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Ibrahim Y. Tawbe, Jihad Elnaboulsi

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CRESE
30, avenue de l'Observatoire
25009 Besançon
France
http://crese.univ-fcomte.fr/

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Maternal residential proximity to the most polluting facilities and birth weight in France

Ibrahim Y. Tawbe

tawbeibrahim@hotmail.com

Université de Franche-Comté, CRESE (UR 3190), F-25000 Besançon, France

and

Jihad C. Elnaboulsi[1]

Jihad.elnaboulsi@univ-fcomte.fr

Université de Franche-Comté, CRESE (UR 3190), F-25000 Besançon, France

Abstract

This study seeks to investigate the impact of maternal residential proximity to toxic pollutant sites on birth weight using data from the European Pollutant Release and Transfer Register (E-PRTR) and the Etude Longitudinale Française depuis l'Enfance (ELFE) cohort. In line with the literature, we categorized the distance between the mother's residence during gestation and the E-PRTR sites into three ranges: 0-3 km, 3.1-5 km, and 5.1-10 km. Using linear regression model, we did not find statistically significant associations between proximity to E-PRTR sites and birth weight. However, upon further examination of specific industrial sectors, we observed that mining sites had a detrimental effect on birth weight for infants whose mothers resided within distances of 0-3 km and 3.1-5 km compared to those between 5.1 and 10 km from these sites. Specifically, residing within 0-3 km and 3.1-5 km of a mineral industry resulted in reduced birth weight compared to other distances, with respective decreases of 68 and 56 grams.

Key words: air pollution, birth weight, polluting sites, maternal exposure, Elfe cohort, Disclosure programs, E-PRTR.

JEL Classification Numbers: Q5, G53, I1, I18, K3.

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1. Introduction

In recent years, toxic releases from industrial and polluting sites have become a significant global environmental concern. These releases can harm air, water, and soil quality and lead to the contamination of large areas, disrupting ecosystems. Such releases can originate from various sources, such as manufacturing facilities, power generation plants, mining operations, and waste disposal sites. They can include various harmful compounds, including hazardous chemicals, heavy metals, organic compounds, and radioactive materials. Toxic releases not only present a significant threat to the environment but can also pose many risks to human health. The potential health impacts depend on the specific substances released, the duration and frequency of exposure, and the release quantity.

According to the World Health Organization (WHO, 2005), more than 7 million people die from air pollution yearly. Exposure to air pollutants can lead to various health issues, including respiratory diseases in children and adults, cardiovascular diseases, and diabetes. Releases of fine particles and toxic gases can irritate the airways and cause respiratory disorders such as asthma in children (Amster et al., 2014; Moore et Hotchkiss., 2016; Rodriguez-Villamizar et al., 2018). Some substances released from industrial operations have been shown to be potentially carcinogenic, and hence as likely to cause cancer when inhaled over long periods (Comba et al., 2014; Xing et al., 2019). Additionally, chemicals released into the air can irritate the respiratory tract and cause inflammation of blood vessel walls, which can increase the risk of cardiovascular diseases such as high blood pressure and heart attacks (Ma et al., 2017; Sepandi et al., 2021; Ugalde-Resano et al., 2022), and mortality (Romieu et al., 2012; Shang et al., 2013; Janssen et al., 2013; Adebayo-Ojo et al., 2022).

Recent research has focused on examining the relationship between toxic releases and the health of the mother and fetus during pregnancy. Exposure of the mother to toxic substances can lead to health problems for both her and the fetus. Studies have shown that exposure to high levels of air pollutants found in industrial discharges is associated with an increased risk of congenital disabilities (Geschwind et al., 1992; Orr et al., 2002; Bentov et al., 2006; Brender et al., 2014; Landau et al., 2015), preterm birth (Goldberg et al., 1995; Ha et al., 2015), and infant mortality (Currie et al., 2009; Agarwal et al., 2010). The effects of such exposure can be immediate or occur over the long term and depend on the chemical's nature, exposure duration and intensity, and individual susceptibility. Despite the concerns and risks of living near highly polluting sites, many families continue to reside nearby.

Few studies have been conducted to investigate the impact of exposure to toxic substances on birth weight. A growing body of research suggests that pregnant women in proximity to polluting sites may be exposed to toxic substances that can negatively impact the health of their fetuses and contribute to low birth weight[2] (<2500 g). LBW is associated with higher childhood mortality risks and morbidity (McCormick, 1985; Watkins et al., 2016). Studies have yielded mixed results regarding the association between proximity to polluting sites and LBW. Some studies have found a significant association, such as Ha et al. (2015), who found a 1.1% increase in the probability of LBW for every 5 km closer to a power plant, and Currie et al. (2015), who found a 3% increase in LBW within one mile of a toxic plant. However, other studies have not found a significant association. For instance, Gong et al. (2018) conducted a study in Texas and found a positive association between maternal residential proximity to industrial facilities shared by the Toxic Release Inventory (TRI) and LBW in offspring. In a recent study conducted in Texas by Willis et al. (2021), however, slight negative associations were found between term birth weight and proximity to oil and gas drilling sites within 1-2 km and 2-3 km.

Additionally, a small excess risk of LBW was found in populations living near landfill sites (Elliott et al., 2003). However, other studies have not found a significant association between proximity to polluting sites and LBW. Shaw et al. (1992) found no increased risk of LBW in infants born to women who lived in census tracts with an environmental contamination site. Similarly, Sosniak et al. (1994) found no statistically significant impact between LBW and living near hazardous waste sites, steel and petrochemical industries (Bhopal et al., 1999), or specific waste sites (Morris et al., 2003; Morgan et al., 2004) during pregnancy. It is important to note that proximity to polluting sites is not the only factor that can affect birth weight. Other potential risk factors include maternal lifestyle and dietary habits, pregnancy and birth history, maternal age, and other health conditions.

The current study investigates the relationship between maternal residential proximity to the most pollutant sites and its impact on LBW among pregnant women in France, therefore, our findings may help to evaluate the effectiveness of the European disclosure mandate in reducing pollution exposure. To this end, we used data on the location and activity types of the European Pollutant Release and Transfer Register (E-PRTR) sites in France, and detailed birth data from the ELFE nationwide cohort. Both datasets include geographic coordinates, allowing for an analysis of the impact of proximity to polluting sites on birth weight. In line with the related literature, the study's estimates are based on comparing birth outcomes within various distances (0-3 km, 3.1-5 km, and 5.1-10 km) to those of women living more than 10 km away from pollution sites. Our work also considers other factors affecting birth weight, such as maternal age, lifestyle, and health conditions.

The remainder of the paper is organized as follows: Section 2 briefly introduces the ELFE cohort, the E-PRTR pollutant sites, and the analytical methods used to investigate the impact of E-PRTR sites on birth weight. Section 3 details the data and provides summary statistics. Section 4 presents the econometric models used in our analysis and reports the results. Section 5 discusses the strengths and limitations of our study. Finally, Section 6 provides the conclusion.

[2] LBW is defined by the World Health Organization as a birth weight strictly below 2500g.

2. Materials and Methods

2.1. Study population: ELFE

The ELFE cohort is a long-term study investigating how the environment influences children's physical development, health, and socialization. The data collection for the study[3] included an interview with the mother in the days following delivery, during which parental consent and contact arrangements were obtained, as well as a face-to-face questionnaire to report on the development and progress of the infants. The recorded observations include information on the health of each birth, maternal information, and other environmental and socialization factors. In the current study, we focus on the issue of LBW, defined as a birth weight below 2500 grams. LBW is a significant indicator of infant health status and is associated with morbidity, infant mortality, and congenital diseases.

The data collected for each birth in the ELFE cohort includes a personal identification code, date of birth, sex of the child, and birth weight. Additionally, maternal information recorded includes the mother's residence, age, gestational length, Body Mass Index (BMI), ethnicity, education level, marital status, parity, multiple births, number of antenatal visits, alcohol, and tobacco use during pregnancy, and if the delivery occurred during months characterized by hot or cold temperatures. Other factors, such as household income and maternal employment status, were also included in the study. The covariates were selected based on previous research identifying potential risk factors for LBW (Chay et Greenstone, 2003a-b; Currie et al., 2017; Hill, 2018). These covariates were chosen to control for potential confounding factors in analyzing the relationship between proximity to polluting sites and birth weight.

In this study, we aim to investigate the impact of various factors on birth weight, including proximity to polluting sites. Additionally, we aim to examine the effect of proximity to polluting sites by distinguishing the sectors of activity of these sites. This will enable us to identify the external costs of polluting sites, specifically regarding child health, by sector of activity. This will provide valuable information for policymakers and stakeholders to determine the most effective strategies for reducing the negative impact of pollution on child health.

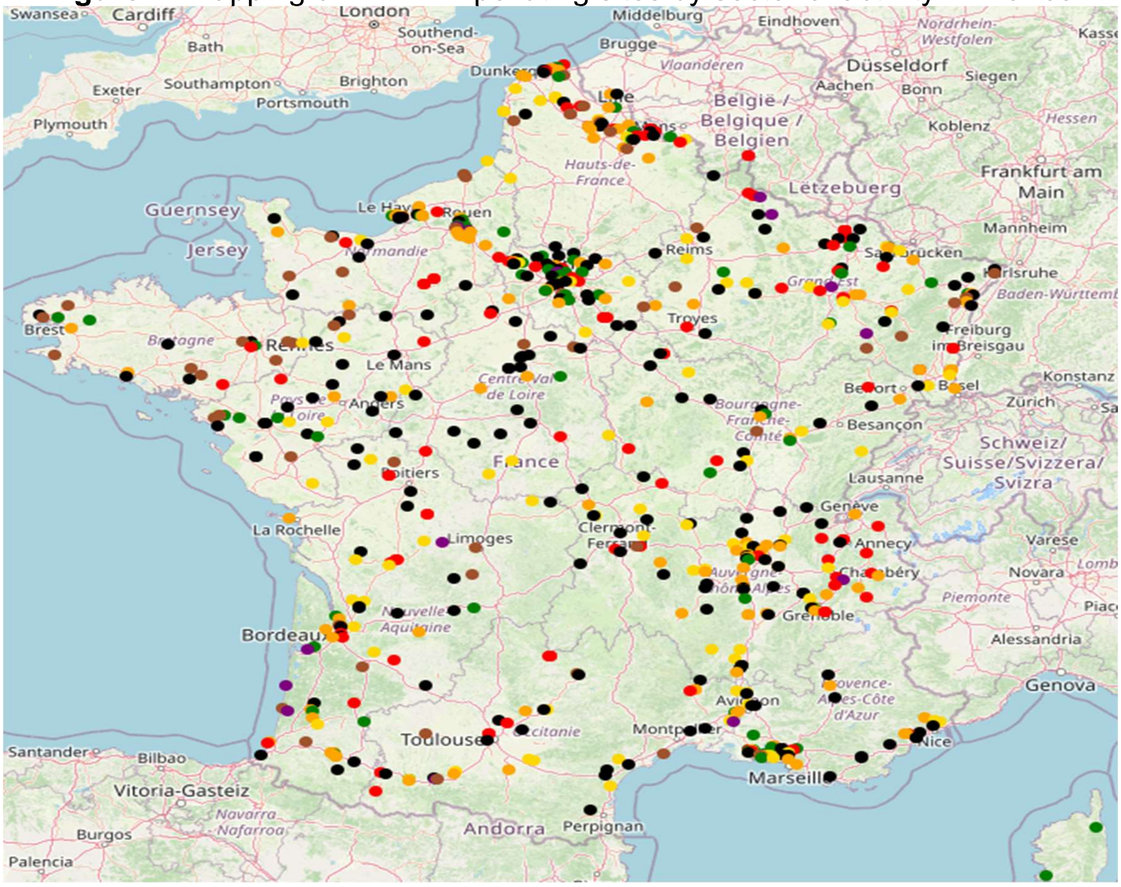
2.1.1. E-PRTR data

The current study utilizes the European Pollutant Release and Transfer Register (E-PRTR) database to identify industrial facilities emitting toxic air pollutants. The E-PRTR is

[3] The study was approved by the relevant ethics committees, including the National Commission for Information Technology and Civil Liberties, the Advisory Committee on the Treatment of Health Research Information, and the National Council for Statistical Information.

an environmental information disclosure program established by the European Environment Agency (EEA) through Regulation (EC) No 166/2006[4]. It is publicly accessible and provides data on toxic releases from highly polluting industrial installations in the European Union member states. The register contains data reported annually by "toxic" industries across 65 economic activities in Europe, covering various sectors such as the energy, chemical, and mineral industries.

Figure 1: Mapping of E-PRTR polluting sites by sector of activity in France



Note: **Green:** energy sector, **red:** production and processing of metals sector, **gold:** mineral sector, **orange:** chemical sector, **black:** waste and wastewater management sector, **purple:** products paper and wood production and processing sector, **brown**: other activities.

The E-PRTR program is established to facilitate public access to environmental information and to engage civil society in environmental management. In this study, we utilized the E-PRTR data to create a list of all French polluting sites that reported toxic air emissions to the E-PRTR during 2010-2011, which includes more than 2513 polluting sites known for high air emissions. The E-PRTR data contains the names and exact addresses of these polluting industries. To obtain these sites' geographic coordinates (longitude and latitude), we developed a Python script that converts the industries' addresses into geographic coordinates. These geographic coordinates were used to map

[4] Source: https://ec.europa.eu/environment/industry/stationary/e-prtr/legislation.htm

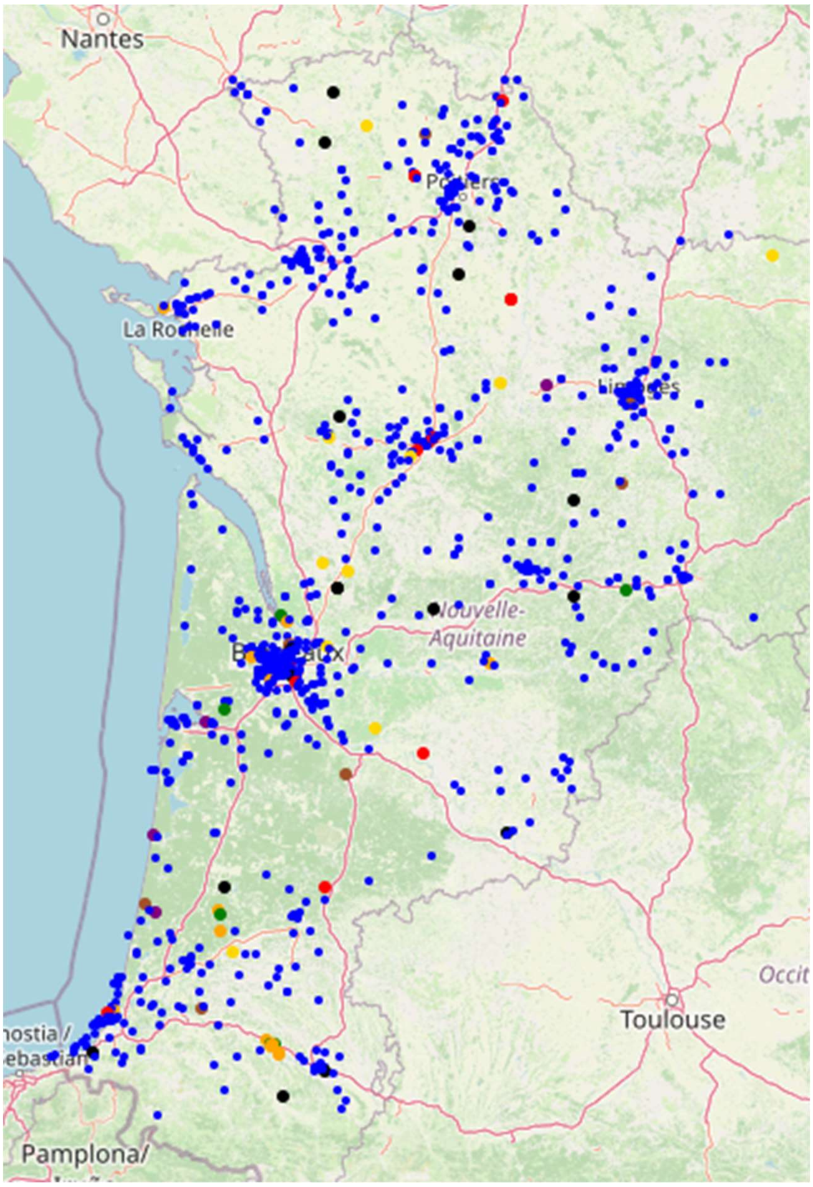
polluting sites and calculate the distance (in km) from the maternal residence during pregnancy. We have restricted our focus to polluting sites that are located within a 10-kilometer radius of the maternal residence, which amounts to a total of 681 polluting sites. Figure 1 illustrates the mapping of E-PRTR sites by sector of activity. This distance calculation will allow us to identify the proximity of maternal residences to these polluting sites and assess the impact on birth weight.

2.2.2. Data linkages and aggregation

To evaluate the impact of E-PRTR sites on child health, we linked the E-PRTR data to vital statistics by using the geographic coordinates of the polluting sites and the maternal residence during pregnancy. We first created a dataset comprising all polluting sites registered in the E-PRTR (2010-2011) and the maternal residence. Then, we analyzed the birth weight of newborns whose maternal residence was within a 10-kilometer radius of these polluting sites[5]. This linking of the E-PRTR data with vital statistics will allow us to investigate the relationship between proximity to polluting sites and birth weight and identify these sites' potential impact on child health.

