



ELISAH

*European Linkage of Initiative
from Science to Action in Health*

**Work Package 6: Urban environment and
breast cancer risk**

Deliverable 6.1

VERSION V. 1.0

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VERSION CONTROL SHEET

• PROJECT SUMMARY

Project acronym	ELISAH
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Grant Agreement	101128640
Call	EU4H-2022-PJ-3
Topic	EU4H-2022-PJ-12 — Call for proposals on cancer and other NCDs prevention – action on health determinants
Start date	01/01/2024
Duration	36 months
Coordinator	Fondazione IRCCS Istituto Nazionale Tumori

• DOCUMENT CONTROL

Work Package related	WP6
Delivery date	30-apr-2025
Dissemination level	public
Lead partner for deliverable	All
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Reviewers	ELISAH wg
Approved by	
Version	1.0

• DOCUMENT REVISION HISTORY

Revision	Issue date	Author	Comments
1.0			

DISCLAIMER

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ABBREVIATIONS

ELISAH WG: working group composed by coordinator (INT) and partners of the ELISAH project

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None

EXECUTIVE SUMMARY

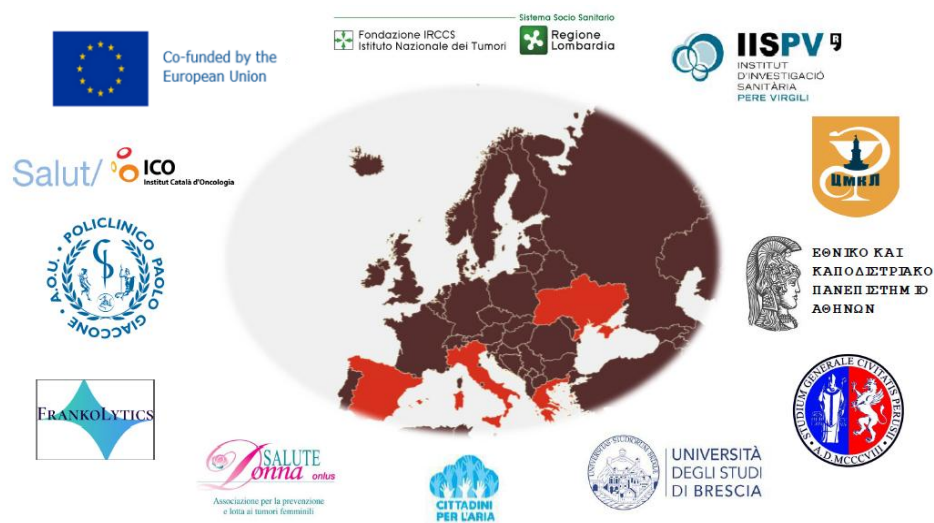
The aim of WP6 of the ELISAH project is to study the urban environment as a conditioning factor for the development and progression of breast cancer in a sample of ten European cities and towns, also by neighbourhood, to suggest local action for improvement dialoguing with Municipalities, citizen and patient associations. This document refers to D6.1 Deliverable specifically aiming to analyzing the relationship between atmospheric pollutants and green spaces. To do this we proceeded into two directions: a) to test the completeness of the two main information sources to assess green space availability: OpenStreetMap and the Urban Atlas; b) to assess the association between PM2.5, NO2, road density and green spaces. The green space assessment performed by OpenStreetMap and Urban Atlas showed a good correlation ($\rho = 0.75$) even if in some cases estimates may differ relevantly. We added road density as an important urban indicator of traffic-related air pollution and tested it versus NO2, another surrogate measure for traffic-related air pollution. Despite the limited number of observation point ($n=11$) relevant aspects were identified: a) an interesting statistically significant association between NO2, main road density and green spaces (forests, parks and woods); b) we identified four cities showing high concentrations of PM2.5, NO2 and low percentages of green spaces, susceptible for urban interventions.

The consortium

ELISAH brings together a consortium of 11 organizations from 4 countries, including cancer research centres, research infrastructures, universities, leading research groups, hospitals, Non-profit organisation of social utility and analytics institutions.

Participating nations include Italy, Greece, Spain, Ukraine, with Fondazione IRCCS Istituto Nazionale dei Tumori (Milan, Italy), taking the lead as the project coordinator.

