.72–2.65	8	1.51	0.64–2.81	3	1.75	0.40–4.25
Industrial waste	7	186	1.03	0.73–1.39	133	1.00	0.70–1.37	53	1.14	0.66–1.79
Wastes not otherwise specified	1	3	1.84	0.37–4.84	2	1.61	0.23–4.68	1	3.71	0.22–13.91
Multiple pollutant categories	56	1105	1.18	1.02–1.36	774	1.18	1.01–1.37	331	1.20	0.96–1.49
Gallbladder cancer										
Incineration	12	201	1.24	0.98–1.55	81	1.43	1.04–1.92	120	1.11	0.83–1.44
Scrap metal + ELVs	52	172	1.10	0.90–1.32	65	1.24	0.91–1.62	107	1.04	0.81–1.30
Oil + oily waste	7	116	1.04	0.77–1.36	43	1.23	0.79–1.78	73	1.01	0.71–1.39
Packaging	2	33	1.01	0.66–1.46	12	1.09	0.54–1.87	21	1.01	0.59–1.55
Solvents	6	17	1.22	0.69–1.92	6	1.31	0.49–2.57	11	1.21	0.59–2.07
Spent baths	15	177	1.07	0.83–1.35	64	1.25	0.85–1.76	113	0.97	0.71–1.29
Physico/chemical treatment	5	7	1.75	0.71–3.28	4	2.90	0.85–6.33	3	1.27	0.30–3.02
Industrial waste	7	104	0.94	0.69–1.23	44	1.23	0.78–1.80	60	0.84	0.57–1.17
Wastes not otherwise specified	1	3	2.08	0.47–5.13	1	2.60	0.17–9.31	2	2.24	0.35–6.31
Multiple pollutant categories	56	509	1.13	0.98–1.29	191	1.25	1.01–1.53	318	1.06	0.89–1.25
Lung cancer										
Incineration	12	2960	1.17	1.01–1.34	2682	1.19	1.01–1.38	278	0.94	0.75–1.16
Scrap metal + ELVs	52	2496	1.05	0.96–1.14	2255	1.07	0.98–1.17	241	0.88	0.74–1.05
Oil + oily waste	7	1772	1.13	0.97–1.31	1618	1.15	0.98–1.35	154	0.90	0.67–1.17
Packaging	2	474	1.03	0.85–1.24	414	1.05	0.85–1.28	60	0.96	0.67–1.32
Solvents	6	229	0.94	0.77–1.14	204	0.96	0.77–1.18	25	0.80	0.49–1.19
Spent baths	15	2485	1.12	0.99–1.27	2132	1.13	0.99–1.29	353	1.07	0.84–1.33
Physico/chemical treatment	5	82	1.24	0.94–1.58	69	1.18	0.88–1.54	13	1.72	0.89–2.82
Industrial waste	7	1570	1.09	0.94–1.26	1388	1.13	0.96–1.32	182	0.82	0.62–1.07
Wastes not otherwise specified	1	35	1.20	0.71–1.88	31	1.21	0.69–1.95	4	1.29	0.36–2.95
Multiple pollutant categories	56	7111	1.14	1.06–1.22	6363	1.17	1.08–1.26	748	0.91	0.80–1.03
Pleural cancer										
Incineration	12	55	1.55	0.94–2.39	42	1.98	1.09–3.29	13	1.16	0.52–2.15
Scrap metal + ELVs	52	38	1.37	0.87–2.01	22	1.13	0.63–1.83	16	1.93	0.99–3.27
Oil + oily waste	7	49	3.45	1.97–5.54	43	4.85	2.50–8.34	6	1.25	0.41–2.71
Packaging	2	9	1.64	0.66–3.19	7	1.88	0.65–3.98	2	1.44	0.22–4.04
Solvents	6	2	0.93	0.15–2.57	1	0.74	0.05–2.64	1	2.28	0.15–8.12
Spent baths	15	43	1.50	0.86–2.41	35	1.87	0.98–3.18	8	0.93	0.35–1.88

Table 2 (continued)

	T ^a	Total			Men			Women		
		Obs ^b	RR ^c	95%CrI ^d	Obs	RR ^c	95%CrI ^d	Obs	RR ^c	95%CrI ^d
Pleural cancer										
Physico/chemical treatment	5	1	1.78	0.12–6.32	0	0	0–inf	1	7.11	0.46–25.47
Industrial waste	7	30	1.78	0.95–2.98	20	1.82	0.83–3.35	10	1.85	0.77–3.56
Wastes not otherwise specified	1	0	0	0–inf	0	0	0–inf	0	0	0–inf
Multiple pollutant categories	56	167	1.79	1.31–2.36	114	1.90	1.32–2.64	53	1.83	1.13–2.76
Connective and soft tissue cancer										
Incineration	12	57	1.04	0.74–1.41	24	0.85	0.53–1.26	33	1.29	0.81–1.92
Scrap metal + ELVs	52	58	1.10	0.81–1.45	30	1.13	0.74–1.60	28	1.12	0.71–1.63
Oil + oily waste	7	52	1.48	1.01–2.06	22	1.32	0.80–1.99	30	1.47	0.85–2.28
Packaging	2	13	1.18	0.61–1.94	9	1.59	0.72–2.81	4	0.82	0.24–1.81
Solvents	6	2	0.40	0.07–1.08	1	0.46	0.03–1.61	1	0.52	0.04–1.83
Spent baths	15	53	1.11	0.77–1.54	27	1.15	0.72–1.70	26	1.04	0.61–1.62
Physico/chemical treatment	5	0	0	0–inf	0	0	0–inf	0	0	0–inf
Industrial waste	7	41	1.03	0.69–1.46	23	1.23	0.74–1.86	18	0.97	0.53–1.57
Wastes not otherwise specified	1	1	1.94	0.13–6.89	0	0	0–inf	1	4.38	0.28–15.77
Multiple pollutant categories	56	156	1.06	0.85–1.29	84	1.13	0.86–1.44	72	1.00	0.73–1.32
Skin cancer										
Incineration	12	39	1.12	0.71–1.66	22	1.07	0.61–1.69	17	1.15	0.58–1.99
Scrap metal + ELVs	52	35	0.92	0.61–1.30	18	0.86	0.49–1.33	17	0.99	0.55–1.59
Oil + oily waste	7	54	1.50	0.95–2.22	38	2.14	1.31–3.22	16	1.06	0.50–1.88
Packaging	2	9	1.05	0.45–1.96	8	1.70	0.71–3.18	1	0.36	0.02–1.29
Solvents	6	10	2.34	1.06–4.20	7	3.30	1.30–6.34	3	1.49	0.33–3.70
Spent baths	15	47	1.04	0.65–1.55	25	1.12	0.65–1.77	22	0.96	0.48–1.66
Physico/chemical treatment	5	0	0	0–inf	0	0	0–inf	0	0	0–inf
Industrial waste	7	41	1.00	0.60–1.55	28	1.40	0.82–2.19	13	0.68	0.29–1.29
Wastes not otherwise specified	1	1	1.76	0.11–6.44	0	0	0–inf	1	3.75	0.21–14.19
Multiple pollutant categories	56	116	1.14	0.88–1.46	62	1.07	0.77–1.45	54	1.14	0.77–1.60
Vulvar and vaginal cancer										
Incineration	12							42	1.01	0.70–1.40
Scrap metal + ELVs	52							40	1.03	0.72–1.41
Oil + oily waste	7							47	1.85	1.28–2.56
Packaging	2							6	0.81	0.30–1.59
Solvents	6							6	1.68	0.63–3.27
Spent baths	15							37	0.89	0.58–1.29
Physico/chemical treatment	5							1	1.33	0.09–4.65
Industrial waste	7							41	1.55	1.02–2.24
Wastes not otherwise specified	1							0	0	0–inf
Multiple pollutant categories	56							96	0.89	0.69–1.12
Ovarian cancer										
Incineration	12							251	1.13	0.95–1.34
Scrap metal + ELVs	52							228	1.08	0.92–1.25
Oil + oily waste	7							151	1.08	0.87–1.33
Packaging	2							59	1.34	0.99–1.75
Solvents	6							23	1.07	0.67–1.56
Spent baths	15							281	1.29	1.07–1.53
Physico/chemical treatment	5							8	1.32	0.58–2.37
Industrial waste	7							158	1.08	0.86–1.33
Wastes not otherwise specified	1							2	0.94	0.16–2.56
Multiple pollutant categories	56							691	1.15	1.03–1.27
Bladder cancer										
Incineration	12	567	1.13	0.95–1.34	474	1.13	0.94–1.36	93	0.98	0.75–1.24
Scrap metal + ELVs	52	573	1.11	0.98–1.25	483	1.16	1.02–1.32	90	0.99	0.77–1.24
Oil + oily waste	7	413	1.09	0.88–1.33	348	1.11	0.88–1.38	65	1.11	0.80–1.48
Packaging	2	128	1.27	0.98–1.62	102	1.24	0.93–1.61	26	1.43	0.90–2.09
Solvents	6	46	0.98	0.69–1.33	36	0.95	0.64–1.33	10	1.26	0.60–2.16
Spent baths	15	528	1.01	0.84–1.20	431	1.02	0.84–1.23	97	0.99	0.74–1.28
Physico/chemical treatment	5	15	1.09	0.60–1.72	13	1.16	0.61–1.89	2	1.03	0.17–2.78
Industrial waste	7	363	1.05	0.84–1.28	302	1.04	0.82–1.30	61	1.00	0.71–1.35
Wastes not otherwise specified	1	5	0.87	0.28–1.84	3	0.66	0.15–1.60	2	2.46	0.40–6.73
Multiple pollutant categories	56	1493	1.09	0.99–1.20	1227	1.09	0.98–1.21	266	1.02	0.86–1.19
Renal cancer										
Incineration	12	240	1.08	0.88–1.30	150	1.04	0.83–1.28	90	1.18	0.88–1.53
Scrap metal + ELVs	52	290	1.36	1.17–1.58	198	1.39	1.16–1.64	92	1.33	1.03–1.67
Oil + oily waste	7	151	1.14	0.90–1.44	99	1.10	0.83–1.42	52	1.17	0.81–1.63
Packaging	2	55	1.24	0.90–1.67	36	1.19	0.80–1.66	19	1.32	0.77–2.03
Solvents	6	21	0.98	0.59–1.46	12	0.84	0.43–1.39	9	1.33	0.61–2.35
Spent baths	15	284	1.06	0.86–1.27	189	1.04	0.83–1.28	95	1.16	0.86–1.52
Physico/chemical treatment	5	14	2.25	1.22–3.61	10	2.43	1.16–4.17	4	2.15	0.64–4.66
Industrial waste	7	165	0.95	0.75–1.19	107	0.95	0.73–1.22	58	1.03	0.72–1.39
Wastes not otherwise specified	1	3	1.16	0.27–2.80	3	1.77	0.41–4.26	0	0	0–inf
Multiple pollutant categories	56	695	1.11	0.99–1.25	464	1.11	0.97–1.26	231	1.12	0.93–1.33
Brain cancer										
Incineration	12	322	0.99	0.84–1.16	178	0.97	0.79–1.18	144	1.03	0.82–1.27
Scrap metal + ELVs	52	288	1.00	0.86–1.15	160	0.96	0.80–1.14	128	1.04	0.85–1.26

(continued on next page)

Table 2 (continued)

	T ^a	Total			Men			Women		
		Obs ^b	RR ^c	95%CrI ^d	Obs	RR ^c	95%CrI ^d	Obs	RR ^c	95%CrI ^d
Brain cancer										
Oil + oily waste	7	193	1.00	0.80–1.22	90	0.85	0.65–1.09	103	1.24	0.94–1.59
Packaging	2	82	1.31	0.99–1.68	51	1.41	1.01–1.90	31	1.18	0.77–1.68
Solvents	6	35	1.07	0.73–1.48	22	1.14	0.70–1.69	13	0.98	0.52–1.59
Spent baths	15	300	0.99	0.82–1.19	153	0.94	0.75–1.17	147	1.07	0.84–1.35
Physico/chemical treatment	5	7	0.75	0.31–1.39	6	1.11	0.42–2.15	1	0.37	0.03–1.30
Industrial waste	7	233	1.12	0.90–1.37	132	1.11	0.86–1.41	101	1.15	0.87–1.48
Wastes not otherwise specified	1	9	1.99	0.88–3.60	3	1.32	0.31–3.17	6	3.29	1.20–6.56
Multiple pollutant categories	56	911	1.06	0.96–1.17	490	1.01	0.89–1.14	421	1.14	0.99–1.30
Thyroid cancer										
Incineration	12	31	0.93	0.59–1.36	7	0.63	0.25–1.20	24	1.09	0.64–1.69
Scrap metal + ELVs	52	52	1.63	1.16–2.20	22	1.97	1.17–3.00	30	1.42	0.91–2.06
Oil + oily waste	7	20	1.05	0.59–1.66	6	0.89	0.33–1.77	14	1.13	0.57–1.93
Packaging	2	10	1.51	0.70–2.66	3	1.37	0.32–3.29	7	1.66	0.65–3.18
Solvents	6	5	1.68	0.57–3.45	1	1.20	0.08–4.22	4	2.16	0.63–4.75
Spent baths	15	39	1.14	0.73–1.66	14	1.31	0.67–2.22	25	1.14	0.66–1.79
Physico/chemical treatment	5	2	2.42	0.40–6.57	0	0.00	0–inf	2	3.82	0.62–10.43
Industrial waste	7	25	1.09	0.65–1.68	8	1.08	0.45–2.03	17	1.08	0.57–1.78
Wastes not otherwise specified	1	0	0	0–inf	0	0.00	0–inf	0	0	0–inf
Multiple pollutant categories	56	98	1.06	0.81–1.35	30	0.94	0.59–1.37	68	1.12	0.81–1.49
Hodgkin's lymphoma										
Incineration	12	32	0.87	0.56–1.26	18	0.90	0.51–1.41	14	0.95	0.49–1.56
Scrap metal + ELVs	52	45	1.41	0.99–1.91	27	1.52	0.97–2.21	18	1.38	0.79–2.15
Oil + oily waste	7	15	0.81	0.43–1.32	9	0.89	0.40–1.59	6	0.74	0.27–1.46
Packaging	2	4	0.63	0.19–1.38	3	0.87	0.21–2.06	1	0.53	0.04–1.84
Solvents	6	4	1.14	0.34–2.48	3	1.50	0.36–3.58	1	0.98	0.07–3.43
Spent baths	15	25	0.93	0.56–1.42	11	0.72	0.35–1.25	14	1.12	0.58–1.90
Physico/chemical treatment	5	3	3.39	0.81–8.05	3	5.64	1.34–13.43	0	0	0–inf
Industrial waste	7	16	0.78	0.42–1.26	10	0.89	0.41–1.58	6	0.71	0.26–1.41
Wastes not otherwise specified	1	1	3.46	0.23–12.26	1	5.95	0.40–21.08	0	0	0–inf
Multiple pollutant categories	56	93	1.04	0.79–1.32	48	0.96	0.67–1.30	45	1.21	0.83–1.68
Leukemia										
Incineration	16	416	1.05	0.97–1.13	245	1.08	0.98–1.18	171	1.03	0.93–1.13
Scrap metal + ELVs	56	430	1.14	1.01–1.28	227	1.09	0.93–1.26	203	1.23	1.04–1.43
Oil + oily waste	24	387	1.08	0.90–1.28	216	1.14	0.91–1.39	171	1.03	0.80–1.28
Packaging	9	135	1.15	0.89–1.44	79	1.11	0.80–1.48	56	1.21	0.85–1.64
Solvents	4	33	1.29	0.94–1.70	16	1.28	0.83–1.82	17	1.35	0.85–1.98
Spent baths	14	195	1.01	0.85–1.18	112	1.12	0.92–1.35	83	0.86	0.68–1.06
Physico/chemical treatment	8	1573	1.33	0.74–2.08	840	0.97	0.37–1.87	733	1.95	0.90–3.39
Industrial waste	13	354	1.01	0.84–1.21	188	1.04	0.83–1.28	166	0.99	0.77–1.24
Wastes not otherwise specified	11	22	1.03	0.30–2.25	12	1.40	0.33–3.34	10	0.79	0.06–2.77
Multiple pollutant categories	82	1833	1.13	1.04–1.23	1021	1.14	1.02–1.26	812	1.12	0.99–1.26

^a Number of towns situated at ≤5 km from incinerators and hazardous waste treatment installations as a whole.

