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# Protocol for integrated urban environment stressors generation in LifeCycle (WP3 – Task 3.3)

## Update of Deliverable 3.3

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Version 4

Last update: June 2021

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This project received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 733206 (LifeCycle).

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- ### List of abbreviations

| | |
|---|---|
| ABCD | ABCD cohort |
| ALSPAC | ALSPAC cohort |
| BIB | BiB cohort |
| DNBC | DNBC cohort |
| EDEN | EDEN cohort |
| ELAPSE | Effects of Low-Level Air Pollution: A Study in Europe |
| ESCAPE | European Study of Cohorts for Air Pollution Effects |
| GAS | GASPII cohort |
| GENR | GenR cohort |
| GUIP | INMA Guipúzcoa cohort |
| INMA | INMA cohort |
| KANC | KANC cohort |
| MOBA | MoBa cohort |
| NAN | EDEN Nancy cohort |
| NDVI | Normalized Difference Vegetation Index |
| NFIR | NINFEA Firenze cohort |
| NO | Nitrogen monoxides |
| $NO_2$ | Nitrogen dioxides |
| $NO_x$ | Nitrogen oxides |
| NROM | NINFEA Roma cohort |
| NTOR | NINFEA Torino cohort |
| PFIR | PICCOLIPIÙ Firenze cohort |
| PM | Particulate matter |
| $PM_{10}$ | Particulate matter an aerodynamic diameter less than 10 um |
| $PM_{2.5}$ | Particulate matter an aerodynamic diameter less than 2.5 um |

| | |
|---|---|
| POI | EDEN Poitiers cohort |
| PROM | PICCOLIPIÙ Roma cohort |
| PTOR | PICCOLIPIÙ Torino cohort |
| RHEA | RHEA cohort |
| SBD | INMA Sabadell cohort |
| SES | Socio Economic Status |
| VAL | INMA Valencia cohort |

# 1 Workplan

## *1.1 Objectives*

**To generate integrated harmonised exposure indices for stressors in the urban environment, which include air pollution, noise, green space, connectivity and walkability measurements.**

This subtask is built on the experience obtained in five partner cohorts in the EU Child Cohort Network (INMA, BiB, RHEA, MoBa-Oslo, EDEN) and one non-partner cohort in Lithuania (KANC), as part of the EU-FP7 funded HELIX project (www.projecthelix.eu) that has modeled urban environment stressors using Geographic Information System (GIS) approaches. Intensive personal monitoring campaigns have validated these models.

In this sub-task: **1) we improved the methods previously applied in HELIX**, generating new exposures (i.e. particle composition, land use categories of built environment, area deprivation, and increasing the number of periods of exposure generated up to 12 years); **2) we expanded the GIS work to four EU Child Cohort Network partner cohorts (ALSPAC, DNBC, GenR and NINFEA) and three non-partner cohorts (ABCD, GASPII and PICCOLIPIÙ)** that provided address histories of their participants, and had follow-up data available to participate in the planned papers; 3) **we updated the work done for the six HELIX cohorts generating new periods/time points of exposure, up to the latest available follow-up point** (work done for all HELIX cohorts but MoBa and for the new follow up points available in INMA, and planned for the new follow up points in RHEA and BiB). Among the partners cohorts that were willing to participate five cohorts were excluded for the different reasons: GECKO (cohort set up in a rural environment), ELFE (not cost effective), HBCS (data not suitable for this subtask since the cohort is from 1930-40), NFBC (GIS data available were not representative of the period of interest), and RAINE (geocode transfer not possible).

## 1.2 Study population

The 13 cohorts included in the study are summarised in Table 1. A total of 98,211 mother-child pairs from 16 cities in nine European countries were available for generating **the integrated harmonised exposure indices for stressors in the urban environment** the exposure in this sub-task. The final N for each exposure will vary depending on the available of GIS data in each cohort.

**Table 1** Participating birth cohorts

| cohort | enrollment period | country | cities | number |
|---|---|---|---|---|
| ALSPAC – Avon Longitudinal Study of Parents and Children | 1990-1992 | United Kingdom | Restricted to Bristol area | 13,875 |
| BiB – Born in Bradford | 2007-2010 | United Kingdom | Bradford | 13,775 |
| DNBC - Danish National Birth Cohort | 1997-2002 | Denmark | Restricted to Copenhagen greater area | 24,260 |
| EDEN – Study of determinants of pre and postnatal developmental | 2003-2006 | France | Restricted to Nancy, Poitier | 1,900 |
| GenR – Generation | 2002-2006 | The Netherlands | Rotterdam | 9,523 |
| INMA – Environment and Childhood | 2004-2006 | Spain | Restricted to Gipuzkoa, Sabadell, Valencia | 2,204 |
| MoBa – The Norwegian Mother and Child Cohort Study | 2004-2008 | Norway | Restricted to Oslo region | 13,284 |
| NINFEA | 2005-2016 | Italy | Restricted to Florence, Rome, Turin | 3,774 |
| RHEA – Mother Child Cohort in Crete | 2007-2008 | Greece | Heraklion | 1,249 |
| ABCD | 2003-2004 | The Netherlands | Amsterdam | 7,361 |
| GASPII | 2003-2004 | Italy | Rome | 950 |
| KANC – Kaunas Cohort | 2007-2009 | Lithuania | Kaunas | 4,219 |
| PICCOLIPIÙ | 2011-2015 | Italy | Restricted to Florence, Rome, Turin | 1,836 |

## 1.3 Exposure assessment

A GIS environment for the all study areas was set up at ISGLOBAL for centralized processing of the data, in collaboration with each cohort. Exposures of interest were air pollution, natural spaces, built environment, social context, traffic, noise, unhealthy food environment, and meteorology (the latter is planned to be completed by the end of 2019) (Table 2). Exposures where assigned within GIS tools to all geocoded addresses. The table below shows a summary of all the generated GIS variables. For reasons related to data protection policies specific to GenR, NINFEA, Piccolipiù and GASPII cohorts, the following exposure estimates were calculated directly by the cohorts: air pollution exposures

(GenR), particle composition exposures (NINFEA Turin, PICCOLIPÙ Turin), social context (NINFEA, PICCOLIPÙ, and GASPII), traffic (NINFEA Turin, PICCOLIPÙ Turin) and noise (NINFEA Turin, PICCOLIPÙ Turin).

### Table 2 List of spatial exposure variables

| topic | indicator | description |
|---|---|---|
| air pollution | $NO_X$, $NO_2$, $PM_{2.5}$, $PM_{10}$, $PM_{abs}$, PMcoarse | LUR exposures back-extrapolated in time |
| air pollution[a] | Particle composition ($PM_{25}CU$, $PM_{25}FE$, $PM_{25}K$, $PM_{25}NI$, $PM_{25}S$, $PM_{25}SI$, $PM_{25}V$, $PM_{25}ZN$, $PM_{10}CU$, $PM_{10}FE$, $PM_{10}K$, $PM_{10}NI$, $PM_{10}S$, $PM_{10}SI$, $PM_{10}V$, $PM_{10}ZN$) | LUR exposures |
| natural spaces | Greenness | Average NDVI within buffers of 100, 300 and 500 meters |
| natural spaces | Major green/blue spaces | Straight line distance to nearest major space > 5,000 $m^2$ |
| natural spaces | Major green/blue spaces | Distance and size of closest major space |
| natural spaces | Major green/blue spaces | Is there a major space within 300 meters? |
| built environment | Population density[b] | inhabitants/$km^2$ |
| built environment | Building density[b] | $m^2$ built/$km^2$ within buffers of 100 and 300 meters |
| built environment | Connectivity density | number of intersections / $km^2$ within buffers of 100 and 300 meters |
| built environment | Accessibility | Meters of public transport mode lines (only buses) inside each 100, 300 and 500 meters buffer, divided by the buffer area in $km^2$ |
| built environment | Accessibility | Number of public transport mode stops (only buses) inside each 100, 300 and 500 meters buffer, divided by the buffer area in $km^2$ |
| built environment | Facility richness index | number of different facility types present divided by the maximum potential number of facility types specified, in a buffer of 300 meters |
| built environment | Facility density index | number of facilities present divided by the area of the 300 meters buffer |
| built environment | Land Use Evenness Index | minus the sum, across all land use types, of the proportional abundance of each land use type multiplied by that proportion, divided by the logarithm of the number of land use types, in a buffer of 300 meters |
| built environment[a] | Land use categories | Percentage of presence of different land use categories |
| built environment | Walkability index | how 'walkable' is a buffer of 300 meters around each geocode |
| Social context | Area deprivation | How deprived is the location of the geocode |
| traffic | Trafmajorload | Total traffic load of major roads in a 100 meters buffer |
| traffic | Trafload | Total traffic load in a 100 meters buffer |
| traffic | Trafnear | Traffic density on nearest road |
| traffic | Distinvnear | Inverse distance to the nearest road |
| noise | $L_{den}$ and $L_{night}$ | Noise values from closest street or point location |
| unhealthy food environment (NAVTEQ)[a] | Food facilities density | number of facilities related to unhealthy food divided by the area of the 300 meters buffer (using NAVTEQ data) |

| topic | indicator | description |
|---|---|---|
| meteorology | Erythemal UV, DNA damage UV and Vitamin-D UV doses | Erythemal UV, DNA damage UV and Vitamin-D UV doses |
| meteorology[a] | Spatial resolution data | Land Surface Temperature (ºC) |
| meteorology[a] | Temporal resolution data | Average meanTemperature, minTemperature, maxTemperature (ºC), humidity (%), distance to meteorological station (m) |

[a] new variable created within Lifecycle.

### *1.3.1 Geocoding*

For the period from pregnancy and up to twelve years of childhood, the residential geocodes of the address history of 98,211 mother-child pairs were transferred from cohorts to a central database held at ISGLOBAL in Barcelona.

For natural spaces, noise, traffic, built environment and social environment limited information about temporal variability was available, meaning that for each cohort source data were available for some but not all the years of the period of interest. For these variables, the following exposure time points were made available: trimesters (when available), pregnancy, at birth, one time point for each year (1, 2, …, x) up to the year of the last available follow up. For children who moved between two follow up visits, we will use the point of moving in the middle of the interval. For ALSPAC, DNBC, GenR, and INMA, the complete address history was available for all kids from birth to last follow up, allowing assigning the exact geocode to each period of interest. For the other cohorts, for timepoints without exact geocode we assigned the geocode based on the closest one in time (Table 3).

**Table 3 Geocodes assigned to creat a year by year exposure estimate for variables without information on temporal variability (assumed geocodes in *italics*).**

| cohort | preg | birth | y1 | y2 | y3 | y4 | y5 | y6 | y7 | y8 | y9 | y10 | y11 | y12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ABCD | preg | birth | *birth* | *birth* | *y5* | *y5* | y5 | *y5* | *y8* | y8 | *y8* | *y11* | y11 | - |
| ABCD[d] | preg | birth | *birth* | *birth* | *birth* | *birth* | *y8* | *y8* | *y8* | y8 | *y8* | *y8*[e] | *y8*[e] | - |
| ALSPAC | preg[a] | birth | y1 | y2 | y3 | y4 | y5 | y6 | y7 | y8 | y9 | y10 | y11 | y12 |
| BIB | preg[b] | *preg* | *preg* | *preg* | *y5* | *y5* | y5 | | | | | | | |
| DNBC | preg[b] | birth | y1 | y2 | y3 | y4 | y5 | y6 | y7 | y8 | y9 | y10 | y11 | y12 |
| EDEN | preg[b] | *preg* | *preg* | *preg* | *y5* | *y5* | y5 | - | - | - | - | - | - | - |
| GASPII | *birth* | birth | m6 | m15 | *m15/y4* | y4 | *y4* | *y7* | y7 | - | - | - | - | - |
| GENR | preg[c] | birth | y1 | y2 | y3 | y4 | y5 | y6 | y7 | y8 | y9 | y10 | y11 | y12 |
| INMA | preg[c] | birth | y1 | y2 | y3 | y4 | y5 | y6 | y7 | y8 | y9 | y10 | y11 | y12 |
| KANC | preg[c] | *preg* | *preg* | *preg/y4* | *y4* | y4 | - | - | - | - | - | - | - | - |
| MOBA | preg | birth | 14_18m | *14_18m* | y3 | *y3* | y5 | *y5* | 7_8y | - | - | - | - | - |
| NINFEA | preg | m6 | m18 | *m18* | *y4* | y4 | *y4* | *y7* | y7 | *y7* | *y10* | y10 | - | - |
| PICCOLIPIÙ[e] | preg | preg | preg | preg | preg | preg | - | - | - | - | - | - | - | - |
| RHEA | preg | *preg* | *preg* | *preg/y4* | *y4* | y4 | y4 | | | | | | | |

Abbreviations: m, month; preg, pregnancy; y, year.