We used regression analysis to evaluate the impact of proximity to E-PRTR sites on birth weight. In addition, a Python script was developed to calculate the effective distance between the maternal residence and the polluting sites registered in the E-PRTR within the study area. This allowed us to determine the proximity of each maternal residence to different polluting sites in the geographical area. Figure 2 depicts the spatial overlap between maternal residences and E-PRTR-classified polluting facilities by sector of activity in the Aquitaine region. The illustration highlights the proximity of maternal residences, located within a radius of 10 km, to various pollution sites in the region (showing that maternal residences are within a 10 km radius of all E-PRTR polluting sites). Additional maps displaying the cartography of other geographical areas can be found in the appendix of this document (figures 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 1.10, and 1.11). These maps will aid in visually demonstrating the spatial relationship between maternal residence and polluting sites.

Figure 2: Mapping maternal residences and polluting sites by sector of activity in the Nouvelle-Aquitaine region.



Note: **Green:** energy sector, **red:** production and processing of metals sector, **gold:** mineral sector, **orange:** chemical sector, **black:** waste and wastewater management sector, **purple:** products paper and wood production and processing sector, **brown**: other activities and **blue**: maternal residences (ELFE).

3. Descriptive statistics

Of the 5736 births included in the analysis, the mean birth weight was 3374 ± 435 grams, and 102 births (1.77 %) were classified as LBW (< 2500 grams). The sample consisted of 50.93 % male and 49.07 % female births. The average age of the mothers was 31.25 ± 4.58 years, with the most represented age group being 30-34 years (n= 2330 or 40.61 %).

The majority of the mothers were married (n = 3787 or 66.01%), of European origin (n = 5291 or 92.23 %), had a mean gestational age of 39.45 ± 1.12 weeks, and had a higher education level (n = 4131 or 72.01 %). Of the 5736 mothers, 1460 (25.45 %) had consumed alcohol, and 978 (17.05 %) had smoked during their pregnancy. Most of the mothers were employed (4831 or 84.21 %) and had an income between 2000 and 3999 euros (n = 2930 or 51.07 %). Descriptive statistics for the study population and variables can be found in Table 1. Additional tables for statistical analysis by geographical area can be found in the appendix of this document (Tables 1.1, 1.2, 1.3, 1.4, 1.5, and 1.6).

Table 1: Descriptive statistics of the study population, mean birth weight (SD) and proportion of LBW (1000 g-2500 g), for singleton live births of the ELFE cohort in France (n = 5736)

Variable relating to birth and mother	Number (%)	Average weight (SD)	LBW (%)
Birth weight (g)	*5736*	*3374(435)*	*102(1.77)*
Low birth weight (<2500 g)	*102(1.77)*	*2322(268)*	
Child's sex			
Male	*2919(50.88)*	*3438(429)*	*39(1.34)*
Female	*2817(49.1)*	*3309(426)*	*63(2.24)*
Antenatal care			
None	*11(0.19)*	*3165(336)*	-
1 to 6	*419(7.3)*	*3339(435)*	*10(2.39)*
6+	*5306(92.49)*	*3378 (432)*	*92(1.73)*
Gestational length (weeks)		*39.41 (1.14)*	
37-38	*1138(19.83)*	*3166(414)*	*65(5.71)*
39-40	*3466(60.42)*	*3387(403)*	*36(1.03)*
41-42	*1132(19.73)*	*3596(408)*	*1 (0.08)*
Alcohol use by mother			
Yes	*1460(25.45)*	*3360(422)*	*27(1.85)*
No	*4276(74.53)*	*3379(436)*	*75(1.75)*
Tobacco use by mother			
Yes	*978(17.05)*	*3255(448)*	*43(4.4)*
No	*4758(82.94)*	*3399(425)*	*59(1.24)*
Mother's education			
Elementary School / Middle School	*125(2.18)*	*3324(470)*	*6(4.8)*
Certificate of professional competence	*549(9.57)*	*3312(456)*	*20(3.64)*
High-School	*926(16.14)*	*3375(442)*	*16(1.73)*
Higher education (faculty, University Institute of Technology)	*4131(72.01)*	*3384(425)*	*60(1.45)*
Never been to school	*5(0.09)*	*3236(373)*	-
Mother's ethnicity			
European Union	*5291(92.23)*	*3374(433)*	*92(1.74)*
Maghreb countries	*187(3.26)*	*3435(449)*	*5(2.67)*
Sub-Saharan Africa	*155(2.7)*	*3357(413)*	*3(1.94)*
Other	*103(1.8)*	*3325(402)*	*2(1.94)*
Mother's marital status			
Married	*3787(66.01)*	*3400(430)*	*57(1.51)*
Unmaried	*1949(33.97)*	*3325(434)*	*45(2.31)*
Mother's age (years)		*31.28 (4.58)*	

<20	24(0.42)	3352(394)	-
20-24	277(4.83)	3326(445)	4(1.44)
25-29	1565(27.28)	3359(439)	34(2.17)
30-34	2330 (40.61)	3381(426)	36(1.55)
35-39	1239(21.6)	3402(427)	16(1.29)
>39	301(5.25)	3338(452)	12(3.99)
Season of birth			
Spring	904(15.76)	3375(443)	20(2.21)
Summer	1474(25.69)	3369(437)	28(1.9)
Fall	3358(58.53)	3377(428)	54(1.61)
Mother's BMI (KG/m^2)			
Underweight (<18.5 kg/m)	425(7.41)	3267(418)	14(3.29)
Normal weight (between 18.5 and 24.9)	3755(65.45)	3360(424)	66(1.76)
Overweight (between 25 and 29.9)	1030(17.95)	3419(442)	14(1.36)
Obesity (> 30)	526(9.17)	3475(459)	8(1.52)
Mother worked during pregnancy			
Yes	4831(84.21)	3371(432)	84(1.74)
No	905(15.77)	3391(432)	18(1.99)
Income (euros)			
<2000	874(15.23)	3334(439)	23(2.63)
2000-3999	2930(51.07)	3367(437)	54(1.84)
4000-5999	1430(24.93)	3407(417)	20(1.4)
6000-7999	346(6.03)	3409(407)	3(0.87)
8000-9999	125(2.18)	3365(498)	2(1.6)
>10000	31(0.54)	3342(420)	-

Notes: SD = Standard deviation. Coverage: 5736 births.

Table 2 presents the proximity of the maternal residences during pregnancy to the nearest E-PRTR sites by sector of activity. It also compares the birth weights of newborns between mothers living at varying distances from E-PRTR site. Of the 5736 mothers, the majority (37.55 %) resided within 5.1-10 km of at least one E-PRTR sites, and 266 (35.34 %) lived within 0-3 km of at least one polluting site. Table 2 illustrates newborns' birth weight differences between mothers living at distances 0-3 km, 3.1-5 km, and 5.1-10 km from E-PRTR sites.

Table 2: Difference in birth weight by distance to the E-PRTR activity sectors

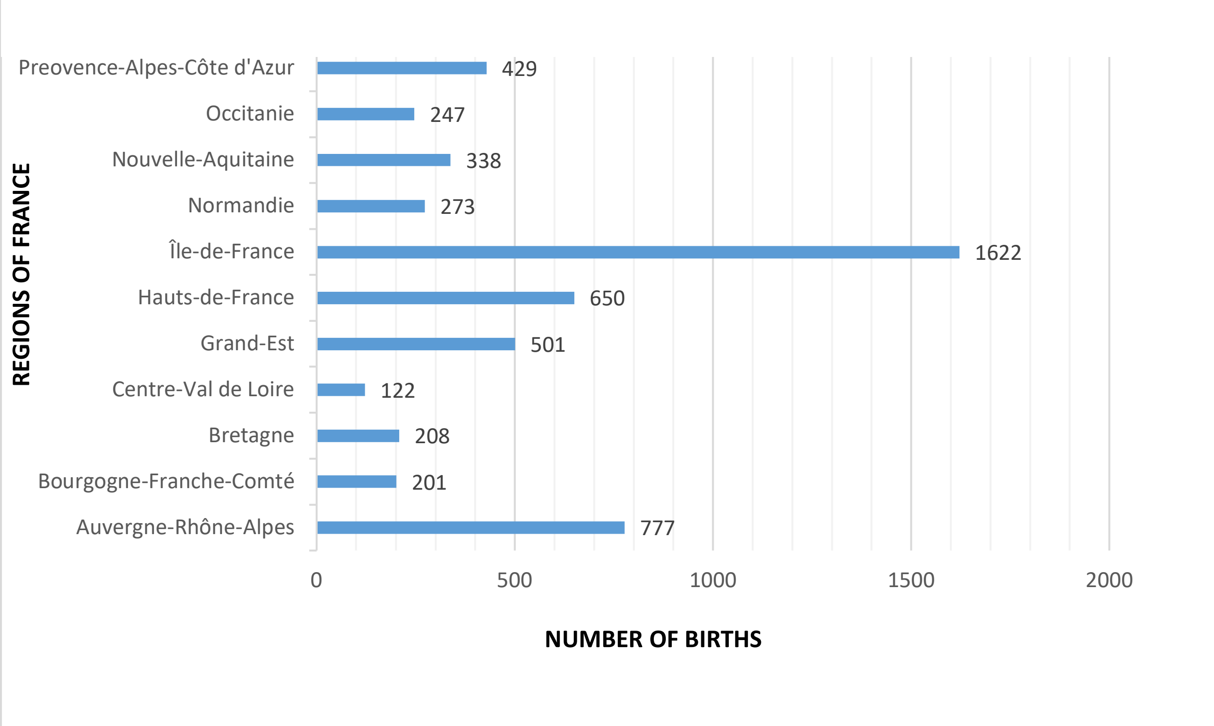
Sector of activity	Number (%)	Difference in birth weight (g)
Energy sector		
0-3 (reference)	611(10.65)	-
3.1-5	623(10.86)	-26.13
5.1-10	1267(22.08)	-29.52
Production and processing of metals		
0-3 (reference)	332(5.79)	-
3.1-5	364(6.34)	-15.21
5.1-10	1102(19.21)	-39.2
Mineral industry		
1.1-3 (reference)	167(2.92)	-
3.1-5	182(3.17)	-24.19
5.1-10	712(12.41)	12.34

Chemical industry		
0-3 (reference)	*456(7.93)*	-
3.1-5	*643(11.19)*	*-31.18*
5.1-10	*1702(29.67)*	*-43.7*
Waste and wastewater management		
0-3 (reference)	*672(11.72)*	-
3.1-5	*923(16.09)*	*-14.28*
5.1-10	*2140(37.3)*	*-6.04*
Paper and wood production and processing		
0-3 (reference)	*126(2.19)*	-
3.1-5	*138(2.58)*	*44.29*
5.1-10	*587(10.23)*	*79.13*
Other activities		
0-3 (reference)	*78(1.36)*	-
3.1-5	*99(1.73)*	*130.65*
5.1-10	*289(5.04)*	*107.98*
All sector		
0-3 (reference)	*2028(35.34)*	-
3.1-5	*1554(27.09)*	*-15.80*
5.1-10	*2154(37.55)*	*-4.97*

- **<u>Regional disparities of ELFE newborns in France:</u>**

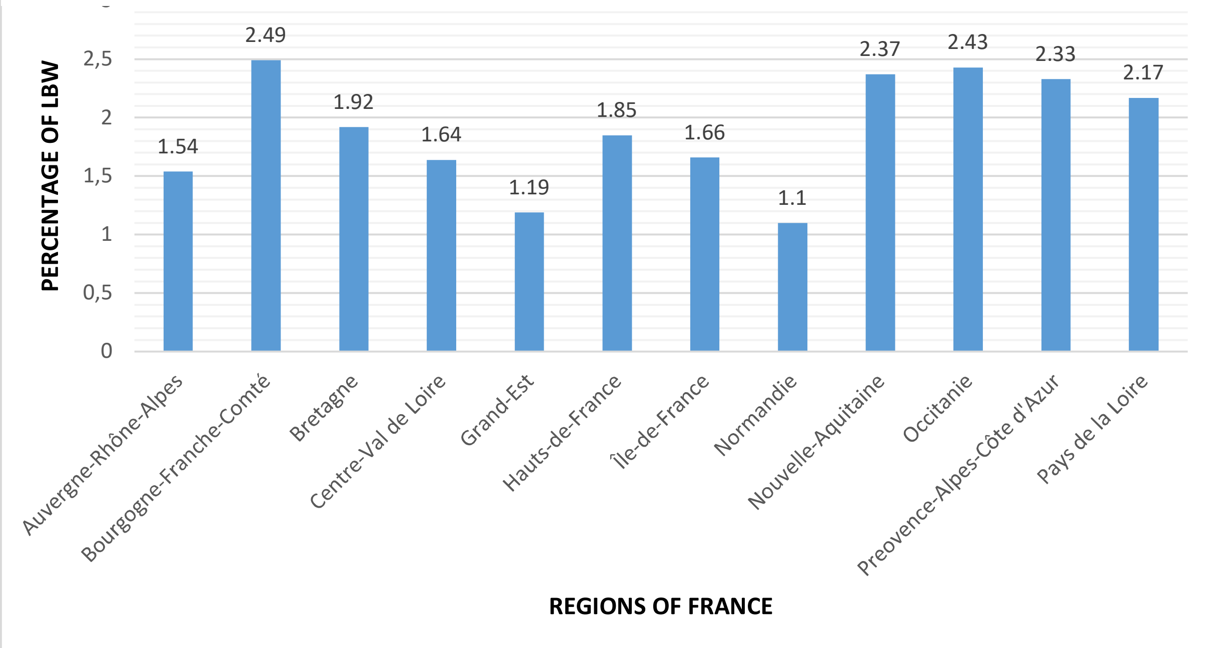
We present histograms to illustrate the regional disparities of ELFE infant births and France's LBW percentage. As shown in Figures 3 and 4, the number of births was highest in Île-de-France (N = 1622 or 28.2 %) with 1.66 % LBW and Auvergne-Rhône-Alpes (N = 777 or 13.54 %) with 1.54 % LBW. The lowest number of births was in Centre-Val de Loire (N = 122 or 2.12 %), with 1.64 % LBW. According to Jean Vaillant (2005), the definition of a representative sample differs depending on whether the sampling plan is probabilistic or non-probabilistic (Gerville-Réache et al., 2011). A non-probability design provides a representative sample if the structure of the sample for some key variables is similar to that of the target population (e.g., the proportions of regional birth disparities are similar in the sample to those of the target population). The ELFE cohort is considered representative because the regional disparity of ELFE infant births is similar to the French

Figure 3: Number of births by region



regional distribution of births published by INSEE in 2011. According to INSEE, the highest number of births in France was in Île-de-France (N = 184525 or 23.04 %) and Auvergne-Rhône-Alpes (N = 49427 or 12.09 %).

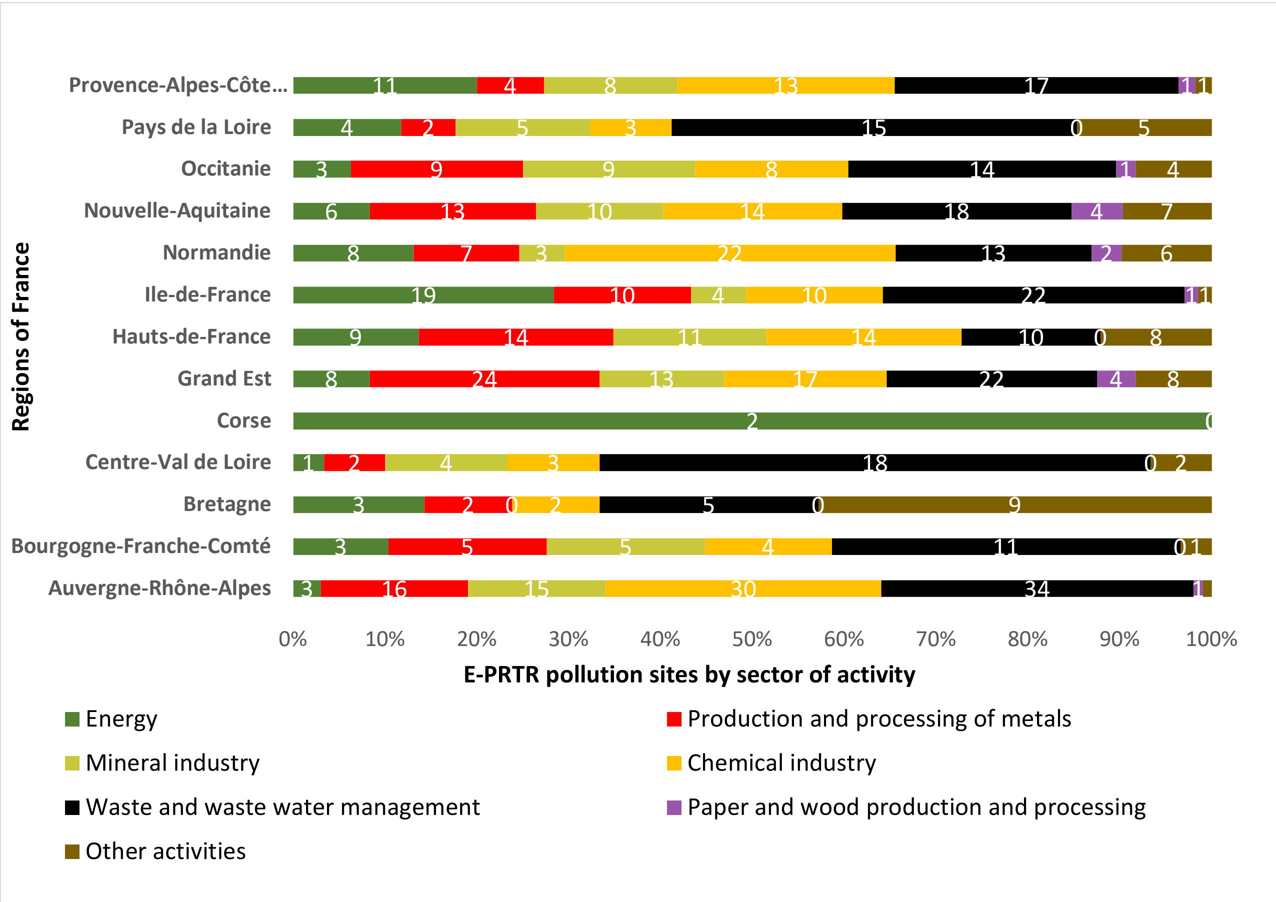
Figure 4: Low birth weight by region



- **<u>Regional disparities of E-PRTR by sector of activity in France:</u>**

In 2010-2011, the E-PRTR register contained nearly 2500 polluting sites in France. However, due to several challenges with the E-PRTR data (such as GPS locations), we retained only 681 sites that reported toxic air emissions to E-PRTR. As shown in Figure 5, waste and wastewater management (29.22 %) and the chemical industry (20.55 %) were the two sectors with the highest proportions of sites. Auvergne-Rhône Alpes and Grand Est regions had the highest number of E-PRTR sites (100 sites in Auvergne-Rhône Alpes and 96 sites in Grand Est). Additionally, Corsica was excluded from our study as it had only two E-PRTR sites, which were far from the maternal residence during gestation (the distance between the two was more than 10 km).