Fig. 1: ELISAH partners



1. INTRODUCTION

The aim of WP6 of the ELISAH project is to study the urban environment as a conditioning factor for the development and progression of breast cancer, analyzing built environment in a sample of ten European cities and towns, also by neighbourhood, to suggest local action for improvement dialoguing with Municipalities, citizen and patient associations. The relationship between the built environment and breast cancer is very complex. Up to 50% of breast cancers are preventable by acting on environmental and behavioural factors, air pollution and physical activity (PA) between the major contributors. These last characteristics are linked with the built environment and are important modifiable risk factors that can influence breast cancer risk. Urban areas with increased pollutant concentrations, such as fine particulate matter (PM_{2.5}) and nitrogen dioxide (NO₂), have been associated to increased risk of breast cancer. Urban green spaces are also associated with increased risk of developing breast cancer, both directly and indirectly, for example mediated by reduced PA and obesity. Importantly, in the last years, some papers demonstrated that residing in green areas could decrease mortality risk from cancer. The aim of the ELISAH project is very pragmatic, mainly centred on public health and less on etiological research, by this reason we decided to study the components of air pollution mainly linked to urban activities. One of the major sources of air pollution in an urban setting is the Traffic-Related Air Pollution (TRAP), we dedicate much attention to this urban factor.

Atmospheric pollution and residential greenness availability are also linked to cardiovascular and respiratory diseases that when affecting persons with a breast cancer diagnosis may worsen prognosis. Over the past decades, increased urbanization and industrialization have released many hazardous chemicals into the atmosphere. Many of these pollutants are released by the combustion of fossil fuels in the form of carbon monoxide and dioxide, sulfur dioxide, particulate matter and nitrogen dioxide. The International Agency for Research on Cancer (IARC) has classified air pollution as a Group 1 carcinogen [1] indicating there is a significant evidence that the exposure is carcinogenic to humans. In urban areas, vehicular emissions are one of the largest source of air pollution. TRAP is a combination of

toxic gases, including NO₂, carbon monoxide (CO), and volatile organic compounds, as well as fine particulate matter (PM). Many of these compounds, like carbonyls, metals, PM, volatile organic compounds and polycyclic aromatic hydrocarbons (PAHs) are carcinogenic to humans. Despite this, fossil fuel combustion is the main cause of NO_x release and variability in urban environments, making it a good marker for air pollution levels, and a proxy for other carcinogens like PAHs [2]. Because NO₂ is a good surrogate measure of TRAP, it is often used in many studies to assess TRAP exposure [3]. Different metrics of TRAP can be proximity to major roads, traffic volume and density. Particulate matter is classified based on its diameter [4]. PM₁₀ includes inhalable particles with a diameter that are smaller than 10 µm, PM_{2.5} are inhalable particles less than 2.5 µm, finally ultrafine particles (UFPs) are any inhalable particle with a diameter less than 0.1 µm. Atmospheric pollution measures are generally provided for a given area or neighbourhood. However, the effect of pollution for a particular individual is dependent on a variety of factors. These include the amount of time spent outdoors, travel within a city, building and vehicle air exchange rates as well as breathing rates. WP6 is taking into account possible bias of exposure classification of atmospheric pollutant by using together pollutant concentrations and road density indicators.

2 - Association between green spaces and atmospheric pollution: general framework

The ability of green spaces to mitigate the effect of air pollution where well described by a critical review by Diener and Mudu based on a systematic analysis of published reviews on the topic reporting quantitative analysis [5]. The conclusion of the authors was that reductive effects of green spaces on air-borne PM concentrations are considerable, multi-mechanistic and varied by scale, context and vegetation characteristics. The reviews included in paper by Diener differentiate three mitigation mechanisms of green spaces for PM, mainly acting by three different mechanisms: deposition, dispersion and modification.

The ability of green spaces to mitigate the effect of air pollution was also confirmed by studies on personal exposure and variations of human biomarkers. The AIRLESS study demonstrated that higher residential greenness is inversely related to the

levels of oxidative stress biomarkers, that higher personal exposure to air pollution was associated with increased oxidative stress and that residential greenness can modify the biological impact of air pollution on oxidative stress [6].