[a]Recruitment (birth); [b]Recruitment (3rd trimester); [c]Recruitment (1st trimester); [d]traffic and particle components; [e]Not movers only.

For air pollution, meteorological variables and UV radiation detailed information about temporal variability was available, and the following exposure periods have been created: trimesters, entire pregnancy, one year averages starting with the date of birth up to the last available follow up (using the last entire year including the date of follow up) (e.g. for a child born 12 May 2000 for which the last visit took place on 30 Sept 2010, the last exposure window that have been calculated will be 12 May 2010 – 11 May 2011) (this will allow researcher to build their own averages when needed). For children who moved between two follow up visits, we will use the point of moving in the middle of the interval, so the exposure window will get half part of the year using the previous gecode and the other half part the following geocode (Table 4).

**Table 4 Geocodes assigned to creat a year by year exposure estimate for variables with information on temporal variability (assumed geocodes in *italics*)**

| cohort | preg | y1 | y2 | y3 | y4 | y5 | y6 | y7 | y8 | y9 | y10 | y11 | y12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ABCD | preg | *birth* | *birth* | *y5* | *y5* | y5 | *y5* | *y8* | y8 | *y8* | *y11* | y11 | |
| ABCD[d] | preg | *birth* | *birth* | *birth/y8* | *birth/y8* | *y8* | *y8* | *y8* | y8 | *y8* | *y8*[c] | *y8*[c] | |
| ALSPAC | preg[a] | y1 | y2 | y3 | y4 | y5 | y6 | y7 | y8 | y9 | y10 | y11 | y12 |
| BIB | preg[b] | *preg* | *preg* | *preg/y5* | *y5* | y5 | | | | | | | |
| DNBC | preg[b] | y1 | y2 | y3 | y4 | y5 | y6 | y7 | y8 | y9 | y10 | y11 | y12 |
| EDEN | preg[b] | *preg* | *preg* | *preg/y5* | *y5* | y5 | - | - | - | - | - | - | - |
| GASPII | *birth* | m6 | m15 | *m15/y4* | y4 | *y4* | *y7* | y7 | - | - | - | - | - |
| GENR | preg[c] | y1 | y2 | y3 | y4 | y5 | y6 | y7 | y8 | y9 | y10 | y11 | y12 |
| INMA | preg[c] | y1 | y2 | y3 | y4 | y5 | y6 | y7 | y8 | y9 | y10 | y11 | y12 |
| KANC | preg[c] | *preg* | *preg/y4* | *y4* | y4 | - | - | - | - | - | - | - | - |
| MOBA[e] | preg | 14_18m | *14_18m* | y3 | *y3* | y5 | *y5* | 7_8y | 7_8y | - | - | - | - |
| NINFEA | preg | m18 | *m18* | *y4* | y4 | *y4* | *y7* | y7 | *y7* | *y10* | y10 | - | - |
| PICCOLIPU[f] | preg | preg | preg | preg | preg | - | - | - | - | - | - | - | - |
| RHEA | preg | preg | *preg/y4* | *y4* | y4 | *y4* | | | | | | | |

Abbreviations: m, month; preg, pregnancy; y, year.
[a]Recruitment (birth); [b]Recruitment (3rd trimester); [c]Recruitment (1st trimester); [d]air pollution; [e]using the HELIX methodology, no update done within Lifecycle; [f]not movers only

### *1.3.2 Outdoor air pollution*

We created exposure estimates to the following outdoor air pollutants: $NO_X$, $NO_2$, $PM_{2.5}$, $PM_{10}$, $PM_{abs}$, $PM_{coarse}$, and particles components. The exposure assessment (including particles composition) was based on the land use regression (LUR) modeling approach developed in the European Study of Cohorts for Air Pollution Effects (ESCAPE) framework, that included most of the cohorts participating to this subtask[1–6]. For those cohorts for which ESCAPE local models were not available, models developed within the ELAPSE project have been used[7] (only available for $NO_2$ and $PM_{2.5}$). $PM_{10}$ local dispersion models[8] were used for EDEN for the pregnancy period. The sources of air pollution data for each cohort/city and the availability of LUR models for particle composition exposure assessment are reported in Table 5 and 6, respectively.

### Table 5 Selected models for air pollution data

| cohort | $NO_X$ | $NO_2$ | $PM_{2.5}$ | $PM_{10}$ | $PM_{abs}$ |
|---|---|---|---|---|---|
| ALSPAC | - | ELAPSE | ELAPSE | - | - |
| BIB | ESCAPE local LUR | ESCAPE local LUR | ESCAPE local LUR | ESCAPE local LUR | ESCAPE local LUR |
| DNBC | - | ELAPSE | ELAPSE | - | - |
| EDEN NAN | - | ESCAPE local LUR | ELAPSE | Local Dispersion Model (only pregnancy period) | - |
| EDEN POI | - | ESCAPE local LUR | ELAPSE | Local Dispersion Model (only pregnancy period) | - |
| GENR | ESCAPE local LUR | ESCAPE local LUR | ESCAPE local LUR | ESCAPE local LUR | ESCAPE local LUR |
| INMA GUIP | ESCAPE local LUR | ESCAPE local LUR | ELAPSE | - | - |
| INMA SAB | ESCAPE local LUR | ESCAPE local LUR | ESCAPE local LUR | ESCAPE local LUR | ESCAPE local LUR |
| INMA VAL | ESCAPE local LUR | ESCAPE local LUR | ELAPSE | - | - |
| MOBA | ESCAPE local LUR | ESCAPE local LUR | ESCAPE local LUR | ESCAPE local LUR | ESCAPE local LUR |
| NFIR | - | ELAPSE | ELAPSE | - | - |
| NROM | ESCAPE local LUR | ESCAPE local LUR | ESCAPE local LUR | ESCAPE local LUR | ESCAPE local LUR |
| NTOR | ESCAPE local LUR | ESCAPE local LUR | ESCAPE local LUR | ESCAPE local LUR | ESCAPE local LUR |
| RHEA | ESCAPE local LUR | ESCAPE local LUR | ESCAPE local LUR | ESCAPE local LUR | - |
| ABCD | ESCAPE local LUR | ESCAPE local LUR | ESCAPE local LUR | ESCAPE local LUR | ESCAPE local LUR |
| GAS | ESCAPE local LUR | ESCAPE local LUR | ESCAPE local LUR | ESCAPE local LUR | ESCAPE local LUR |
| KANC | ESCAPE local LUR | ESCAPE local LUR | ESCAPE local LUR | ESCAPE local LUR | ESCAPE local LUR |
| PFIR | - | ELAPSE | ELAPSE | - | - |
| PROM | ESCAPE local LUR | ESCAPE local LUR | ESCAPE local LUR | ESCAPE local LUR | ESCAPE local LUR |
| PTOR | ESCAPE local LUR | ESCAPE local LUR | ESCAPE local LUR | ESCAPE local LUR | ESCAPE local LUR |

### Table 6 Availability of LUR models for particulate components exposure estimation

| cohort | $PM_{2.5}$ components | | | | | | | | $PM_{10}$ components | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | CU | FE | K | NI | S | SI | V | ZN | CU | FE | K | NI | S | SI | V | ZN |
| ABCD | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| ALSPAC | | | | | | | | | | | | | | | | |
| BIB | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| DNBC | | | | | | | | | | | | | | | | |
| EDEN NAN | | | | | | | | | | | | | | | | |
| EDEN POI | | | | | | | | | | | | | | | | |
| GAS | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| GENR | X | X | X | X | X | X | X | X | | | | | | | | |
| INMA GUIP | | | | | | | | | | | | | | | | |
| INMA SBD | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |

| cohort | $PM_{2.5}$ components | | | | | | | | $PM_{10}$ components | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | CU | FE | K | NI | S | SI | V | ZN | CU | FE | K | NI | S | SI | V | ZN |
| INMA VAL | | | | | | | | | | | | | | | | |
| KANC | X | | X | | | X | X | | X | X | | X | | X | X | X |
| MOBA | | | | | | | | | | | | | | | | |
| NFIR | | | | | | | | | | | | | | | | |
| NROM | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| NTOR | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| PFIR | | | | | | | | | | | | | | | | |
| PROM | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| PTOR | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| RHEA | X | X | X | X | | X | X | X | X | X | X | | | X | X | X |

To obtain estimates for the relevant exposure period within LIFECYCLE, temporal adjustment was conducted using background routine monitoring stations. Temporally adjusted exposure levels to each pollutant was estimated for each study participant by combining the LUR spatial estimates of pollutants for their geocode with a temporal adjusting factor obtained from the routine monitoring data, following ESCAPE guidelines[9]. Specifically, it has been used the ratio of the concentration of the routine monitor of each day of the study period and the annual average during 2009 (year of sampling campaign) or 2010 (year of ELAPSE air pollution grid maps) as the adjustment factor for that day. When data on a specific pollutant were not available from the routine network we did a back-extrapolation based on available pollutants as follow: we used daily $PM_{10}$ to adjust $NO_2$ and $NO_x$; $NO_2$ or $PM_{10}$ factors to adjust $PM_{2.5}$; $NO_2$ to adjust $PM_{10}$; daily $NO_x$ to adjust $PM_{2.5\ absorbance}$ (Table 7). Data on background $NO_2$, $NO_x$, $PM_{10}$, and $PM_{2.5}$ (the latter if available) concentrations were obtained from routine background stations active during whole study period (details in Table 8).