^b Observed deaths.

^c RRs adjusted for population size, percentage illiteracy, farmers and unemployed persons, average persons per household, and mean income.

^d 95% credible interval.

^e Sum of the 33 types of cancer analyzed.

(RRs = 5.64 and 2.43, respectively); bladder and thyroid cancer in men and leukemias in women in the vicinity of scrap metal + ELV recycling installations (RRs = 1.16, 1.97 and 1.23, respectively); brain cancer in women living near other waste treatment installations (RR = 3.29); and cancers of the pleura in men, vulva and vagina in women, and connective tissue in the total population (RRs = 4.85, 1.85 and 1.48, respectively), in the environs of oil and oily waste treatment installations. If we analyze the results on stratifying risk by category of industrial activity, the following associations were found between malignant tumors and residential proximity to certain types of installations: a) "Incinerators", and tumors of the lung, pleura and gallbladder (men) and stomach (women); b) "Installations for the recycling of scrap metal and ELVs", and cancer of the kidney (men and women), tumors of the stomach, bladder and thyroid (men) and leukemia (women); c) "Installations for the treatment of used oil and oily waste", and cancer of the connective tissue (total population), tumors of the stomach, pleura and skin (men), and of vulva and vagina (women); d) "Packaging recycling installations", and tumors of the stomach, colon–rectum and brain (men); e) "Installations for the recovery of used solvents", and skin cancer (men); f) "Installations for the regeneration of spent baths", and cancer of the stomach (total population), colorectal cancer (men), and tumors of the liver and ovary (women); g) "Installations for physico/

chemical treatment of wastes", and cancer of the kidney (men); h) "Industrial waste treatment installations", and tumors of the stomach, vulva and vagina (women); and, i) "Installations for the treatment of wastes not otherwise specified", and cancer of the brain (women). In addition, towns situated near several installations of "Multiple pollutant categories" displayed significant results for malignant tumors of the stomach and pleura (men and women), colon–rectum, liver, gallbladder, lung and leukemia (men), and ovary (women).

Table 3 shows the RRs in the vicinity of specific incinerators and hazardous waste treatment facilities which registered statistically significant excess risks in the "near vs. far" analysis and a number of observed deaths ≥ 15. There are a total of 3 incinerators, 15 installations for the recycling of scrap metal and ELVs, 6 installations for the treatment of used oil and oily waste, 3 packaging recycling installations, 2 installations for the recovery of used solvents, 3 installations for the regeneration of spent baths, 3 installations for physico/chemical treatments of wastes, 4 industrial waste treatment installations, and 6 installations for the treatment of wastes not otherwise specified, with significant results. Many of the installations displayed considerably high RRs for more than one tumor simultaneously, and this was especially true for installations '372', '4699' and '5692' ("Scrap metal + ELVs"), '3710' ("Industrial waste"), and '6053' ("Wastes not otherwise

specified"), with statistically significant results for 6 tumors, and installations '3055' and '7476' ("Scrap metal + ELVs"), '3713' ("Spent baths"), '3110' ("Physico/chemical treatment"), '3711' ("Industrial waste"), and '7478' ("Wastes not otherwise specified"), with statistically significant results for 5 tumors. It is also noteworthy to note that there are 11 facilities with significant excess risk for all cancers combined: installations '372' (RR = 1.28 in women), '3055' (RR = 1.10 in the total population), '5692' (RR = 1.30 in women), '6051' (RR = 1.21 in women), '3050' (RR = 1.19 in women), '3110' (RR = 1.30 in women), and '7478' (RR = 1.10 in the total population), located in the province of Barcelona; installations '4699' (RR = 1.13 in men), '5910' (RR = 1.27 in men), '3710' (RR = 1.13 in men), and '3711' (RR = 1.33 in men), located in the province of Vizcaya); and, installation '5493' (RR = 1.20 in men), located in the province of Granada.

4. Discussion

This study is one of the first to use IPPC- and E-PRTR-registered industrial data to explore the effects of industrial waste-treatment on cancer mortality in neighboring towns. In general, our results suggest that there is a moderate increased risk of dying of all cancers combined, higher among men than among women, in the vicinity of Spanish incinerators and hazardous waste treatment plants as a whole. Stratifying the risk by industrial activity, high statistically significant excess risks were detected in towns lying near "Incinerators" (total population), "Installations for the recycling of scrap metal and ELVs", "Installations for the regeneration of spent baths" (men), and various installations of "Multiple pollutant categories" (men and women).

On analyzing cancers individually, significant excess risks were observed for malignant tumors of the stomach, liver, pleura and kidney (men and women), colon-rectum, lung, bladder, gallbladder and leukemia (men), and brain and ovary (women). Furthermore, on stratifying risk by category of industrial activity, the following associations were found between other malignant tumors and residential proximity to certain types of installations: "Installations for the recycling of scrap metal and ELVs", and tumors of the stomach and thyroid (men); "Installations for the treatment of used oil and oily waste", and cancer of the connective tissue (total population), tumors of the skin (men), and of the vulva and vagina (women); "Installations for the recovery of used solvents", and skin tumor (men); and, "Industrial waste treatment installations", and tumor of the vulva and vagina (women).

The fact that statistically significant results, with RRs ≥ 1.10 , appeared mainly for tumors of both the digestive and respiratory system (in total population), leads us to suspect two possible routes of exposure to the pollution released by these installations, namely: direct exposure to pollutants released to air; and indirect exposure, both to pollutants and liquid effluents which are released to water and can then pass into the soil and aquifers, and pollutants which are released to air and then settle on plants. In such cases, the toxins may pass into the trophic chain, affecting the population.

The hypothesis that some excess cancer mortality may be due to population exposure to industrial pollution is reinforced by recent studies that have reported associations between residential proximity to certain types of industrial installations and certain malignant tumors (Garcia-Perez et al., 2010, 2012; Lopez-Abente et al., 2012; Musti et al., 2009; Tsai et al., 2009). As regards incinerators and hazardous waste treatment plants, studies have almost exclusively focused on the environs of incinerators, where associations have been found with some tumors, such as NHL (Floret et al., 2003; Viel et al., 2011), soft tissue sarcomas (Comba et al., 2003), and childhood tumors (Knox, 2000).

Ecologic studies, such as that reported here, are proposing new hypotheses and lines of research with respect to population exposure to industrial pollution. In this regard, one of the principal strengths of our study resides in the completeness of its exploratory analysis, which consisted of an in-depth examination of mortality due to 33 types of cancer with reference to different categories of industrial

activity. Another strength was its use of different methodological approaches to perform the statistical analysis: one, based on a hierarchical spatial model at a municipal level, with inclusion of explanatory variables (BYM model), in which the use of spatial terms in the model, not only meant that it was less susceptible to the presence of the ecological fallacy (Clayton et al., 1993), but also ensured that the geographic heterogeneity of the distribution of mortality was taken into account; and the other, based on a Poisson mixed regression model, was justified by its ease of adjustment and shorter computation times. Although the results in the two models used are not very different in general, the presence of spatial autocorrelation in some of the tumors studied renders the use of spatial models advisable. Moreover, the method of estimation afforded by INLA, as an alternative to Markov chain Monte Carlo methods, amounts to a qualitative leap in the use of hierarchical models with explanatory variables (Rue et al., 2009). A consideration to bear in mind is that mixed models seem to be more sensitive to detect potential statistical associations than spatial models, which are more restrictive. An example of the above mentioned can be seen in our results on NHL in males, where the mixed model provided statistically significant results (RR = 1.12, 95%CI = 1.03–1.22) whereas the model BYM did not show a statistically significant association (RR = 1.07, 95%CI = 0.97–1.19).

Further advantages of the study are: its high statistical power, thanks to the inclusion of a great number of reported deaths, a factor that enables it to identify excess mortality of a lower magnitude, in line with the expected effects of environmental exposures; analysis of risk in the vicinity of industrial activities such as ELV-disposal or scrap-metal recycling plants, which had never before been studied as a whole, as well as detailed individual analyses of the respective installations; elimination for study purposes of those installations that had come into operation most recently, and whose possible influence on tumor development is debatable if the minimum latency periods of the tumors analyzed are taken into account; and inclusion of towns lying close to industries other than incinerators and hazardous waste treatment installations, as the "intermediate category" in the analyses, something that avoids the confounding effect of such industries (which release toxic substances that could be related to the tumors under study) and allows for the establishment of a "clean" reference group made up of towns having no industry in their vicinity.

Aside from the limitations inherent to all ecologic studies, in our case mention should also be made of the following: the inclusion of many variables in the models that could make the analyses very susceptible to type I error; the non-inclusion of possible confounding factors that might be associated with distance (though adjustment for socioeconomic variables goes some way to mitigating this lack of information, since many life-style-related risk factors, such as smoking, alcohol consumption, type of diet or infectious agents, show a distribution correlated with socioeconomic status (Prattala et al., 2009; Woitas-Slubowska et al., 2010)); the use of distance from town of residence to industrial centers as a "proxy" of population exposure to industrial pollution, based on the assumption of an isotropic model, since real exposure may depend on prevailing wind patterns or geographical landforms (though this would limit the capacity for detecting positive results, without invalidating the associations found); and the use of mortality rather than incidence data, due to the absence of a national population-based incidence register (though in Spain, tumors with lower survival rates are well represented by death certificates (Perez-Gomez et al., 2006)).

A critical decision when designing the study was the choice of categories of industrial activity for stratifying risk in the analyses. In this respect, we chose to construct the categories according to the characteristics of the waste applicable and type of treatment used (Agència de Residus de Catalunya, 2012; Special Territorial Plan of Waste Management (PTEOR), 2012). Furthermore, landfills, composting

Table 3

Relative risk of dying from cancers with significant results and a number of observed deaths ≥ 15 in towns situated at a distance of less than 5 km from specific incinerators and hazardous waste treatment installations, estimated using BYM models. Significant results are in bold.