Figure 5: E-PRTR sites by sector of activity in France (2010-2011)

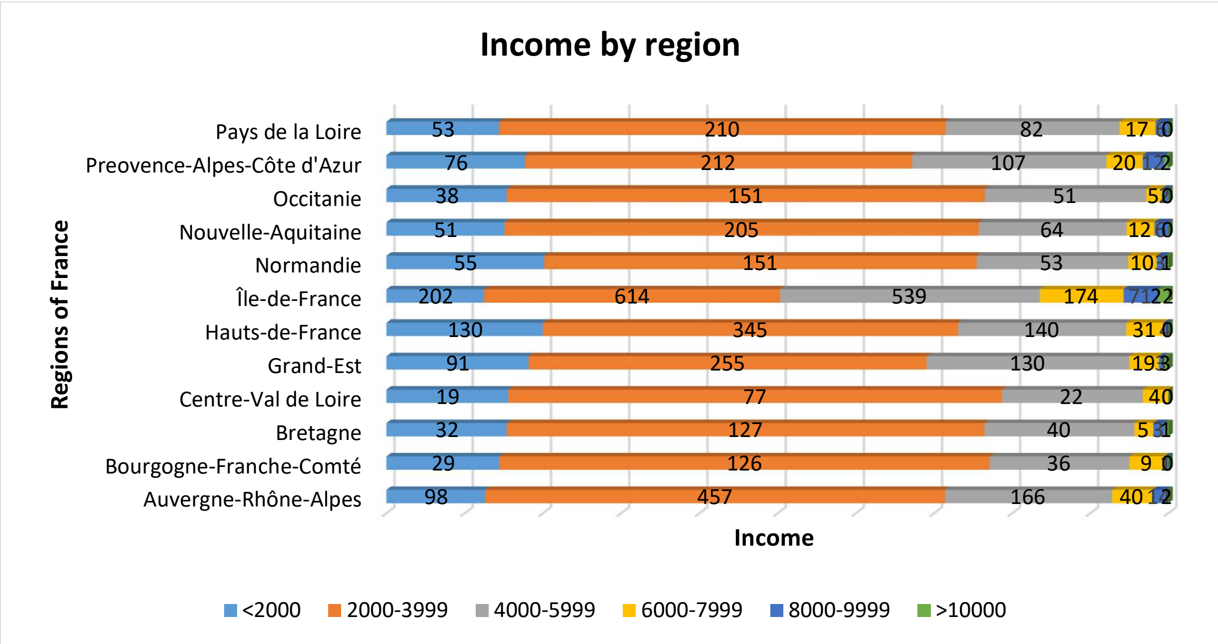


Source : authors

- **France Household Income per region:**

In addition to data on child health and E-PRTR sites, we also utilized microdata on household income from the French Longitudinal Study. As shown in Figure 6, half of the households in our sample (N = 2930) had an income between 2000 and 3999 euros per month, 15% had less than 2000 euros, 24% had between 4000 and 5999 euros, and 8.75 % of the households had an income above 6000 euros per month. The average income of all families was 3,360 euros.

Figure 6: Income by region



4. Empirical Model

To study the impact of proximity to E-PRTR polluting sites on birth weight, we employed a multiple linear regression model with birth weight as the continuous dependent variable. This linear model relates the dependent variable (birth weight) to independent variables such as socio-economic and sociodemographic factors and the distance to E-PRTR polluting sites. All models were adjusted for previously identified risk factors for LBW. Models were adjusted for factors that could affect birth weight, including smoking during pregnancy (yes/no), smoking during pregnancy (yes/no), mother's marital status (married/unmarried), and mother's status (working/not working). The models contained categorical variables: the mother's ethnicity was defined as European Union, Maghreb countries, Sub-Saharan Africa, and others. The birth seasons of the newborn were spring, summer, and fall. We adjusted the covariates of the proximities of the E-PRTR sites by activity sector, the distance between 0 and 3 km (yes/no), the distance between 3.1 km and 5 km (yes/no), and 5.1 km and 10 km (yes/no). To complete our model, additional covariates were considered, such as the sex of the newborn, the mother's age, length of gestation, the mother's education level, prenatal visit, household income, and the mother's BMI.

In the first phase of our study, we employed a linear model (model 1) to analyze the association between various sociodemographic and socioeconomic variables and birth weight. The variables included in the model were maternal education, maternal age, smoking during pregnancy, newborn gender, and income. However, we did not include variables related to the distance between the mother's residence during gestation and E-PRTR sites. Model 1 can be expressed as follows.

$$W_i = \beta_0 + \sum_{c=1}^{C} \beta_c X_{c,i} + \varepsilon_i \quad (1)$$

where W_i is the birth weight of newborns, X are the sociodemographic and socioeconomic variables of the mother and the newborn. β are the regression coefficients determining the impact of sociodemographic and socioeconomic variables on the newborn's birth weight, and ε is the residual error that represents the difference between the actual values and the values predicted by the model.

In the second phase of our analysis, we assumed that different activity sectors of the E-PRTR (energy sector, production and processing of metals, mineral industry, chemical industry, waste, and wastewater management, paper and wood production and processing, and other activities) would have a homogeneous impact on newborns' birth weight. Therefore, we created a variable that aggregates all E-PRTR activity sectors, referred to as "All E-PRTR activity sectors," to represent the residential proximity to E-PRTR sites. Model 2 can be expressed as follows:

$$W_i = \beta_0 + \sum_{c=1}^{C} \beta_c X_{c,i} + \alpha_a Y_{a,i} + \varepsilon_i \quad (2)$$

where Y is the variable representing E-PRTR polluting sites, and α is the regression coefficient determining the impact of proximity to E-PRTR sites on birth weight.

In linear model (3), we included covariates related to the proximity of E-PRTR sites. These covariates consisted of the distance between the mother's residence and E-PRTR sites, subdivided into three categories: a distance of 0 to 3 km (yes/no), a distance of 3.1 km to 5 km (yes/no), and a distance of 5.1 km to 10 km (yes/no). We compared the birth weight of newborns whose mothers resided within a radius of 0 to 3 km and 3.1 to 5 km, respectively, to mothers living at a greater distance from the polluting sites. Model (3) can be expressed as follows:

$$W_i = \beta_0 + \sum_{c=1}^{C} \beta_c X_{c,i} + \delta_b Z_{b,i} + \varepsilon_i \quad (3)$$

where Z represents the mother's residence radius in relation to E-PRTR sites, and δ is the coefficient determining the impact of proximity to E-PRTR sites by the mother's residence radius on birth weight.

In model (4), we assessed the effect of proximity to pollutant sites on birth weight, considering the different activity sectors of E-PRTR sites. We examined the specific impact of each activity sector on birth weight. Model (4) can be expressed as follows:

$$W_i = \beta_0 + \sum_{c=1}^{C} \beta_c X_{c,i} + \gamma_d K_{d,i} + \varepsilon_i \quad (4)$$

where K represents the variable representing the activity sectors of E-PRTR sites, and γ is the regression coefficient determining the impact of each E-PRTR activity sector on birth weight.

Lastly, in the final linear model, we introduced interaction variables between the proximity radii of pollutant sites and E-PRTR activity sectors to explore the joint effects of these two factors on birth weight. Model (5) can be expressed as follows:

$$W_i = \beta_0 + \sum_{c=1}^{C} \beta_c X_{p,i} + \theta_L F_{p,i} + \varepsilon_i \quad (5)$$

where F represents the mother's residence radius in relation to E-PRTR sites by activity sectors, and θ is the regression coefficient determining the impact of proximity to E-PRTR sites by activity sectors on birth weight.

Our methodological approach allowed us to consider the impact of proximity to E-PRTR pollutant sites and the specific effect of different activity sectors on birth weight. Furthermore, by introducing interaction variables, we explored the combined effects of proximity and activity sectors, which will provide a deeper understanding of the underlying mechanisms.

Table 3: Estimation results of the linear model of the impact of proximity to E-PRTR sites on birth weight

	Dependent variable: birth weight				
	(1)	**(2)**	**(3)**	**(4)**	**(5)**
(Intercept)	***-2747.75****	***-2759.60****	***-2743.44****	***-2742.67****	***-2748.05****
	(210.036)	*(210.419)*	*(210.129)*	*(211.053)*	*(210.981)*
Child's sex (ref. male)					
Female	***-138.540****	***-138.417****	***-138.408****	***-138.287****	***-137.650****
	(10.251)	*(10.252)*	*(10.253)*	*(10.259)*	*(10.266)*
Alcohol use by mother (ref. no)					
Yes	*-16.056*	*-16.118*	*-16.106*	*-16.126*	*-15.796*
	(11.921)	*(11.921)*	*(11.922)*	*(11.928)*	*(11.937)*
Tobacco use by mother (ref. no)					
Yes	***-105.614****	***-105.698****	***-105.724****	***-106.470****	***-106.946****
	(14.308)	*(14.308)*	*(14.309)*	*(14.319)*	*(14.324)*
Mother's education (ref. ES/MS)					
Certificate of professional competence	*-33.240*	*-33.528*	*-33.702*	*-31.231*	*-34.656*
	(39.045)	*(39.047)*	*(39.052)*	*(39.083)*	*(39.106)*
High-School	*-9.322*	*-9.351*	*-9.430*	*-7.479*	*-10.820*
	(37.595)	*(37.595)*	*(37.598)*	*(37.630)*	*(37.649)*
Higher education reference	*-17.368*	*-17.213*	*-17.287*	*-16.224*	*-19.954*
	(36.999)	*(37.000)*	*(37.003)*	*(37.036)*	*(37.067)*
Never been to school	*-58.450*	*-54.633*	*-54.085*	*-57.408*	*-62.415*

	(177.524)	(177.573)	(177.608)	(177.681)	(177.763)
Mother's marital status (ref. married)					
PACS	**-46.226***	**-46.239**	**-46.230**	**-45.922**	**-45.593**
	(14.703)	(14.703)	(14.704)	(14.723)	(14.735)
Divorced	-72.842	-72.979	-72.816	-73.716	-74.431
	(56.630)	(56.631)	(56.634)	(56.656)	(56.683)
Single	**-60.278***	**-59.826***	**-59.772***	**-60.440***	**-59.311***
	(12.317)	(12.327)	(12.327)	(12.325)	(12.353)
Widowed	-180.931	-184.055	-184.313	-174.781	-182.042
	(224.100)	(224.128)	(224.142)	(224.391)	(224.199)
Mother worked during pregnancy (ref. no)					
Yes	**-37.414**	**-37.757**	**-37.813**	**-36.985**	**-37.536**
	(15.118)	(15.123)	(15.124)	(15.139)	(15.145)
Mother's age (years)	3.332	3.459	3.491	3.052	3.667
	(5.708)	(5.710)	(5.710)	(5.714)	(5.718)
Antenatal care (visits)	**-7.058***	**-7.034***	**-7.023***	**-7.067***	**-7.076***
	(2.125)	(2.125)	(2.126)	(2.126)	(2.130)
Mother's BMI (kg/m²)	**11.496***	**11.495***	**11.499***	**11.423***	**11.396***
	(1.132)	(1.132)	(1.132)	(1.133)	(1.134)
Gestational length	**144.448***	**144.448***	**144.451***	**144.381***	**144.305***
	(4.571)	(4.571)	(4.571)	(4.573)	(4.575)
Season of birth (ref. Fall)					
Summer	-11.275	-11.101	-11.048	-11.533	-10.457
	(16.388)	(16.389)	(16.390)	(16.408)	(16.408)
Spring	5.277	5.273	5.236	5.077	5.263
	(14.532)	(14.532)	(14.533)	(14.542)	(14.543)
Mother's ethnicity (ref. European Union)					
Maghreb countries	14.857	16.145	16.340	12.698	14.485
	(30.012)	(30.043)	(30.057)	(30.070)	(30.079)
Sub-Saharan Africa	-16.062	-14.885	-14.698	-16.515	-15.890
	(32.239)	(32.264)	(32.268)	(32.343)	(32.375)
Other	-30.539	-29.464	-29.335	-31.916	-30.179
	(39.048)	(39.065)	(39.065)	(39.087)	(39.109)
Log (Income)	**45.971***	**46.209***	**46.210***	**46.161***	**47.717***
	(13.504)	(13.507)	(13.515)	(13.617)	(13.645)
All E-PRTR activity sectors		1.505			
		(1.608)			
E-PRTR activity sectors by distance (ref. 5-10km)					
All E-PRTR activity sectors 0-3 km			-12.337		
			(12.037)		
All E-PRTR activity sectors 3.1- 5km			-10.997		
			(12.909)		
Activity sectors					
Energy sector (ES)				-4.112	
				(12.045)	
Production and processing of metals (PPMS)				5.931	
				(13.793)	
Mineral industry (MIS)				**-36.887**	
				(16.979)	
Chemical industry (CIS)				8.358	
				(11.959)	
Waste and wastewater management (WWMS)				-1.465	
				(11.357)	
Paper and wood production and processing (PWPPS)				-6.491	
				(25.393)	
Other activities (OAS)				-2.379	
				(23.358)	
Industry-specific distance for E-PRTR					
ES x All-PRTR activity sectors 0-3 km					-14.354
					(17.413)
ES x All-PRTR activity sectors 3.1-5 km					2.044

					(22.617)
PPMS x All-PRTR activity sectors 0-3 km					8.343
					(22.554)
PPMS x All-PRTR activity sectors 3.1-5 km					15.494
					(23.610)
MIS x All-PRTR activity sectors 0-3 km					***-68.961*****
					(31.043)
MIS x All-PRTR activity sectors 3.1-5 km					***-56.773****
					(33.761)
CIS x All-PRTR activity sectors 0-3 km					6.033
					(19.557)
CIS x All-PRTR activity sectors 3.1-5 km					-1.498
					(19.535)
WWMS x All-PRTR activity sectors 0-3 km					3.696
					(16.598)
WWMS x All-PRTR activity sectors 3.1-5 km					-9.710
					(17.328)
PWPPS x All-PRTR activity sectors 0-3 km					-29.058
					(35.990)
PWPPS x All-PRTR activity sectors 3.1-5 km					-52.839
					(55.303)
OAS x All-PRTR activity sectors 0-3 km					-64.355
					(44.448)
OAS x All-PRTR activity sectors 3.1-5 km					13.993
					(48.551)
Sample Size	5736	5736	5736	5736	5736
R^2	0.2041	0.2043	0.2043	0.205	0.2059
F-statistic	66.61***	63.75***	61.1***	50.73***	41.06***

Note: The table presents linear models where the dependent variable is the birth weight. Multiplication (x) is used to indicate an interaction variable. ES/MS: Elementary School/ Middle School. Standard errors in brackets.
*p < 0.10, **p < 0.05, *** p < 0.01.

The results of the linear regression analyses describing the relationships between birth weight and various socio-demographic and socio-economic factors and the proximity to E-PRTR pollutant sites are presented in Model (1) of Table 3. We observed a significant association between infant sex and birth weight, with female infants weighing approximately 138 grams less than male infants. Additionally, smoking during pregnancy was strongly linked to a significant decrease in birth weight, with mothers giving birth to infants weighing approximately 105 grams less than non-smokers, while alcohol consumption did not show a significant effect. The results also revealed that infants born to single or cohabiting mothers had a lower birth weight than those born to married mothers, with a difference of approximately 60 and 46 grams, respectively, while no significant association was observed between birth weight and the marital status of widowed and divorced mothers. Furthermore, a significant relationship was identified between gestational age and birth weight, with each additional week of gestation increasing the birth weight by 144 grams. The results of our models highlighted a positive association between birth weight and maternal pre-pregnancy body mass index (BMI), with higher BMI being associated with higher birth weight.