**Table 7 Pollutants used for back-extrapolation when daily values of the specific pollutants were available (ratio method ONLY)**

| cohort | $NO_2$ | $NO_x$ | $PM_{10}$ | $PM_{2.5}$ | $PM_{2.5abs}$ | $PM_{coarse}$ | $NO_2$ (ELAPSE) | $PM_{2.5}$ (ELAPSE) |
|---|---|---|---|---|---|---|---|---|
| ABCD | $NO_2$ | $NO_x$ | $PM_{10}$ | $NO_2$ | $NO_x$ | $NO_2$ | | |
| ALSPAC | | | | | | | $NO_2$ | $NO_2$ |
| BIB | $NO_2$ | $NO_x$ | $NO_2$ | $NO_2$ | $NO_x$ | $NO_2$ | | |
| DNBC | | | | | | | $NO_2$ | $PM_{2.5}$ |
| EDEN NAN | $NO_2$ | | | | | | | $NO_2$ |
| EDEN POI | $NO_2$ | | | | | | | $NO_2$ |
| GAS | $NO_2$ | $NO_x$ | $PM_{10}$ | $NO_2$ | $NO_x$ | $NO_2$ | | |
| GENR | $NO_2$ | $NO_x$ | $PM_{10}$ | $PM_{2.5}$ | $PM_{2.5abs}$ | $PM_{coarse}$ | | |
| INMA GUIP | $NO_2$ | $NO_x$ | | | | | | $NO_2$ |
| INMA SAB | $NO_2$ | $NO_x$ | $NO_2$ | $NO_2$ | $NO_x$ | $NO_2$ | | |
| INMA VAL | $NO_2$ | $NO_x$ | | | | | | $NO_2$ |
| KANC | $NO_2$ | $NO_x$ | $PM_{10}$ | $NO_2$ | $NO_x$ | $NO_2$ | | |
| MOBA | $NO_2$ | $NO_x$ | $PM_{10}$ | $PM_{2.5}$ | $NO_x$ | $NO_2$ | | |

| cohort | $NO_2$ | $NO_x$ | $PM_{10}$ | $PM_{2.5}$ | $PM_{2.5abs}$ | $PM_{coarse}$ | $NO_2$ (ELAPSE) | $PM_{2.5}$ (ELAPSE) |
|---|---|---|---|---|---|---|---|---|
| NFIR | | | | | | | $NO_2$ | $NO_2$ |
| NROM | $NO_2$ | $NO_x$ | $PM_{10}$ | $NO_2$ | $NO_x$ | $NO_2$ | | |
| NTOR | $NO_2$ | $NO_x$ | $PM_{10}$ | $NO_2$ | $NO_x$ | $NO_2$ | | |
| PFIR | | | | | | | $NO_2$ | $NO_2$ |
| PROM | $NO_2$ | $NO_x$ | $PM_{10}$ | $PM_{2.5}$ | $NO_x$ | $NO_2$ | | |
| PTOR | $NO_2$ | $NO_x$ | $PM_{10}$ | $PM_{2.5}$ | $NO_x$ | $NO_2$ | | |
| RHEA | $PM_{10}$ | $PM_{10}$ | $PM_{10}$ | $PM_{10}$ | | $PM_{10}$ | | |

## Table 8 Background stations data

| cohort | period | station name | pollutants |
|---|---|---|---|
| ABCD | 2002-2017 | Amsterdam-Vondelpark | $NO_2$, $NO_x$, $PM_{10}$ |
| ALSPAC | 1990-2016 | BRISTOL CENTRE (AURN) station for the period (1990-2004) (period 1990-1993 have been filled with the average of period 1994-1997)<br>PARSON ST (215) station for the period (2005-2016) | $NO_2$ |
| BIB | 1998-2015 | MOBILE | $NO_2$, $NO_x$ |
| DNBC | 1997-2017 | HCOE (Copenhagen background) | $NO_2$, $PM_{2.5}$ |
| EDEN NAN | 2002-2013 | stations 1, 2, 3, 4, 10, 12, 17 | $NO_2$ |
| EDEN POI | 2002-2015 | station 70 | $NO_2$ |
| GAS | 2002-2018 | ADA | $NO_2$, $NO_x$, $PM_{10}$ |
| GENR | 2002-2016 | 131: Vredepeel-Vredeweg<br>133: Wijnandsrade-Opfergeltstraat<br>230: Biest Houtakker-Biestsestraat<br>318: Philippine-Stelleweg<br>437: Westmaas-Groeneweg<br>538: Wieringerwerf-Medemblikkerweg<br>722: Eibergen-Lintveldseweg | $NO_2$, $NO_x$, $PM_{10}$, $PM_{2.5}$, $PM_{2.5abs}$, $PM_{coarse}$ |
| INMA GUIP | 2005-2016 | AZP ($NO_2$)<br>ZUM ($NO_x$) | $NO_2$, $NO_x$ |
| INMA SBD | 2000-2018 | SAN CUGAT ($NO_2$), SANT CUGAT ($NO_x$, 2004), RUBÍ ($NO_x$, all period except 2004) | $NO_2$, $NO_x$ |
| INMA VAL | 2003-2017 | QUART DE POBLET (2003-2004 and 2012-2017), VIVEROS (2005-2011) | $NO_2$, $NO_x$, $PM_{2.5}$ |
| KANC | 2007-2015 | KAUNAS | $NO_2$, $NO_x$, $PM_{10}$ |
| MOBA | 2003-2015 | KIRKEVEIEN | $NO_2$, $NO_x$, $PM_{10}$, $PM_{2.5}$ |
| NFIR | 2011-2016 | BASSI | $NO_2$ |
| NROM | 2002-2018 | ADA | $NO_2$, $NO_x$, $PM_{10}$ |
| NTOR | 2005-2016 | RUBINO | $NO_2$, $NO_x$, $PM_{10}$ |
| PFIR | 2011-2016 | BASSI | $NO_2$ |
| PROM | 2002-2018 | ADA | $NO_2$, $NO_x$, $PM_{10}$, $PM_{2.5}$ |
| PTOR | 2005-2016 | LINGOTO | $NO_2$, $NO_x$, $PM_{10}$, $PM_{2.5}$ |
| RHEA | 2007-2015 | IRAKLION | $PM_{10}$ |

### *1.3.3 Natural spaces*

Normalized Difference Vegetation Index (NDVI) quantifies vegetation by measuring the difference between near-infrared (which vegetation strongly reflects) and red light (which vegetation absorbs). NDVI values range from +1.0 to -1.0. Areas of barren rock, sand, or snow usually show very low NDVI values (for example, 0.1 or less). Sparse vegetation such as shrubs and grasslands or senescing crops may result in moderate NDVI values (approximately 0.2 to 0.5). High NDVI values (approximately 0.6 to 0.9) correspond to dense vegetation such as that found in temperate and tropical forests or crops at their peak growth stage. Negative values of NDVI (values approaching -1) correspond to water.

NDVI derived from the Landsat 4–5 Thematic Mapper (TM), Landsat 7 Enhanced Thematic Mapper Plus (ETM+), and Landsat 8 Operational Land Imager (OLI)/Thermal Infrared Sensor (TIRS) with 30m x 30m resolution was used to determine the surrounding greenness. The imagery had been selected according to the following criteria: i) cloud cover less than 10 %, ii) Standard Terrain Correction (Level 1T) and iii) greenest period of the year. Two or more images were selected for each cohort/city to cover the entire study period, and assigned to time points of interest as detailed in Table 9.

Surrounding greenness was abstracted as the average of NDVI in buffers of 100, 300 and 500 meters[10] around each geocode. Negative values in the images have been reclassified to null values previously.

**Table 9 Year of Landsat image assigned to each time point**

| cohort | period | preg | birth | y1 | y2 | y3 | y4 | y5 | y6 | y7 | y8 | y9 | y10 | y11 | y12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ABCD | 2003-2016 | 2005 | | | | | | 2010 | | | | | 2016 | | |
| ALSPAC | 1990-2005 | 1990 | | | | | 1994 | | | | | | 2002 | | |
| BIB | 2007-2015 | 2006 | | | 2011 | | | | | | | | | | |
| DNBC | 1997-2014 | 1994 | | | 2001 | | | | | 2006 | | | | | |
| EDEN NAN | 2003-2010 | 2004 | | | | | 2010 | | | | | | | | |
| EDEN POI | 2003-2013 | 2001-2004 | | | | 2007-2010 | | | | | | | | | |
| GAS | 2003-2012 | 2005 | | | | | | 2010 | | | | | | | |
| GENR | 2002-2016 | 2005 | | | | | | | 2010 | | | | 2016 | | |
| INMA GUIP | 2004-2018 | 2001 | | | | 2010 | | | | | | | 2017 | | |
| INMA SBD | 2004-2018 | 2007 | | | | | | 2011 | | | | | | 2017 | |
| INMA VAL | 2004-2017 | 2003 | | | | | 2009 | | | | | 2015 | | | |
| KANC | 2007-2015 | 2007 | | | | | 2014 | | | | | | | | |

| cohort | period | preg | birth | y1 | y2 | y3 | y4 | y5 | y6 | y7 | y8 | y9 | y10 | y11 | y12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MOBA | 2004-2015 | 2009 | | | | | | | | | | | | | |
| NFIR | 2005-2018 | 2007 | | | | | | 2013 | | | | | | | |
| NROM | 2005-2018 | 2005 | | | | 2010 | | | | | | 2017 | | | |
| NTOR | 2005-2018 | 2005 | | | | 2011 | | | | | 2016 | | | | |
| PFIR | 2011-2018 | 2013 | | | | | | | | | | | | | |
| PROM | 2011-2018 | 2010 | | | | 2017 | | | | | | | | | |
| PTOR | 2011-2018 | 2011 | | | 2016 | | | | | | | | | | |
| RHEA | 2007-2015 | 2008 | | | | | | | | | | | | | |

Furthermore, an indicator for "residential proximity to major green spaces" was created, as it covers different aspects of green exposure. The EU defined this as living within 300 m of public open area with more than 5000m$^2$ (Europe 2003) (or 15 minute walk). Also the distance to the nearest green or blue major spaces and the area of this space were calculated as other greenness indicators. The Europe-wide "Urban Atlas" (prepared by European Environmental Protection Agency) was used to extract maps of urban and natural green and blue spaces across HELIX study regions[11], with the exceptions of MoBa and INMA Guipúzcoa, where local layers were used instead (Table 10). One or two maps were selected for each cohort/city to cover the entire study period, and assigned to time points of interest as detailed in Table 11.

### Table 10 Source of major green spaces data

| cohort | source | year |
|---|---|---|
| ABCD | URBANATLAS | 2006/2012 |
| ALSPAC | URBANATLAS | 2006 |
| BIB | URBANATLAS | 2006/2012 |
| DNBC | URBANATLAS | 2006 |
| EDEN NAN | URBANATLAS | 2006 |
| EDEN POI | URBANATLAS | 2006 |
| GAS | URBANATLAS | 2006 |
| GENR | URBANATLAS | 2006/2012 |
| INMA GUIP | EUNIS | 2009 |
| INMA SBD | URBANATLAS | 2006/2012 |
| INMA VAL | URBANATLAS | 2006/2012 |
| KANC | URBANATLAS | 2006 |
| MOBA | Kartverket (The Norwegian Mapping Authority) | 2014 |
| NFIR | URBANATLAS | 2006/2012 |

| cohort | source | year |
|---|---|---|
| NROM | URBANATLAS | 2006/2012 |
| NTOR | URBANATLAS | 2006/2012 |
| PFIR | URBANATLAS | 2006/2012 |
| PROM | URBANATLAS | 2006/2012 |
| PTOR | URBANATLAS | 2006/2012 |
| RHEA | URBANATLAS | 2006 |

**Table 11 Year of major green spaces data assigned to each time point**

| cohort | period | preg | birth | y1 | y2 | y3 | y4 | y5 | y6 | y7 | y8 | y9 | y10 | y11 | y12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ABCD | 2003-2016 | 2006 | | | | | | | | | | 2012 | | | |
| ALSPAC | 1990-2005 | 2006 | | | | | | | | | | | | | |
| BIB | 2007-2015 | 2006 | | | | | | 2012 | | | | | | | |
| DNBC | 1997-2014 | 2006 | | | | | | | | | | | | | |
| EDEN NAN | 2003-2010 | 2006 | | | | | | | | | | | | | |
| EDEN POI | 2003-2013 | 2006 | | | | | | | | | | | | | |
| GAS | 2003-2012 | 2006 | | | | | | | | | | | | | |
| GENR | 2002-2016 | 2006 | | | | | | | | | | | 2012 | | |
| INMA GUIP | 2004-2018 | 2009 | | | | | | | | | | | | | |
| INMA SBD | 2004-2018 | 2006 | | | | | | | | | 2012 | | | | |
| INMA VAL | 2004-2017 | 2006 | | | | | | | | | 2012 | | | | |
| KANC | 2007-2015 | 2006 | | | | | | | | | | | | | |
| MOBA | 2004-2015 | 2014 | | | | | | | | | | | | | |
| NFIR | 2005-2018 | 2006 | | | | | | | | 2012 | | | | | |
| NROM | 2005-2018 | 2006 | | | | | | | | 2012 | | | | | |
| NTOR | 2005-2018 | 2006 | | | | | | | | 2012 | | | | | |
| PFIR | 2011-2018 | 2006 | | 2012 | | | | | | | | | | | |
| PROM | 2011-2018 | 2006 | | 2012 | | | | | | | | | | | |
| PTOR | 2011-2018 | 2006 | | 2012 | | | | | | | | | | | |
| RHEA | 2007-2015 | 2006 | | | | | | | | | | | | | |

### *1.3.4 Built environment data*

#### 1.3.4.1 Population Density

Population density is the number of inhabitant per square kilometre. The Global Human Settlement Layer (GHSL)[12], a project supported by European Commission, has been used to characterize the population density for all the cohorts, with the exception of MOBA for which local data were used (from HELIX project) (Table 12). Population density values were obtained doing an intersection between population density grid maps and geocodes. Between one and four grid maps were selected for each cohort/city to cover the entire study period, and assigned to time points of interest as detailed in Table 13.