Industrial activity ^a	PRTR Code	T ^b	Obs ^c	BYM model		Industrial activity ^a	PRTR code	T ^b	Obs ^c	BYM model	
				RR ^d	95% CrI ^e					RR ^d	95% CrI ^e
All cancers^f											
2	372	Total	4	949	1.11 1.01–1.23	2	5680	Total	5	24	1.94 1.11–3.09
		Men	4	591	1.03 0.91–1.17			Men	5	12	1.35 0.61–2.47
		Women	4	358	1.28 1.10–1.48			Women	5	12	3.15 1.38–5.95
2	3055	Total	5	1370	1.10 1.00–1.20	2	5691	Total	3	27	2.08 1.27–3.14
		Men	5	916	1.10 0.98–1.22			Men	3	15	2.06 1.07–3.47
		Women	5	454	1.09 0.95–1.25			Women	3	12	2.16 1.02–3.84
2	4699	Total	6	4803	1.10 0.99–1.21	2	7476	Total	2	137	1.36 0.90–1.95
		Men	6	3184	1.13 1.00–1.27			Men	2	71	1.09 0.62–1.77
		Women	6	1619	1.04 0.91–1.19			Women	2	66	1.86 1.04–3.06
2	5692	Total	3	864	1.09 0.98–1.21	7	3110	Total	3	32	1.27 0.77–1.94
		Men	3	531	0.99 0.87–1.13			Men	3	23	1.86 1.05–3.00
		Women	3	333	1.30 1.11–1.51			Women	3	9	0.76 0.31–1.45
2	6051	Total	3	2441	1.11 1.00–1.23	8	65	Total	2	388	1.67 1.01–2.60
		Men	3	1612	1.06 0.94–1.20			Men	2	202	2.08 1.08–3.66
		Women	3	829	1.21 1.04–1.39			Women	2	186	1.30 0.61–2.41
3	5493	Total	3	561	1.18 1.00–1.38	8	6749	Total	9	299	1.30 0.85–1.90
		Men	3	350	1.20 1.00–1.42			Men	9	153	1.79 1.03–2.89
		Women	3	211	1.11 0.90–1.36			Women	9	146	0.93 0.49–1.58
3	5910	Total	3	472	1.25 1.08–1.43	9	6053	Total	2	137	1.36 0.90–1.95
		Men	3	309	1.27 1.07–1.51			Men	2	71	1.10 0.62–1.78
		Women	3	163	1.21 0.97–1.47			Women	2	66	1.84 1.03–3.05
4	3050	Total	3	1308	1.12 1.01–1.24						
		Men	3	847	1.08 0.95–1.23						
		Women	3	461	1.19 1.02–1.38						
7	3110	Total	3	654	1.09 0.97–1.22	6	3713	Total	6	42	2.00 0.59–5.00
		Men	3	398	0.99 0.86–1.14			Men	6	19	9.04 4.80–32.66
		Women	3	256	1.30 1.09–1.52			Women	6	23	0.93 0.22–2.80
8	3710	Total	6	4803	1.10 0.99–1.21						
		Men	6	3184	1.13 1.00–1.27						
		Women	6	1619	1.04 0.91–1.19						
8	3711	Total	4	713	1.26 1.11–1.42	2	3055	Total	4	21	1.91 1.02–3.21
		Men	4	478	1.33 1.14–1.54			Men	4	21	2.11 1.12–3.58
		Women	4	235	1.13 0.93–1.35			Women	4	0	0–inf
9	7478	Total	5	1370	1.10 1.00–1.20						
		Men	5	916	1.10 0.98–1.22						
		Women	5	454	1.09 0.95–1.25						
Esophageal cancer											
2	3055	Total	5	45	1.59 1.00–2.38						
		Men	5	44	1.74 1.08–2.64						
		Women	5	1	0.47 0.05–1.51						
9	7478	Total	5	45	1.59 1.00–2.38						
		Men	5	44	1.74 1.08–2.64						
		Women	5	1	0.47 0.05–1.51						
Lung cancer											
2	6049	Total	5	49	1.63 0.96–2.58	2	7476	Total	2	566	1.39 1.05–1.81
		Men	5	27	1.35 0.73–2.29			Men	2	511	1.43 1.07–1.90
		Women	5	22	2.26 1.00–4.29			Women	2	55	1.04 0.55–1.84
3	5493	Total	3	36	1.31 0.82–1.94						
		Men	3	25	1.73 1.02–2.68						
		Women	3	11	0.82 0.36–1.51						
6	4719	Total	8	43	1.72 1.03–2.69	3	7412	Total	1	819	1.31 0.97–1.71
		Men	8	31	1.60 0.87–2.70			Men	1	743	1.40 1.02–1.87
		Women	8	12	1.98 0.77–4.07			Women	1	76	0.81 0.43–1.38
6	4833	Total	2	94	1.59 1.05–2.32	5	1678	Total	2	164	1.24 0.98–1.56
		Men	2	44	1.27 0.73–2.05			Men	2	143	1.29 1.00–1.63
		Women	2	50	2.26 1.24–3.78			Women	2	21	0.89 0.50–1.46
Stomach cancer											
2	372	Total	4	134	1.25 0.98–1.58	8	3711	Total	6	990	1.20 0.96–1.48
		Men	4	71	1.14 0.82–1.52			Men	6	893	1.30 1.02–1.64
		Women	4	63	1.41 1.00–1.92			Women	6	97	0.77 0.47–1.19
2	4699	Total	6	605	1.19 0.95–1.47	9	6053	Total	3	135	1.39 1.04–1.81
		Men	6	380	1.35 1.02–1.74			Men	3	120	1.33 0.98–1.76
		Women	6	225	1.00 0.72–1.37			Women	3	15	2.27 1.06–4.14
2	7476	Total	2	433	1.35 1.04–1.72						
		Men	2	247	1.48 1.09–1.96						
		Women	2	186	1.23 0.81–1.75						
6	3713	Total	6	1976	1.19 0.96–1.46	2	4699	Total	6	30	4.75 0.74–13.97
		Men	6	1182	1.34 1.03–1.72			Men	6	25	4.33 4.56–13.64
		Women	6	794	1.03 0.74–1.38			Women	6	5	inf 0–inf
						6	3713	Total	6	61	2.82 0.73–9.02

Table 3 (continued)

Industrial activity ^a	PRTR Code	T ^b	Obs ^c	BYM model		Industrial activity ^a	PRTR code	T ^b	Obs ^c	BYM model	
				RR ^d	95% CrI ^e					RR ^d	95% CrI ^e
Colorectal cancer						Pleural cancer					
7	3110	Total	3	87	1.14 0.86–1.49						
		Men	3	41	0.92 0.62–1.31						
		Women	3	46	1.49 1.01–2.09	8	65				
8	3710	Total	6	605	1.19 0.95–1.47						
		Men	6	380	1.35 1.02–1.74						
		Women	6	225	1.00 0.72–1.37	8	3710				
9	6053	Total	2	433	1.35 1.04–1.71						
		Men	2	247	1.47 1.08–1.95						
		Women	2	186	1.23 0.81–1.75	8	6749				
Liver cancer											
2	7476	Total	2	99	2.40 1.40–3.87						
		Men	2	73	2.59 1.42–4.36						
		Women	2	26	2.29 0.75–5.34						
3	1612	Total	1	176	2.25 1.23–3.77	1	467				
		Men	1	102	1.91 0.92–3.56						
		Women	1	74	3.79 1.32–8.43	1	4857				
6	4833	Total	2	58	2.51 0.98–5.29						
		Men	2	34	2.12 0.69–4.96						
		Women	2	24	3.65 1.08–9.53	6	3713				
9	6053	Total	2	99	2.36 1.37–3.79						
		Men	2	73	2.56 1.40–4.30						
		Women	2	26	2.17 0.71–5.08	8	65				
Connective and soft tissue						III-defined tumors					
3	6789	Total	2	34	2.55 0.62–7.25	2	5664				
		Men	2	19	9.41 3.10–35.45						
		Women	2	15	0.90 0.02–3.65						
8	6749	Total	9	36	2.28 0.52–6.03	2	5682				
		Men	9	19	6.65 4.82–23.45						
		Women	9	17	0.93 0.11–3.55						
Melanoma						6	4833				
2	5063	Total	1	16	19.55 10.16–79.17						
		Men	1	10	NE ^g NE ^g						
		Women	1	6	NE ^g NE ^g						
6	3713	Total	6	114	1.80 0.82–3.46	1	467				
		Men	6	56	1.54 0.55–3.49						
		Women	6	58	2.58 1.18–6.89						
Skin cancer						1	4857				
3	7412	Total	1	39	6.39 1.35–17.89						
		Men	1	29	17.38 2.92–52.97	2	5692				
		Women	1	10	3.04 0.35–10.62						
Vulvar and vaginal cancer						2	6051				
3	7412	Women	1	21	6.66 1.06–23.49						
Uterine cancer											
4	5557	Women	1	27	2.12 1.00–3.94	3	5910				
8	3711	Women	4	15	2.27 1.05–4.17						
Ovarian cancer						8	3711				
1	2438	Women	2	51	1.95 1.09–3.29						
2	5685	Women	4	17	2.72 1.38–4.70						
2	7328	Women	3	15	2.68 1.39–4.48						
3	445	Women	8	156	1.49 1.03–2.09	2	372				
4	3050	Women	3	28	1.82 1.04–2.94						
4	5557	Women	1	36	2.45 1.24–4.31						
5	2999	Women	3	16	2.58 1.29–4.52						
7	3110	Women	3	17	1.98 1.02–3.39						
7	3452	Women	4	57	2.39 1.39–3.84						
9	6431	Women	7	151	1.46 1.00–2.06	2	5692				
Prostate cancer											
3	5493	Men	3	43	1.66 1.10–2.38	6	3713				
Bladder cancer											
2	5680	Total	5	24	2.39 1.34–3.86	7	3110				
		Men	5	21	2.68 1.45–4.45						
		Women	5	3	1.36 0.24–3.76						
2	7476	Total	2	116	1.48 0.93–2.19	7	3452				

(continued on next page)

Table 3 (continued)

Industrial activity ^a	PRTR Code	T ^b	Obs ^c	BYM model		Industrial activity ^a	PRTR code	T ^b	Obs ^c	BYM model				
				RR ^d	95% CrI ^e					RR ^d	95% CrI ^e			
Bladder cancer						Myeloma								
				Men	2	97	1.68	1.03–2.56		Men	4	23	1.73	0.78–3.34
				Women	2	19	0.85	0.33–1.81		Women	4	31	2.24	1.05–4.32
9	6053	Total	2	116	1.47	0.92–2.19	9	7478	Total	5	31	1.91	1.11–3.04	
		Men	2	97	1.67	1.01–2.55			Men	5	20	2.25	1.09–4.09	
		Women	2	19	0.86	0.33–1.81			Women	5	11	1.56	0.64–3.09	
Brain cancer						Leukemia								
1	2438	Total	2	69	1.14	0.70–1.79	2	372	Total	4	42	1.59	1.03–2.30	
		Men	2	27	0.78	0.37–1.66			Men	4	22	1.27	0.72–2.05	
		Women	2	42	2.05	1.01–3.72			Women	4	20	2.28	1.16–3.98	
2	372	Total	4	30	1.49	0.89–2.31	2	3055	Total	5	59	1.58	1.08–2.23	
		Men	4	13	0.99	0.47–1.78			Men	5	36	1.56	0.96–2.38	
		Women	4	17	2.59	1.17–4.92			Women	5	23	1.69	0.90–2.87	
2	4699	Total	6	111	1.42	0.92–2.10	2	3594	Total	10	50	1.63	1.06–2.40	
		Men	6	59	1.90	1.04–3.20			Men	10	28	1.70	0.96–2.79	
		Women	6	52	1.12	0.59–1.90			Women	10	22	1.65	0.84–2.88	
2	5692	Total	3	27	1.43	0.84–2.25	2	4699	Total	6	136	1.24	0.82–1.80	
		Men	3	12	0.98	0.45–1.78			Men	6	77	0.96	0.58–1.51	
		Women	3	15	2.50	1.09–4.86			Women	6	59	1.97	1.01–3.49	
3	5910	Total	3	16	2.25	1.11–3.95	2	5680	Total	5	16	2.31	1.18–3.95	
		Men	3	8	2.63	0.94–5.52			Men	5	10	2.83	1.16–5.51	
		Women	3	8	2.05	0.73–4.36			Women	5	6	1.92	0.63–4.13	
4	3050	Total	3	46	1.60	1.02–2.40	2	5692	Total	3	39	1.60	1.03–2.35	
		Men	3	25	1.36	0.76–2.24			Men	3	20	1.26	0.69–2.05	
		Women	3	21	2.14	1.03–3.92			Women	3	19	2.37	1.19–4.18	
7	2088	Total	3	37	1.91	1.02–3.24	2	6051	Total	3	81	1.28	0.85–1.86	
		Men	3	22	1.97	0.84–3.86			Men	3	43	1.01	0.60–1.60	
		Women	3	15	1.88	0.68–4.12			Women	3	38	2.02	1.02–3.67	
8	3710	Total	6	111	1.42	0.92–2.10	3	6789	Total	2	147	2.11	1.13–3.65	
		Men	6	59	1.90	1.04–3.20			Men	2	85	2.87	1.25–5.82	
		Women	6	52	1.12	0.59–1.90			Women	2	62	1.57	0.63–3.27	
8	3711	Total	4	25	2.42	1.31–4.03	4	3120	Total	5	49	1.60	1.07–2.29	
		Men	4	14	3.42	1.47–6.66			Men	5	25	1.25	0.72–1.97	
		Women	4	11	1.78	0.70–3.60			Women	5	24	2.37	1.26–4.05	
9	2089	Total	3	43	1.92	1.03–3.28	8	3710	Total	6	136	1.24	0.82–1.80	
		Men	3	22	1.52	0.62–3.07			Men	6	77	0.96	0.58–1.51	
		Women	3	21	2.47	0.94–5.31			Women	6	59	1.97	1.01–3.49	
9	7403	Total	3	43	1.92	1.03–3.28	9	5703	Total	5	49	1.60	1.07–2.29	
		Men	3	22	1.52	0.62–3.07			Men	5	25	1.25	0.72–1.97	
		Women	3	21	2.47	0.94–5.31			Women	5	24	2.37	1.26–4.05	
Thyroid cancer						9		6053	Total	2	109	1.65	1.00–2.51	
1	467	Total	3	21	1.11	0.38–2.59			Men	2	57	1.69	0.89–2.88	
		Men	3	6	0.66	0.13–2.18			Women	2	52	1.78	0.97–3.00	
		Women	3	15	2.05	1.52–6.14								
1	4857	Total	3	21	1.10	0.38–2.57		7478	Total	5	59	1.58	1.08–2.23	
		Men	3	6	0.65	0.14–2.14			Men	5	36	1.56	0.96–2.38	
		Women	3	15	2.04	1.49–6.13			Women	5	23	1.69	0.90–2.87	

^a 1 = incineration. 2 = scrap metal + ELVs. 3 = oil + oily waste. 4 = packaging. 5 = solvents. 6 = spent baths. 7 = physico/chemical treatment. 8 = industrial waste. 9 = wastes not otherwise specified.

^b Number of towns situated at ≤5 km from specific incinerators and hazardous waste treatment installations.

^c Observed deaths.

^d RRs adjusted for population size, percentage illiteracy, farmers and unemployed persons, average persons per household, and mean income.

^e 95% credible interval.

^f Sum of the 33 types of cancer analyzed.

^g Not estimated: risk could not be estimated using INLA.

plants, and waste water treatment facilities were not included in our study, since they do not come under IPPC categories 5.1 and 5.2.

Another aspect to consider is that poor communities are forced to live in polluted areas, near waste and industrial sites (Parodi et al., 2005), so it is particularly important to emphasize that the results and conclusions are not simply a reflection of socioeconomic status.

4.1. Incinerators

Incineration is a thermal treatment that generates recognized and suspected carcinogens such as dioxins, arsenic, chromium, benzene, PAHs, cadmium, lead, tetrachloroethylene, hexachlorobenzene, nickel, and naphthalene (European Commission, 2006).

Epidemiologic studies addressing increases in cancer in towns lying in the vicinity of incinerators have provided limited evidence (Porta et al., 2009): the results of a study on incidence of cancer in the environs of 72 incinerators in the United Kingdom (Elliott et al., 1996) which showed statistically significant increases in certain cancers, were critically reviewed (Elliott et al., 2000) and, according to the authors, these results could be affected by different biases, which would in turn mean that the observed effects would not be attributable to incinerator emissions. Nevertheless, studies undertaken in other countries have reported excess risks for hematologic tumors, lung cancer, and some cancers of the digestive system (Biggeri et al., 1996; Comba et al., 2003; Floret et al., 2003; Knox, 2000; Ranzi et al., 2011; Viel et al., 2011).

The results reported in our study show excess risks for all cancers combined and for lung cancer, and in particular, marked increases in risk of tumors of the pleura and gallbladder (men) and stomach (women). Individualized analyses of the installations revealed statistically significant RRs in NHL in the vicinity of installations '467' and '4857' situated in the same town, as well as high excess risks of tumors of the ovary and brain in women in the environs of incinerator '2438'.