The results of this study are very important for the ELISAH project. They suggest biological and etiological evidence of integrating built environment factors such as greenness in the assessment of the health impacts of air pollution, supporting the need for public health strategies that incorporate the enhancement of urban green spaces.

The Work Package 6 of the ELISAH project is dedicated to the urban environment, analysing built environment in a sample of European cities and towns, also by neighbourhood, to suggest local action for improvement dialoguing with Municipalities, citizen and patient associations. This is the reason for which we dedicate particular attention to the traffic-related air pollution, very linked to Municipality urban policy.

3- Aims

The aims of deliverable D6.1 of WP6 described in this document are the following:

- to test the completeness and reliability of public information sources to assess green spaces availability
- to study the association between green spaces and environmental pollution, fine particulate matter (PM2.5) and NO2 also as a tracer of traffic-related atmospheric pollution

4 Methods for project development

The project was developed according to the following steps:

By first we select cities to be analysed, then we proceed with:

- 1 Information source selection to assess green space presence
- 2 Identifying green spaces with OSM
- 3 Identify green spaces with Urban Atlas Land Cover/Land Use 2018
- 4 Pollution exposure assessment: concentration measures and built environment

- 5 PM2.5 and NO2 concentration assessment with COPERNICUS
- 6 Identifying road density with OSM
- 7 Statistical analysis

Cities selected as study target: Milan, Palermo, Tarragona, Girona, Athens, Ivano-Frankivsk, Brussels, Berlin, Helsinki, Oslo, Paris, Warsaw. The selection was based on the cities of the Institution directly participating to the ELISAH project (the first six), and further six European Capitals.

4.1 INFORMATION SOURCE SELECTION TO ASSESS GREEN SPACES PRESENCE

This is a study exploring aiming to study the association between green spaces and atmospheric pollutant mainly the one due to urban sources. The ELISAH study as a whole needs to study the link between breast cancer development and prognosis and green spaces availability both in relation to the environmental meaning of green spaces but also in association with physical activities favoured by their presence. This last depend on the accessibility of green spaces and led us to look for public databases on green spaces classifying the accessibility of green spaces. OpenStreetMap (OSM) is a crowded sourced geographic database that make it possible to classify accessibility to green spaces. The use of OSM for scientific purposes and above all to identify green spaces was explored by very few studies, looking in Pubmed with the keywords “OpenStreetMap and green spaces” only ten papers could be retrieved. A study by Cristina Ludwig [7] showed that there are regional commonalities but also some differences in how OSM identify green spaces in urban setting. For this reason we used together OSM and the URBAN Atlas. The first step of the WP6 study was a cross validation of this two information sources. Two independent team of the ELISAH project worked independently to assess green spaces by OSM and Urban Atlas.

4.2- IDENTIFYING GREEN SPACES WITH OSM

The R-language and the ‘osmdata’ package were used to extract vector data from OSM. The “Land use”, “Natural” and “Leisure” keys covering the areas of the cities selected for the study were extracted separately and specific values of land use, natural and leisure pertaining to urban green space were selected. The relevant

values chosen were the following: from “Land use”: forest, recreation ground, grass, meadow, orchard, greenfield, village green, vineyard, allotments, cemetery and farmland. From “Leisure”: common, dog park, garden, nature reserve, golf course, pitch and park; from nature reserve; park and pitch. Finally, from “Natural”: scrub; fell, grassland, heath, moor and wood. These key/value couples were listed on the OSM Wiki as being representative of green space availability. We built three sf (simple feature) objects by using the ‘osmdata’ package and then they were merged into one list representing all green spaces. The polygons contained in the list were dissolved to remove any overlap and intersection functions were applied to cut off extra-area parts of polygons on boundaries. We introduced in the analysis also a more strict category for green spaces selecting only “forest”, “park” and “wood”, usually more easily accessible by people.

4.3 – IDENTIFY GREEN SPACES WITH URBAN ATLAS LAND COVER/LAND USE 2018

For the mapping of green spaces in the cities identified and selected for the ELISAH Project, we used Urban Atlas Land Cover/Land Use 2018 (vector), Europe, 6-yearly.

This methodology provides land cover and use data with integrated population estimates for 788 Functional Urban Areas (FUAs) with more than 50 000 inhabitants in the 38 EEA countries for the reference year 2018. The dataset maps land cover and use for 17 urban classes with a Minimum Mapping Unit (MMU) of 0.25 ha and for 10 rural classes with a MMU of 1 ha, and is available as vector data.