### Table 12 Source of population density data

| cohort | source | year |
|---|---|---|
| ABCD | GHSL | 2000 |
| ALSPAC | GHSL | 1990/2000 |
| BIB | GHSL | 2000 |
| DNBC | GHSL | 1990/2000 |
| EDEN NAN | GHSL | 2000 |
| EDEN POI | GHSL | 2000 |
| GAS | GHSL | 2000 |
| GENR | GHSL | 2000/2015 |
| INMA GUIP | GHSL | 2000/2015 |
| INMA SBD | GHSL | 2000/2015 |
| INMA VAL | GHSL | 2000/2015 |
| KANC | GHSL | 2000 |
| MOBA | Statistics Norway/AB | 2005_2010, 2006_2012, 2010_2013, 2011_2013 |
| NFIR | GHSL | 2000/2015 |
| NROM | GHSL | 2000/2015 |
| NTOR | GHSL | 2000/2015 |
| PFIR | GHSL | 2000/2015 |
| PROM | GHSL | 2000/2015 |
| PTOR | GHSL | 2000/2015 |
| RHEA | GHSL | 2000 |

### Table 13 Year of population density data assigned to each time point

| cohort | period | preg | birth | y1 | y2 | y3 | y4 | y5 | y6 | y7 | y8 | y9 | y10 | y11 | y12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ABCD | 2003-2016 | 2000 | | | | | | | | | | | | | |
| ALSPAC | 1990-2005 | 1990 | | | | | | | | | | | 2000 | | |
| BIB | 2007-2015 | 2000 | | | | | | | | | | | | | |
| DNBC | 1997-2014 | 1990 | | | | 2000 | | | | | | | | | |
| EDEN NAN | 2003-2010 | 2000 | | | | | | | | | | | | | |
| EDEN POI | 2003-2013 | 2000 | | | | | | | | | | | | | |
| GAS | 2003-2012 | 2000 | | | | | | | | | | | | | |
| GENR | 2002-2016 | 2000 | | | | | | | | | | | | | |
| INMA | 2004-2018 | 2000 | | | | | | | | | | | | 2015 | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GUIP | | | | | | | | | | | | | | | |
| INMA SBD | 2004-2018 | 2000 | | | | | | | | | | | | 2015 | |
| INMA VAL | 2004-2017 | 2000 | | | | | | | | | | | | 2015 | |
| KANC | 2007-2015 | 2000 | | | | | | | | | | | | | |
| MOBA | 2004-2015 | 2005-2010 | | | | 2006-2012 | | 2010-2013 | | 2011-2013 | | | | | |
| NFIR | 2005-2018 | 2000 | | | | | | | | | | | 2015 | | |
| NROM | 2005-2018 | 2000 | | | | | | | | | | | 2015 | | |
| NTOR | 2005-2018 | 2000 | | | | | | | | | | | 2015 | | |
| PFIR | 2011-2018 | 2000 | | | | | 2015 | | | | | | | | |
| PROM | 2011-2018 | 2000 | | | | | 2015 | | | | | | | | |
| PTOR | 2011-2018 | 2000 | | | | | 2015 | | | | | | | | |
| RHEA | 2007-2015 | 2000 | | | | | | | | | | | | | |

### 1.3.4.2 Building Density

Building density is the sum of the built area divided by the buffer area. The European Settlement Map 2017 (ESM2p5m)[13] has been used to create building density variable, with the exception of MOBA for which open street maps[14] was used (Table 14). ESM2p5m is the latest release of the European Settlement Map (ESM) produced in the frame of the URBA project (WPK 1193). The ESM products have been financed by the Directorate-General for Regional and Urban Policy (DG REGIO) and exploit the Copernicus core 003 dataset made of satellite images SPOT5 and SPOT6 ranging from 2010 to 2013. We created 100 and 300 meters buffers around the residential address.

**Table 14 Source of building density data**

| cohort | source | year |
|---|---|---|
| ABCD | ESM2p5m | 2010-2013 |
| ALSPAC | ESM2p5m | 2010-2013 |
| BIB | ESM2p5m | 2010-2013 |
| DNBC | ESM2p5m | 2010-2013 |
| EDEN NAN | ESM2p5m | 2010-2013 |
| EDEN POI | ESM2p5m | 2010-2013 |
| GAS | ESM2p5m | 2010-2013 |
| GENR | ESM2p5m | 2010-2013 |
| INMA GUIP | ESM2p5m | 2010-2013 |
| INMA SBD | ESM2p5m | 2010-2013 |
| INMA VAL | ESM2p5m | 2010-2013 |
| KANC | ESM2p5m | 2010-2013 |
| MOBA | OpenStreetMap | 2014 |
| NFIR | ESM2p5m | 2010-2013 |
| NROM | ESM2p5m | 2010-2013 |

| | | |
|---|---|---|
| NTOR | ESM2p5m | 2010-2013 |
| PFIR | ESM2p5m | 2010-2013 |
| PROM | ESM2p5m | 2010-2013 |
| PTOR | ESM2p5m | 2010-2013 |
| RHEA | ESM2p5m | 2010-2013 |

#### 1.3.4.3 Street Connectivity

Street network from each study area was obtained using NAVTEQ[15](2012). Intersection density was defined as the number of intersections - that are not dead-ends – inside a buffer of 100 and 300 meters, divided by the area in square km of each buffer. A higher value indicates more intersections and a greater degree of connectivity enabling more direct travel between two points using existing streets and pathways.

#### 1.3.4.4 Accessibility

Public transport network and stops were obtained from local authorities of each study area and/or from Open Street Maps[14] in those cases where local layers were not available (Table 15).

Public transportation network density was calculated as meters of public transport lines (only bus lines) inside each 100, 300 and 500 meters buffer, divided by the buffer area in square kilometres. Public transportation stop density was calculated as number of public transport stops (only bus stops) inside each 100, 300 and 500 meters buffer, divided by the buffer area in square kilometres.

**Table 15 Source of public transport data**

| cohort | source | year |
|---|---|---|
| ABCD | Open Street Maps | 2019 |
| ALSPAC | Open Street Maps | 2019 |
| BIB | Bradford Metropolitan District Council, Open Street Maps | 2014/2015 |
| DNBC | Open Data DK/Open Street Maps | 2016/2019 |
| EDEN NAN | Grand Nancy | 2014 |
| EDEN POI | Grand Poitiers | 2013 |
| GAS | Open Street Maps | 2019 |
| GENR | Open Street Maps | 2019 |
| INMA GUIP | Diputación de Guipúzcoa | 2011 |
| INMA SBD | Sabadell Municipality | 2014 |
| INMA VAL | Open Street Maps | 2015 |
| KANC | Open Street Maps | 2015 |
| MOBA | Company “Ruter” (only bus stops) | 2015 |
| NFIR | Google transit Feed (information from Azienda trasporti area Fiorentina) | 2016 |
| NROM | Open Street Maps | 2019 |

| | | |
|---|---|---|
| NTOR | Google transit Feed (information from Gruppo Trasporti Torinesi) | 2015 |
| PFIR | Google transit Feed (information from Azienda trasporti area Fiorentina) | 2016 |
| PROM | Open Street Maps | 2019 |
| PTOR | Google transit Feed (information from Gruppo Trasporti Torinesi) | 2015 |
| RHEA | Open Street Maps | 2019 |

#### 1.3.4.5 Facilities

Facilities from each study area were obtained using NAVTEQ[15] (2012). Facilities were all points of interest for pedestrians as part of their daily life activities, like restaurants, shops, medical centres, schools, libraries, etc. One hundred different subcategories of facilities were available in the NAVTEQ database, grouped in 17 categories. All of them were included, except Border Crossings, Auto Services and Parking categories.

Two different indicators were calculated: Facility richness index and facility density index.

- Facility richness index: equals the number of different facility types present divided by the maximum potential number of facility types specified, in a buffer of 300 meters. Range: 0 ≤ FRI ≤ 1. A higher value indicates a more availability of different facility types.

**Equation 1 Facility richness (FR)**

$$FR = \frac{m}{m_{max}}$$

m = number of facilities types (classes) in the study area

- Facility density index: equals the number of facilities present divided by the area of the 300 meters buffer (number of facilities / $km^2$). A higher value indicates a more availability of different facility types.

#### 1.3.4.6 Land Use

Land Use Mix corresponds to the diversity of land uses within a given area. Land Use Mix was obtained through the Shannon's Evenness Index, using Urban Atlas database, except for INMA Guipuzcoa and MoBa where local data was used (Table 16). Land use Shannon's Evenness Index is the degree of mixing of different types of land uses (such as residential, commercial, entertainment, and office development). A higher value indicates a more even distribution of land between the different types of land uses. Land Use Evenness Index equals minus the sum, across all land use types, of the proportional abundance of each land use type multiplied by that proportion, divided by the logarithm of the number of land use types, in a buffer of 300 meters. In other words, the observed Shannon's Diversity Index[16] divided by the maximum Shannon's Diversity Index for that number of land use types. One or two maps were selected for each cohort/city to cover the entire study period, and assigned to time points of interest as detailed in Table 17.

### Equation 2 Land Use Shannon's Evenness Index (LUEI)

$$LUEI = \frac{-\sum_{i=1}^{m} (Pi * \ln Pi)}{\ln m}$$

Pi = proportion of the area occupied by land use type (class) i.

m = number of land use types (classes) present in the study area

LUEI = Land Use Shannon's Evenness Index

### Table 16 Source of land use data

| cohort | source | year |
|---|---|---|
| ABCD | URBANATLAS | 2006/2012 |
| ALSPAC | URBANATLAS | 2006 |
| BIB | URBANATLAS | 2006/2012 |
| DNBC | URBANATLAS | 2006 |
| EDEN NAN | URBANATLAS | 2006 |
| EDEN POI | URBANATLAS | 2006 |
| GAS | URBANATLAS | 2006 |
| GENR | URBANATLAS | 2006/2012 |
| INMA GUIP | EUNIS | 2009 |
| INMA SBD | URBANATLAS | 2006/2012 |
| INMA VAL | URBANATLAS | 2006/2012 |
| KANC | URBANATLAS | 2006 |
| MOBA | Kartverket (The Norwegian Mapping Authority) | 2014 |
| NFIR | URBANATLAS | 2006/2012 |
| NROM | URBANATLAS | 2006/2012 |
| NTOR | URBANATLAS | 2006/2012 |
| PFIR | URBANATLAS | 2006/2012 |
| PROM | URBANATLAS | 2006/2012 |
| PTOR | URBANATLAS | 2006/2012 |
| RHEA | URBANATLAS | 2006 |