4.2. Installations for the recycling of scrap metal and scrapping of motor vehicles

One of the most surprising results of our study is the excess risk detected – statistically significant in all cancers combined, malignant tumors of the stomach, bladder, and thyroid (in men), renal cancer (in men and women), and leukemia (in women), and very close to statistical significance in malignant tumors of the colon-rectum and lung (in men), pleural cancer (in women), and Hodgkin's lymphoma (in the total population) – in the vicinity of installations engaged in the recycling of scrap metal and the scrapping/decontamination of ELVs. The reason for pooling these activities into one category for analysis purposes was because, until relatively recently, these types of waste came within the scope of the Spanish scrap metal sector (Muñoz et al., 2011). In Europe, ELVs have been defined as hazardous waste since 2002, due to the toxic composition of their constituent materials, i.e., used oils, brake liquid, oil filters, absorbent materials, batteries, and fuel. The treatment applied by these types of installations (Joung et al., 2007; Nourredine, 2007; Santini et al., 2012) generates recognized and suspected carcinogens, such as dioxins, furans, dioxin-like PCBs, lead, chromium, PAHs, cadmium or nickel, and other hazardous substances, such as shredder dusts.

To the best of our knowledge, no epidemiologic studies have been conducted on populations living near these types of installations. Insofar as occupational exposure is concerned, some studies have reported associations between organic dust exposure and gastrointestinal (e.g., stomach) and respiratory problems among workers at material recovery and recycling facilities (Gladding et al., 2003; Ivens et al., 1997). The point should be made, however, that there are studies which have assessed exposure to ionizing radiation and radioactive materials among scrap metal-processing and -recycling workers (Lubena and Yusko, 1998; Vearrier et al., 2009); these agents are recognized carcinogens for leukemia and thyroid cancer and could be related with significant excess risk of these tumors detected in the proximity of these installations by our study.

4.3. Installations for treatment of used oils and oily waste

These installations include the treatment (cleaning, re-refining, thermal fractionation, gasification and distillation) of all types of used oils and oily waste, and decontamination of equipment contaminated by PCBs, a group of organochlorine substances defined as oil waste by the European Waste Catalogue and Hazardous Waste List (Environmental Protection Agency, 2002). Among the substances released by these installations are recognized and suspected carcinogens, such as dioxins, arsenic, PAHs, benzene, chromium, nickel, lead, naphthalene or tetrachloroethylene.

To our knowledge, there are no epidemiologic or occupational studies of populations living near these types of installations. In this respect, therefore, our study is a pioneer in terms of analyzing the risk of dying due to cancer in the environs of such pollution sources and, indeed, detecting high excess risks for malignant tumors of the connective tissue (total population), pleura, skin, and stomach (men), and vulva and vagina (women). Some of these installations carry out oil re-refining, an activity which may involve significant levels of polycyclic aromatic compounds and PCBs derived from comingling used cutting oils with used engine and transformer oils (Hewstone, 1994). Long-term exposure to certain cutting fluids and

mineral oils is known to be associated with an increase in certain occupational cancers, such as those of stomach and skin (DHHS (NIOSH), 1998; Mackerer, 1989). This could account for the excess risks observed in these tumors, given that they were only found in men, and would suggest a possible occupational exposure, assuming that workers' residence was homogenously distributed.

4.4. Installations for the regeneration of spent baths

In metal-scaling operations (i.e., immersion of metals, such as stainless steel, in acid baths to eliminate the layer of oxides formed on their surface after thermal treatments), a large quantity of effluents is discharged from spent baths in Europe every year (Frias and Perez, 1998). These effluents represent a serious environmental problem, as they are a type of waste that contains nitrates, fluorides, acids, and heavy metals (Singhal et al., 2006; Vijay and Sihorwala, 2003). In addition, treatment of such wastes gives rise to exposure to radioactive materials among workers at these plants (Donzella et al., 2007). Our study observed a statistically significant increase in the overall risk of dying from all cancers (men) in the vicinity of these installations, and particularly so in the case of malignant tumors of the stomach (total population), colon-rectum (men), liver (women) and ovary, and close to statistical significance in tumors of the lung and pleura (men).

5. Conclusion

Our results support the hypothesis of a statistically significant higher risk, among men and women alike, of dying from all cancers in towns situated near incinerators and hazardous waste treatment plants, and specifically, a higher excess risk in respect of tumors of the stomach, liver, pleura, kidney, and ovary. Furthermore, this is one of the first studies to analyze the risk of dying of cancer related with specific industrial activities in this sector at a national level, and to highlight the excess risk observed in the vicinity of incinerators and installations for the recycling of scrap metal and scrapping of ELVs, regeneration of spent baths, and treatment of oil and oily waste.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <http://dx.doi.org/10.1016/j.envint.2012.10.003>.

References

- Agència de Residus de Catalunya. Type of waste; 2012. Available: http://www20.gen.cat/portal/site/arc/menuitem.0b722e55d906c87b624a1d25b0c0e1a0/?vgnextoid=04082010862b6210VgnVCM1000008d0c1e0aRCRD&vgnextchannel=04082010862b6210VgnVCM1000008d0c1e0aRCRD&vgnextfnt=default&newLang=en_GB [accessed 24 September 2012].
- Ayuso Orejana J, Fernández Cuesta JA, Plaza Ibeas JL. Anuario del Mercado Español. Madrid: Banco Español de Crédito; 1993.
- Besag J, York J, Mollié A. Bayesian image restoration, with two applications in spatial statistics (with discussion). Ann Inst Stat Math 1991;43:1–59.
- Biggeri A, Barbone F, Lagazio C, Bovenzi M, Stanta G. Air pollution and lung cancer in Trieste, Italy: spatial analysis of risk as a function of distance from sources. Environ Health Perspect 1996;104:750–4.
- Bivand RS, Pebesma EJ, Gomez-Rubio V. Applied spatial data analysis with R. New York: Springer; 2008.
- Clayton DG, Bernardinelli L, Montomoli C. Spatial correlation in ecological analysis. Int J Epidemiol 1993;22:1193–202.

- Comba P, Ascoli V, Belli S, Benedetti M, Gatti L, Ricci P, et al. Risk of soft tissue sarcomas and residence in the neighbourhood of an incinerator of industrial wastes. *Occup Environ Med* 2003;60:680–3.
- DHHS (NIOSH). Criteria for a recommended standard: occupational exposure to metalworking fluids. No. 98–102. National Institute for Occupational Safety and Health; 1998.
- Donzella A, Formisano P, Giroletti E, Zenoni A. Risk assessment for chemical pickling of metals contaminated by radioactive materials. *Radiat Prot Dosimetry* 2007;123:74–82.
- Dummer TJ, Dickinson HO, Parker L. Adverse pregnancy outcomes around incinerators and crematoriums in Cumbria, north west England, 1956–93. *J Epidemiol Community Health* 2003;57:456–61.
- Elliott P, Shaddick G, Kleinschmidt I, Jolley D, Walls P, Beresford J, et al. Cancer incidence near municipal solid waste incinerators in Great Britain. *Br J Cancer* 1996;73:702–10.
- Elliott P, Eaton N, Shaddick G, Carter R. Cancer incidence near municipal solid waste incinerators in Great Britain. Part 2: histopathological and case-note review of primary liver cancer cases. *Br J Cancer* 2000;82:1103–6.
- Environmental Protection Agency. European waste catalogue and hazardous waste list; 2002. Available: http://www.environ.ie/en/Publications/Environment/Waste/WEEE/FileDownload_1343.en.pdf. [accessed 24 September 2012].
- European Commission. Integrated pollution prevention and control (IPPC). Reference document on best available techniques for the waste incineration; 2006. Available: <http://www.pprr-es.es/data/images/BREF%20Incineraci%C3%B3n%20de%20Residuos-43EA4732C41F2B44.pdf> [accessed 24 September 2012].
- Federico M, Pirani M, Rashid I, Caranci N, Cirilli C. Cancer incidence in people with residential exposure to a municipal waste incinerator: an ecological study in Modena (Italy), 1991–2005. *Waste Manag* 2010;30:1362–70.
- Floret N, Mauny F, Challier B, Arveux P, Cahn JY, Viel JF. Dioxin emissions from a solid waste incinerator and risk of non-Hodgkin lymphoma. *Epidemiology* 2003;14:392–8.
- Frias O, Perez O. Acids and metals recovery from spent pickling baths of stainless steels. *Rev Metal Madrid* 1998;34:427–31.
- Garcia-Perez J, Lopez-Cima MF, Boldo E, Fernandez-Navarro P, Aragones N, Pollan M, et al. Leukemia-related mortality in towns lying in the vicinity of metal production and processing installations. *Environ Int* 2010;36:746–53.
- Garcia-Perez J, Lopez-Cima MF, Pollan M, Perez-Gomez B, Aragones N, Fernandez-Navarro P, et al. Risk of dying of cancer in the vicinity of multiple pollutant sources associated with the metal industry. *Environ Int* 2012;40:116–27.
- Gelman A, Hill J. Data analysis using regression and multilevel/hierarchical models. New York: Cambridge University Press; 2007.
- Gladding T, Thorn J, Stott D. Organic dust exposure and work-related effects among recycling workers. *Am J Ind Med* 2003;43:584–91.
- Hewstone RK. Health, safety and environmental aspects of used crankcase lubricating oils. *Sci Total Environ* 1994;156:255–68.
- IARC. Monographs on the evaluation of carcinogenic risks to humans. Volume 69: polychlorinated dibenzo-*para*-dioxins and polychlorinated dibenzofurans; 1997. Available: <http://monographs.iarc.fr/ENG/Monographs/vol69/volume69.pdf> [accessed 24 September 2012].
- Ivenz Ul, Ebbehob N, Poulse OM, Skov T. Gastrointestinal symptoms among waste recycling workers. *Ann Agric Environ Med* 1997;4:153–7.
- Joung HT, Seo YC, Kim KH. Distribution of dioxins, furans, and dioxin-like PCBs in solid products generated by pyrolysis and melting of automobile shredder residues. *Chemosphere* 2007;68:1636–41.
- Knox E. Childhood cancers, birthplaces, incinerators and landfill sites. *Int J Epidemiol* 2000;29:391–7.
- Landrigan PJ, Halper LA, Silbergeld EK. Toxic air pollution across a state line: implications for the siting of resource recovery facilities. *J Public Health Policy* 1989;10:309–23.
- Leem JH, Lee DS, Kim J. Risk factors affecting blood PCDDs and PCDFs in residents living near an industrial incinerator in Korea. *Arch Environ Contam Toxicol* 2006;51:478–84.
- Lopez-Abente G, Ramis R, Pollan M, Perez-Gomez B, Gomez-Barroso D, Carrasco JM, et al. Atlas municipal de mortalidad por cáncer en España, 1989–1998. Instituto de Salud Carlos III; 2006.
- Lopez-Abente G, Fernandez-Navarro P, Boldo E, Ramis R, Garcia-Perez J. Industrial pollution and pleural cancer mortality in Spain. *Sci Total Environ* 2012;424:57–62.
- Lopez-Cima MF, Garcia-Perez J, Perez-Gomez B, Aragones N, Lopez-Abente G, Tardon A, et al. Lung cancer risk and pollution in an industrial region of Northern Spain: a hospital-based case-control study. *Int J Health Geogr* 2011;10:10.
- Lubenu JO, Yusko JG. Radioactive materials in recycled metals—an update. *Health Phys* 1998;74:293–9.
- Mackerer CR. Health effects of oil mists: a brief review. *Toxicol Ind Health* 1989;5:429–40.
- Ministerio de Agricultura Alimentación y Medio Ambiente. SIGPAC; 2012. Available: <http://sigpac.mapa.es/fea/visor/>. [accessed 24 September 2012].
- Miyake Y, Yura A, Misaki H, Ikeda Y, Usui T, Iki M, et al. Relationship between distance of schools from the nearest municipal waste incineration plant and child health in Japan. *Eur J Epidemiol* 2005;20:1023–9.
- Muñoz C, Vidal MR, Justel D. Análisis ambiental del proceso de fin de vida de vehículos en España; 2011. Available: <http://www.gid.uji.es/sites/default/files/libros/Analisis%20ambiental%20del%20proceso%20de%20fin%20de%20vida%20de%20vehiculos.pdf> [accessed 24 September 2012].
- Musti M, Pollice A, Cavone D, Dragonieri S, Bilancia M. The relationship between malignant mesothelioma and an asbestos cement plant environmental risk: a spatial case-control study in the city of Bari (Italy). *Int Arch Occup Environ Health* 2009;82:489–97.
- Nourreddine M. Recycling of auto shredder residue. *J Hazard Mater* 2007;139:481–90.
- Parodi S, Stagnaro E, Casella C, Puppo A, Daminelli E, Fontana V, et al. Lung cancer in an urban area in Northern Italy near a coke oven plant. *Lung Cancer* 2005;47:155–64.
- Perez-Gomez B, Aragones N, Pollan M, Suarez B, Llorente V, Llacer A, et al. Accuracy of cancer death certificates in Spain: a summary of available information. *Gac Sanit* 2006;20(Suppl. 3):42–51.
- Porta D, Milani S, Lazzarino AI, Perucci CA, Forastiere F. Systematic review of epidemiological studies on health effects associated with management of solid waste. *Environ Health* 2009;8:60.
- Prattala R, Hakala S, Roskam AJ, Roos E, Helmert U, Klumbiene J, et al. Association between educational level and vegetable use in nine European countries. *Public Health Nutr* 2009;12:2174–82.
- Ranzi A, Fano V, Ersamer L, Lauriola P, Perucci CA, Forastiere F. Mortality and morbidity among people living close to incinerators: a cohort study based on dispersion modeling for exposure assessment. *Environ Health* 2011;10:22.
- Rue H, Martino S, Chopin N. Approximate Bayesian inference for latent Gaussian models using integrated nested Laplace approximations (with discussion). *J R Stat Soc Ser B* 2009;71:319–92.
- Santini A, Passarini F, Vassura I, Serrano D, Dufour J, Morselli L. Auto shredder residue recycling: mechanical separation and pyrolysis. *Waste Manag* 2012;32:852–8.
- Singhal A, Tewari VK, Prakash S. A study on sludge minimization during the treatment of pickling effluent. *J Environ Sci Eng* 2006;48:109–12.
- Special Territorial Plan of Waste Management (PTEOR). Appendix I: Study of national and international waste management models (Anexo I: Estudio nacional e internacional de modelos de gestión de residuos); 2012. Available: http://www.tenerife.es/planes/PTEORResiduos/adjuntos/Anexo01_Info13.pdf. [accessed 24 September 2012].
- The R-INLA project; 2012. Available: <http://www.r-inla.org/>. [accessed 24 September 2012].
- Tsai SS, Tiao MM, Kuo HW, Wu TN, Yang CY. Association of bladder cancer with residential exposure to petrochemical air pollutant emissions in Taiwan. *J Toxicol Environ Health A* 2009;72:53–9.
- United Nations Scientific Committee on the Effects of Atomic Radiation. UNSCEAR 2006 report: volume I – annex A: epidemiological studies of radiation and cancer; 2006. Available: <http://www.unscear.org/unscear/en/publications.html>. [accessed 24 September 2012].
- Vearrier D, Curtis JA, Greenberg MI. Technologically enhanced naturally occurring radioactive materials. *Clin Toxicol (Phila)* 2009;47:393–406.
- Viel JF, Daniau C, Goria S, Fabre P, Crouy-Chanel P, Sauleau EA, et al. Risk for non Hodgkin's lymphoma in the vicinity of French municipal solid waste incinerators. *Environ Health* 2008;7:51.
- Viel JF, Floret N, Deconinck E, Focant JF, De Pauw E, Cahn JY. Increased risk of non-Hodgkin lymphoma and serum organochlorine concentrations among neighbors of a municipal solid waste incinerator. *Environ Int* 2011;37:449–53.
- Vijay R, Sihorwala TA. Identification and leaching characteristics of sludge generated from metal pickling and electroplating industries by toxicity characteristics leaching procedure (TCLP). *Environ Monit Assess* 2003;84:193–202.
- Wojtas-Slubowska D, Hurnik E, Skarpanska-Stejnborn A. Correlates of smoking with socioeconomic status, leisure time physical activity and alcohol consumption among Polish adults from randomly selected regions. *Cent Eur J Public Health* 2010;18:179–85.