Additionally, the number of prenatal visits was negatively associated with birth weight, with more visits being linked to lower birth weight. This observation may be explained by complications related to maternal health during pregnancy. Our results also showed that mothers working during pregnancy, and household income, significantly impacted birth weight. Infants born to employed mothers had a higher birth weight of approximately 37 grams than infants born to unemployed mothers, and higher household income was associated with higher birth weight. These socio-economic factors may reflect the household's financial situation, particularly the maternal economic status during pregnancy, which can influence the mother's ability to meet her needs and ensure her and the fetus's health. No significant association was observed between birth weight and maternal age, maternal education level, maternal ethnic origin, infant's season of birth, and alcohol consumption during pregnancy.

The results from the other regression models revealed similar coefficient estimates for socio-demographic and socio-economic factors. However, no significant association was found between birth weight and the variable "All E-PRTR Activity Sectors" (Model 2). This contradicts our expectations, which predicted a positive and statistically significant correlation between birth weight and proximity to E-PRTR sites, whereas no significant relationship was observed. Additionally, when comparing the birth weight of mothers living at different distances from E-PRTR pollutant sites (0-3 km, 3.1-5 km, and 5.1-10 km) in Model 3, no significant association was found between birth weight and proximity of maternal residence to these sites. However, in Model 4, we found that increased proximity to the mineral sector had a negative impact on birth weight. The closer the maternal residence during pregnancy was to a mineral-type pollutant site within the E-PRTR, the lower the newborn's birth weight, with a decrease of approximately 36 grams per kilometer.

Furthermore, living between 0-3 km and 3.1-5 km from a mineral industry decreased birth weight compared to other distances, with respective decreases of 68 and 56 grams. It is noteworthy that the negative impact of the mineral sector on birth weight is consistent with previous studies showing that children exposed to a mining environment in utero are more likely to experience growth retardation or severe growth delay compared to control groups, with an increased incidence of five percentage points (Von Der Goltz and Barnwal, 2019). No such associations were observed for other activity sectors.

5. Strengths and limitations of this study

The databases in this study concerning polluting sites and child health were sourced from reliable and ethically approved entities. The ELFE cohort, for instance, received the necessary clearance from relevant ethics committees such as CNIL (Commission nationale de l'informatique et des libertés), CCTIRS (Comité Consultatif sur le traitement de l'Information en matière de Recherche dans le domaine de la Santé), and CNIS (Conseil National de l'Information Statistique). Meanwhile, the E-PRTR register, which encompasses all sectors of activity, was established through Regulation (EC) No 166/2006 of the European Parliament and of the Council.

Figure 7 in the document's appendix shows that the model tests were subjected to thorough verification. The reference line indicates a horizontal trend for most of the data, while the scatterplot does not demonstrate any discernible linear, quadratic, or other patterns, thus showing homogeneous variance. The predicted values are also closely aligned with the actual weight values, falling within one error, which suggests that the model is a robust fit. Moreover, there were no instances of atypical contributions. Although normality was established for most observations, some discrepancies were observed at the weight's extreme values.

This study is novel in that it is the first to investigate the effect of living near polluting sites on newborn birth weight, with a comprehensive examination of all activity sectors listed in the European E-PRTR register. Other studies have focused on the association between proximity to a single polluting site or activity sector and birth weight, while some have looked into the link between birth weight and air pollution. In addition, the study's ability to control for sociodemographic and household financial factors is also noteworthy.

Our study has several limitations that are common to retrospective studies. Firstly, we used buffer zones to establish the distance between the E-PRTR sites and the residence of the mothers of ELFE children. This did not allow us to obtain precise distances, which would have been helpful for more accurately assessing the impact of polluting sites on the birth weight of newborns. For example, a finer comparison between the birth weights of babies born close to polluting sites (within one kilometer) and those born further away would have been desirable. However, due to confidentiality reasons on the part of ELFE, we could not obtain this information.

Moreover, we needed precise information on the quantity and type of toxic emissions emitted by the E-PRTR sites studied. These data would have been helpful for a more detailed understanding of these sites' impact on newborns' health. Another important limitation of our study is that we could not consider the air quality index in the mother's city of residence. We had to limit ourselves to the available data so as not to compromise the confidentiality of the ELFE children and their families. This may have consequences for evaluating pollution's effects on children's birth weight.

Finally, we used residential addresses at birth to assess the proximity of E-PRTR sites, assuming that mothers did not change their addresses during pregnancy. This may be a source of error because mothers may be exposed to different pollution levels if they have changed their address during pregnancy.

While our study provides valuable insights into the relationship between pollution from E-PRTR sites and birth weight, the above limitations must be considered when interpreting our findings. Future research could address these limitations by obtaining more precise data on distances and emissions and considering the air quality index and changes in residence during pregnancy.

6. Conclusion

The present study aimed to investigate the association between proximity to polluting sites E-PRTR, and birth weight among term infants using data from the ELFE cohort. We controlled for several socio-demographic and socio-economic factors in our analysis. Our results indicate that proximity to E-PRTR sites generally was not associated with LBW. However, upon further examination of specific industrial sectors, we observed that mining sites had a detrimental effect on birth weight for infants whose mothers resided within distances of 0-3 km and 3.1-5 km compared to those between 5.1 and 10 km from these sites. Specifically, residing within 0-3 km and 3.1-5 km of a mineral industry resulted in reduced birth weight compared to other distances, with respective decreases of 68 and 56 grams.

This finding suggests that proximity to certain types of polluting facilities may have a negative impact on birth weight, specifically those related to mineral industries. However, it is essential to note that our study did not have information on the specific pollutants or emissions released by these sites. It would be necessary to understand the mechanisms behind this association fully.

Additionally, our study found that other factors such as infant sex, number of prenatal visits, alcohol consumption, marital status, mother's BMI, gestational length, household income, and maternal status were also associated with birth weight. These factors may also play a role in the overall health and well-being of the mother and fetus during pregnancy and should be considered in future research on this topic.

It is also important to note that our study has some limitations. The addresses used to determine proximity to E-PRTR sites were residential addresses at birth and assumed that mothers did not change their addresses during pregnancy. Mothers may have moved during pregnancy and been exposed to different pollution levels. Additionally, our study did not have information on the exact distances between maternal residence and E-PRTR sites, which would have allowed for a more detailed analysis of the impact of these sites on birth weight.

In conclusion, our study provides evidence that proximity to certain polluting industrial facilities, specifically those related to mineral industries, may be associated with an increased risk of LBW. However, more research is needed to fully understand the mechanisms behind this association and the potential impact of other polluting industrial facilities on birth weight.

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References

Adebayo-Ojo Temitope Christina, Wichmann Janine, Arowosegbe Oluwaseyi, Olalekan Probst-Hensch, Schindler Christian, and Künzli Nino, (2022). Short-term effects of PM_{10}, NO_2, SO_2 and O_3 on cardio-respiratory mortality in Cape Town, South Africa. *International Journal of Environmental Research and Public Health*, 19, 1, 495.

Agarwal Nikhil, Banternghansa Chanont, and Bui Linda T. M., (2010). Toxic exposure in America: Estimating fetal and infant health outcomes from 14 years of TRI reporting. *Journal of Health Economics*, 29, 557–574.

Agresti Alan, (2012). *Categorical Data Analysis*, Third Edition, John Wiley & Sons.

Amster Eric D., Haim Maayan, Dubnov Jonathan, and Broday David M., (2014). Contribution of nitrogen oxide and sulfur dioxide exposure from power plant emissions on respiratory symptom and disease prevalence. *Environmental Pollution*, 186, 20–28.

Basu Rupa., Woodruff Tracey J., Parker Jennifer D., Saulnier Louise, and Schoendorf Kenneth C., (2004). Comparing exposure metrics in the relationship between $PM_{2.5}$ and birth weight in California. *Journal of Exposure Science and Environmental Epidemiology*, 14, 391–396.

Bell Michelle L., Ebisu Keita and Belanger Kathleen, (2007). Ambient air pollution and low birth weight in Connecticut and Massachusetts. *Environmental Health Perspectives*, 115, 7, 1118–1124.

Bentov Yaakov, Kordysh Ella, Hershkovitz Reli, Belmaker Ilana, Polyakov Marina, Bilenko Natasha, and Sarov Batia, (2006). Major congenital malformations and residential proximity to a regional industrial park including a national toxic waste site: An ecological study. *Environmental Health*, 5, 1, 8.

Bhopal R. S., Tate J. A., Foy C., Moffatt S. and Phillimore P. R., (1999). Residential proximity to industry and adverse birth outcomes. *The Lancet*, 354, 9182, 920–921.

Brender Jean D., Shinde Mayura U., Zhan Benjamin, Gong Xi, and Langlois Peter H., (2014). Maternal residential proximity to chlorinated solvent emissions and birth defects in offspring: a case-control study. *Environmental Health*, 13, 1, 96.

Chay Kenneth Y. and Greenstone Michael, (2003a). Air quality, infant mortality, and the Clean Air Act of 1970. *National Bureau of Economic Research*, WP 10053.

Chay Kenneth. Y. and Greenstone Michael, (2003b). The impact of air pollution on infant mortality: Evidence from geographic variation in pollution shocks induced by a recession. *The Quarterly Journal of Economics*, 118, 3, 1121–1167.

Comba Pietro, Ricci Paolo, Iavarone Ivano, Pirastu Roberta, Buzzoni Carlotta, Fusco Mario, Ferretti Stefano, Fazzo Lucia, Pasetto, Roberto, Zona Amerigo, Crocetti, Emanuele, ISS-AIRTUM Working Group for the study of cancer incidence in contaminated sites, (2014). Cancer incidence in Italian contaminated sites. *Annali dell Istituto Superiore di Sanità*, 50, 2, 186–191.

Currie Janet and Schmieder Johannes F., (2009). Fetal exposures to toxic releases and infant health. *American Economic Review*, 99, 2, 177–183.

Currie Janet, Davis Lucas, Greenstone Michael, and Walker Reed, (2015). Environmental health risks and housing values: Evidence from 1,600 Toxic plant openings and closings. *American Economic Review*, 105, 2, 678–709.

Currie Janet, Greenstone Michael, and Meckel Katherine, (2017). Hydraulic fracturing and infant health: new evidence from Pennsylvania. *Science Advances*, 3, 12, e1603021.

Gerville-Réache Léo, Couallier Vincent, and Paris Nicolas, (2011). *Echantillon représentatif* (*d'une population finie*) : *définition statistique et propriétés*. HAL-00655566.

Geschwind Sandra A., Stolwijk Jan A., Bracken Michael, Fitzgerald Edward, Stark Alice, Olsen Carolyn, and Melius James., (1992). Risk of congenital malformations associated with proximity to hazardous waste sites. *American Journal of Epidemiology*, 135, 11, 1197–1207 (1992).

Goldberg M. S., Goulet L., Riberdy H., and Bonvalot Y., (1995). Low birth weight and preterm births among infants born to women living near a municipal solid waste landfill site in Montreal, Quebec. *Environmental Research*, 69, 1, 37–50.

Gong Xi., Lin Yan., Bell Michelle L., and Zhan F. Benjamin, (2018). Associations between maternal residential proximity to air emissions from industrial facilities and low birth weight in Texas, USA. *Environment International*, 120, 181–198.

Ha Sandie, Hu Hui, Roth Jeffrey, Kan Haidong, and Xu Xiaohui, (2015). Associations between residential proximity to power plants and adverse birth outcomes. *American Journal of Epidemiology*, 182, 3, 215–224.

Hill Elaine L., (2018). Shale gas development and infant health: Evidence from Pennsylvania. *Journal of Health Economics*, 61, 134–150.

Janssen Nicole A. H., Fischer Paul, Marra Marten, Ameling Caroline, and Cassee Flemming R., (2013). Short-term effects of $PM_{2.5}$, PM_{10} and $PM_{2.5\text{-}10}$ on daily mortality in the Netherlands. *Science of The Total Environment*, 463–464, 20–26.

Lancelot Renault and Lesnoff Matthieu, (2005). *Sélection de modèles avec l'AIC et critères d'information dérivés*. CIRAD, Montpellier.

Landau D., Novack L., Yitshak-Sade M., Sarov B., Kloog I., Hershkovitz R., Grotto I., and Karakis I., (2015). Nitrogen Dioxide pollution and hazardous household environment: what impacts more congenital malformations. *Chemosphere*, 139, 340–348.

Ma Yuxia, Zhao Yuxin, Yang Sixu, Zhou Jianding, Xin Jinyuan, Wand Shigon, and Yand Dandan, (2017). Short-term effects of ambient air pollution on emergency room admissions due to cardiovascular causes in Beijing, China. *Environmental Pollution*, 230, 974–980.

McCormick M. C., (1985). The contribution of low birth weight to infant mortality and childhood morbidity. *New England Journal of Medicine*, 312, 82-90.

Moore Roberta J. H. and Hotchkiss, Julie L. (2016). The importance of toxicity in determining the impact of hazardous air pollutants on the respiratory health of children in Tennessee. *Environmental Pollution*, 216, 616–623.

Morgan Oliver W. C., Vrijheid Martine and Dolk Helen, (2014). Risk of low birth weight near EUROHAZCON hazardous waste landfill sites in England. *Archives of Environmental Health: An International Journal*, 59, 149–151.

Morris S. E., Thomson A. O., Jarup L., de Hoogh C., Briggs D. J., and Elliott P., (2003). No excess risk of adverse birth outcomes in populations living near special waste landfill sites in Scotland. Scottish Medical Journal, 48, 4, 105–107.

Orr Maureen, Bove Frank, Kaye Wendy, and Stone Melanie, (2002). Elevated birth defects in racial or ethnic minority children of women living near hazardous waste sites. *International Journal of Hygiene and Environmental Health*, 205, 1-2, 19–27.

Parker Jennifer D., Woodruff Tracey J., Basu Rupa, and Schoendorf Kenneth C., (2005). Air pollution and birth weight among term infants in California. *Pediatrics*, 115, 1, 121–128.

Rodriguez-Villamizar, Laura A., Rosychuk Rhonda J., Osornio-Vargas Alvaro, Villeneuve Paul J., and Rowe Brian H., (2018). Proximity to two main sources of industrial outdoor air pollution and emergency department visits for childhood asthma in Edmonton, Canada. *Canadian Journal of Public Health*, 108, 5-6, e523–e529.

Isabelle Romieu, Nelson Gouveia, Luis A. Cifuentes, Antonio Ponce de Leon, Washington Junger, Jeanette Vera, Valentina Strappa, Magali Hurtado-Díaz, Victor Miranda-Soberanis, Leonora Rojas-Bracho, Luz Carbajal-Arroyo, Guadalupe Tzintzun-Cervantes; HEI Health Review Committee, (2012). *Multicity study of air pollution and mortality in Latin America* (*the ESCALA study*). Research Report, Health Effects Institute, 5–86.

Sepandi Mojtaba, Akbari Hamed, Naseri Mohammad Hassan, and Alimohamadi Yousef, (2021). Emergency hospital admissions for cardiovascular diseases attributed to air pollution in Tehran during 2016-2019. *Environmental Science and Pollution Research*, 28, 38426–38433.

Yu Shang, Zhiwei Sun, Junji Cao, Xinming Wang, Liuju Zhong, Xinhui Bi, Hong Li, Wenxin Liu, Tong Zhu, and Wei Huang, (2013). Systematic review of Chinese studies of short-term exposure to air pollution and daily mortality. Environment International, 54, 100–111.

Shaw Gary M., Schulman Jane, Frisch Jonathan D., Cummins Susan K., and Harris John A., (1992). Congenital malformations and birthweight in areas with potential environmental contamination. *Archives of Environmental Health*: *An International Journal*, 47, 2, 147–154.

Sosniak Waldemar A., Kaye Wendy E., and Gomez T. M. Data linkage to explore the risk of low birthweight associated with maternal proximity to hazardous waste sites from the National Priorities List. *Archives of Environmental Health*: *An International Journal*, 49, 4, 251–255.

Ugalde-Resano Rodrigo, Riojas-Rodríguez Horacio, Texcalac-Sangrador José Luis, Cruz Julio C., and Hurtado-Díaz Magali, (2022). Short term exposure to ambient air pollutants and cardiovascular emergency department visits in Mexico City. Environmental Research 207, 1, 112600.

Vaillant Jean, (2005). *Initiation à la théorie de l'échantillonnage*. https://scholar.google.fr/citations?user=stc7DpUAAAAJ&hl=ca.

Watkins W. John, Kotecha Sarah J., and Kotecha Sailesh, (2016). All-cause mortality of low birthweight infants in infancy, childhood, and adolescence: Population study of England and Wales. *PLOS Medicine*, 13, 6, e1002018.

Willis Mary D., Hill Elaine L., Boslett Andrew, Kile Molly L., Carozza Susan E., and Hystad Perry, (2021). Associations between Residential Proximity to Oil and Gas Drilling and Term Birth Weight and Small-for-Gestational-Age Infants in Texas: A Difference-in-Differences Analysis. Environmental Health Perspectives, 129, 7, 77002.