Table 17 Year of land use data assigned to each time point

| cohort | period | preg | birth | y1 | y2 | y3 | y4 | y5 | y6 | y7 | y8 | y9 | y10 | y11 | y12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ABCD | 2003-2016 | 2006 | | | | | | | | | | 2012 | | | |
| ALSPAC | 1990-2005 | 2006 | | | | | | | | | | | | | |
| BIB | 2007-2015 | 2006 | | | | | | 2012 | | | | | | | |
| DNBC | 1997-2014 | 2006 | | | | | | | | | | | | | |
| EDEN NAN | 2003-2010 | 2006 | | | | | | | | | | | | | |
| EDEN POI | 2003-2013 | 2006 | | | | | | | | | | | | | |
| GAS | 2003-2012 | 2006 | | | | | | | | | | | | | |
| GENR | 2002-2016 | 2006 | | | | | | | | | | | 2012 | | |
| INMA GUIP | 2004-2018 | 2006 | | | | | | | | | | | | | |
| INMA SBD | 2004-2018 | 2006 | | | | | | | | | 2012 | | | | |
| INMA VAL | 2004-2017 | 2006 | | | | | | | | | 2012 | | | | |
| KANC | 2007-2015 | 2006 | | | | | | | | | | | | | |
| MOBA | 2004-2015 | 2006 | | | | | | | | | | | | | |
| NFIR | 2005-2018 | 2006 | | | | | | | | 2012 | | | | | |
| NROM | 2005-2018 | 2006 | | | | | | | | 2012 | | | | | |
| NTOR | 2005-2018 | 2006 | | | | | | | | 2012 | | | | | |
| PFIR | 2011-2018 | 2006 | | 2012 | | | | | | | | | | | |
| PROM | 2011-2018 | 2006 | | 2012 | | | | | | | | | | | |
| PTOR | 2011-2018 | 2006 | | 2012 | | | | | | | | | | | |
| RHEA | 2007-2015 | 2006 | | | | | | | | | | | | | |

### 1.3.4.7 Main Land Use

Main land use gives the percentage of all types of land use within an area of a buffer of 300 meters for each geocode. Land use information was obtained from the Urban Atlas database[11], except for INMA Guipuzcoa and MoBa where local data was used (Table 18). One or two maps were selected for each cohort/city to cover the entire study period, and assigned to time points of interest as detailed in Table 19. The following main land use categories were created, by grouping the land use categories available in the selected databases (Table 20-25): “high density residential”, “low density residential”, “very low density residential”, “industrial, commercial, public, military and private units”, “transports”, “port areas”, “airport areas”, “other”, “urban green”, “agricultural green”, “natural green”, “water”.

### Table 18 Source of main land use data

| cohort | source | year |
|---|---|---|
| ABCD | URBANATLAS | 2006/2012 |
| ALSPAC | URBANATLAS | 2006 |
| BIB | URBANATLAS | 2006/2012 |
| DNBC | URBANATLAS | 2006 |
| EDEN NAN | URBANATLAS | 2006 |
| EDEN POI | URBANATLAS | 2006 |
| GAS | URBANATLAS | 2006 |
| GENR | URBANATLAS | 2006/2012 |
| INMA GUIP | EUNIS | 2009 |
| INMA SBD | URBANATLAS | 2006/2012 |
| INMA VAL | URBANATLAS | 2006/2012 |
| KANC | URBANATLAS | 2006 |
| MOBA | Kartverket (The Norwegian Mapping Authority) | 2014 |
| NFIR | URBANATLAS | 2006/2012 |
| NROM | URBANATLAS | 2006/2012 |
| NTOR | URBANATLAS | 2006/2012 |
| PFIR | URBANATLAS | 2006/2012 |
| PROM | URBANATLAS | 2006/2012 |
| PTOR | URBANATLAS | 2006/2012 |
| RHEA | URBANATLAS | 2006 |

### Table 19 Year of main land use data assigned to each time point

| cohort | period | preg | birth | y1 | y2 | y3 | y4 | y5 | y6 | y7 | y8 | y9 | y10 | y11 | y12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ABCD | 2003-2016 | 2006 | | | | | | | | | | 2012 | | | |
| ALSPAC | 1990-2005 | 2006 | | | | | | | | | | | | | |
| BIB | 2007-2015 | 2006 | | | | | | 2012 | | | | | | | |
| DNBC | 1997-2014 | 2006 | | | | | | | | | | | | | |
| EDEN NAN | 2003-2010 | 2006 | | | | | | | | | | | | | |
| EDEN POI | 2003-2013 | 2006 | | | | | | | | | | | | | |
| GAS | 2003-2012 | 2006 | | | | | | | | | | | | | |
| GENR | 2002-2016 | 2006 | | | | | | | | | | | 2012 | | |
| INMA GUIP | 2004-2018 | 2006 | | | | | | | | | | | | | |
| INMA SBD | 2004-2018 | 2006 | | | | | | | | | 2012 | | | | |
| INMA VAL | 2004-2017 | 2006 | | | | | | | | | 2012 | | | | |
| KANC | 2007-2015 | 2006 | | | | | | | | | | | | | |
| MOBA | 2004-2015 | 2006 | | | | | | | | | | | | | |
| NFIR | 2005-2018 | 2006 | | | | | | | | 2012 | | | | | |
| NROM | 2005-2018 | 2006 | | | | | | | | 2012 | | | | | |

| cohort | period | preg | birth | y1 | y2 | y3 | y4 | y5 | y6 | y7 | y8 | y9 | y10 | y11 | y12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NTOR | 2005-2018 | 2006 | | | | | | | | 2012 | | | | | |
| PFIR | 2011-2018 | 2006 | | 2012 | | | | | | | | | | | |
| PROM | 2011-2018 | 2006 | | 2012 | | | | | | | | | | | |
| PTOR | 2011-2018 | 2006 | | 2012 | | | | | | | | | | | |
| RHEA | 2007-2015 | 2006 | | | | | | | | | | | | | |

### Table 20 Urban atlas categories (year 2006 version)

| vector data code | nomenclature | main land use category |
|---|---|---|
| 11100 | Continuous Urban Fabric (S.L. > 80%) | hdres |
| 11210 | Discontinuous Dense Urban Fabric (S.L. 50% - 80%) | ldres |
| 11220 | Discontinuous Medium Density Urban Fabric (S.L. 30% - 50%) | ldres |
| 11230 | Discontinuous Low Density Urban Fabric (S.L. 10% - 30%) | ldres |
| 11240 | Discontinuous Very Low Density Urban Fabric (S.L. < 10%) | vldres |
| 11300 | Isolated structures | vldres |
| 12100 | Industrial, commercial, public, military and private units | indtr |
| 12200 | Road and rail network and associated land | trans |
| 12210 | Fast transit roads and associated land | trans |
| 12220 | Other roads and associated land | trans |
| 12230 | Railways and associated land | trans |
| 12300 | Port areas | port |
| 12400 | Airports | airpt |
| 13100 | Mineral extraction and dump sites | other |
| 13300 | Construction sites | other |
| 13400 | Land without current use | other |
| 14100 | Green urban areas | urbgr |
| 14200 | Sports and leisure facilities | urbgr |
| 20000 | Agricultural areas, semi-natural areas and wetlands | agrgr |
| 30000 | Forests | natgr |
| 50000 | Water | water |

Legend: hdres, high density residential; ldres, low density residential; vldres, very low density residential; indtr, industrial, commercial, public, military and private units; trans, transports; port, port areas; airpt, airport areas; agrgr, agricultural green; urb, green urban areas, sports and leisure facilities; natgr, natural green.

### Table 21 Urban atlas categories (year 2012 version)

| vector data code | nomenclature | main land use category |
|---|---|---|
| 11100 | Continuous Urban Fabric (S.L. > 80%) | hdres |
| 11210 | Discontinuous Dense Urban Fabric (S.L. 50% - 80%) | ldres |
| 11220 | Discontinuous Medium Density Urban Fabric (S.L. 30% - 50%) | ldres |
| 11230 | Discontinuous Low Density Urban Fabric (S.L. 10% - 30%) | ldres |
| 11240 | Discontinuous Very Low Density Urban Fabric (S.L. < 10%) | vldres |
| 11300 | Isolated structures | vldres |
| 12100 | Industrial, commercial, public, military and private units | indtr |
| 12210 | Fast transit roads and associated land | indtr |
| 12220 | Other roads and associated land | trans |
| 12230 | Railways and associated land | trans |
| 12300 | Port areas | port |
| 12400 | Airports | airpt |
| 13100 | Mineral extraction and dump sites | other |
| 13300 | Construction sites | other |
| 13400 | Land without current use | other |
| 14100 | Green urban areas | urbgr |
| 14200 | Sports and leisure facilities | urbgr |
| 21000 | Arable land (annual crops) | agrgr |
| 22000 | Permanent crops | agrgr |
| 23000 | Pastures | agrgr |
| 24000 | Complex and mixed cultivation | agrgr |
| 25000 | Orchards | agrgr |
| 31000 | Forests | natgr |
| 32000 | Herbaceous vegetation associations | natgr |
| 33000 | Open spaces with little or no vegetation | natgr |
| 40000 | Wetlands | agrgr |
| 50000 | Water | water |

Legend: hdres, high density residential; ldres, low density residential; vldres, very low density residential; indtr, industrial, commercial, public, military and private units; trans, transports; port, port areas; airpt, airport; agrgr, agricultural green; urb, green urban areas, sports and leisure facilities; natgr, natural green.

### Table 22 Kartverket categories (used for MoBa)

| kartverket | main land use category |
|---|---|
| Farmland | agrgr |
| Densely populated area, desnely built-up area | hdres |
| Industrial area | indtr |
| Urban area | ldres |
| Open area | natgr |
| Vood, forest | natgr |
| Stone quarry | other |
| Gravesite, burial ground, burial site | urbgr |
| Athletic and sports ground, playing field | urbgr |
| Golf Course (or golf links) | urbgr |
| Alpine ski hill | urbgr |
| Park | urbgr |
| Surface of the sea (sea level) | water |
| River/Brook (small stream) | water |
| Bog, marsh | water |
| Lake | water |

Legend: hdres, high density residential; ldres, low density residential; vldres, very low density residential; indtr, industrial, commercial, public, military and private units; trans, transports; port, port areas; airpt, airport; agrgr, agricultural green; urb, green urban areas, sports and leisure facilities; natgr, natural green.

### Table 23 EUNIS categories (used for INMA Guipuzkoa)

| eunis code | level | eunis name | main land use category |
|---|---|---|---|
| A | 1 | Marine habitats | water |
| B | 1 | Coastal habitats | natgr |
| C | 1 | Inland surface waters | water |
| D1 | 2 | Raised and blanket bogs | water |
| D2 | 2 | Valley mires, poor fens and transition mires | natgr |
| D3 | 2 | Aapa, palsa and polygon mires | natgr |
| D4 | 2 | Base-rich fens and calcareous spring mires | water |
| D5 | 2 | Sedge and reedbeds, normally without free-standing water | natgr |
| D6 | 2 | Inland saline and brackish marshes and reedbeds | water |
| E | 1 | Grasslands and lands dominated by forbs, mosses or lichens | natgr |
| F | 1 | Heathland, scrub and tundra | natgr |
| G | 1 | Woodland, forest and other wooded land | natgr |
| H | 1 | Inland unvegetated or sparsely vegetated habitats | natgr |

| eunis code | level | eunis name | main land use category |
|---|---|---|---|
| I | 1 | Regularly or recently cultivated agricultural, horticultural and domestic habitats | agrgr |
| J1 | 2 | Buildings of cities, towns and villages | hdres |
| J2 | 2 | Low density buildings | ldres |
| J3 | 2 | Extractive industrial sites | other |
| J4 | 2 | Transport networks and other constructed hard-surfaced areas | trans |
| J4.1 | 3 | Disused road, rail and other constructed hard-surfaced areas | trans |
| J4.2 | 3 | Road networks | trans |
| J4.3 | 3 | Rail networks | trans |
| J4.4 | 3 | Airport runways and aprons | airpt |
| J4.5 | 3 | Hard-surfaced areas of ports | port |
| J4.6 | 3 | Pavements and recreation areas | urbgr |
| J4.7 | 3 | Constructed parts of cemeteries | urbgr |
| J5 | 2 | Highly artificial man-made waters and associated structures | water |
| J6 | 2 | Waste deposits | other |
| X | 1 | Habitat complexes | natgr |

Legend: hdres, high density residential; ldres, low density residential; vldres, very low density residential; indtr, industrial, commercial, public, military and private units; trans, transports; port, port areas; airpt, airport; agrgr, agricultural green; urb, green urban areas, sports and leisure facilities; natgr, natural green.