Title of the manuscript: "Cancer mortality in towns in the vicinity of incinerators and installations for the recovery or disposal of hazardous waste."

Supplementary Data

This document is available as supplementary data for inclusion as online documentation. It includes:

- a) Table 1, showing the list of tumors analyzed and their codes as per the International Classification of Diseases-9th Revision (ICD-9) and 10th Revision (ICD-10).
- b) Table 2, showing a description of industrial facilities analyzed in the paper, including the following information: PRTR code; category of industrial activity; industrial sub-activity; province and municipality where the respective facilities are located; and pollutants released in the last decade to both air and water.
- c) Table 3, showing the types of substances and amounts released to air by Spanish-based incinerators and hazardous waste treatment installations (IPPC, 2007).
- d) Table 4, showing the types of substances and amounts released to water by Spanish-based incinerators and hazardous waste treatment installations (IPPC, 2007).
- e) Table 5, showing observed and expected cases, and the relative risk of dying from leukemia and brain cancer among the under-15 and under-25 age groups in towns situated at a distance of 5 km or less from incinerators and hazardous waste treatment installations, estimated using BYM models.
- f) Table 6, showing observed and expected cases, and the relative risk of dying from cancer in towns situated at a distance of 5 km or less from incinerators and hazardous waste treatment installations as a whole, estimated using Poisson mixed regression and BYM models.
- g) Table 7, showing Moran's I statistics and *p*-values for spatial autocorrelation analyses, by tumor type.
- h) Figure 1, showing graphs plotting deviance residuals against the distance to the nearest incinerator or hazardous waste treatment installation.

Supplementary data, Table 1.

Tumor	ICD-9	ICD-10
Malignant neoplasm of lip, oral cavity, and pharynx	140-149	C00, C14
Malignant neoplasm of esophagus	150	C15
Malignant neoplasm of stomach	151	C16
Malignant neoplasm of small intestine, including duodenum	152	C17
Malignant neoplasm of colon, rectum, rectosigmoid junction, and anus	153-154, 159.0	C18-C21
Malignant neoplasm of liver, primary	155.0	C22.0
Malignant neoplasm of gallbladder and extrahepatic bile ducts	156	C23-C24
Malignant neoplasm of pancreas	157	C25
Malignant neoplasm of retroperitoneum and peritoneum	158	C45.1-C48
Malignant neoplasm of nasal cavities, middle ear, and accessory	160	C30-C31
Malignant neoplasm of larynx	161	C32
Malignant neoplasm of trachea, bronchus, and lung	162	C33-C34
Malignant neoplasm of pleura	163	C38.4, C45.0
Malignant neoplasm of bone and articular cartilage	170	C40-C41
Malignant neoplasm of connective and other soft tissue	171	C49
Malignant melanoma of skin	172	C43
Other malignant neoplasm of skin	173	C44
Malignant neoplasm of female breast	174	C50
Malignant neoplasm of other and unspecified female genital organs (vulva and vagina)	184	C51, C52
Malignant neoplasm of uterus	179-182	C53-C55
Malignant neoplasm of ovary and other uterine adnexa	183	C56, C57
Malignant neoplasm of prostate	185	C61
Malignant neoplasm of testis	186	C62
Malignant neoplasm of bladder	188	C67
Malignant neoplasm of kidney and other and unspecified urinary organs	189	C64-C66, C68
Malignant neoplasm of brain	191	C71
Malignant neoplasm of other and unspecified parts of nervous system	192	C70, C72
Malignant neoplasm of thyroid gland	193	C73
Malignant neoplasm of other and ill-defined sites, or without specification of site	195-199	C76-C80
Non-Hodgkin lymphoma	200, 202	C82-C85
Hodgkin lymphoma	201	C81
Multiple myeloma and immunoproliferative neoplasms	203	C90
Leukemia	204-208	C91-C95

Supplementary data, Table 2.

PRTR code	Industrial activity	Industrial sub-activity	Province	Municipality	Pollutants released in the last decade ^a	
					Air	Water
132	Incineration	Incineration of solid urban waste	BALEARIC ISLANDS	Palma de Mallorca	Ammonia, cadmium, chlorine, copper, NMVOC, ^b chromium, CO ₂ , fluorine, PAHs, mercury, CO, nickel, SO ₂ , NO ₂ , PM ₁₀ , dioxins and furans, lead	
467	Incineration	Incineration of solid urban waste	BARCELONA	Sant Adrià de Besòs	CO ₂ , NO ₂ , cadmium, mercury, chlorine	
838	Incineration	Incineration of solid urban waste	GERONA	Gerona	Antimony, arsenic, cadmium, total organic carbon, chlorine, cobalt, copper, chromium, CO ₂ , fluorine, manganese, mercury, CO, nickel, SO ₂ , NO ₂ , PM ₁₀ , lead, thallium, vanadium, dioxins and furans	
1700	Incineration	Incineration of solid urban waste	MELILLA	Melilla	Ammonia, arsenic, benzene, cadmium, hydrogen cyanide, chlorine, copper, NMVOC, ^b chromium, CO ₂ , fluorine, mercury, CO, naphthalene, nickel, SO ₂ , NO ₂ , PM ₁₀ , dioxins and furans, lead, zinc, dichloromethane, hexachlorobenzene, pentachlorobenzene, tetrachloroethylene, trichlorobenzenes, vinyl chloride, PAHs	
2438	Incineration	Incineration of solid urban waste	TARRAGONA	Tarragona	Ammonia, antimony, arsenic, cadmium, total organic carbon, chlorine, copper, chromium, CO ₂ , fluorine, mercury, CO, nickel, SO ₂ , NO ₂ , PM ₁₀ , dioxins and furans, lead, thallium, vanadium	Cadmium, chlorides, copper, chromium, nickel, lead, zinc
2469	Incineration	Incineration of special waste	TARRAGONA	Constantí	Antimony, arsenic, cadmium, cobalt, copper, chromium, manganese, mercury, nickel, dioxins and furans, lead, thallium, vanadium	Arsenic, cadmium, copper, chromium, COD, ^c mercury, nickel, lead, zinc
3094	Incineration	Incineration of solid urban waste	BARCELONA	Mataró	Arsenic, antimony, cadmium, chromium, cobalt, copper, CO, CO ₂ , fluorine, manganese, mercury, NO ₂ , nickel, lead, SO ₂ , chlorine, thallium, vanadium, total suspended particles, dioxins and furans	
3455	Incineration	Incineration of solid urban waste	MADRID	Madrid	Cadmium, chlorine, copper, NMVOC, ^b chromium, CO ₂ , fluorine, methane, CO, SO ₂ , NO ₂ , PAHs, total suspended particles, dioxins and furans, lead, zinc	
4857	Incineration	Incineration of solid urban waste	BARCELONA	Sant Adrià de Besòs	Ammonia, arsenic, cadmium, chlorine, copper, NMVOC, ^b chromium, CO ₂ , fluorine, mercury, CO, nickel, SO ₂ , NO ₂ , total suspended particles, dioxins and furans, lead	
372	Scrap metal+ELVs	Recycling of scrap metal	BARCELONA	Castellbisbal	Total suspended particles	
899	Scrap metal+ELVs	Recycling of scrap metal and metal	GERONA	Sant Julià del Llor i Bonmatí	CO, SO ₂ , NO ₂ , PM ₁₀ , lead, nitrous oxide	Chlorides, lead, phosphorus, nitrogen, COD ^c
3055	Scrap metal+ELVs	Management and recycling of scrap metal from ferrous and non-ferrous products	BARCELONA	Molins de Rei	<i>Unvalidated releases</i>	
3594	Scrap metal+ELVs	Recycling of ferrous and non-ferrous products	VALENCIA	Massalfassar	Arsenic, benzene, cadmium, copper, NMVOC, ^b chromium, CO ₂ , mercury, methane, CO, nickel, nitrous oxide, SO ₂ , NO ₂ , PM ₁₀ , dioxins and furans, PAHs, lead, zinc	Total organic carbon, copper, chromium, phosphorus, nickel, nitrogen, lead, zinc
4699	Scrap metal+ELVs	Management and recycling of electrical and electronic equipment, and complex scrap metal	VIZCAYA	Erandio	Cadmium, nickel, chromium, lead, copper, zinc, CO, PM ₁₀	Arsenic, chlorides, halogenated organic compounds, zinc
4885	Scrap metal+ELVs	Management and recycling of ferrous and non-ferrous scrap metal; recycling of ELVs	GERONA	Gerona	CO, SO ₂ , NO ₂ , total suspended particles	
4899	Scrap metal+ELVs	Decontamination and scrapping of ELVs; recovery or disposal of scrap metal, non-ferrous metals	BARCELONA	Terrassa		Phosphorus, PAHs, nitrogen
4905	Scrap metal+ELVs	Scrapping of ELVs	BARCELONA	Hostalets de Pierola (Els)		COD, ^c phosphorus, PAHs, nitrogen
5063	Scrap metal+ELVs	Scrapping of ELVs	HUELVA	Huelva		<i>Unvalidated releases</i>
5664	Scrap metal+ELVs	Recovery of scrap metal and waste products	GERONA	Llagostera		<i>Unvalidated releases</i>
5665	Scrap metal+ELVs	Recovery of ferrous and non-ferrous materials (scrap metal)	BARCELONA	Granollers	Total organic carbon, CO, NO ₂ , total suspended particles	COD, ^c phosphorus, lead
5678	Scrap metal+ELVs	Scrapping of ELVs	BARCELONA	Castellar del Vallès		<i>Unvalidated releases</i>
5680	Scrap metal+ELVs	Scrapping of ELVs; recycling of ferrous and non-ferrous products	LERIDA (LLEIDA)	Mollerussa		COD, ^c PAHs, total organic carbon
5682	Scrap metal+ELVs	Scrapping of ELVs	TARRAGONA	Reus		<i>Unvalidated releases</i>
5685	Scrap metal+ELVs	Scrapping of ELVs	TARRAGONA	Valls		<i>Unvalidated releases</i>
5691	Scrap metal+ELVs	Recycling, recovery or disposal of ferrous and non-ferrous scrap metal; decontamination and recycling of ELVs	BARCELONA	Sant Fruitós de Bages		<i>Unvalidated releases</i>
5692	Scrap metal+ELVs	Recovery of non-ferrous metal containing wastes	BARCELONA	Sant Andreu de la Barca		<i>Unvalidated releases</i>
5693	Scrap metal+ELVs	Decontamination and scrapping of ELVs	BARCELONA	Sant Fruitós de Bages		<i>Unvalidated releases</i>
5695	Scrap metal+ELVs	Metal recycling and recovery; recycling and recovery of ELVs; classification of wastes from electrical and electronic equipment	BARCELONA	Sant Sadurní D'Anoia		<i>Unvalidated releases</i>
5704	Scrap metal+ELVs	Scrapping of ELVs	GERONA	Gerona		COD ^c
6037	Scrap metal+ELVs	Recovery of ELVs	BARCELONA	Mataró		Chlorides, COD, ^c phosphorus, nitrogen
6038	Scrap metal+ELVs	Recovery of industrial ELVs	BARCELONA	Hostalets de Pierola (Els)		COD, ^c PAHs, phosphorus, nitrogen