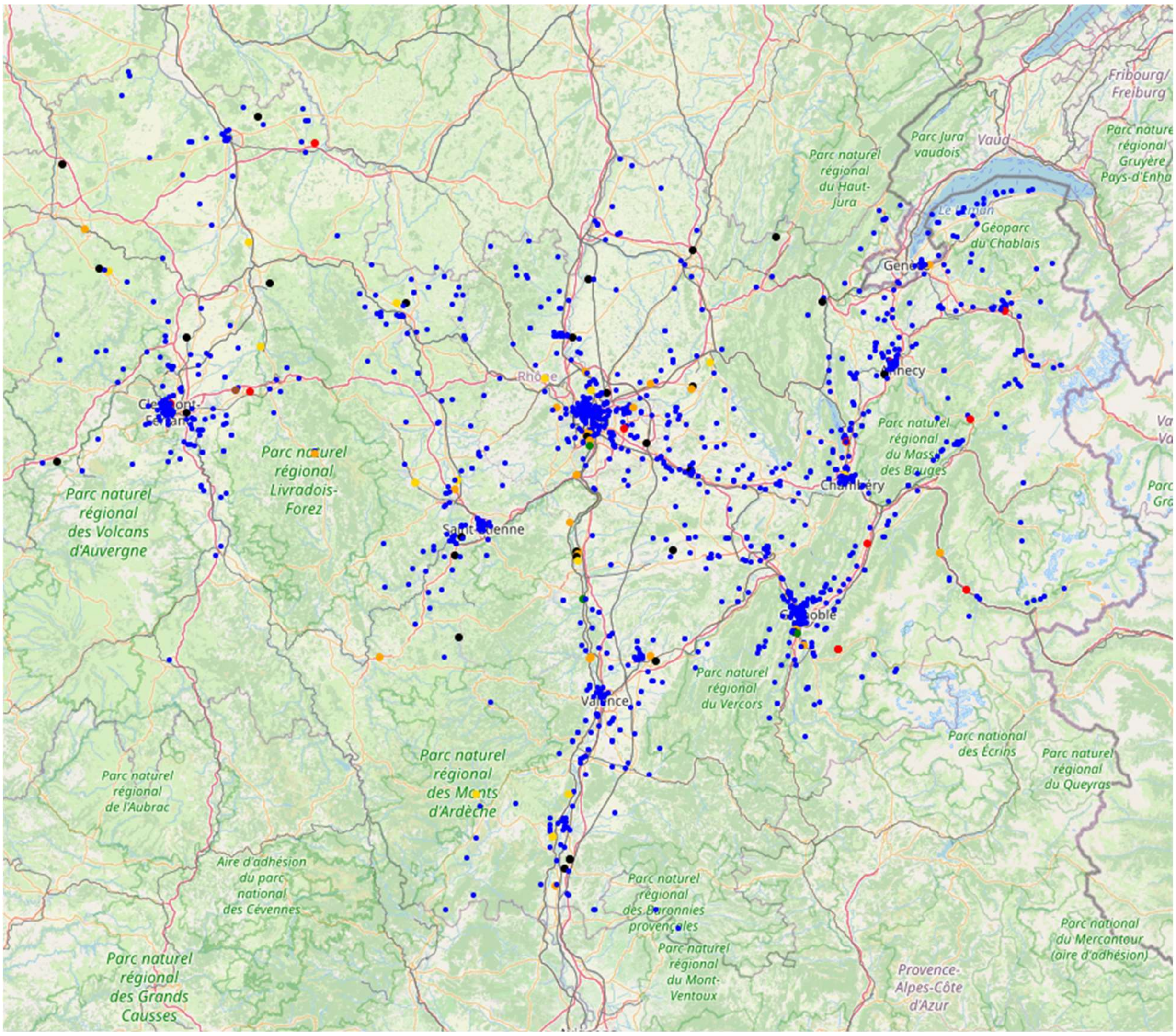
World Health Organization, (2005). *Effects of air pollution on children's health and development*: *a review of the evidence*. Regional Office for Europe & European Centre for Environment and Health, https://iris.who.int/handle/10665/107652.

Xing D. F., Xu C. D., Liao X. Y., Xing T. Y., Cheng S. P., Hu M. G., and Wand J. X., (2019). Spatial association between outdoor air pollution and lung cancer incidence in China. *BMC Public Health*, 19, 1, 1377.

Appendix

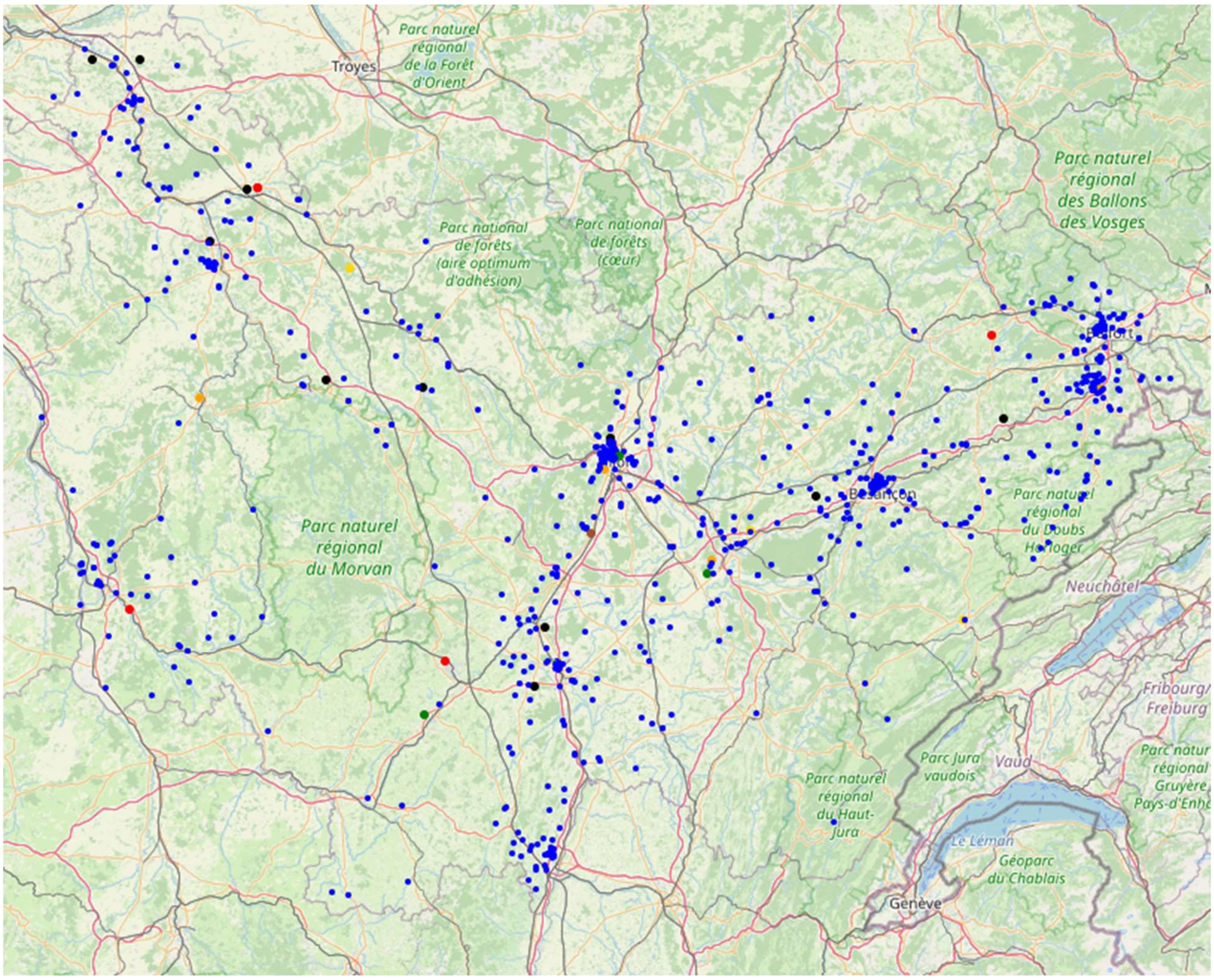
1. Cartographic representations of maternal residences and E-PRTR pollutant sites by sector of activity per region in France

Figure 2.1: Mapping maternal residences and polluting sites by sector of activity in the Auvergne-Rhône-Alpes region.



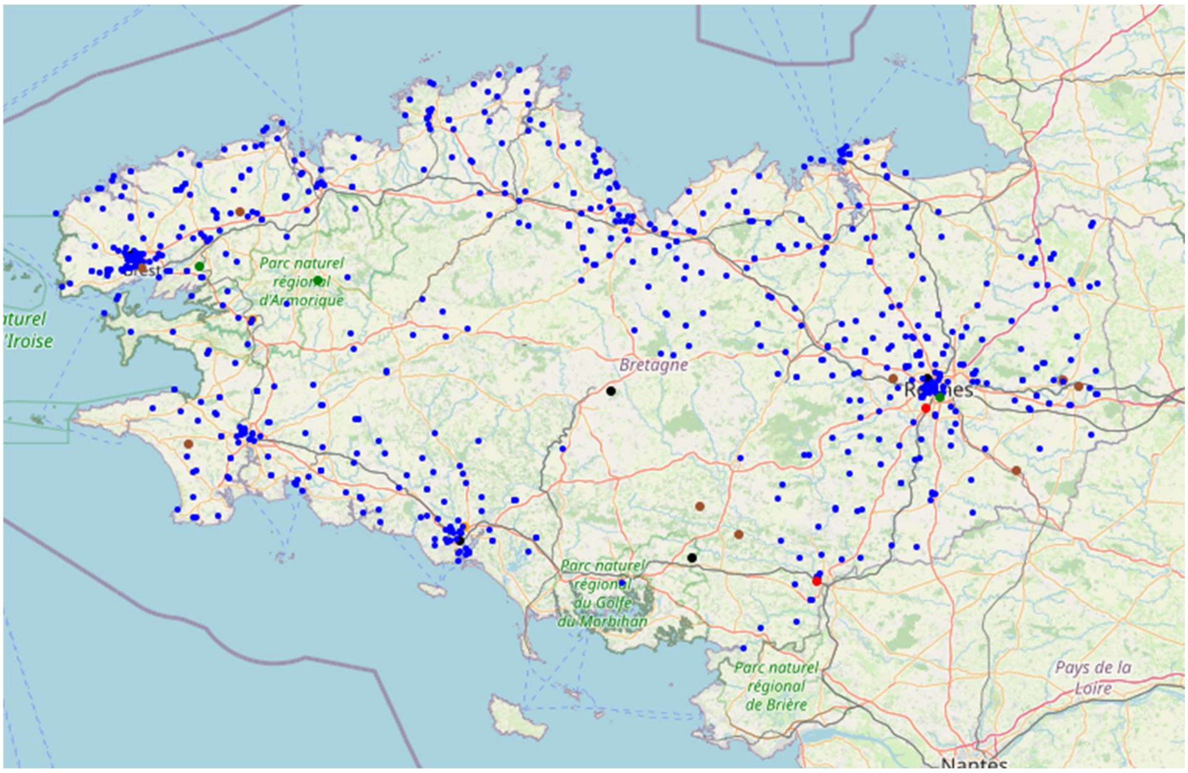
Note: Green: energy sector, **red:** production and processing of metals sector, **gold:** mineral sector, **orange:** chemical sector, **black:** waste and wastewater management sector, p**urple:** products paper and wood production and processing sector **brown**: other activities.

Figure 2.2: Mapping maternal residences and polluting sites by sector of activity in the Bourgogne-Franche-Comté region.



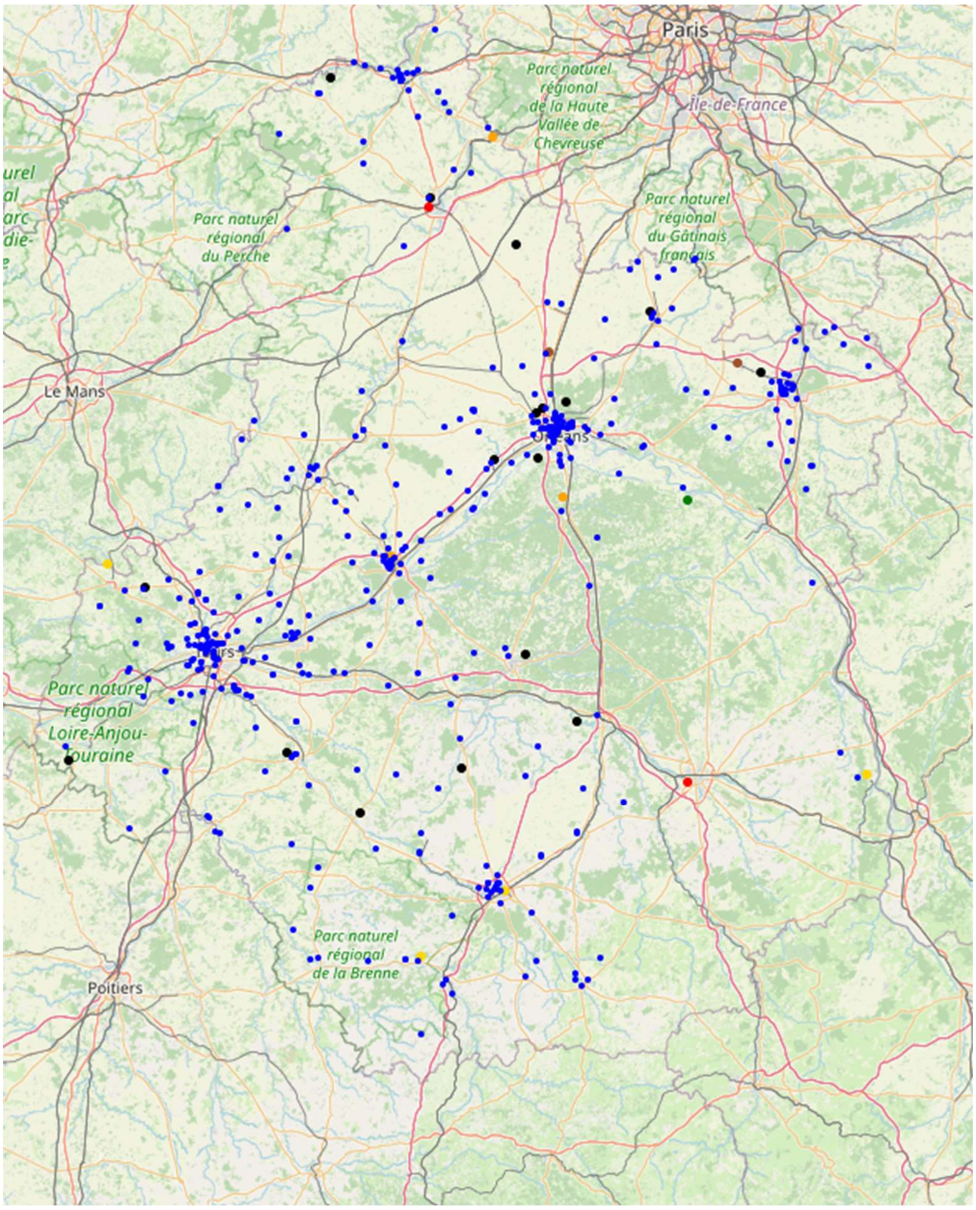
Note: **Green:** energy sector, **red:** production and processing of metals sector, **gold:** mineral sector, **orange:** chemical sector, **black:** waste and wastewater management sector, **purple:** products paper and wood production and processing sector, **brown**: other activities.

Figure 2.3: Mapping maternal residences and polluting sites by sector of activity in the Bretagne region



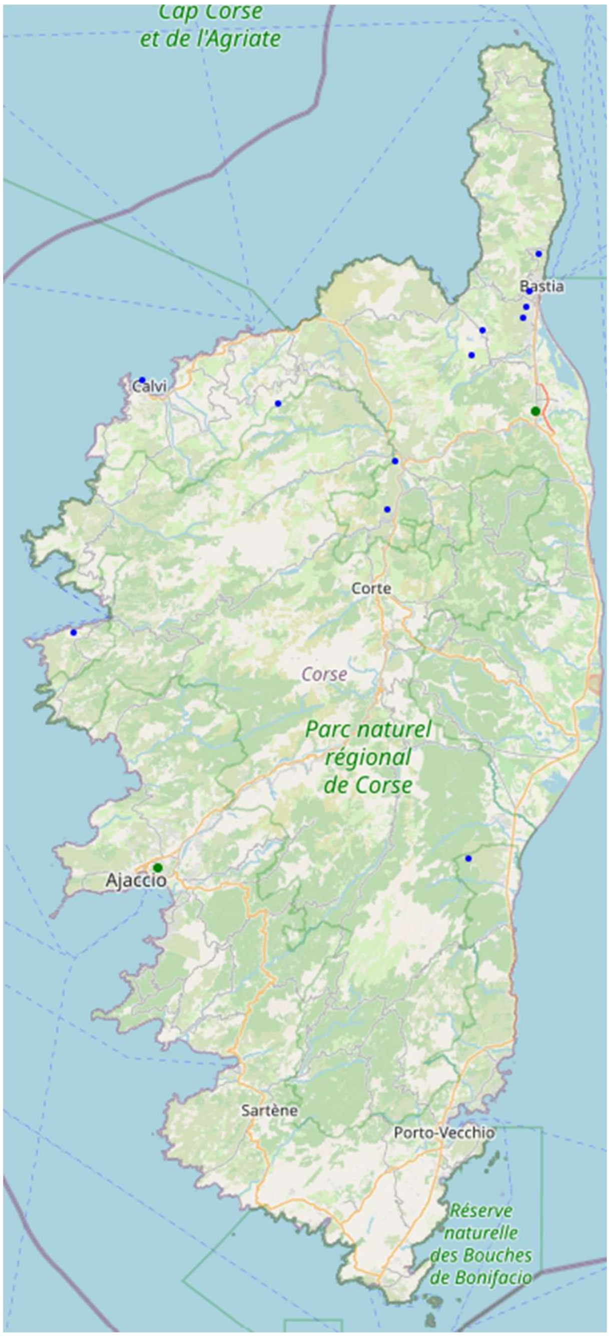
Note: **Green:** energy sector, **red:** production and processing of metals sector, **gold:** mineral sector, **orange:** chemical sector, **black:** waste and wastewater management sector, **purple:** products paper and wood production and processing sector, **brown**: other activities.