#### 1.3.4.8 Walkability

A walkability index for LIFECYCLE project was developed by ISGlobal to quantify how 'walkable' was a buffer of 300 meters around each geocode.

This walkability index is based on the methods of Frank et al[17] and Walk Score[18]. Moreover, it also takes into account the criteria described below:

- Availability of the data
- Objectivity of all input variables
- Resulting index comparable between cohorts

Equation 3 was used to calculate the walkability index in the HELIX project. It included the following four components capturing differences in the physical environment. Each index was converted to deciles before entering to formula to have equal weight:

- Land use Shannon's Evenness Index
- Facility richness
- Population density.
- Connectivity index

**Equation 3 Walkability Index (WI)**

$$WI = \frac{LUEI + FR + PD + CI}{4}$$

Range: 0 ≤ WI ≤ 1

LUEI = Land use Shannon's Evenness Index

FR = Facility richness

PD = Population density

CI = Connectivity index

### *1.3.5 Socioeconomic data*

Socioeconomic level was described using country specific deprivation indexes (Table 24), categorized into tertiles and quintiles, where 1 means less deprived and 3/5 means more deprived. Between one and four layers were selected for each country to cover the entire study period, and assigned to time points of interest as detailed in Table 25.

**Table 24 Source of socioeconomic data**

| country | cohort | name | source | description | year |
|---|---|---|---|---|---|
| DENMARK | DNBC | Socioeconomic Status | Open data DK | Based on education level | 2016 |
| FRANCE | EDEN | French european deprivation index (EDI) score | Plate-forme méthodologique nationale pour l'étude et la réduction des inégalités sociales en cancérologie (ERISC) | Includes Overcrowding, No access to a system of central or electric heating, Non-owner, Unemployment, Foreign nationality, No access to a car , Unskilled worker–farm worker, Household with more than six, Low level of education, Single-parent household. | 2007 |
| GREECE | RHEA | Deprivation index | ISGLOBAL based on data from Hellenic Statistical Authority | Calculated based on educational level | 2001 |
| ITALY | NINFEA/ GASPII/ PICCOLIPIÙ | Indice di deprivazione | Agenzia sanitaria e sociale regionale, Emilia-Romagna | Built on the basis of 5 variables: Percentage of population with low level of study, Percentage of unemployed population, Percentage of people with non-home ownership, percentage of one parent family; population density | 2001 |
| LITHUANIA | KANC | Deprivation index | Vytautas Magnus University | Calculated based on educational level | 2013 |
| NORWAY | MOBA | Deprivation | Statistics | Calculated based on income | 2013 |

| country | cohort | name | source | description | year |
|---|---|---|---|---|---|
| | | index | Norway | | |
| SPAIN | INMA | Urban vulnerability index | Spanish Statistical Office (INE) | Classification according to Socioeconomic criteria, includes the whole of 5 socioeconomic indicators: Percentage of unemployed population, Percentage of unemployed youth population, Percentage of employed persons eventual, Percentage of unqualified employed persons and Percentage of population without studies | 2001 |
| THE NETHERLANDS | GENR/ ABCD | Status scores | The Social and Cultural Planning Office (SCP), Netherland Government | Status scores are scores that the SCP calculates and that indicate the social status of a neighborhood compared to other neighborhoods in the Netherlands. By social status, we do not mean the prestige or popularity of a neighborhood. The social status of a neighborhood is derived from a number of characteristics of the people who live there: their education, income and position on the labor market. | 2002/ 2006/ 2010/ 2014 |
| UK | BIB/ ALSPAC | Index of Multiple Deprivation (IMD) | Ministry of Housing, Communities & Local Government (UK Government) | Combines information from the seven domains to produce an overall relative measure of deprivation. The domains are combined using the following weights: Income Deprivation (22.5%) Employment Deprivation (22.5%) Education, Skills and Training Deprivation (13.5%) Health Deprivation and Disability (13.5%) Crime (9.3%) Barriers to Housing and Services (9.3%) Living Environment Deprivation (9.3%) | 2015 |

## Table 25 Year of socio-economic data assigned to each time point

| cohort | period | preg | birth | y1 | y2 | y3 | y4 | y5 | y6 | y7 | y8 | y9 | y10 | y11 | y12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ABCD | 2003-2016 | 2002 | | | | 2006 | | | | 2010 | | | | 2014 | |
| ALSPAC | 1990-2005 | 2015 | | | | | | | | | | | | | |
| BIB | 2007-2015 | 2015 | | | | | | | | | | | | | |
| DNBC | 1997-2014 | 2016 | | | | | | | | | | | | | |
| EDEN NAN | 2003-2010 | 2007 | | | | | | | | | | | | | |
| EDEN POI | 2003-2013 | 2007 | | | | | | | | | | | | | |
| GAS | 2003-2012 | 2001 | | | | | | | | | | | | | |
| GENR | 2002-2016 | 2002 | | | | | 2006 | | | | 2010 | | | | 2014 |
| INMA GUIP | 2004-2018 | 2001 | | | | | | | | | | | | | |
| INMA SBD | 2004-2018 | 2001 | | | | | | | | | | | | | |
| INMA VAL | 2004-2017 | 2001 | | | | | | | | | | | | | |
| KANC | 2007-2015 | 2013 | | | | | | | | | | | | | |
| MOBA | 2004-2015 | - | 2013 | | | | | | | | | | | | |
| NFIR | 2005-2018 | 2001 | | | | | | | | | | | | | |
| NROM | 2005-2018 | 2001 | | | | | | | | | | | | | |
| NTOR | 2005-2018 | 2001 | | | | | | | | | | | | | |
| PFIR | 2011-2018 | 2001 | | | | | | | | | | | | | |
| PROM | 2011-2018 | 2001 | | | | | | | | | | | | | |

| cohort | period | preg | birth | y1 | y2 | y3 | y4 | y5 | y6 | y7 | y8 | y9 | y10 | y11 | y12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PTOR | 2011-2018 | 2001 | | | | | | | | | | | | | |
| RHEA | 2007-2015 | 2001 | | | | | | | | | | | | | |

### *1.3.6 Traffic*

Traffic assessment was done using local layers of traffic for all areas (not available for Florence), except for RHEA (Table 26). In RHEA we used data collected in a traffic monitoring campaign conducted by ISGlobal as part EXPOsOMICS project to characterize the traffic of the streets of Heraklion. Traffic variables generated were as detailed below:

- Trafmajorload: Total traffic load of major roads in a 100m buffer
- Trafload: Total traffic load in a 100m buffer
- Trafnear: Traffic density on nearest road
- Distinvnear: Inverse distance to the nearest road

One or two layers were selected for each cohort/city to cover the entire study period, and assigned to time points of interest as detailed in Table 27.

**Table 26 Source of traffic data**

| cohort | source | year | variables |
|---|---|---|---|
| ALSPAC | DEFRA (uk government) | 2000-2017 | All except trafload |
| BIB | City of bradford metropolitan district, Leeds City Council | 2012 | All |
| DNBC | NAVTEQ | 2012 | Distance only |
| EDEN NAN | Air Lorraine | 2010 | All |
| EDEN POI | Atmo Poitou Charentes | 2005 | All except trafmajorload |
| GENR | Nationale Databank Wegverkeersgegevens | 2011/2013 | All except trafmajorload |
| INMA GUIP | Spain Government | 2014 | All except trafmajorload |
| INMA SBD | Gencat | 2007 | All |
| INMA VAL | Diputación de Valencia, DGT and Valencia municipality | 2004 | All except trafmajorload |
| MOBA | Municipality of Oslo, Norwegian Public Roads Administration | 2011 | All except trafload and trafmajorload |
| NFIR | NA | NA | NA |
| NROM | Mobility Agency of Rome | 2009/2013 | All |
| NTOR | Local company of public transportation (5T S.C.R.L). ARPA Piedmont. | 2005 | All |
| PFIR | NA | NA | NA |
| RHEA | ISGLOBAL | 2015 | All except trafmajorload |
| ABCD | PBL Netherlands Environmental Assessment | 2008 | All except trafload |

| | | | |
|---|---|---|---|
| | Agency (PlanBureau voor de Leefomgeving) | | |
| GAS | Mobility Agency of Rome | 2009 | All |
| KANC | Vytautas Magnus University, Audrius Dėdelė | 2010 | All |
| PROM | Mobility Agency of Rome | 2009/2013 | All |
| PTOR[b] | Local company of public transportation (5T S.C.R.L). ARPA Piedmont. | 2005 | All |

Legend: NA, not available.

### Table 27 Year of traffic layer data assigned to each time point

| cohort | period | preg | birth | y1 | y2 | y3 | y4 | y5 | y6 | y7 | y8 | y9 | y10 | y11 | y12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ALSPAC | 1990-2005 | 2000 | | | | | | | | | | | | | |
| BIB | 2007-2015 | 2012 | | | | | | | | | | | | | |
| DNBC[a] | 1997-2014 | | | | | | | | | | | | | | |
| EDEN NAN | 2003-2010 | 2010 | | | | | | | | | | | | | |
| EDEN POI | 2003-2013 | 2005 | | | | | | | | | | | | | |
| GENR | 2002-2016 | 2011 | | | | | | | | | | | | 2013 | |
| INMA GUIP | 2004-2018 | 2014 | | | | | | | | | | | | | |
| INMA SBD | 2004-2018 | 2007 | | | | | | | | | | | | | |
| INMA VAL | 2004-2017 | 2004 | | | | | | | | | | | | | |
| MOBA | 2004-2015 | 2011 | | | | | | | | | | | | | |
| NFIR | 2005-2018 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | | |
| NROM | 2005-2018 | 2009 | | | | | | | | | 2013 | | | | |
| NTOR | 2005-2018 | 2005 | | | | | | | | | | | | | |
| RHEA | 2007-2015 | 2015 | | | | | | | | | | | | | |
| ABCD | 2003-2016 | 2008 | | | | | | | | | | | | | |
| GAS | 2003-2012 | 2009 | | | | | | | | | | | | | |
| KANC | 2007-2015 | 2010 | | | | | | | | | | | | | |
| PFIR | 2011-2018 | NA | NA | NA | NA | NA | NA | | | | | | | | |
| PROM | 2011-2018 | 2009 | | | 2013 | | | | | | | | | | |
| PTOR | 2011-2018 | 2005 | | | | | | | | | | | | | |

Legend: NA, not available.

### *1.3.7 Noise*

The noise exposure assessment was based on existing European road traffic noise maps, which were generated under EC Directive 2002/49/EC (Assessment and Management of Environmental Noise) in the framework of the European Noise Directive (END). Noise maps were available for all cities but INMA Guipuzkoa, INMA Valencia and RHEA (Table 28). As making new noise maps was outside the scope of the project, for LIFECYCLE the existing noise maps were used. As an exception, a new noise map was developed by ISGlobal for RHEA making use of data generated in a traffic monitoring campaign done as part of the EXPOsOMICS project. One or two maps were selected for each cohort/city to cover the entire study period, and assigned to time points of interest as detailed in a No weaker noise levels of the daily value of the noise have been mapped in the Copenhagen noise map. Following this, we have assumed that all the points outside the noise polygons have Lden < 55 dB and Ln < 50 dB.

Table 29.The primary noise indicators were the Lden and the Lnight. Lden is the long-term average indicator designed to assess annoyance and defined by the END. It refers to an annual average of day, evening and night period of exposure. Lnight is the long-term average indicator designed to assess sleep disturbance and defined by the END. It refers to an annual average of night period of exposure.

Noise values were obtained depending on the noise layer type (“line”, “polygon” or “raster”):

- doing an intersection between noise map and geocodes, if noise layer type was “polygon” or “raster”;
- assigning noise value from closest street, if noise layer type was “line”.

For those cohorts with layer type “line” another variable was created, indicating the distance to the closest street.