PRTR code	Industrial activity	Industrial sub-activity	Province	Municipality	Pollutants released in the last decade ^a	
					Air	Water
6041	Scrap metal+ELVs	Scrapping of ELVs	BARCELONA	Masies de Voltregà (Les)		Chlorides, COD, ^c PAHs, nitrogen, phosphorus
6042	Scrap metal+ELVs	Decontamination and scrapping of ELVs	BARCELONA	Polinyà		Unvalidated releases
6043	Scrap metal+ELVs	Recycling of ELVs, scrap metal and waste metal in general	BARCELONA	Montcada i Reixac		Unvalidated releases
6049	Scrap metal+ELVs	Recycling of scrap metal and waste metal	LERIDA (LLEIDA)	Seu D'Urgell (La)		Unvalidated releases
6051	Scrap metal+ELVs	Decontamination of ELVs	BARCELONA	Viladecans		Unvalidated releases
6584	Scrap metal+ELVs	Scrapping of ELVs	NAVARRE	Berrioplano		Unvalidated releases
6936	Scrap metal+ELVs	Recycling of scrap metal and waste metal	ZARAGOZA	Pina de Ebro		Unvalidated releases
7328	Scrap metal+ELVs	Treatment of scrap metal wastes	GUADALAJARA	Chiloeches	NO ₂	
7443	Scrap metal+ELVs	Scrapping of ELVs	GERONA	Quart		Unvalidated releases
7476	Scrap metal+ELVs	Recycling of ELVs; recycling of scrap metal	LERIDA	Lérida		Halogenated organic compounds, PAHs, phosphorus, nitrogen
445	Oil + oily waste	Treatment of used mineral oils	BARCELONA	Barberà del Vallès	Chlorine, PAHs, NMVOC ^b	Phosphorus, nitrogen, chlorides
772	Oil + oily waste	Recovery or disposal and regeneration of industrial oils	CORUNNA (A CORUÑA)	Laracha (A)	Arsenic, benzene, cadmium, copper, NMVOC, ^b chromium, CO ₂ , PAHs, mercury, methane, CO, nickel, nitrous oxide, SO ₂ , NO ₂ , PM ₁₀ , lead, zinc	Total organic carbon
1612	Oil + oily waste	MARPOL-waste treatment	CADIZ	Cádiz	Total organic carbon	Phenols
1879	Oil + oily waste	Treatment of used oil and fuel production	LA RIOJA	Alfaro	Total organic carbon, CO, SO ₂ , NO ₂ , PM ₁₀ , NMVOC, ^b methane	COD, ^c PAHs
2029	Oil + oily waste	Regeneration of used oil	CORUNNA	Somoza (As)	CO ₂ , CO, SO ₂	Arsenic, cadmium, cyanides, copper, chromium, phenols, mercury, nickel, lead, zinc
2378	Oil + oily waste	Treatment of oily waste	SEVILLE	Lebrija		Unvalidated releases
3114	Oil + oily waste	Treatment of used oil	TARRAGONA	Alicover	Arsenic, cadmium, chlorine, copper, chromium, fluorine, hexachlorobenzene, mercury, CO, NO ₂ , PM ₁₀ , SO ₂ , dioxins and furans, lead, zinc	
3119	Oil + oily waste	Recovery of vegetable oils	TARRAGONA	Constantí		Unvalidated releases
3457	Oil + oily waste	Recovery and treatment of used oil	MADRID	Paracuellos del Jarama	NO ₂ , dioxins and furans, zinc	
3474	Oil + oily waste	Treatment of and energy recovery from used oil	VALENCIA	Buñol	1,1,1-trichloroethane, arsenic, cadmium, copper, chromium, benzene, methane, CO, CO ₂ , NO ₂ , copper, mercury, nickel, NMVOC, ^b nitrous oxide, PM ₁₀ , lead, dioxins and furans, PAHs, SO ₂ , chlorine, fluorine, zinc	Chlorides, halogenated organic compounds, mercury, nitrogen, phosphorus, total organic carbon
3504	Oil + oily waste	Regeneration of used mineral oils	MADRID	Fuenlabrada	Copper, chromium, CO ₂ , fluorine, CO, SO ₂ , NO ₂ , PM ₁₀ , SO ₂ , lead, dioxins and furans, total suspended particles, total organic carbon	COD, ^c total organic carbon, trichloromethane
3508	Oil + oily waste	MARPOL-waste treatment, and fuel production	VALENCIA	Valencia	1,1,1-trichloroethane, arsenic, benzene, cadmium, chlorine, copper, NMVOC, ^b chromium, CO ₂ , fluorine, PAHs, mercury, methane, CO, nickel, nitrous oxide, SO ₂ , NO ₂ , PM ₁₀ , dioxins and furans, lead, zinc	Arsenic, total organic carbon, chromium, phenols, phosphorus, PAHs, nitrogen
3556	Oil + oily waste	MARPOL-waste treatment, and fuel production	CADIZ	Algeciras	Arsenic, cadmium, chlorine, chromium, CO ₂ , fluorine, PAHs, methane, CO, nickel, SO ₂ , NO ₂ , PM ₁₀ , nitrous oxide, dioxins and furans, lead, total suspended particles	Arsenic, cadmium, chromium, copper, nickel, total organic carbon, COD, ^c phosphorus, nitrogen, lead
3636	Oil + oily waste	Treatment of used oil and lubricants	ALAVA	Vitoria	NO ₂ , SO ₂	
3825	Oil + oily waste	Decontamination of transformers and condensers contaminated by PCBs	MURCIA	Cartagena	Benzene, PAHs, NMVOC, ^b PM ₁₀	Cadmium, copper, COD, ^c dichloromethane, nickel, polychlorinated biphenyls
3905	Oil + oily waste	Decontamination of products contaminated by PCBs	ASTURIAS	Carreño	CO ₂ , CO, SO ₂ , NO ₂ , tetrachloroethylene, trichlorobenzenes	COD, ^c halogenated organic compounds, polychlorinated biphenyls, trichlorobenzenes
4557	Oil + oily waste	Treatment of oil and oily waste	CANTABRIA	Santander	CO ₂ , CO, SO ₂ , NO ₂	Total organic carbon, COD ^c
4740	Oil + oily waste	Recovery of used oil	VIZCAYA	Zamudio	NMVOC, ^b CO ₂ , methane, CO, nitrous oxide, NO ₂	
5311	Oil + oily waste	Recycling of used oil and oily products	CORUNNA (A CORUÑA)	Somoza (As)	CO ₂ , CO, SO ₂ , NO ₂	
5493	Oil + oily waste	Treatment and recycling of used oil	GRANADA	Santa Fe		Unvalidated releases
5910	Oil + oily waste	Treatment of oil and fats	VIZCAYA	Muskiz		Unvalidated releases
6789	Oil + oily waste	Treatment of used oil	NAVARRE	Aranguren		Unvalidated releases
7167	Oil + oily waste	Treatment of oil and fats	ZARAGOZA	Puebla de Alfindén (La)	CO, SO ₂ , NO ₂	COD ^c
7412	Oil + oily waste	Treatment of oily waste and MARPOL waste	MURCIA	Cartagena		Benzene, COD, ^c toluene, vinyl chloride, xylenes
426	Packaging	Recovery and destruction of industrial packaging (drums)	BARCELONA	Granollers	Total organic carbon, CO, SO ₂	
427	Packaging	Recovery of plastic packaging	BARCELONA	Terrassa	CO ₂ , CO, SO ₂ , NO ₂	Chlorides, phosphorus, nitrogen
692	Packaging	Treatment of packaging	CASTELLON	Onda		Unvalidated releases
2449	Packaging	Recycling of industrial packaging	TARRAGONA	Cambrils	NMVOC, ^b SO ₂ , PM ₁₀	Total organic carbon, COD ^c
3050	Packaging	Recycling of metallic and plastic packaging	BARCELONA	Rubi		Unvalidated releases
3091	Packaging	Recycling of metallic and plastic packaging	BARCELONA	Vila-seca	Total organic carbon, CO, NO ₂	Chlorides, COD, ^c phosphorus, nitrogen, nonylphenol
3112	Packaging	Recycling of packaging	BARCELONA	Polinyà	NMVOC, ^b PM ₁₀	
3120	Packaging	Recycling of plastic packaging	BARCELONA	Sant Andreu de la Barca		Unvalidated releases
5557	Packaging	Recovery or disposal of metallic and plastic packaging	GUADALAJARA	Guadalajara	CO ₂ , CO, SO ₂ , NO ₂ , total suspended particles	
370	Solvents	Recovery of solvents	BARCELONA	Santa Perpètua de Mogoda	CO ₂ , CO, SO ₂ , NO ₂	Total organic carbon, chlorides
439	Solvents	Recycling of solvents	BARCELONA	Montornès del Vallès	NO ₂ , CO, NMVOC, ^b SO ₂	Phosphorus, nitrogen

PRTR code	Industrial activity	Industrial sub-activity	Province	Municipality	Pollutants released in the last decade ^a		
					Air	Water	
1325	Solvents	Regeneration of solvents	BARCELONA	Santa Perpètua de Mogoda	<i>Unvalidated releases</i>		
1678	Solvents	Recovery of solvents	MADRID	Arganda del Rey	NMVOC, ^b CO ₂ , methane, CO, SO ₂ , NO ₂ , PM ₁₀	Total organic carbon, COD ^c	
2999	Solvents	Recovery and recycling of solvents	TARRAGONA	Valls	NMVOC, ^b CO ₂ , CO, nitrous oxide, SO ₂ , NO ₂	Chlorides, dichloromethane, ethyl benzene, halogenated organic compounds, tetrachloroethylene, trichloromethane, trichloroethylene, phenols, phosphorus, nitrogen, toluene, vinyl chloride, total organic carbon, xylenes	
3049	Solvents	Recovery or disposal of used solvents	BARCELONA	Gualba	Total organic carbon, CO ₂ , CO, NO ₂		
3439	Solvents	Recovery of solvents	AVILA	San Pedro del Arroyo	NMVOC, ^b CO ₂ , CO, SO ₂ , NO ₂ , PM ₁₀		
1928	Spent baths	Recovery of hydrochloric acid	ASTURIAS	Avilés	CO, CO ₂ , NO ₂ , SO ₂ , chlorine, PM ₁₀		
3713	Spent baths	Recovery of spent acid pickling baths	VIZCAYA	Bilbao	NMVOC, ^b CO ₂ , methane, CO, nitrous oxide, NO ₂	Arsenic, cadmium, chlorides, copper, organotin compounds, chromium, nickel, nitrogen, lead, phenols, total organic carbon, zinc	
4613	Spent baths	Regeneration of spent hydrochloric-acid-based pickling baths used for descaling	ALAVA	Vitoria	Chlorine, copper, NMVOC, ^b CO ₂ , fluorine, methane, CO, nickel, nitrous oxide, NO ₂ , lead, zinc		
4614	Spent baths	Recovery of hydrochloric acid for obtaining iron (ferric and/or ferrous) chloride (spent baths)	ALAVA	Lantarón	Chlorine, NMVOC, ^b CO ₂ , methane, CO, nitrous oxide, SO ₂ , NO ₂ , PM ₁₀	Arsenic, cyanides, chlorides, chromium, ethyl benzene, nickel, xylenes	
4719	Spent baths	Neutralization of spent acid pickling and alkaline baths containing neither cyanide nor hexavalent chromium	GUIPUZCOA	Aduna	Ammonia, chlorine, SO ₂ , NO ₂	Arsenic, cadmium, total organic carbon, cyanides, chlorides, copper, halogenated organic compounds, chromium, phenols, fluoranthene, fluorides, phosphorus, mercury, naphthalene, nickel, nitrogen, lead, zinc	
4833	Spent baths	Recovery of hydrochloric acid	VALENCIA	Sagunto	<i>Unvalidated releases</i>		
4903	Spent baths	Recovery of spent baths containing trivalent chrome	BARCELONA	Igualada	<i>Unvalidated releases</i>		
1664	Physico/chemical treatment	Physico/chemical waste treatment	MADRID	Madrid	Ammonia, hydrogen cyanide, fluorine, mercury, di-(2-ethyl hexyl) phthalate	1,2-dichloroethane, anthracene, arsenic, cadmium, total organic carbon, Chloroalkanes,C10-C13, chlorides, copper, halogenated organic compounds, organotin compounds, chromium, dichloromethane, COD, ^c ethyl benzene, phenols, fluorides, phosphorus, mercury, naphthalene, nickel, nitrogen, lead, toluene, xylenes, zinc	
1667	Physico/chemical treatment	Physico/chemical waste treatment	MADRID	Madrid			
2088	Physico/chemical treatment	Physico/chemical hazardous waste treatment	CANTABRIA	Astillero (El)	Ammonia, arsenic, cadmium, copper, chlorine, chromium, CO ₂ , mercury, nickel, SO ₂ , NO ₂ , lead, zinc	Cadmium, copper, chromium, COD, ^c fluorides, phosphorus, nickel, nitrogen, lead, zinc, total organic carbon	
3057	Physico/chemical treatment	Physico/chemical waste treatment	BARCELONA	Barcelona	Total organic carbon, chlorine, CO ₂ , CO, SO ₂ , NO ₂ , PM ₁₀	Cadmium, total organic carbon, copper, chlorides, chromium, cyanides, phosphorus, PAHs, nickel, nitrogen, lead, zinc	
3086	Physico/chemical treatment	Physico/chemical waste treatment	CASTELLON	Villarreal	Ammonia, arsenic, cadmium, copper, NMVOC, ^b chromium, CO ₂ , mercury, methane, CO, nickel, nitrous oxide, SO ₂ , NO ₂ , PM ₁₀ , dioxins and furans, lead, zinc	Total organic carbon, copper, chromium, mercury, nickel, zinc	
3110	Physico/chemical treatment	Physico/chemical waste treatment	BARCELONA	Martorell	Ammonia, chlorine, NMVOC, ^b CO, NO ₂ , PAHs, total suspended particles	Cadmium, total organic carbon, cyanides, chlorides, copper, chromium, phosphorus, nickel, nitrogen, lead, zinc	
3452	Physico/chemical treatment	Physico/chemical waste treatment	TARRAGONA	Constantí	Ammonia, chlorine, total organic carbon, fluorine, CO, SO ₂ , NO ₂ , total suspended particles, dioxins and furans	Chlorides, copper, halogenated organic compounds, COD, ^c phosphorus	
3818	Physico/chemical treatment	Physico/chemical waste treatment	VALLADOLID	Santovenia de Pisuerga	Ammonia, arsenic, CO ₂ , cadmium, chromium, copper, lead, chlorine, fluorine, NO ₂ , PM ₁₀	Total organic carbon, chlorides, nitrogen, phosphorus, zinc	
65	Industrial waste	Integrated treatment and recovery of saline slags; recovery or disposal of wastes from aluminum thermal metallurgy	VALLADOLID	Valladolid	Ammonia, chlorine, NMVOC, ^b CO ₂ , CO, NO ₂ , PM ₁₀ , SO ₂		
1083	Industrial waste	Elimination, recovery or disposal of industrial waste	HUELVA	Palos de la Frontera	PM ₁₀ , total suspended particles		
1665	Industrial waste	Industrial waste treatment	MADRID	San Fernando de Henares	<i>Unvalidated releases</i>		
1938	Industrial waste	Treatment and recycling of metallurgical waste	ASTURIAS	Gijón	Total suspended particles		
2103	Industrial waste	Industrial waste treatment	CANTABRIA	Astillero (El)	Arsenic, cadmium, chlorine, copper, chromium, CO ₂ , fluorine, hexachlorobenzene, PAHs, CO, nickel, SO ₂ , NO ₂ , PM ₁₀ , lead, zinc	Cadmium, total organic carbon, cyanides, chlorides, copper, chromium, phenols, fluorides, phosphorus, nickel, nitrogen, lead, zinc	
2568	Industrial waste	Industrial waste treatment	TOLEDO	Casarrubios del Monte	Arsenic, cadmium, chlorine, copper, NMVOC, ^b chromium, CO, CO ₂ , nickel, SO ₂ , NO ₂ , total suspended particles, lead, zinc	Arsenic, cadmium, chlorides, chromium, copper, cyanides, fluorides, mercury, nickel, lead, nitrogen, phosphorus, total organic carbon, zinc	
3028	Industrial waste	Recovery and smelting of aluminum skimmings	LERIDA	Seròs	Chlorine, CO, SO ₂ , NO ₂ , total suspended particles		
3082	Industrial waste	Recovery or disposal of sands and industrial waste	BARCELONA	Granollers	<i>Unvalidated releases</i>		
3710	Industrial waste	Recycling of steel mill dust	VIZCAYA	Erandio	Cadmium, copper, NMVOC, ^b chromium, CO ₂ , mercury, methane, CO, nickel, nitrous oxide, SO ₂ , NO ₂ , PM ₁₀ , lead, zinc, dioxins and furans	Arsenic, cadmium, chromium, copper, chlorides, fluorides, lead, zinc	
3711	Industrial waste	Treatment of refinery waste	VIZCAYA	Muskiz	NMVOC, ^b CO ₂ , PAHs, methane, CO, nitrous oxide, SO ₂ , NO ₂ , PM ₁₀	Arsenic, total organic carbon, cyanides, chlorides, halogenated organic compounds, phosphorus, PAHs, mercury, nitrogen, zinc	
4065	Industrial waste	Recycling of aluminum skimmings and other industrial waste	MADRID	Fuenlabrada	PM ₁₀ , total suspended particles	COD, ^c chlorides, copper, zinc	
4733	Industrial waste	Treatment of metallurgical waste	GUIPUZCOA	Azkoitia	<i>Unvalidated releases</i>		
5907	Industrial waste	Treatment of metallurgical waste	GUIPUZCOA	Azkoitia	<i>Unvalidated releases</i>		
6749	Industrial waste	Industrial waste treatment	NAVARRE	Pamplona	<i>Unvalidated releases</i>		