We downloaded the urban atlas data from the following official website: <https://land.copernicus.eu/en/products/urban-atlas/urban-atlas-2018#download> for the following cities: Milan, Palermo, Tarragona, Girona, Brussels, Berlin, Helsinki, Oslo, Paris, Athens, Warsaw.

We then loaded the city map data in shape file format into QGIS program for visualizing the Urban Atlas categories on the identified cities.

We have calculated for each city, the number of inhabitants in 2018, the area expressed in Km² for each UA category, and the percentage of green areas always expressed in Km².

4.4 -POLLUTION EXPOSURE ASSESSMENT: CONCENTRATION MEASURES AND BUILT ENVIRONMENT

We study environmental pollution taking into account PM_{2.5} and NO₂. We use NO₂ not only to take into account of its direct effect but also as a tracer of TRAP. The assessment of PM_{2.5} and NO₂ was performed by using the COPERNICUS system, as describe in more detail on a specific paragraph. Differences were observed by studies between the concentration of some atmospheric pollutants and the personal exposure of people living in urban areas. This last is very important for us because the ELISAH project is centred on public health applications for the prevention of breast cancer. A study by Van Ryswyk et al comparing different method to assess Children's exposure to Traffic-Related Air Pollution Children's suggested that available TRAP exposure indicators have the potential for exposure misclassification more so for land use regression model than for metrics of major road density. By this reason we decided to add as TRAP population exposure the weighted road density as suggested by the validated methodology by Rose et al. [8-] and them applied by Hansell. In the same way we used to classify green spaces we used OSM to compute road density aggregating roads into two main categories, primary roads and local roads.

4.5 - PM_{2.5} AND NO₂ CONCENTRATION ASSESSMENT WITH COPERNICUS

PM_{2.5} and NO₂ concentration data were retrieved from the Copernicus Atmosphere Monitoring Service (CAMS)¹. Specifically, the dataset used was the CAMS European Air Quality Reanalysis, which provides annual air quality estimates for Europe by integrating both validated and invalidated observations with model outputs. The regional reanalysis are based on an ensemble (Institut national de l' environnement industriel et des risques (Ineris) et al., 2022) of eleven state-of-the-art chemical transport models developed by various European institutions, including CHIMERE, EMEP, EURAD-IM, LOTOS-EUROS, MATCH, MOCAGE, SILAM, DEHM, GEM-AQ,

¹ CAMS European air quality reanalysis:

<https://ads.atmosphere.copernicus.eu/datasets/cams-europe-air-quality-reanalyses?tab=overview>

<https://ads.atmosphere.copernicus.eu/datasets/cams-europe-air-quality-reanalyses?tab=download>

MONARCH, and MINNI. The median ensemble output is computed from the outputs of individual models to obtain higher performance compared to the outputs of single models.

The spatial resolution of the dataset is approximately $0.1^\circ \times 0.1^\circ$ (10km $\times$ 10km). The reanalysis is based on a data assimilation approach, where observational data—provided by the European Environment Agency (EEA)—are combined with estimates from the models. For each year, an interim reanalysis is released first, based on near-real-time observational data that have not yet undergone full quality control. Once quality-assured datasets become available—typically with a delay of about one year—a final validated annual reanalysis is published. Both the interim and final reanalyses are provided at hourly temporal resolution and at multiple height levels. The main features of the data are summarized in [Table 2](#).

Table 2. Main features of air pollution data retrieved from Copernicus.

Data type	Gridded
Horizontal coverage	Europe (east boundary=25.0° W, west=45.0° E, south=30.0° N, north=72.0°)
Horizontal resolution	$0.1^\circ \times 0.1^\circ$ (10 km $\times$ 10 km)
Vertical coverage	Surface, 50m, 100m, 250m, 500m, 750m, 1000m, 2000m, 3000m, 5000m
Temporal coverage	2013 - 2023
Temporal resolution	monthly files containing 1-hourly analyses
File format	NetCDF
Update frequency	twice a year
Reanalysis tipe	Interim, validated