### Table 28 Source of noise data

| cohort | source | layer type | year | comments |
|---|---|---|---|---|
| ABCD | Gemeente Amsterdam | Polygon | 2006 | |
| ALSPAC | DEFRA (uk government) | Raster | 2006 | Only categorical |
| BIB | Department of Environment food and rural affairs (DEFRA) GOV. UK | Polygon | 2006 | Only categorical |
| DNBC | Denmark Government | Polygon | 2012 | Only categorical[a] |
| EDEN NAN | Mairie de Poitiers | Polygon | 2005 | |
| EDEN POI | CUGN | Raster | 2007-2009 | |
| GAS | Acoustic model (Soundplan) from road traffic data provided by the Mobility Agency of Rome | Polygon | 2009 | |
| GENR | Gemeente Rotterdam | Polygon | 2012 | |
| INMA GUIP | NA | - | - | - |
| INMA SBD | Gencat | Line | 2006/2012 | |
| INMA VAL | NA | - | - | - |
| KANC | Kaunas Municipality | Raster | 2007 | Only Lden |
| MOBA | Oslo Municipality | Polygon | 2006 | |
| NFIR | ARPAT | Polygon | 2008 | Only categorical |

| cohort | source | layer type | year | comments |
|---|---|---|---|---|
| NROM | Acoustic model (Soundplan) from road traffic data provided by the Mobility Agency of Rome | Polygon | 2009 | |
| NTOR | Agenzia Regionale Protezione Ambientale (ARPA) | Polygon | 2013 | |
| PFIR | ARPAT | Polygon | 2008 | Only categorical |
| PROM | Acoustic model (Soundplan) from road traffic data provided by the Mobility Agency of Rome | Polygon | 2009 | |
| PTOR | Agenzia Regionale Protezione Ambientale (ARPA) | Polygon | 2013 | |
| RHEA | CREAL | Line | 2015 | Only Lden |

[a] No weaker noise levels of the daily value of the noise have been mapped in the Copenhagen noise map. Following this, we have assumed that all the points outside the noise polygons have Lden < 55 dB and Ln < 50 dB.

### Table 29 Year of noise data assigned to each time point

| cohort | period | preg | birth | y1 | y2 | y3 | y4 | y5 | y6 | y7 | y8 | y9 | y10 | y11 | y12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ABCD | 2003-2016 | 2006 | | | | | | | | | | | | | |
| ALSPAC | 1990-2005 | 2006 | | | | | | | | | | | | | |
| BIB | 2007-2015 | 2006 | | | | | | | | | | | | | |
| DNBC | 1997-2014 | 2012 | | | | | | | | | | | | | |
| EDEN NAN | 2003-2010 | 2005 | | | | | | | | | | | | | |
| EDEN POI | 2003-2013 | 2009 | | | | | | | | | | | | | |
| GAS | 2003-2012 | 2013 | | | | | | | | | | | | | |
| GENR | 2002-2016 | 2012 | | | | | | | | | | | | | |
| INMA GUIP | 2004-2018 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| INMA SBD | 2004-2018 | 2006 | | | | | | | | | 2012 | | | | |
| INMA VAL | 2004-2017 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| KANC | 2007-2015 | 2007 | | | | | | | | | | | | | |
| MOBA | 2004-2015 | 2006 | | | | | | | | | | | | | |
| NFIR | 2005-2018 | 2008 | | | | | | | | | | | | | |
| NROM | 2005-2018 | 2013 | | | | | | | | | | | | | |
| NTOR | 2005-2018 | 2013 | | | | | | | | | | | | | |
| PFIR | 2011-2018 | 2008 | | | | | | | | | | | | | |
| PROM | 2011-2018 | 2013 | | | | | | | | | | | | | |
| PTOR | 2011-2018 | 2013 | | | | | | | | | | | | | |
| RHEA | 2007-2015 | 2015 | | | | | | | | | | | | | |

Legend: NA, not available.

### 1.3.8 Unhealthy food environment

Unhealthy food environment variable was created based the NAVTEQ[15] database (2012). Among the 100 different subcategories of facilities in the NAVTEQ database we selected the subcategories related to unhealthy food (detailed in Table 30). The unhealthy food environment variable equals the number of unhealthy facilities present divided by the area of the 300 meters buffer (number of facilities / $km^2$). A higher value indicates a more availability of different unhealthy facilities.

**Table 30 Subcategories related to unhealthy food in the NAVTEQ database (type1: less detailed; and type2: more detailed)**

| type1 | type2 |
|---|---|
| Auto Maintenance, Service, and Petrol | Petrol/Gasoline Station |
| Entertainment | Bar or Pub |
| Restaurants | Coffee Shop |
| Restaurants | Restaurant |
| Shopping | Convenience Store |
| Shopping | Shopping |

### 1.3.9 Meteorological variables

#### 1.3.9.1 Temperature and humidity

Meteorological stations in the study area have been used to obtain data on temporal variability in temperature. Daily meteorological data from meteorological station measurements have been obtained for all the study period (temperature and humidity) and have been assigned to those geocodes located inside a 50 km buffer around the station/s. The distance between the geocode and the meteorological station is provided as an additional variable.

**Table 31 Meteorological stations**

| cohort | period | source | station name | variables |
|---|---|---|---|---|
| ABCD | 2002-2015 | KONINKLIJK NEDERLANDS METEOROLOGISCH INSTITUUT (KNMI) | SCHIPHOL | TM, TMIN, TMAX, HUM, HMIN, HMAX |
| ALSPAC | 1990-2017 | European Climate Assessment & Dataset project (ECAD) https://www.ecad.eu/ | LONG ASHTON | TM, TMIN, TMAX, HUM |
| BIB | 2001-2017 | European Climate Assessment & Dataset project (ECAD) https://www.ecad.eu/ | BRADFORD | TM, TMIN, TMAX, HUM |
| DNBC | 1990-2018 | European Climate Assessment & Dataset project (ECAD) https://www.ecad.eu/ | KOEBENHAVN: LANDBOHOJSKOLEN-1 | TM, TMIN, TMAX |

| | | | | |
|---|---|---|---|---|
| EDEN NAN | 2002-2013 | Méteo France | NANCY | TM, TMIN, TMAX, HUM |
| EDEN POI | 2002-2015 | Méteo France | POITIERS | TM, TMIN, TMAX, HUM |
| GAS | 2003-2018 | Centro Nazionale di Meteorologia e Climatologia dell'Aeronautica Militare (CNMCA) | ROMA | TM, TMIN, TMAX, HUM, HMIN, HMAX |
| GENR | 1956-2018 | KONINKLIJK NEDERLANDS METEOROLOGISCH INSTITUUT (KNMI) | 344 | TM, TMIN, TMAX, HUM, HMIN, HMAX |
| INMA GUIP | 1998-2019 (TMIN, TMAX: 1998-2016, HMIN, HMAX: 2006-2016) | Statal Agency of Meteorolgy (AEMET) / Air Quality Surveillance Network of the Department of the Environment, Territorial Planning, Agriculture and Fisheries of the Basque Government | SAN SEBASTIÁN,IGUELDO / Azpeitia / Beasain / Zumarraga | TM, TMIN, TMAX, HUM, HMIN, HMAX |
| INMA SBD | 2004-2018 (HMAX: 2009-2018) | Meteorology Service of Catalonia (METEOCAT) | Cerdanyola del Vallès (2004-2008) / Sabadell Parc Agrari (2008-2018) | TM, TMIN, TMAX, HUM, HMIN, HMAX |
| INMA VAL | 1998-2017 (HMAX, HMIN: 2006-2017) | Statal Agency of Meteorolgy (AEMET) | VALENCIA/AEROPUERTO | TM, TMIN, TMAX, HUM, HMIN, HMAX |
| KANC | 2007-2015 (HUM: 2007-2015/05) | Kaunas Municipality | KAUNAS | TM, TMIN, TMAX, HUM |
| MOBA | 2000-2015 | Norwegian Meteorological Institute | TRYVANNSHØGDA | TM, HUM |
| NFIR | 2005-2018 | CNR-Florence | PERTOLA | TM, TMIN, TMAX, HUM, HMIN, HMAX |
| NROM | 2003-2018 | Centro Nazionale di Meteorologia e Climatologia dell'Aeronautica Militare (CNMCA) | ROMA | TM, TMIN, TMAX, HUM, HMIN, HMAX |
| NTOR | 2005-2018 | CNR-Florence | CASELLE | TM, TMIN, TMAX, HUM, HMIN, HMAX |
| PFIR | 2011-2018 | Centro Nazionale di Meteorologia e Climatologia dell'Aeronautica Militare (CNMCA) | PERTOLA | TM, TMIN, TMAX, HUM, HMIN, HMAX |
| PROM | 2003-2018 | Centro Nazionale di Meteorologia e Climatologia dell'Aeronautica Militare (CNMCA) | ROMA | TM, TMIN, TMAX, HUM, HMIN, HMAX |
| PTOR | 2011-2018 | Centro Nazionale di Meteorologia e Climatologia dell'Aeronautica Militare (CNMCA) | CASELLE | TM, TMIN, TMAX, HUM, HMIN, HMAX |
| RHEA | 2006-2015 (HUM: 2010-2015) | METEO.GR | IRAKLION | TM, TMIN, TMAX, HUM |

Legend: TM: mean temperature, TMIN: minimum temperature, TMAX: maximum temperature, HUM: mean relative humidity, HMAX: maximum relative humidity, HMIN: minimum relative humidity.

#### 1.3.9.2 Land surface temperature

Spatial assessment of annual average exposure to heat have been based on MODIS Land Surface Temperature and Emissivity (MOD11A2)[19]. The Land Surface Temperature (LST) and Emissivity daily data are retrieved at 1km pixels by the generalized split-window algorithm and at 6km grids by the day/night algorithm. In the split-window algorithm, emissivities in bands 31 and 32 are estimated from land cover types, atmospheric column water vapor and lower boundary air surface temperature are separated into tractable sub-ranges for optimal retrieval. In the day/night algorithm, daytime and nighttime LSTs and surface emissivities are retrieved from pairs of day and night MODIS observations in seven TIR bands. The MOD11A2 Version 6 product provides an average 8-day per-pixel Land Surface Temperature and Emissivity (LST&E) with a 1 kilometer (km) spatial resolution in a 1,200 by 1,200 km grid. Each pixel value in the MOD11A2 is a simple average of all the corresponding MOD11A1 LST pixels collected within that 8-day period. One imagery per month from MOD11A2 product have been selected to calculate annual averages. Results were filtered by two criteria:

a) Quality criteria:

   a. Mandatory QA flag: “LST produced, good quality, not necessary to examine more detailed QA” or “LST produced, other quality, recommend examination of more detailed QA”.

   b. Data quality flag: “good data quality” or “other quality data”.

   c. LST Error flag: “average LST error <= 1K” or “average LST error <= 2K” or “average LST error <= 3K”.

b) Availability criteria: the annual average have been calculated if at least 75% of monthly results were available.

#### 1.3.9.3 UV

The UV dose is the effective UV irradiance (given in kJ/m2) reaching the Earth's surface integrated over the day and taking into account the attenuation of the UV radiation due to clouds. UV dose is computed for three different action spectra, i.e. for three different health effects: erythema (sunburn) of the skin, vitamin-D production in the skin and DNA-damage in the skin.

Data on daily spatial distribution of the ambient Ultraviolet radiation (UVR) levels have been obtained from TEMIS project[20]. It provides maps of daily Erythemal UV dose, Vitamin-D UV dose and DNA-damage UV dose from UVR levels adjusted for cloud cover, stratospheric ozone and atmospheric particles with a spatial resolution of 0.25° × 0.25°. UV value was obtained overlapping between UV raster map and geocodes.

## 2 Data description

Hereby we present the distribution of representative variables for each exposure domain (i.e. air pollution, built environment, natural spaces, traffic, noise, social context, unhealthy food environment) in the entire cohort. All the new variables for the online catalogue are reported in Annex 1 (ongoing work). Opal data dictionaries will be created in the next months based on this file.