PRTR code	Industrial activity	Industrial sub-activity	Province	Municipality	Pollutants released in the last decade ^a	
					Air	Water
6807	Industrial waste	Recovery or disposal and reuse of industrial waste	NAVARRE	Pamplona	<i>Unvalidated releases</i>	
537	Wastes not otherwise specified	Integrated waste treatment (metallic and plastic packaging, paper, textile fibers, ELVs)	CADIZ	Jerez de la Frontera	Methane, CO ₂	Total organic carbon, COD ^c
707	Wastes not otherwise specified	Recovery or disposal of plastic packaging, waste ceramics; soil decontamination	CASTELLON	Vall D'Alba	Arsenic, cadmium, copper, NMVOC, ^b chromium, CO ₂ , mercury, methane, CO, nickel, nitrous oxide, SO ₂ , NO ₂ , PM ₁₀ , dioxins and furans, lead, zinc	
734	Wastes not otherwise specified	Treatment of special waste; treatment of used oil; recovery or disposal of used packaging; soil decontamination	CORDOBA	Córdoba	Chlorine, NMVOC, ^b CO ₂ , fluorine, CO, SO ₂ , NO ₂ , PM ₁₀ , total suspended particles	
1567	Wastes not otherwise specified	Recycling, crushing and shredding of spent lead batteries	ZARAGOZA	Pina de Ebro	<i>Unvalidated releases</i>	
2031	Wastes not otherwise specified	Medical waste treatment	TARRAGONA	Constantí	CO, SO ₂ , NO ₂	COD ^c
2032	Wastes not otherwise specified	Medical waste treatment	MADRID	Arganda del Rey	CO ₂ , CO	Total organic carbon, nitrogen, phosphorus, mercury, COD ^c
2089	Wastes not otherwise specified	Recovery of silver from photochemical wastes	CANTABRIA	Camargo	CO, SO ₂ , NO ₂	Cadmium, copper, chromium, COD ^c , fluorides, phosphorus, nickel, lead, zinc, total organic carbon
2470	Wastes not otherwise specified	Treatment of special waste	BARCELONA	Barberà del Vallès		Chlorides, COD ^c , phosphorus, nitrogen
2702	Wastes not otherwise specified	Treatment of batteries and other lead wastes	VALLADOLID	Medina del Campo	Lead	
3187	Wastes not otherwise specified	Integrated waste management and waste transfer center	BARCELONA	Montmeló	Chlorine, NMVOC, ^b PM ₁₀ , total organic carbon	Chlorides, COD ^c , phosphorus
3690	Wastes not otherwise specified	Treatment of hazardous waste (wastes from the photographic industry, solvents, dyes, absorbents, packaging)	VIZCAYA	Bilbao	<i>Unvalidated releases</i>	
5703	Wastes not otherwise specified	Recovery of solid and liquid waste from radiologic and photographic processes	BARCELONA	Sant Andreu de la Barca		COD ^c , phosphorus, nitrogen
5781	Wastes not otherwise specified	Crushing and shredding of spent lead batteries; recovery of lead capacitors	ZARAGOZA	Pina de Ebro	<i>Unvalidated releases</i>	
6053	Wastes not otherwise specified	Treatment of scrap metal, ELVs, paper and cardboard, metals. Containers	LERIDA	Lérida		COD ^c , PAHs, phosphorus
6251	Wastes not otherwise specified	Treatment of hospital waste matter	MURCIA	Cartagena	CO ₂ , CO, SO ₂ , NO ₂	Arsenic, cadmium, chromium, cyanides, COD ^c , fluorides, lead, total organic carbon, copper, mercury, nickel, nitrogen, organotin compounds, phenols, zinc
6431	Wastes not otherwise specified	Recovery of textile waste (rags, cleaning cloths, gloves)	BARCELONA	Barberà del Vallès	NMVOC, ^b CO ₂ , methane, CO, NO ₂	Cadmium, cyanides, chlorides, copper, halogenated organic compounds, chromium, phosphorus, PAHs, nickel, nitrogen, lead, zinc
7403	Wastes not otherwise specified	Recovery of silver from photochemical wastes	CANTABRIA	Camargo	<i>Unvalidated releases</i>	
7478	Wastes not otherwise specified	Recovery of metal, scrap metal, ELVs, wastes from electrical and electronic equipment, batteries, refrigerators, transformers contaminated by PCBs	BARCELONA	Molins de Rei	PM ₁₀	COD ^c , phosphorus, PAHs, nitrogen

^aPollutants released in the period 2001-2010 and included in the IPCC database.

^bNon-methane organic compounds.

^cChemical oxygen demand.

Supplementary data, Table 3.

PRTR Code	Releases to air (IPPC, 2007) (kg/year) ^a																																			
	A1 ^b	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18	A19	A20	A21	A22	A23	A24	A25	A26	A27	A28	A29	A30	A31	A32	A33	A34	A35	TOTAL
4833	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0					
4857	0	5790	0	10	0	2	0	0	11400	0	6	2400	3	106000000	66	0	0	0	10	0	69700	0	3	0	43900	297000	0	11500	0.01	55	0	0	0	0	106441845	
4885	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9					
4899	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
4903	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0					
4905	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
5063	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0					
5311	0	0	0	0	0	0	0	0	0	0	0	0	0	2900000	0	0	0	0	0	0	3800	0	0	0	2700	24000	0	0	0	0	0	0	0	2930500		
5493	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0					
5557	0	0	0	0	0	0	0	0	0	0	0	0	0	258000	0	0	0	0	0	0	47	0	0	0	12	307	0	0.92	0	0	0	0	0	258367		
5664	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0					
5665	0	0	0	0	0	0	7390	0	0	0	0	0	0	0	0	0	0	0	0	0	2640	0	0	0	0	195	0	1950	0	0	0	0	0	12175		
5678	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0					
5680	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0					
5682	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0					
5685	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0					
5691	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0					
5692	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0					
5693	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0					
5695	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0					
5703	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
5704	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
5781	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0					
5907	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0					
5910	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0					
6037	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
6038	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
6041	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
6042	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0					
6043	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0					
6049	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0					
6051	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0					
6053	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0					
6251	0	0	0	0	0	0	0	0	0	0	0	0	0	166000	0	0	0	0	0	10	0	0	0	3	230	0	0	0	0	0	0	0	166243			
6431	0	0	0	0	0	0	0	0	0	5	0	61	0	0	0	0	2	11	0	0	0	0	68	0	0	0	0	0	0	0	0	147				
6584	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0					
6749	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0					
6789	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0					
6807	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0					
6936	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0					
7167	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	31	0	0	0	525	731	0	0	0	0	0	0	1287				
7328	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13					
7403	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0					
7412	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0					
7443	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0					
7476	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
7478	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14					
TOTAL	0.01	43962	13	32	0.06	17	35521	6	46692	8	96	106416	81	506898419	640	17	48	9	15	406618	16624594	0.01	62	2732	125729	1061090	51851	22097	0.01	459	12	62	0.002	10	223	525427530

^aNA: Unvalidated releases

Supplementary data, Table 4.

PRTR Code	Releases to water (IPPC 2007) (kg/year) ^a																													
	W1 ^b	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15	W16	W17	W18	W19	W20	W21	W22	W23	W24	W25	W26	W27	W28	TOTAL	
65	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
132	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
370	0	0	0	1960	0	0	24500	0	0	0	0	0	7150	0	0	0	0	0	702	0	0	0	0	1010	0	0	0	0	0	35320
372	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
426	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
427	0	0	0	0	0	0	407	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2	0	0	0	0	0	410
439	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
445	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.05	0	0	0	0	3	0	0	0	0	0	0	
467	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
537	0	0	0	20	0	0	0	0	0	0	0	0	68	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	80
692	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
707	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
734	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
772	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
838	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
899	0	0	0	0	0	0	253	0	0	0	0	0	0	0	0	0	0	0	14	0	0	0	0	142	0	0	0	0	0	400
1083	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1325	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
1567	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
1612	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1664	0.0004	0.15	2	3830	0	0.54	564000	9	15	0.0002	2	0.34	16900	0.67	13	0	6	19	0	0.003	0.28	6	644	0	2	0.97	0	12	58546	
1665	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
1667	0	0	0	575	0	0	2550	0	2	0	0	0.88	0	0.06	6	0	0	13	0	0	0	2	123	0	0	0	0.20	0	327	
1678	0	0	0	23	0	0	0	0	0	0	0	0	68	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	
1700	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1879	0	0	0	0	0	0	0	0	0	0	0	0	0.0002	0	0	0	0	0	0.0001	0	0	0	0	0	0	0	0	0	0.000	
1928	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1938	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
2029	0	0.004	0.01	0	0.21	0	0	0.01	0	0	0.01	0	0	0	0.36	0	0	0	0	0.002	0	0.04	0	0	0.003	0	0	0.02	0.60	
2031	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
2032	0	0	0	216	0	0	0	0	0	0	0	0	0	652	0	0	0	0	0	0	0.02	0	0	0	0	0	0	0	0	86
2088	0	0	1	0	0	0	0	0	6	0	0	1	0	0	7	0	0	0	21	0	0	0	12	685	0	1	0	0	61	
2089	0	0	0.36	0	0	0	0	0.30	0	0	0.03	0	3380	0	0	0	1	6	0	0	0.55	0	0	0.02	0	0	3	339		
2103	0	0	0.15	23100	0.08	0	66800	34	0	0	0.77	0	0	0	10	0	0	40	658	0	0	0	12	15300	0	3	0	0	50	10600
2378	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
2438	0	0	0.0001	0	0	0	0.75	0.0001	0	0	0.0001	0	0	0	0	0	0	0	0	0.0003	0	0	0.0003	0	0	0.0003	0	0.7532		
2449	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
2469	0	0.93	1	0	0	0	0	13	0	0	6	0	5950	0	0	0	0	0	0	0.66	0	3	0	0	16	0	0	0	64	
2470	0	0	0	0	0	0	0	14	0	0	0	0	0	136	0	0	0	0	3	0	0	0	35	0	0	0	0	0	18	
2568	0	0.47	0.47	21100	2.35	0	278000	33	0	0	52	0	0	0	0	0	0	47	612	0	0.47	0	0	9510	0	19	0	0	235	30961
2702	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
2999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19
3028	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
3049	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
3050	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
3055	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
3057	0	0	4	8010	0	0	0	18	0	0	4	0	0	0	0	0	0	0	167	4	0	0	18	4170	0	18	0	0	85	1249
3082	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
3086	0	0	0	1940	0	0	0	0.47	0	0	0.20	0	0	0	0	0	0	0	0	0.004	0	1	0	0	0	0	0	0	194	
3091	0	0	0	0	0	0	0	144	0	0	0	0	0	641	0	0	0	0	4	0	0	0	0	11	5	0	0	0	0	800
3094	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
3110	0	0	10	2060	6.03	0	57200	10	0	0	10	0	0	0	0	0	0	77	0	0	0	12	3760	0	10	0	0	10	6316	
3112	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
3114	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
3119	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
3120	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
3187	0	0	0	0	0	0	0	0	0	0	0	0	0	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
3439	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
3452	0	0	0	0	0	0	0	15500	9	8	0	0	0	0																

PRTR Code	Releases to water (IPPC 2007) (kg/year) ^a																												
	W1 ^b	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15	W16	W17	W18	W19	W20	W21	W22	W23	W24	W25	W26	W27	W28	TOTAL
3710	0	29	0	0	0	0	3240000	0	0	0	0	0	0	0	0	0	10200	0	0	0	0	0	0	0	5	0	0	4.97	3250239
3711	0	0.25	0	1020	0.337	0	23700	0	25	0	0	0	0	0	0	0	0	50	0.05	0.08	0	0	0	1290	0	0	0	0	16
3713	0	0	0.08	0	0	0	16100	4	0	0.76	1	0	0	0	0	0	0	0	0	0	0	0	12	1750	0	8	0	0	7
3818	0	0	0	110	0	0	500	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	30	
3825	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
3905	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
4065	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
4557	0	0	0	49	0	0	0	0	0	0	0	0	0	0	0	0	171	0	0	0	0	0	0	0	0	0	0	220	
4613	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
4614	0	0.44	0	0	0.653	0	85400	0	0	0	0.15	0	0	0.02	0	0	0	0	0	0	0	0.44	0	0	0	0	0.02	0	
4699	0	0.67	0	0	0	0	5020	0	0.47	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	5025
4719	0	0.45	0.45	2200	0.45	0	428000	8	7	0	0.45	0	0	0	4	0.89	4	4	0	0.45	0.89	2	327	0	0.45	0	0	7	430569
4733	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
4740	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
4833	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
4857	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
4885	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
4899	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.03	0.02	0	0	0	0	0.35	0	0	0		
4903	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.39	
4905	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	7	0	0	0	0	52	0	0	0	
5063	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
5311	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
5493	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
5557	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
5664	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
5665	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.15	0	0	0	0	0	0	0	0	0.08		
5678	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
5680	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
5682	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
5685	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
5691	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
5692	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
5693	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
5695	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
5703	0	0	0	0	0	0	0	0	0	0	0	0	0.17	0	0	0	0	0.01	0	0	0	0	0.05	0	0	0	0	0.22	
5704	0	0	0	0	0	0	0	0	0	0	0	0	0.001	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.001	
5781	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
5907	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
5910	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
6037	0	0	0	0	0	0	0.04	0	0	0	0	0	0.004	0	0	0	0	0.001	0	0	0	0	0.001	0	0	0	0	0.04	
6038	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0.33	
6041	0	0	0	0	0	0	0	0	0	0	0	0	0.50	0	0	0	0	0	0.01	0	0	0	0.01	0	0	0	0	0.52	
6042	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
6043	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
6049	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
6051	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
6053	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
6251	0	0	0	652	0	0	0.08	0	0	0	0	0	0	0	0	0	0	0	0	0.06	0	0.05	84	0	0	0	0.19	736	
6431	0	0	0.30	0	0.30	0	493	0.30	0.11	0	0.30	0	0	0	0	0	0	11	0.60	0	0	0.30	14	0	0.60	0	0	0.60	
6584	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
6749	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
6789	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
6807	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
6936	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
7167	0	0	0	0	0	0	0	0	0	0	0	0	0.06	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.06	
7328	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
7403	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
7412	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
7443	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
7476	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	21	
7478	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1166	
TOTAL	0.0004	33	20</																										

^aNA: Unvalidated releases

^bW1: Anthracene. W2: Arsenic and compounds. W3: Cadmium and compounds. W4: Total organic carbon. W5: Cyanides. W6: Chloroalkanes, C10-C13. W7: Chlorides. W8: Copper and compounds. W9: Halogenated organic compounds. W10: Organotin compounds. W11: Chromium and compounds. W12: Dichloromethane. W13: Chemical oxygen demand. W14: Ethyl benzene. W15: Phenols. W16: Fluoranthene. W17: Fluorides. W18: Total phosphorus. W19: PAHs. W20: Mercury and compounds. W21: Naphthalene. W22: Nickel and compounds. W23: Total nitrogen. W24: Nonylphenol and monovinylphenol ethoxylates. W25: Lead and compounds. W26: Toluene. W27: Xylenes. W28: Zinc and compounds.