Raw NetCDF data were processed using MATLAB 2024b (The MathWorks, Inc, Natick, MA, USA) to generate a single CSV file containing the annual mean

concentrations of PM_{2.5} (or NO₂), along with corresponding latitude and longitude values representing the centroid of 0.1° × 0.1° grid cells. To ensure consistency with Urban Atlas data, we selected 2018 as the reference year. Air pollution values were spatially extracted for each city using QGIS (QGIS Geographic Information System) by overlapping the gridded pollution data with the corresponding municipal boundaries. The boundaries (LAU - Local Administrative Units) were obtained from the official Eurostat GISCO database: (<https://ec.europa.eu/eurostat/web/gisco/geodata/statistical-units/local-administrative-units>). Finally, for each city, the mean concentration was computed as a spatially weighted average, where weights were proportional to the area of intersection between the city's administrative boundary and each overlapping grid cell.

4.6 – IDENTIFYING ROAD DENSITY WITH OSM

In the same way of green spaces, by the 'osmdata' package the key "highway" were used to extract data by OSM. To select main roads were used the following values: "motorway", "primary", "secondary". To select minor roads the following values were selected: "tertiary", "residential". In the same way of greenspaces, polygons captured by OSM was submitted to processes of merge and intersection. We computed weighted road density assigning the weight "3" to main roads and "1" to minor. We also evaluate main road density in the analysis by itself.

4.7 – STATISTICAL ANALYSIS

The statistical analysis was performed by using the R-language package. Measures of association were computed by using the lm function by R-language. Univariate models were run to link PM_{2.5} and road density indicators, one by time, PM_{2.5} and green space indicators. The same process was followed for NO₂. Multivariate models were run to assess the linear relationship between PM_{2.5} (or NO₂) and green spaces and road density indicators simultaneously. Adjusted R-squared metrics were computed for every run model to evaluate how much variance is explained by the covariates under analysis.

5- Results

In table 2 descriptive statistics for weighted road density, green space availability according to OSM and Urban Atlas are shown, by city. Weighted road density show important variations from 0.40 km/km² (Oslo) to 3.88 km/km² (Paris).

City	major road density	minor road density	selected OSM green s (km2)	N02 (mg/ m3)	PM2.5 (mg/ m3)	total OSM green s. (km2)	total UA green s. (km2)	total OSM green s. (%)	total UA green s. (%)	selected OSM green s. (%)
Milano	1,76	10,91	21,56	35,46	22,58	60,79	53,59	33,46	29,50	11,87
Palermo	0,62	6,83	23,8	9,37	8,96	40,87	82,81	25,45	51,57	14,82
Bruxelles	1,63	11,64	14,49	23,19	12,15	46,32	38,66	28,70	23,96	8,98
Oslo	0,40	3,35	270	7,94	6,42	298,24	299,99	65,69	66,08	59,47
Parigi	3,88	29,99	10,2	27,45	12,1	65,26	17,72	37,15	16,81	9,68
Tarragona	1,79	10,97	16,31	12,93	8,47	19,84	32,21	34,27	55,63	28,17
Girona	0,53	6,73	18,37	7,71	9,38	23,43	25,27	59,92	64,63	46,98
Berlin	1,48	9,18	229	17,36	13,63	368,65	291,38	41,29	32,63	25,65
Warsaw	1,40	8,70	120,6	16,91	21,02	246,88	211,54	47,74	40,90	23,32
Helsinki	1,91	9,76	89,43	8,88	6,55	117,46	92,55	55,96	44,09	42,616

Table 2: road density and green spaces indicators, by information sources (OSM, UA) by city

Percentages of green space varied from 25.45% (Palermo) to 65.89% (Oslo) according to OSM, from 16.81% (Paris) to 66.08% (Oslo) for UA. Despite the spearman correlation coefficient reported a relevant association between the two information sources, $\rho = 0.75$, very strong differences were observed for Paris, 37.15% for OSM vs 16.81 and Palermo, 25.45% for OSM and 51.57 for UA. Four cities, Athens, Milan, Brussels and Paris showed high levels of N02 and low percentage of parks, woods and forests. Test on green spaces by OSM revealed incompleteness for Athens and Ivano-Frankivsk that will be solved submitting to OSM team green spaces enhancement.