Figure 2.4: Mapping maternal residences and polluting sites by sector of activity in the Centre-Val de Loire region



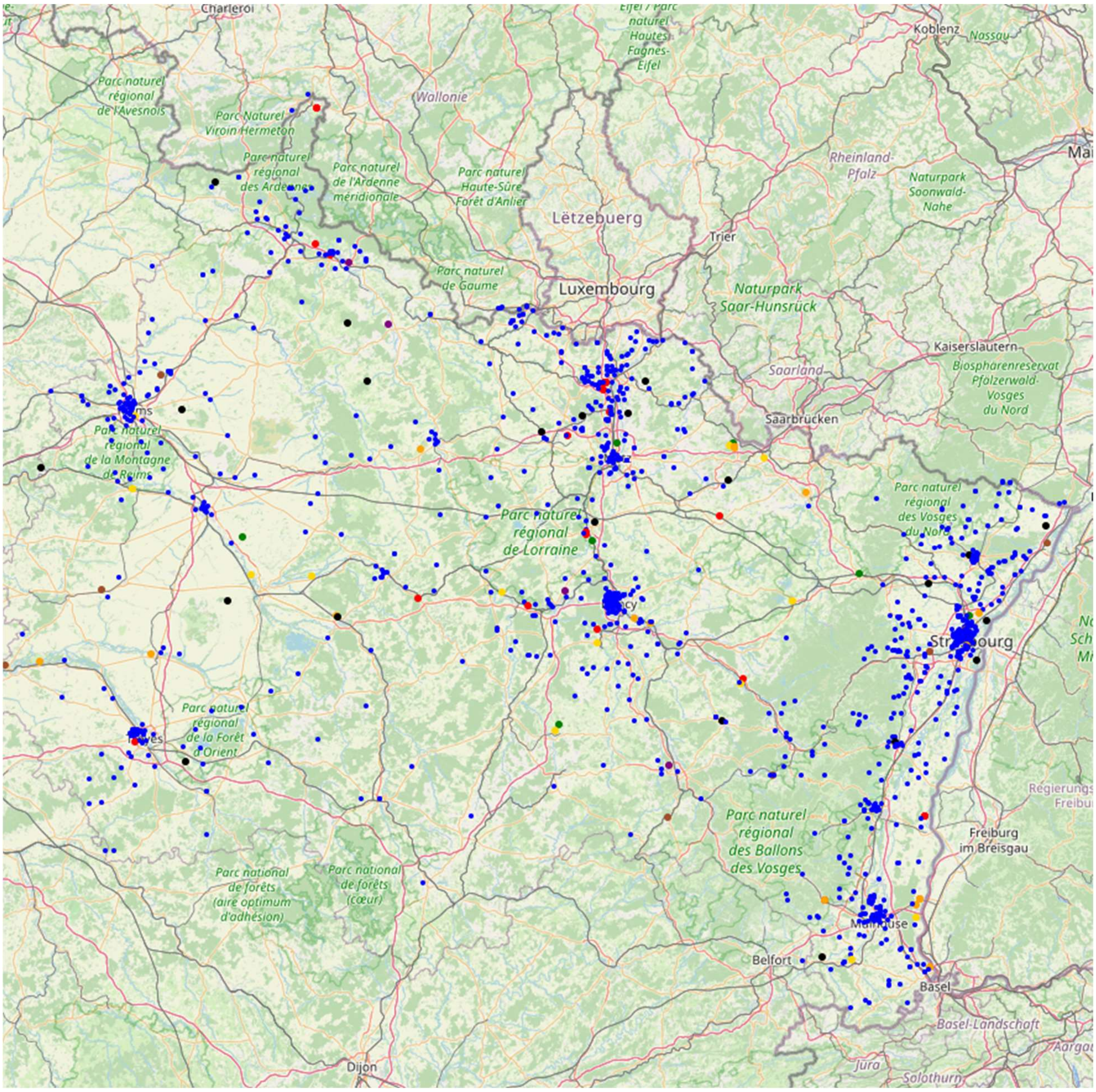
Note: Green: energy sector, **red:** production and processing of metals sector, **gold:** mineral sector, **orange:** chemical sector, **black:** waste and wastewater management sector, **purple:** products paper and wood production and processing sector, **brown**: other activities.

Figure 2.5: Mapping maternal residences and polluting sites by sector of activity in the Corse region



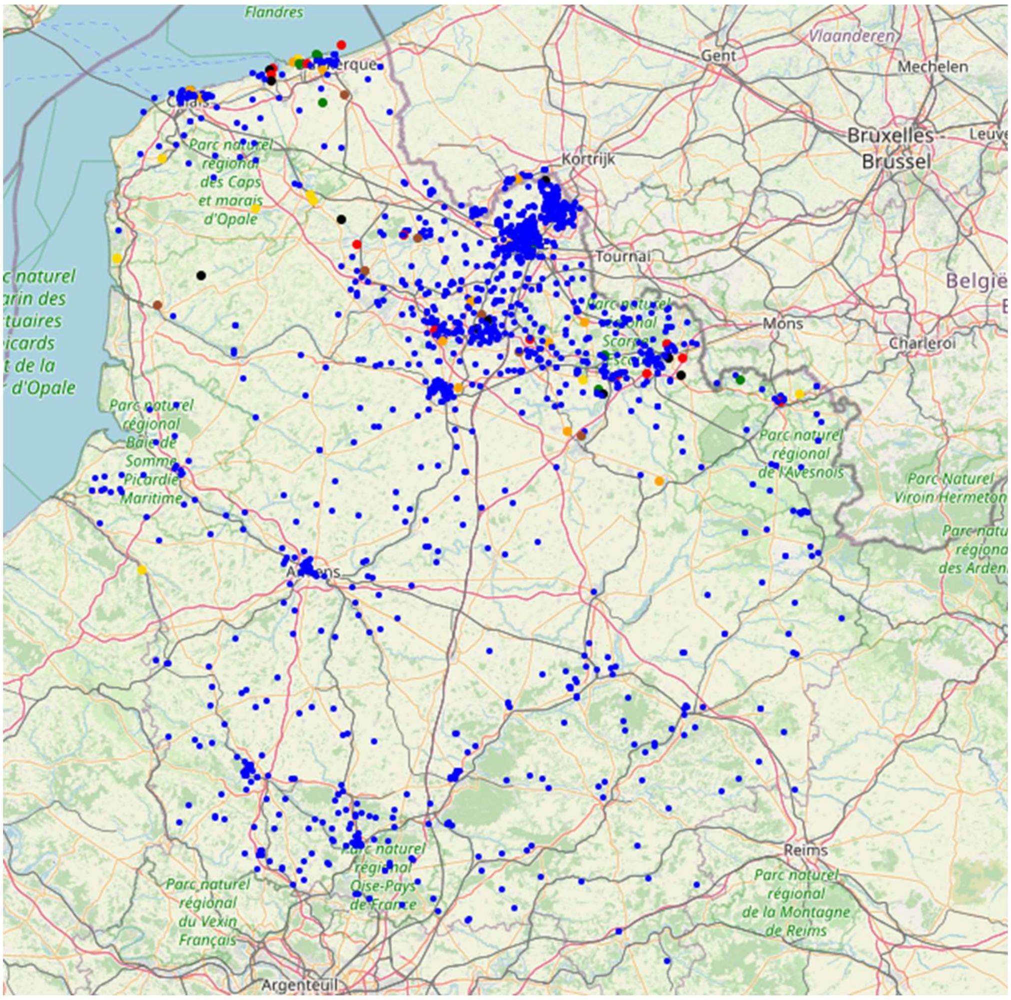
Note: **Green:** energy sector, **red:** production and processing of metals sector, **gold:** mineral sector, **orange:** chemical sector, **black:** waste and wastewater management sector, **purple:** products paper and wood production and processing sector, **brown**: other activities.

Figure 2.6: Mapping maternal residences and polluting sites by sector of activity in the Grand Est region



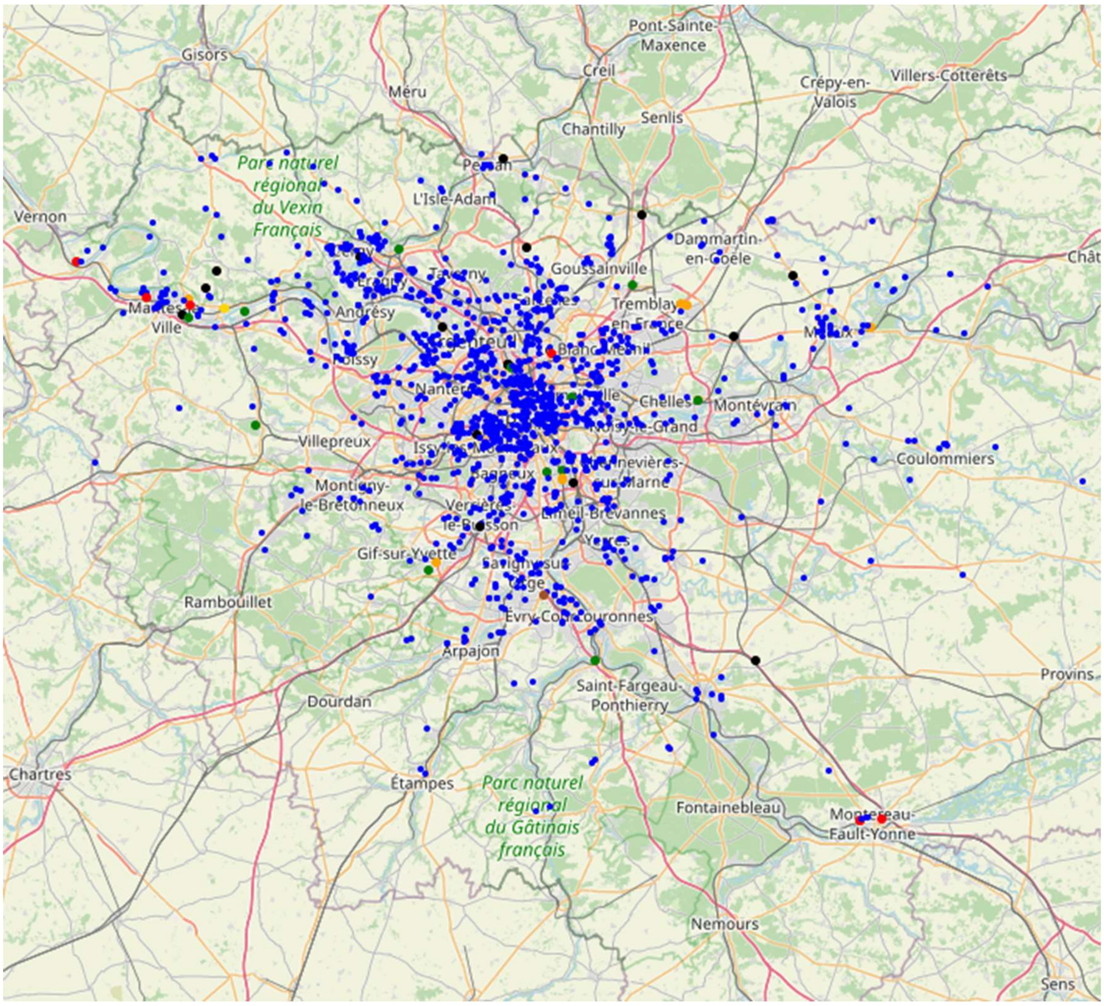
Note: **Green:** energy sector, **red:** production and processing of metals sector, **gold:** mineral sector, **orange:** chemical sector, **black:** waste and wastewater management sector, **purple:** products paper and wood production and processing sector, **brown**: other activities.

Figure 2.7: Mapping maternal residences and polluting sites by sector of activity in the Hauts-de-France region



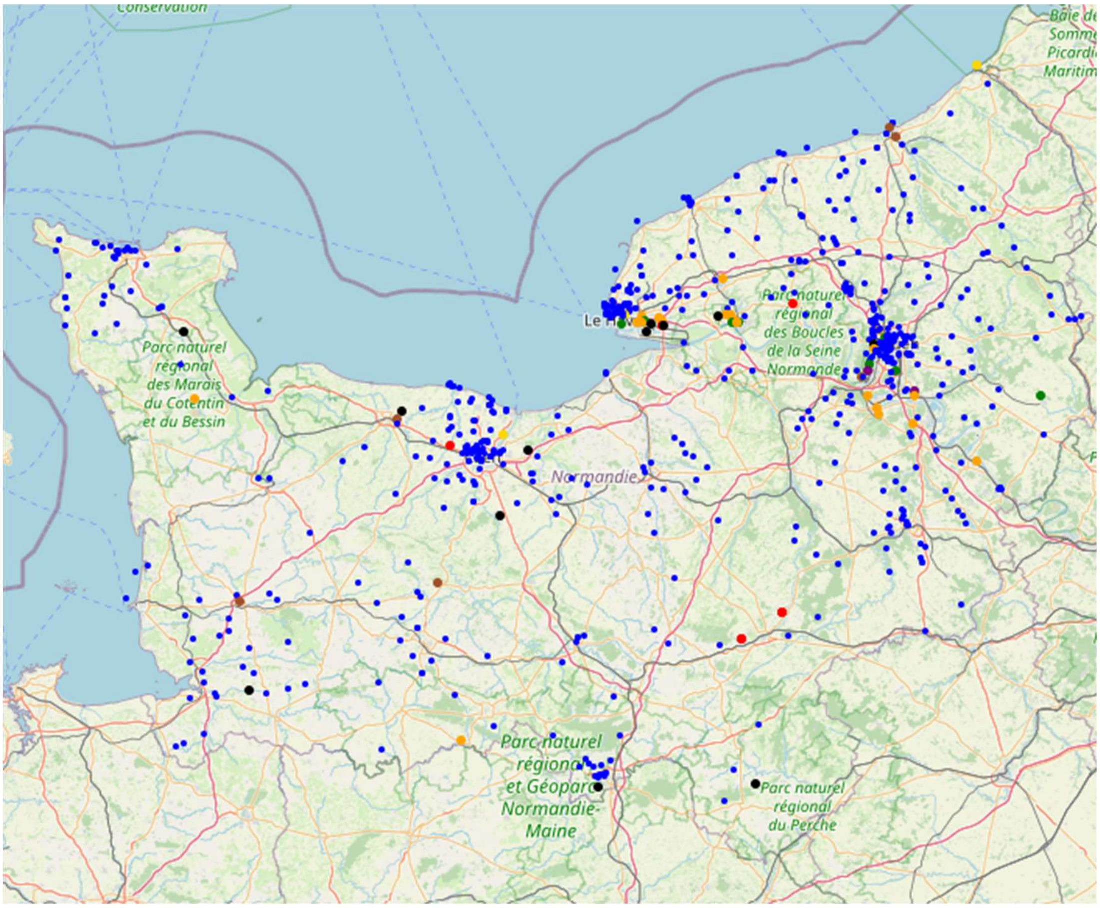
Note: Green: energy sector, **red:** production and processing of metals sector, **gold:** mineral sector, **orange:** chemical sector, **black:** waste and wastewater management sector, **purple:** products paper and wood production and processing sector, **brown**: other activities.

Figure 2.8: Mapping maternal residences and polluting sites by sector of activity in the Île-de-France region



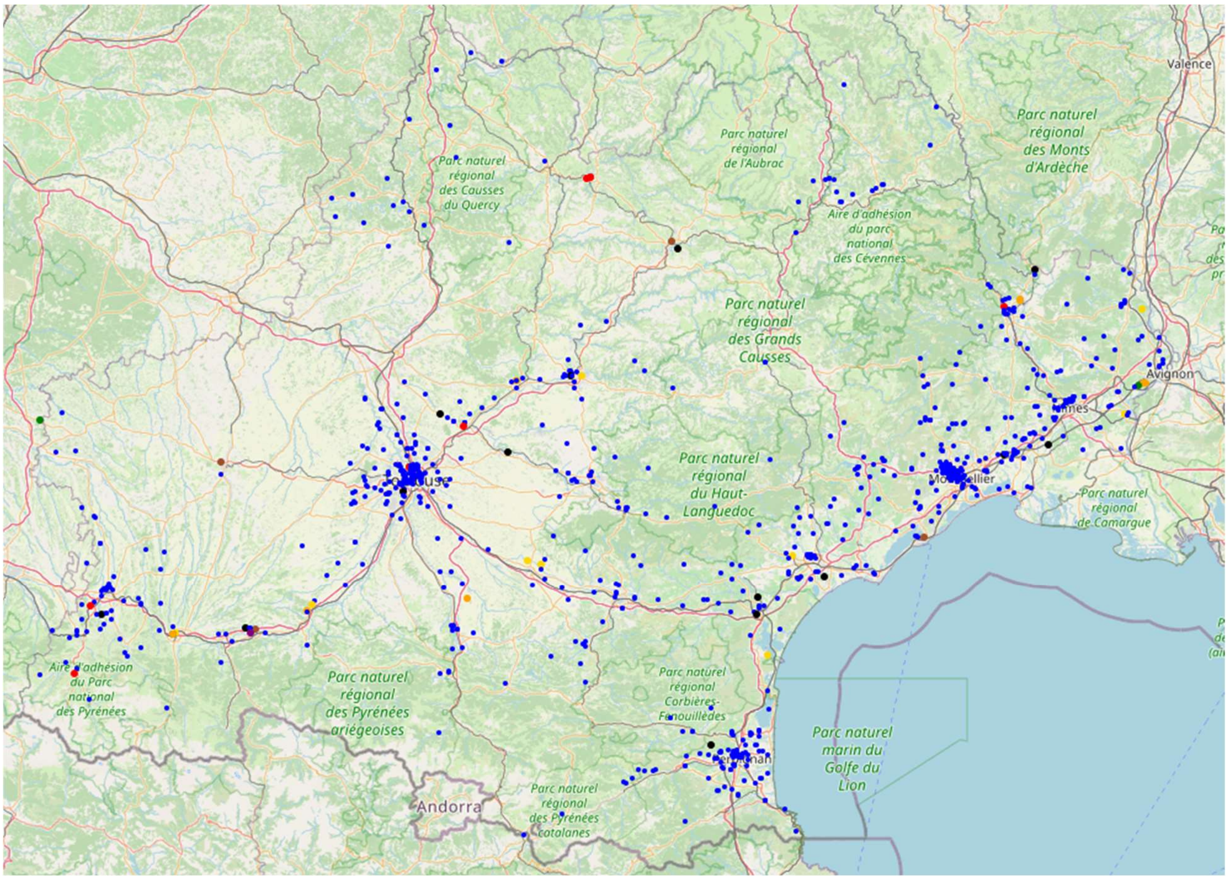
Note: **Green:** energy sector, **red:** production and processing of metals sector, **gold:** mineral sector, **orange:** chemical sector, **black:** waste and wastewater management sector, **purple:** products paper and wood production and processing sector, **brown**: other activities.