Supplementary data, Table 5.

				BYM model	
	T ^a	Obs ^b	Exp ^c	RR ^d	95%CrI ^e
Leukemia<15 years	237	126	133.5	1.00	0.74-1.31
Total	237	72	80.2	0.98	0.66-1.39
Men	237	54	53.3	1.03	0.66-1.54
Women					
Leukemia<25 years					
Total	237	248	247.3	1.01	0.81-1.25
Men	237	145	153.4	0.97	0.72-1.27
Women	237	103	93.9	1.10	0.79-1.49
Brain cancer<15 years ^f					
Total	237	66	67.7	0.84	0.56-1.21
Men	237	43	41.8	0.95	0.57-1.48
Women	237	23	26.0	0.73	0.37-1.28
Brain cancer<25 years ^f					
Total	237	136	133.6	0.95	0.71-1.24
Men	237	75	76.8	1.01	0.69-1.43
Women	237	61	56.8	0.91	0.59-1.33
Brain cancer<15 years ^g					
Total	163	41	40.5	0.92	0.59-1.36
Men	163	29	25.0	1.11	0.64-1.79
Women	163	12	15.5	0.69	0.31-1.29
Brain cancer<25 years ^g					
Total	163	107	79.5	0.94	0.68-1.26
Men	163	45	45.7	1.05	0.68-1.54
Women	163	62	33.8	0.84	0.51-1.29

^aNumber of towns situated at ≤5 km from incinerators and hazardous waste treatment installations as a whole.^bObserved deaths.^cExpected deaths.^dRRs adjusted for population size, percentage illiteracy, farmers and unemployed persons, average persons per household, and mean income^e95% credible interval.^fTaking 1 year as the minimum induction period.^gTaking 10 years as the minimum induction period.

Supplementary data, Table 6.

T ^a	Obs ^b	Exp ^c	BYM model		Mixed model		T ^a	Obs ^b	Exp ^c	BYM model		Mixed model	
			RR ^d	95%CrI ^e	RR ^d	95%CI ^f				RR ^d	95%CrI ^e	RR ^d	95%CI ^f
<i>All cancers^g</i>													
Total	163	91708	85109.6	1.06	1.04-1.09	1.06	1.05-1.07						
Men	163	58275	53071.8	1.08	1.05-1.11	1.08	1.07-1.10						
Women	163	33433	32037.8	1.03	1.01-1.06	1.03	1.01-1.04						
<i>Oral and pharyngeal cancer</i>													
Total	163	2482	2178.7	1.04	0.95-1.14	1.11	1.05-1.19						
Men	163	2056	1804.5	1.03	0.94-1.13	1.11	1.04-1.19						
Women	163	426	374.2	1.09	0.94-1.26	1.07	0.93-1.24						
<i>Esophageal cancer</i>													
Total	163	1960	1733.3	0.99	0.90-1.09	1.07	1.00-1.15						
Men	163	1710	1504.0	1.01	0.91-1.11	1.08	1.00-1.16						
Women	163	250	229.4	0.92	0.74-1.13	1.02	0.84-1.24						
<i>Stomach cancer</i>													
Total	163	6123	5646.0	1.18	1.10-1.27	1.07	1.03-1.11						
Men	163	3822	3461.8	1.18	1.09-1.28	1.09	1.04-1.15						
Women	163	2301	2184.3	1.16	1.06-1.27	1.04	0.98-1.11						
<i>Small intestine cancer</i>													
Total	163	123	129.8	0.87	0.65-1.12	0.86	0.66-1.10						
Men	163	67	70.5	0.86	0.61-1.17	0.85	0.62-1.17						
Women	163	56	59.3	0.88	0.60-1.24	0.85	0.59-1.24						
<i>Colorectal cancer</i>													
Total	163	12265	11367.2	1.08	1.03-1.13	1.06	1.03-1.09						
Men	163	7084	6343.6	1.12	1.06-1.18	1.08	1.04-1.12						
Women	163	5181	5023.6	1.04	0.98-1.10	1.03	0.99-1.08						
<i>Liver cancer</i>													
Total	163	2929	2310.4	1.18	1.06-1.30	1.23	1.15-1.31						
Men	163	2075	1678.6	1.17	1.05-1.30	1.22	1.13-1.31						
Women	163	854	631.8	1.20	1.02-1.40	1.24	1.10-1.40						
<i>Gallbladder cancer</i>													
Total	163	1339	1262.6	1.10	0.99-1.21	1.10	1.01-1.19						
Men	163	511	432.5	1.26	1.08-1.45	1.23	1.07-1.41						
Women	163	828	830.1	1.02	0.90-1.15	1.04	0.94-1.15						
<i>Pancreatic cancer</i>													
Total	163	4272	4004.6	1.01	0.95-1.07	1.00	0.96-1.05						
Men	163	2272	2133.0	1.01	0.94-1.09	1.00	0.94-1.07						
Women	163	2000	1871.6	1.02	0.94-1.10	1.01	0.94-1.08						
<i>Peritoneal cancer</i>													
Total	163	260	226.6	1.20	0.97-1.46	1.12	0.92-1.36						
Men	163	115	102.6	1.30	0.96-1.73	1.28	0.97-1.69						
Women	163	145	124.0	1.10	0.85-1.40	1.01	0.79-1.30						
<i>Nasal cancer</i>													
Total	163	98	88.1	1.21	0.88-1.62	1.18	0.87-1.60						
Men	163	67	61.8	1.21	0.82-1.70	1.15	0.79-1.65						
Women	163	31	26.4	1.12	0.65-1.79	1.10	0.66-1.85						
<i>Laryngeal cancer</i>													
Total	163	1805	1681.5	1.07	0.97-1.17	1.06	0.98-1.14						
Men	163	1751	1620.0	1.08	0.98-1.19	1.06	0.99-1.15						
Women	163	54	61.5	0.87	0.59-1.23	0.86	0.60-1.23						
<i>Lung cancer</i>													
Total	163	19214	17394.4	1.10	1.05-1.15	1.10	1.07-1.12						
Men	163	17156	15336.5	1.12	1.06-1.18	1.12	1.10-1.15						
Women	163	2058	2057.8	0.92	0.84-1.00	0.91	0.85-0.97						
<i>Pleural cancer</i>													
Total	163	394	206.8	1.71	1.34-2.14	1.74	1.44-2.11						
Men	163	284	147.0	1.84	1.39-2.40	1.86	1.48-2.34						
Women	163	110	59.7	1.52	1.04-2.14	1.51	1.07-2.14						
<i>Bone cancer</i>													
Total	163	286	288.6	1.05	0.88-1.24	1.04	0.88-1.23						
Men	163	177	168.6	1.03	0.83-1.27	1.02	0.83-1.26						
Women	163	109	120.1	1.09	0.83-1.40	1.06	0.82-1.38						
<i>Connective and soft tissue cancer</i>													
Total	163	433	412.6	1.08	0.93-1.25	1.07	0.93-1.23						
Men	163	220	211.1	1.09	0.90-1.31	1.08	0.90-1.30						
Women	163	213	201.5	1.06	0.85-1.30	1.06	0.87-1.30						

^aNumber of towns situated at ≤5 km from incinerators and hazardous waste treatment installations as a whole.^bObserved deaths.^cExpected deaths.^dRRs adjusted for population size, percentage illiteracy, farmers and unemployed persons, average persons per household, and mean income^e95% credible interval.^f95% confidence interval.^gSum of the 33 types of cancer analyzed.

Supplementary data, Table 7.

Tumor	Sex	Observed	Moran's I statistic	P-value
All cancers ^a	Total	893060	0.13609260	0.0001
All cancers ^a	Men	561225	0.13390940	0.0001
All cancers ^a	Women	331835	0.03867270	0.0006
Oral cavity-pharynx	Total	21978	0.02851527	0.0039
Oral cavity-pharynx	Men	18136	0.03281445	0.0031
Oral cavity-pharynx	Women	3842	-0.00497693	0.4660
Esophagus	Total	17760	0.01497462	0.0725
Esophagus	Men	15377	0.01346098	0.0979
Esophagus	Women	2383	0.00217831	0.7441
Stomach	Total	59671	0.05919367	0.0001
Stomach	Men	36754	0.02406238	0.0073
Stomach	Women	22917	0.02936369	0.0049
Small intestine	Total	1364	0.02321788	0.0163
Small intestine	Men	744	0.00324212	0.5262
Small intestine	Women	620	0.00357149	0.3594
Colon-rectum	Total	120841	0.03348700	0.0004
Colon-rectum	Men	68095	0.02178990	0.0131
Colon-rectum	Women	52746	0.00376531	0.6319
Liver	Total	24255	0.03272991	0.0012
Liver	Men	17609	0.03650195	0.0014
Liver	Women	6646	0.00174938	0.8100
Gallbladder	Total	13467	0.00899794	0.2574
Gallbladder	Men	4682	0.00450373	0.5436
Gallbladder	Women	8785	-0.00320082	0.6723
Pancreas	Total	41918	0.00662672	0.4224
Pancreas	Men	22328	-0.00178663	0.8569
Pancreas	Women	19590	0.00416046	0.5961
Peritoneum	Total	2347	-0.00743644	0.2266
Peritoneum	Men	1066	-0.00181122	0.7607
Peritoneum	Women	1281	-0.00604124	0.2213
Nasal	Total	908	-0.00354655	0.4886
Nasal	Men	636	-0.00236683	0.6296
Nasal	Women	272	-0.00282667	0.2493
Larynx	Total	17297	0.00871922	0.2829
Larynx	Men	16674	0.00830898	0.3049
Larynx	Women	623	-0.00460573	0.1950
Lung	Total	181027	0.13861970	0.0001
Lung	Men	160104	0.14922080	0.0001
Lung	Women	20923	-0.00076182	0.9473
Pleura	Total	2156	0.00991473	0.1093
Pleura	Men	1538	0.01131336	0.0688
Pleura	Women	618	-0.00120012	0.8281
Bone	Total	2921	0.00620273	0.3433
Bone	Men	1702	0.01073817	0.0778
Bone	Women	1219	-0.00403557	0.4080
Connective and soft tissue	Total	4182	-0.00422738	0.5665
Connective and soft tissue	Men	2148	-0.00242306	0.7297
Connective and soft tissue	Women	2034	-0.00170239	0.7879
Melanoma	Total	7401	-0.00359993	0.6458
Melanoma	Men	3987	-0.00314765	0.6672
Melanoma	Women	3414	0.00252278	0.7087
Skin	Total	4632	0.00603235	0.3792
Skin	Men	2498	0.00456981	0.4815
Skin	Women	2134	0.00701161	0.2312
Breast	Women	57830	0.01816782	0.0409
Vulva and vagina	Women	3355	-0.00728299	0.2742
Uterus	Women	18080	0.01081323	0.1745
Ovary	Women	18046	0.00180327	0.8134
Prostate gland	Men	55772	0.02395405	0.0060
Testis	Men	425	-0.00083472	0.8640
Bladder	Total	41282	0.02099862	0.0140
Bladder	Men	34107	0.02300539	0.0092
Bladder	Women	7175	-0.00249227	0.7499
Kidney	Total	17341	0.00365353	0.6497
Kidney	Men	11532	0.00548841	0.4631
Kidney	Women	5809	-0.00015571	0.9937
Brain	Total	22689	0.00063534	0.9354
Brain	Men	12622	-0.01103704	0.1687
Brain	Women	10067	0.00870612	0.2573
Other central nervous system	Total	801	-0.00565016	0.1698
Other central nervous system	Men	400	-0.00331781	0.2930
Other central nervous system	Women	401	-0.00124413	0.7755
Thyroid gland	Total	2711	0.00413772	0.5100
Thyroid gland	Men	911	-0.00197359	0.7459
Thyroid gland	Women	1800	0.00385805	0.4953
III-defined	Total	60638	0.01733277	0.0393
III-defined	Men	33968	0.00926813	0.2712
III-defined	Women	26670	0.00911907	0.2623
Non-Hodgkin lymphoma	Total	23338	0.00724669	0.3802
Non-Hodgkin lymphoma	Men	12229	0.00254773	0.7342
Non-Hodgkin lymphoma	Women	11109	0.01269486	0.1000
Hodgkin lymphoma	Total	2379	-0.00386222	0.5652
Hodgkin lymphoma	Men	1345	-0.00582930	0.2573
Hodgkin lymphoma	Women	1034	-0.00223628	0.6798
Myeloma	Total	15178	0.01292908	0.1116
Myeloma	Men	7541	-0.00104481	0.8915
Myeloma	Women	7637	0.00892536	0.2204
Leukemia	Total	29070	0.00379937	0.6310
Leukemia	Men	16295	0.01199455	0.1279
Leukemia	Women	12775	-0.00888875	0.2602

^aSum of the 33 types of cancer analyzed.

Supplementary data, Figure 1.