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<i>Linear model, univariate</i>	<i>Predicted coefficient (IC)</i>	<i>Adjusted R-square</i>
N02 ~ w. road_density_t	0.75 (-0.04 , 1.54)	0.27
N02 ~ main_road_density	5.79 (0.10 , 11.48) *	0.30
PM2.5 ~ w.road_density_t	0.12 (-2.02 , 18.26)	0.024
PM2.5 ~ main_road_density	1.13 (-3.07 , 5.32)	0.039
N02 ~ green_s_OSM	-0.37 (-0.84 , 0.10)	0.07
N02 ~ green_s_UA	-0.02 (-0.15,0.10)	0.02
PM2.5 ~ green_s_OSM	-0.13 (-0.45 , 0.19)	0.09
PM2.5 ~ green_s_UA	0.01 (-0.08, 0.07)	0.01
N02 ~ p_green_s_OSM	- 0.37 (-0.64 , -0.11) *	0.37
PM2.5 ~ p_green_OSM	-0.16 (-0.36, 0.02)	0.26
<i>Linear model, multivariate</i>		
PM2.5 ~ p_green_s_OSM + main_road_density	green_s_OSM: - 0.11 (-0.48, 0.25) main_road_density : 0.59 (-4.48,5.66)	0.11
N02 ~ p_green_s_OSM + main_road_density	green_s_OSM: - 0.29 (-0.60, 0.13) main_road_density : 3.03 (-2.61,8.67)	0.51

Table 3: linear association between PM2.5, N02 and weighted road density (w_road_density), main road density (main_road_density) green spaces by OSM (green_s_OSM), by UA (green_s_UA), green spaces limited to forests, parks and woods (p_green_s_OSM). “*” indicate statistically significant estimates

In table 3 the results for the association assessment between PM2.5 and N02 as dependent variables, and weighted road density and green spaces availability as

independent variables. Table 2 follows the following format: in the linear model column are listed in order the depend variable, then the “~” character to express the link and at last the dependent variables. Linear predictor and adjusted R-square listed in second and third column.

Interestingly we observed a significant linear association in the univariate model between no2 and main road density, not significant but interesting similar association for PM2.5. The road density indicators were always positively associated with PM2.5 and NO2 meanwhile negatively associated with green spaces. The multivariate analysis did not identify significant associations but interestingly the linear model linking NO2 with limited green spaces (forest, wood and park) and main road density explain the 51% of the variability of the observations.

6- Discussion

The correlation ($\rho = 0.75$) between OSM and UA green spaces assessment was acceptable despite differences in some observation points, similar to the results described by a study published by C. Ludwig [ref]. Despite the low number of observation points ($n=11$) we identified associations between NO2 and main road density in the univariate model. These results confirm the study by Rose et al showing the good linkage between road density indicators and concentration measurements. The association between NO2 and green spaces limited to forests, parks and woods find its biological and etiological explanation in the review by Diener. The ELISAH WP6 was planned to be a public health study, our results do have not to be interpreted as a causal relationship between the variables under analysis but as a basis for public health actions.

7 - Conclusion

Main points:

- the two indicators under test to analyse the association between built environment and atmospheric pollution, road density and green spaces as assessed by OSM and UA, showed to be useful for the aims of the ELISAH project

- the analysis showed is limited by the number of observation point (n=11) but identified two relevant aspects:

a) associations between NO₂, main road density and green spaces (forests, parks and woods)

b) cities which , if the results of this study will be confirmed, that required urban environment actions

As stated by Dinier green spaces may mitigate the dangerous effect of exposure to atmospheric pollutants, cities with high NO₂ and PM_{2.5} and low green spaces fail to take advantage of this possible mitigation effect.

To be noted the methodology we applied is very new in the scientific world and put together public available information sources such as OpenStreetMap, the Urban Atlas and the Copernicus Atmosphere Monitoring Service, making it possible to be easily replicated in other EU countries.

8- Further developments and

link with other ELISAH WP

The results based on the low number of observation we analysed need to be confirmed by a larger study that will be performed by WP6 prosecution taking into account city neighbourhood and other cities.

The results presented are very useful for the development of ELISAH WP3 that will apply the methodology to assess the link between breast cancer survival, NO₂, PM_{2.5} and green spaces. The same is for the WP5 acting on inequalities.

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