Figure 2.9: Mapping maternal residences and polluting sites by sector of activity in the Normandie region



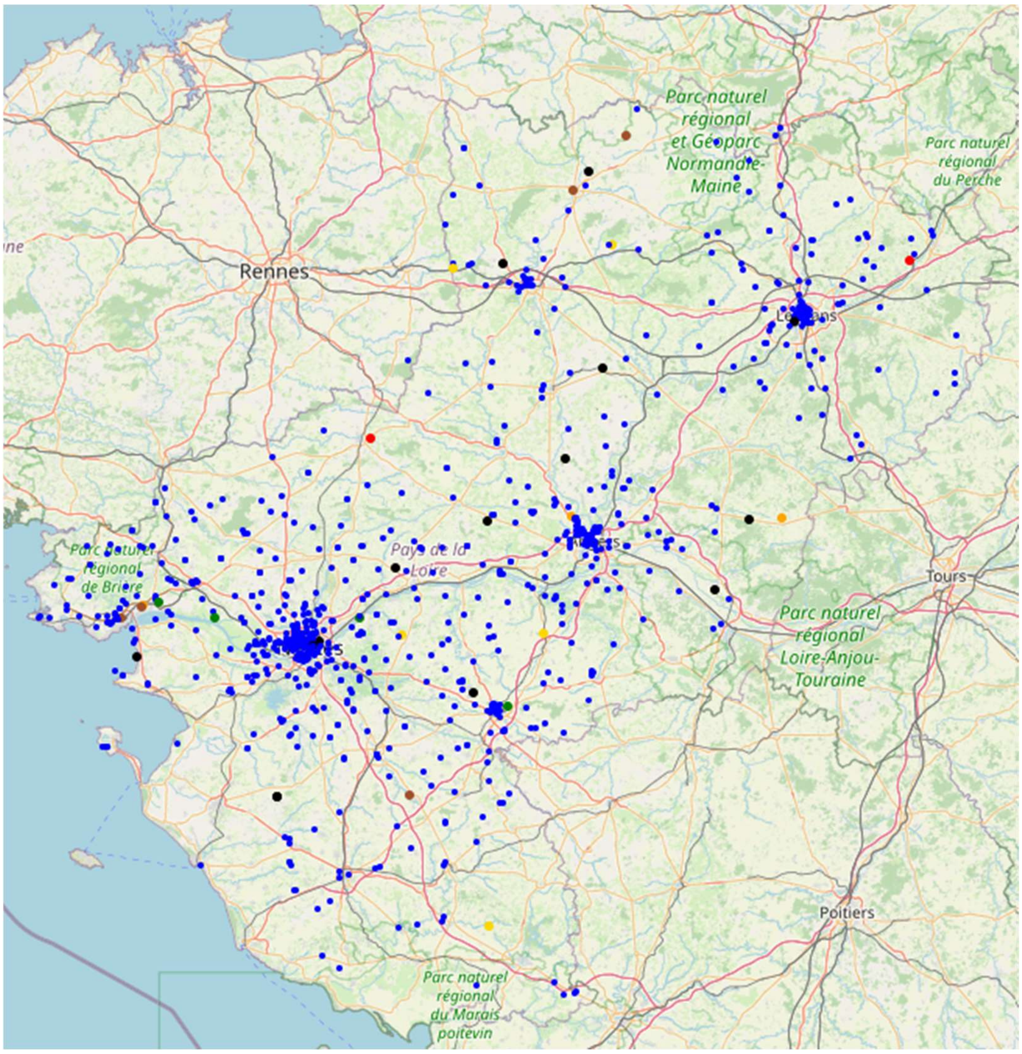
Note: **Green:** energy sector, **red:** production and processing of metals sector, **gold:** mineral sector, **orange:** chemical sector, **black:** waste and wastewater management sector, **purple:** products paper and wood production and processing sector, **brown**: other activities.

Figure 2.10: Mapping maternal residences and polluting sites by sector of activity in the Occitanie region



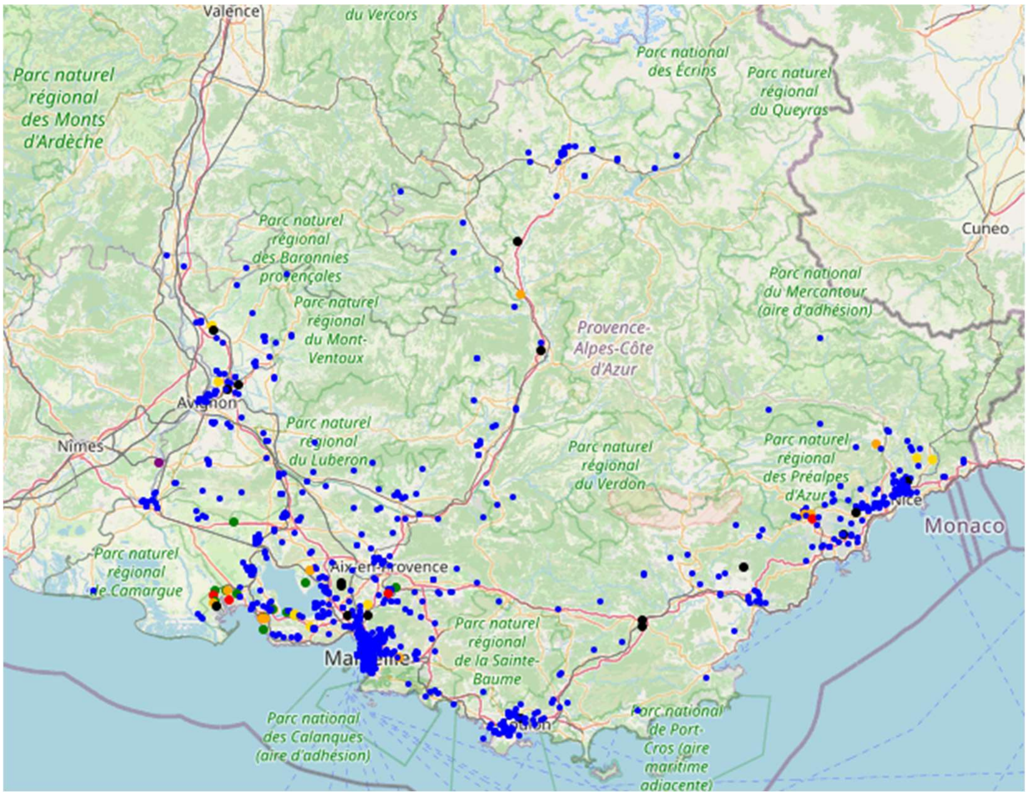
Note: **Green:** energy sector, **red:** production and processing of metals sector, **gold:** mineral sector, **orange:** chemical sector, **black:** waste and wastewater management sector, **purple:** products paper and wood production and processing sector, **brown**: other activities.

Figure 2.11: Mapping maternal residences and polluting sites by sector of activity in the Pays de la Loire region



Note: Green: energy sector, **red:** production and processing of metals sector, **gold:** mineral sector, **orange:** chemical sector, **black:** waste and wastewater management sector, **purple:** products paper and wood production and processing sector, **brown**: other activities.

Figure 2.12: Mapping maternal residences and polluting sites by sector of activity in the Provence-Alpes-Côte d'Azur region



Note: **Green:** energy sector, **red:** production and processing of metals sector, **gold:** mineral sector, **orange:** chemical sector, **black:** waste and wastewater management sector, **purple:** products paper and wood production and processing sector, **brown**: other activities.

1. Tables of descriptive statistics by region in France

Table 1.1: Descriptive statistics of the study population, mean birth weight (SD) and proportion of low birth weight (1000 g-2500 g), for singleton live births of the ELFE cohort in the Auvergne-Rhône-Alpes region (n = 777) and in the Bourgogne-Franche-Comté region (n = 201)

Region	**Auvergne-Rhône-Alpes**		**Bourgogne-Franche-Comté**	
Variable relating to birth and mother	**Number (%)**	**LBW(%)**	**Number (%)**	**LBW(%)**
Birth weight (g)	*777*	*12(1.54)*	*201*	*5(2.49)*
Low birth weight (<2500 g)				
Child's sex	*410(52.77)*	*6(1.46)*	*104(51.74)*	*3(2.88)*
Male	*367(47.23)*	*6(1.63)*	*96(47.76)*	*1(1.04)*
Female				
Antenatale care	*1(0.13)*	-	-	-
None	*54(6.95)*	*2(3.7)*	*10(4.98)*	*2(20)*
1 to 6	*722(92.92)*	*10(1.39)*	*190(94.53)*	*2(1.05)*
6+				
Gestational length (weeks)	*146(18.79)*	*8(5.47)*	*35*	*3(2.05)*
37-38	*495(63.71)*	*3(0.61)*	*122(60.7)*	*1(0.82)*
39-40	*136(17.5)*	*1(0.74)*	*44(21.89)*	-
41-42	-	-	-	-
Alcohol use by mother				
Yes	*194(24.97)*	*2(1.03)*	*62(30.85)*	*3(4.84)*
No	*583(75.03)*	*10(1.72)*	*138(68.66)*	*1(0.72)*
Tobacco use by mother				
Yes	*123(15.83)*	*5(4.07)*	*30(14.93)*	*3(10)*
No	*654(84.17)*	*7(1.07)*	*170(84.58)*	*1(0.59)*
Mother's education				
Elmentary School/ Middle School	*15(1.93)*	*0*	*4(1.99)*	-
Certificate of professional competence	*71(9.14)*	*5(7.04)*	*21(10.45)*	-
High-School	*128(16.47)*	*1(0.78)*	*33(16.42)*	*1(3.03)*
Higher education	*563(72.46)*	*6(1.07)*	*140(69.65)*	*3(2.14)*
Never been to school	-	-	*2(1)*	-
Mother's ethnicity				
European Union	*748(96.27)*	*12(1.6)*	*189(94.03)*	*4(2.12)*
Maghreb countries	*13(1.67)*	-	*4(1.99)*	-
Sub-Saharan Africa	*7(0.9)*	-	*3(1.49)*	-
Other	*9(1.16)*	-	*4(1.99)*	-
Mother's marital status				
Married	*509(65.51)*	*7(1.38)*	*136(67.66)*	-
Unmaried	*268(34.49)*	*5(1.87)*	*64(31.84)*	*4(6.25)*
Mother's age (years)				
<20	*1(0.13)*	-	-	-
20-24	*41(5.28)*	*1(2.44)*	*12(5.97)*	-
25-29	*228(29.34)*	*4(1.75)*	*62(30.85)*	*1(1.61)*
30-34	*305(39.25)*	*3(0.98)*	*75(37.31)*	*1(1.33)*
35-39	*157(20.21)*	*2(1.27)*	*42(20.9)*	*2(4.76)*
>39	*45(5.79)*	*2(4.44)*	*9(4.48)*	-
Season of birth				

Spring	120(15.44)	2(1.67)	38(18.91)	1(2.63)
Summer	193(24.84)	3(1.55)	43(21.39)	12.33)
Fall	464(59.72)	7(1.51)	119(59.2)	21.68)
Mother's BMI (KG/m^2)				
Underweight (<18.5 kg/m)	60(7.72)	1(1.67)	17	-
Normal weight (between 18.5 and 24.9)	523(67.31)	9(1.72)	113	3(2.65)
Overweight (between 25 and 29.9)	133(17.12)	1(0.75)	23.88	1(2.08)
Obesity (> 30)	61(7.85)	1(1.64)	10.95	-
Mother worked during pregnancy				
Yes	674(86.74)	10(1.48)	170(84.58)	4(2.35)
No	103(13.26)	2(1.94)	30(14.93)	-
Income (euros)				
<2000	98(12.61)	2(2.04)	29(14.43)	1(3.45)
2000-3999	457(58.82)	7(1.53)	125(62.19)	3(2.4)
4000-5999	166(21.36)	1(0.6)	36(17.91)	-
6000-7999	40(5.15)	2(5)	9(4.48)	-
8000-9999	14(1.8)	-	1(0.5)	-
>10000	2(0.26)	-	-	-

Note: SD = Standard deviation

Table 1.2: Descriptives statistics of the study population, mean birth weight (SD) and proportion of low birth weight (1000 g-2500 g), for singleton live births of the ELFE cohort in the Bretagne region (n = 208) and in the Centre-Val de Loire region (n = 122)

Region	**Bretagne**		**Centre-Val de Loire**	
Variable relating to birth and mother	**Number (%)**	**LBW(%)**	**Number (%)**	**LBW(%)**
Birth weight (g)	208	4(1.92)	122	2(1.64)
Low birth weight (<2500 g)				
Child's sex	111(53.37)	1(0.9)	56(45.9)	1(1.79)
Male	97(46.63)	3(3.09)	66(54.1)	1(1.52)
Female				
Antenatale care	-	-	-	-
None	7(3.37)	-	8(6.56)	1(12.5)
1 to 6	201(96.63)	4(1.99)	14(93.44)	1(0.88)
6+				
Gestational length (weeks)	30(14.42)	-	19(15.57)	1(5.26)
37-38	125(60.1)	3(2.4)	73(59.84)	-
39-40	39(18.75)	-	25(20.49)	-
41-42	-	-	-	-
Alcohol use by mother				
Yes	57(27.4)	-	35(28.69)	2(5.71)
No	151(72.6)	4(2.65)	87(71.31)	-
Tobacco use by mother				
Yes	51(24.52)	3(5.88)	23(18.85)	1(4.35)
No	157(75.48)	1(0.64)	99(81.15)	1(1.01)
Mother's education				
Elmentary School/ Middle School	3(1.44)	-	3(2.46)	-
Certificate of professional competence	28(13.46)	1(3.57)	13(10.66)	-
High-School	35(16.83)	-	22(18.03)	2(9.09)
Higher education	142(68.27)	3(2.11)	84(68.85)	-

Never been to school	-	-	-	-
Mother's ethnicity				
European Union	200(96.15)	4(2)	112(91.8)	1(0.89)
Maghreb countries	-	-	3(2.46)	-
Sub-Saharan Africa	8(3.85)	-	5(4.1)	1(20)
Other	-	-	2(1.64)	-
Mother's marital status				
Married	129(62.02)	1(0.78)	73(59.84)	-
Unmaried	79(37.98)	3(3.8)	49(40.16)	2(4.08)
Mother's age (years)				
<20	-	-	-	-
20-24	13(6.25)	-	5(4.1)	-
25-29	60(28.85)	1(1.67)	52(42.62)	-
30-34	88(42.31)	3(3.41)	40(32.79)	-
35-39	34(16.35)	-	18(14.75)	-
>39	13(6.25)	-	7(5.74)	2(28.57)
Season of birth				
Spring	36(17.31)	-	14(11.48)	1(7.14)
Summer	52(25)	2(3.85)	34(27.87)	-
Fall	120(57.69	2(1.67)	74(60.66)	1(1.35)
Mother's BMI (KG/m^2)				
Underweight (<18.5 kg/m)	14(6.73)	-	6(4.92)	-
Normal weight (between 18.5 and 24.9)	139(66.83)	4(2.88)	85(69.67)	2(2.35)
Overweight (between 25 and 29.9)	36(17.32)	-	19(15.57)	-
Obesity (> 30)	19(9.13)	-	12(9.84)	-
Mother worked during pregnancy				
Yes	173(83.17)	3(1.73)	101(82.79)	2(1.98)
No	35(16.83)	1(2.86)	21(17.21)	-
Income (euros)				
<2000	32(15.38)	1(3.12)	19(15.57)	1(5.26)
2000-3999	127(61.06)	2(1.57)	77(63.11)	1(1.3)
4000-5999	40(19.23)	1(2.5)	22(18.03)	-
6000-7999	5(2.4)	-	4(3.28)	-
8000-9999	3(1.44)	-	-	-
>10000	1(0.48)	-	-	-

Note : SD = Standard deviation

Table 1.3: Descriptive statistics of the study population, mean birth weight (SD) and proportion of low birth weight (1000 g-2500 g), for singleton live births of the ELFE cohort in the Grand-Est region (n = 501) and in the Hauts-de-France region (n = 650)

Region	Grand-Est		Hauts-de-France	
Variable relating to birth and mother	**Number (%)**	**LBW(%)**	**Number (%)**	**LBW(%)**
Birth weight (g)	501	6(1.19)	650	12(1.85)
Low birth weight (<2500 g)				
Child's sex	252(50.3)	2(0.79)	331(50.92)	2(0.6)
Male	249(49.7)	4(1.6)	319(49.08)	10(3.13)
Female				
Antenatale care	3(0.6)	-	1(0.15)	-
None	12(3.39)	-	66(10.15)	2(3.03)
1 to 6	486(97.01)	6(1.23)	583(89.69)	10(1.72)

6+				
Gestational length (weeks)	100(19.96)	5(5)	148(22.77)	5(3.37)
37-38	301(60.07)	1(0.33)	373(57.38))	7(1.88)
39-40	100(19.96)	-	129(19.85)	-
41-42	-	-	-	-
Alcohol use by mother				
Yes	142(28.34)	1(0.7)	99(15.23)	2(2.02)
No	359(71.65)	5(1.39)	551(84.77)	10(1.81)
Tobacco use by mother				
Yes	95(18.96)	3(3.15)	104(16)	5(4.81)
No	406(81.03)	3(0.73)	546(84)	7(1.28)
Mother's education				
Elmentary School/ Middle School	7(1.39)	-	16(2.46)	-
Certificate of professional competence	57(11.37)	2(3.5)	69(10.62)	4(5.8)
High-School	98(19.56)	1(1.02)	137(21.08)	3(2.19)
Higher education	339(67.66)	3(0.88)	428(65.85)	5(1.17)
Never been to school	-	-	-	-
Mother's ethnicity				
European Union	474(94.61)	5(1.05)	629(96.77)	12(1.91)
Maghreb countries	10(1.99)	-	15(2.31)	-
Sub-Saharan Africa	9(1.79)	-	5(0.77)	-
Other	8(1.59)	1(12.5)	1(0.15)	-
Mother's marital status				
Married	326(65.06)	2(0.61)	451(69.38	7(1.55)
Unmaried	175(34.93)	4(2.28)	199(30.62)	5(2.51)
Mother's age (years)				
<20	1(0.2)	-	4(0.62)	-
20-24	29(5.78)	-	39(6)	1(2.56)
25-29	153(30.53)	4(2.61)	200(30.77)	7(3.5)
30-34	204(40.71)	-	262(40.31)	3(1.15)
35-39	91(18.16)	2(2.19)	116(17.85)	1(0.86)
>39	23(4.59)	-	29(4.46)	-
Season of birth				
Spring	84(16.76)	2(2.38)	94(14.46)	2(2.13)
Summer	124(24.75)	2(1.61)	157(24.15)	3(1.91)
Fall	293(58.48)	2(0.68)	399(61.38)	7(1.75)
Mother's BMI (KG/m^2)				
Underweight (<18.5 kg/m)	30(5.98)	-	45(6.92)	1(2.22)
Normal weight (between 18.5 and 24.9)	316(63.07)	4(1.26)	379(58.31)	8(2.11)
Overweight (between 25 and 29.9)	93(18.56)	1(1.07)	134(20.62)	1(0.75)
Obesity (> 30)	62(12.37)	1(1.61)	92(14.15)	2(2.17)
Mother worked during pregnancy				
Yes	420(83.83)	3(0.71)	507(78)	10(1.97)
No	81(16.16)	3(3.7)	143(22)	2(1.4)
Income (euros)				
<2000	91(18.16)	4(4.39)	130(20)	4(3.08)
2000-3999	255(50.89)	2(0.78)	345(53.08)	6(1.74)
4000-5999	130(25.89)	-	140(21.54)	2(1.43)
6000-7999	19(3.79)	-	31(4.77)	-
8000-9999	3(0.6)	-	4(0.62)	-
>10000	3(0.6)	-	-	-

Note: SD = Standard deviation

Table 1.4: Descriptives statistics of the study population, mean birth weight (SD) and proportion of low birth weight (1000 g-2500 g), for singleton live births of the ELFE cohort in the Île-de-France region (n = 1622) and in the Normandie region (n = 273)

Region	Île-de-France		Normandie	
Variable relating to birth and mother	**Number (%)**	**LBW(%)**	**Number (%)**	**LBW(%)**
Birth weight (g)	*1622*	*27(1.66)*	*273*	*3(1.1)*
Low birth weight (<2500 g)	*3(1.1)*			
Child's sex				
Male	*834(51.42)*	*10(1.2)*	*135(49.45)*	*1(0.74)*
Female	*788(48.58)*	*17(2.16)*	*138(50.55)*	*2(1.45)*
Antenatale care				
None	*5(0.31)*	-	-	-
1 to 6	*15(7.09)*	*2(1.74)*	*32(11.72)*	-
6+	*1502(92.6)*	*25(1.66)*	*241(88.28)*	*3-1(1.24)*
Gestational length (weeks)				
37-38	*300(18.49)*	*18(6)*	*47(17.22)*	*2(4.25)*
39-40	*1003(61.84)*	*9(0.9)*	*162(59.34)*	*1(0.62)*
41-42	*319((19.67)*	-	*64(23.44)*	-
Alcohol use by mother	-	-	-	-
Yes				
No	*441(27.19)*	*6(1.36)*	*68(24.91)*	*1(1.47)*
Tobacco use by mother	*1181(72.81)*	*21(1.78)*	*205(75.09)*	*2(0.98)*
Yes				
No	*226(13.93)*	*8(3.54)*	*59(21.61)*	*2(3.39)*
Mother's education	*1396(86.07)*	*19(1.36)*	*214(78.39)*	*1(0.47)*
Elmentary School/ Middle School				
Certificate of professional competence	*43(2.65)*	*3(6.98)*	*6(2.2)*	-
High-School	*96(5.92)*	*1(1.04)*	*36(13.19)*	*1(2.78)*
Higher education	*208(12.82)*	*4(1.92)*	*46(16.85)*	-
Never been to school	*1273(78.48)*	*19(1.49)*	*185(67.77)*	*2(1.08)*
Mother's ethnicity	*2(0.12)*	-	-	-
European Union				
Maghreb countries	*1388(85.57)*	*22(1.59)*	*264(96.7)*	*3(1.14)*
Sub-Saharan Africa	*96(5.92)*	*4(4.17)*	-	-
Other	*82(5.06)*	-	*6(2.2)*	-
Mother's marital status	*56(3.45)*	*1(1.79)*	*3(1.1)*	-
Married				
Unmaried	*1076(66.34)*	*19(1.77)*	*169(61.9)*	*2(1.18)*
Mother's age (years)	*546(33.66)*	*8(1.47)*	*104(38.1)*	*1(0.96)*
<20				
20-24	*10(0.62)*	-	*3(1.1)*	-
25-29	*59(3.64)*	*2(3.39)*	*15(5.49)*	-
30-34	*368(22.69)*	*11(2.99)*	*82(30.04)*	*1(1.22)*
35-39	*659(40.63)*	*9(1.37)*	*120(43.96)*	*1(0.83)*
>39	*422(26.02)*	*2(0.47)*	*42(15.38)*	-
Season of birth	*104(6.41)*	*3(2.88)*	*11(4.03)*	*1(9.09)*
Spring				
Summer	*245(15.1)*	*3(1.22)*	*41(15.02*	-
Fall	*445(27.44)*	*8(1.8)*	*65(23.81*	-
Mother's BMI (KG/m^2)	*932(57.46)*	*16(1.72)*	*167(61.17)*	*3(1.8)*

Underweight (<18.5 kg/m)				
Normal weight (between 18.5 and 24.9)	*112(6.91)*	*3(2.68*	*23(8.42)*	-
Overweight (between 25 and 29.9)	*1075(66.2)*	*17(1.58*	*170(62.27)*	*3*
Obesity (> 30)	*302(18.62)*	*4(1.32*	*47(17.22)*	-
Mother worked during pregnancy	*133(8.2)*	*3(2.26)*	*33(12.09)*	-
Yes				
No	*1393(85.88)*	*24(1.72)*	*227(83.15)*	*2(0.88)*
Income (euros)	*229(14.12)*	*3(1.31)*	*46(16.85)*	*1(2.17)*
<2000				
2000-3999	*202(12.45)*	*4(1.98)*	*55(20.15)*	-
4000-5999	*614(37.85)*	*12(1.95)*	*151(55.31)*	*3(1.99)*
6000-7999	*539(33.23)*	*9(1.67)*	*53(19.41)*	-
8000-9999	*174(10.73)*	*1(0.57)*	*10(3.66)*	-
>10000	*71(4.38)*	*1(1.41)*	*3(1.1)*	-

Note: SD = Standard deviation

Table 1.5: Descriptive statistics of the study population, mean birth weight (SD) and proportion of low birth weight (1000 g-2500 g), for singleton live births of the ELFE cohort in the Nouvelle-Aquitaine region (n = 338) and in the Occitanie region (n = 247)

Region	**Nouvelle-Aquitaine**		**Occitanie**	
Variable relating to birth and mother	**Number (%)**	**LBW(%)**	**Number (%)**	**LBW(%)**
Birth weight (g)	*338*	*8(2.37)*	*247*	*6(2.43)*
Low birth weight (<2500 g)				
Child's sex	*161(47.63)*	*3(1.86)*	*127(51.42)*	-
Male	*177(52.37)*	*5(2.82)*	*120(48.58)*	*6(5)*
Female				
Antenatale care	*1(0.3)*	-	-	-
None	*28(8.28)*	-	*18(7.29)*	*1(5.56)*
1 to 6	*309(91.42)*	*8(2.59)*	*229(92.71)*	*5(2.18)*
6+				
Gestational length (weeks)	*59(17.46)*	*6(10.16)*	*61(24.69)*	*1(2.38)*
37-38	*198(58.58)*	*2(1.01)*	*141(57.08)*	*2(1.43)*
39-40	*81(23.96)*	-	*45(18.21)*	-
41-42	-	-	-	-
Alcohol use by mother				
Yes	*85(25.15)*	*3(3.53)*	*78(31.58)*	*4(5.13)*
No	*253(74.85)*	*5(1.98)*	*169(68.42)*	*21.18)*
Tobacco use by mother				
Yes	*65(19.23)*	*4(6.15)*	*46(18.62)*	*1(2.17)*
No	*273(80.77)*	*4(1.47)*	*201(81.38)*	*5(2.49)*
Mother's education				
Elmentary School/ Middle School	*6(1.78*	*1(16.67*	*3(1.21*	-
Certificate of professional competence	*42(12.43*	*1(2.38*	*27(10.93*	*1(3.7)*
High-School	*52(15.38*	*1(1.92*	*31(12.55*	-
Higher education	*238(70.41*	*5(2.1*	*185(74.9*	*5(2.7)*
Never been to school	-	-	*1(0.4*	-
Mother's ethnicity				
European Union	*316(93.49)*	*8(2.53)*	*231(93.52)*	*5(2.16)*
Maghreb countries	*11(3.25)*	-	*4(1.62)*	-

Sub-Saharan Africa	*7(2.07)*	-	*6(2.43)*	*1(16.67)*
Other	*4(1.18)*	-	*6(2.43)*	-
Mother's marital status				
Married	*223(65.98)*	*6(2.69)*	*161(65.18)*	*3(1.86)*
Unmaried	*115(34.02)*	*2(1.74)*	*86(34.82)*	*3(3.49)*
Mother's age (years)				
<20	-	-	*1(0.4)*	-
20-24	*18(5.33)*	-	*12(4.86)*	-
25-29	*100(29.59)*	-	*56(22.67)*	*1(1.79)*
30-34	*132(39.05)*	*5(3.79)*	*110(44.53)*	*2(1.82)*
35-39	*77(22.78)*	*2(2.6)*	*57(23.08)*	*1(1.75)*
>39	*11(3.25)*	*1(9.09)*	*11(4.45)*	*2(18.18)*
Season of birth				
Spring	*50(14.79)*	*2(4)*	*46(18.62)*	*3(6.52)*
Summer	*71(21.01)*	*2(2.82)*	*66(26.72)*	*1(1.52)*
Fall	*217(64.2)*	*4(1.84)*	*135(54.66)*	*2(1.48)*
Mother's BMI (KG/m^2)				
Underweight (<18.5 kg/m)	*27(7.99)*	*4(14.81)*	*19(7.69)*	-
Normal weight (between 18.5 and 24.9)	*232(68.64)*	*3(1.29)*	*182(73.68)*	*4(2.2)*
Overweight (between 25 and 29.9)	*54(15.98)*	-	*31(12.55)*	*2(6.45)*
Obesity (> 30)	*25(7.4)*	*1(4)*	*15(6.07)*	-
Mother worked during pregnancy				
Yes	*284(84.02)*	*8(2.82)*	*210(85.02)*	*5(2.38)*
No	*54(15.98)*	-	*37(14.98)*	*1(2.7)*
Income (euros)				
<2000	*51(15.09)*	*1(1.96)*	*38(15.38)*	-
2000-3999	*205(60.65)*	*5(2.44)*	*151(61.13)*	*4(2.65)*
4000-5999	*64(18.93)*	*2(3.12)*	*51(20.65)*	*2(3.92)*
6000-7999	*12(3.55)*	-	*5(2.02)*	-
8000-9999	*6(1.78)*	-	*2(0.81)*	-
>10000	-	-	-	-

Note: SD = Standard deviation

Table 1.6: Descriptive statistics of the study population, mean birth weight (SD) and proportion of low birth weight (1000 g-2500 g), for singleton live births of the ELFE cohort in the Provence-Alpes-Côte d'Azur region (n = 429) and in the Pays de la Loire region (n = 368)

Region	**Provence-Alpes-Côte d'Azur**		**Pays de la Loire**	
Variable relating to birth and mother	***Number (%)***	***LBW(%)***	***Number (%)***	***LBW(%)***
Birth weight (g)	*429*	*10(2.33)*	*368*	*8(2.17)*
Low birth weight (<2500 g)				
Child's sex	*209(48.72)*	*7(3.35)*	*189(51.36)*	*3(1.59)*
Male	*220(51.28)*	*3(1.36)*	*179(48.64)*	*5(2.79)*
Female				
Antenatale care	-	-	-	-
None	*23(5.36)*	-	*46(12.5)*	-
1 to 6	*406(94.65)*	*10(2.46)*	*322(87.5)*	*8(2.48)*

6+				
Gestational length (weeks)	97(22.61)	3(3.9)	77(20.93)	4(7.02)
37-38	258(60.14)	4(1.55)	215(58.42)	3(1.4)
39-40	74(17.25)	-	76(20.65)	-
41-42	-	-	-	-
Alcohol use by mother				
Yes	87(20.28	1(1.15	112(30.43)	2(1.79)
No	342(79.72	9(2.63	256(69.57)	6(2.34)
Tobacco use by mother				
Yes	86(20.05	4(4.65	70(19.02)	4(5.71)
No	343(79.95	6(1.75	298(80.98)	4(1.34)
Mother's education				
Elmentary School/ Middle School	12(2.8)	-	7(1.9)	2(28.57)
Certificate of professional competence	51(11.89)	2(3.92)	38(10.33)	2(5.26)
High-School	68(15.85)	3(4.41)	68(18.48)	-
Higher education	298(69.46)	5(1.68)	255(69.29)	4(1.57)
Never been to school	-	-	-	-
Mother's ethnicity				
European Union	391(91.14)	9(2.3)	348(94.57)	7(2.01)
Maghreb countries	25(5.83)	1(4)	6(1.63)	-
Sub-Saharan Africa	8(1.86)	-	9(2.45)	1(11.11)
Other	5(1.17)	-	5(1.36)	-
Mother's marital status				
Married	278(64.8)	5(1.8)	255(69.29)	5(1.96)
Unmaried	151(35.2)	5(3.31)	113(30.71)	3(2.65)
Mother's age (years)				
<20	2(0.47)	-	2(0.54)	-
20-24	19(4.43)	-	15(4.08)	-
25-29	104(24.24)	2(1.92)	100(27.17)	2(2)
30-34	179(41.72)	5(2.79)	155(42.12)	4(2.58)
35-39	105(24.48)	3(2.86)	78(21.2)	1(1.28)
>39	20(4.66)	-	18(4.89)	1(5.56)
Season of birth				
Spring	68(15.85)	4(5.88)	68(18.48)	-
Summer	119(27.74)	4(3.36)	105(28.53)	2(1.9)
Fall	242(56.41)	2(0.83)	195(52.99)	6(3.08)
Mother's BMI (KG/m^2)				
Underweight (<18.5 kg/m)	40(9.32)	4(10)	32(8.7)	1(3.12)
Normal weight (between 18.5 and 24.9)	295(68.76)	4(1.36)	245(66.58)	5(2.04)
Overweight (between 25 and 29.9)	62(14.45)	2(3.23)	71(19.29)	2(2.82)
Obesity (> 30)	32(7.46)	-	20(5.43)	-
Mother worked during pregnancy				
Yes	354(82.52)	7(1.98)	317(86.14)	6(1.89)
No	75(17.48)	3(4)	51(13.86)	2(3.92)
Income (euros)				
<2000	76(17.72)	2(2.63)	53(14.4)	3(5.66)
2000-3999	212(49.42)	6(2.83)	210(57.07)	3(1.43)
4000-5999	107(24.94)	2(1.87)	82(22.28)	1(1.22)
6000-7999	20(4.66)	-	17(4.62)	-
8000-9999	12(2.8)	-	6(1.63)	1(16.67)
>10000	2(0.47)	-	-	-

Note : SD = Standard deviation

Figure 7: check model