**Figure 1 $NO_2$ exposure levels during pregnancy**

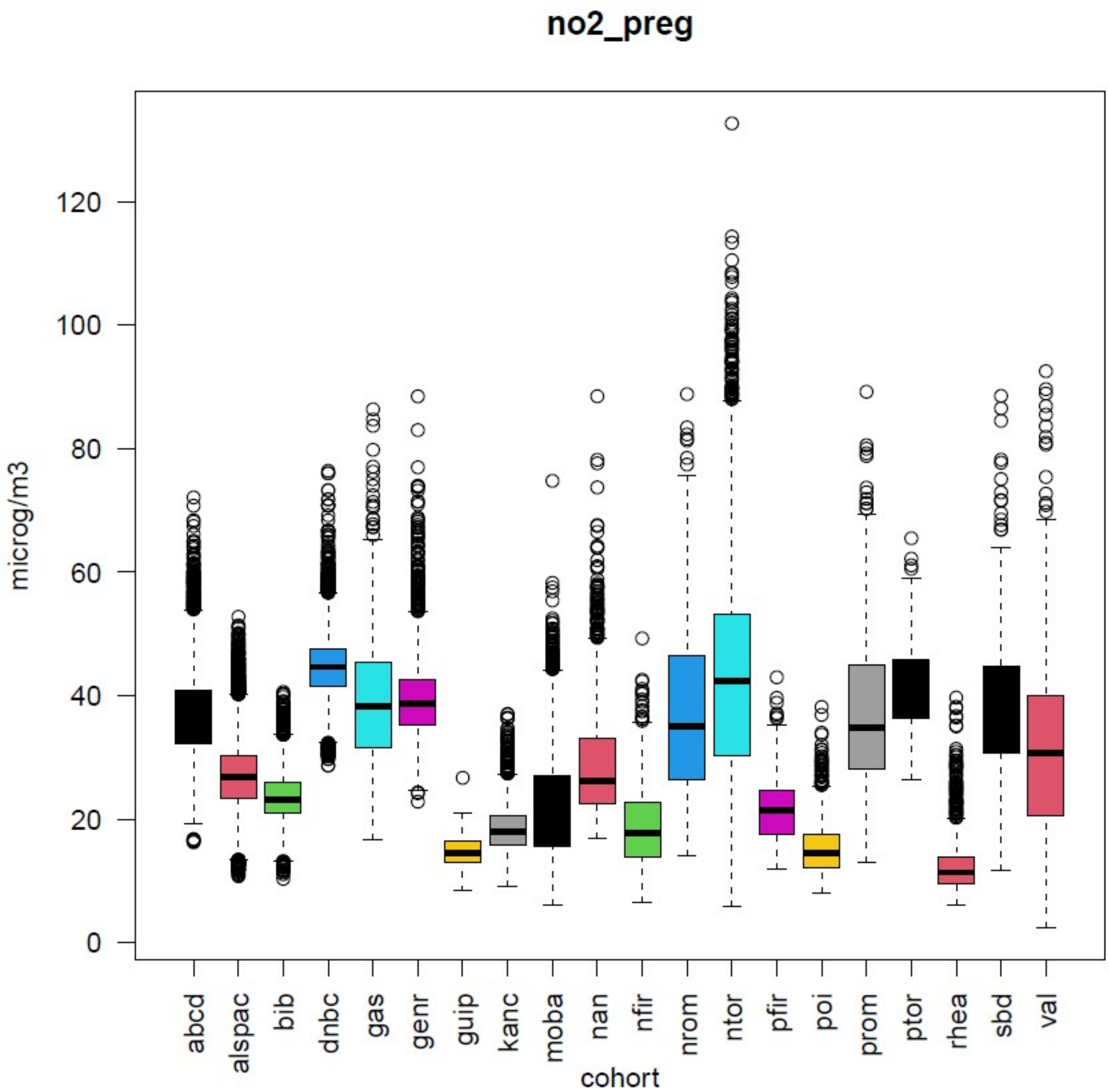


**Figure 2 $NO_x$ exposure levels during pregnancy**

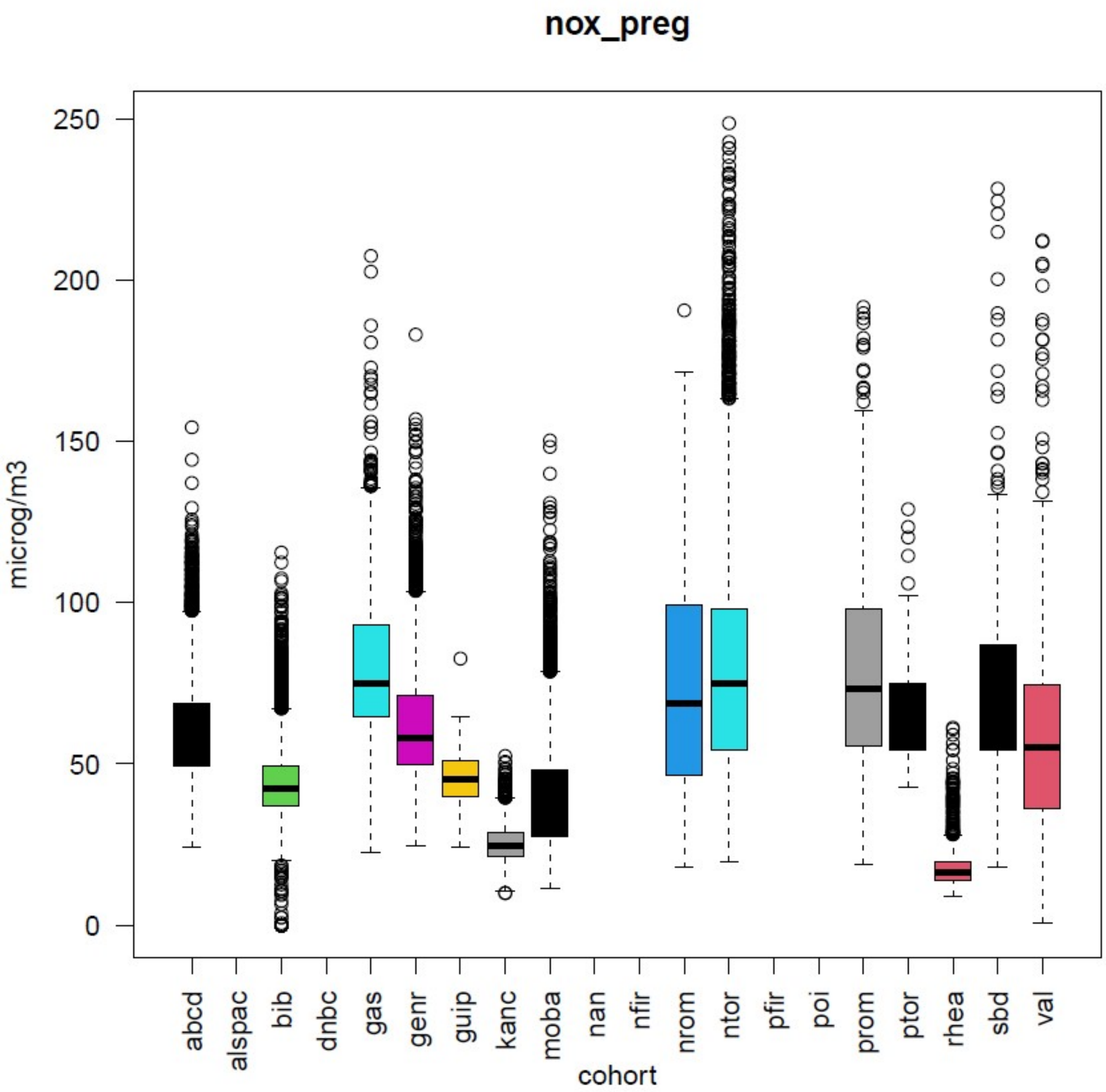


Figure 3 $PM_{10}$ exposure levels during pregnancy

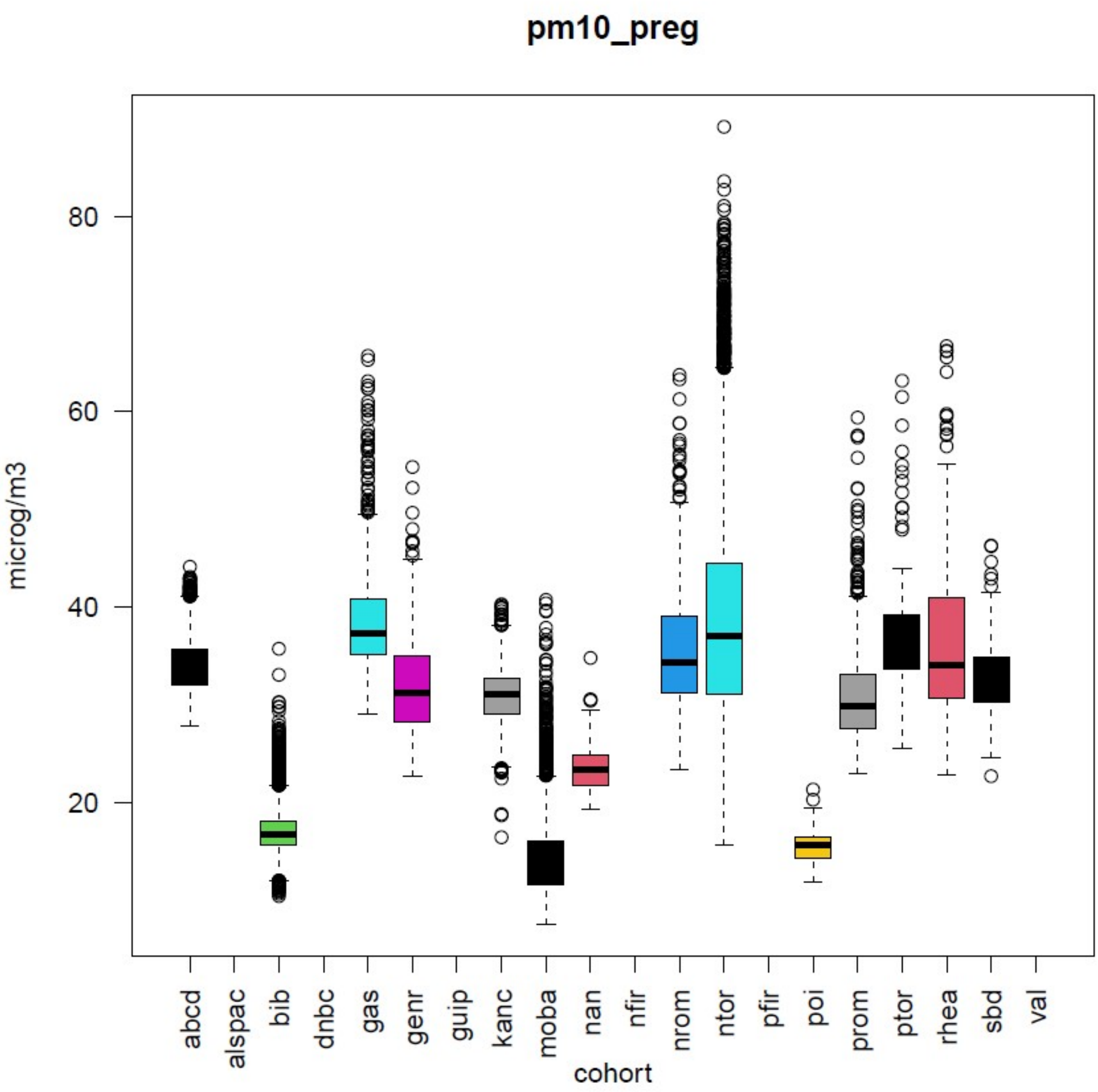


Figure 4 $PM_{2.5}$ exposure levels during pregnancy

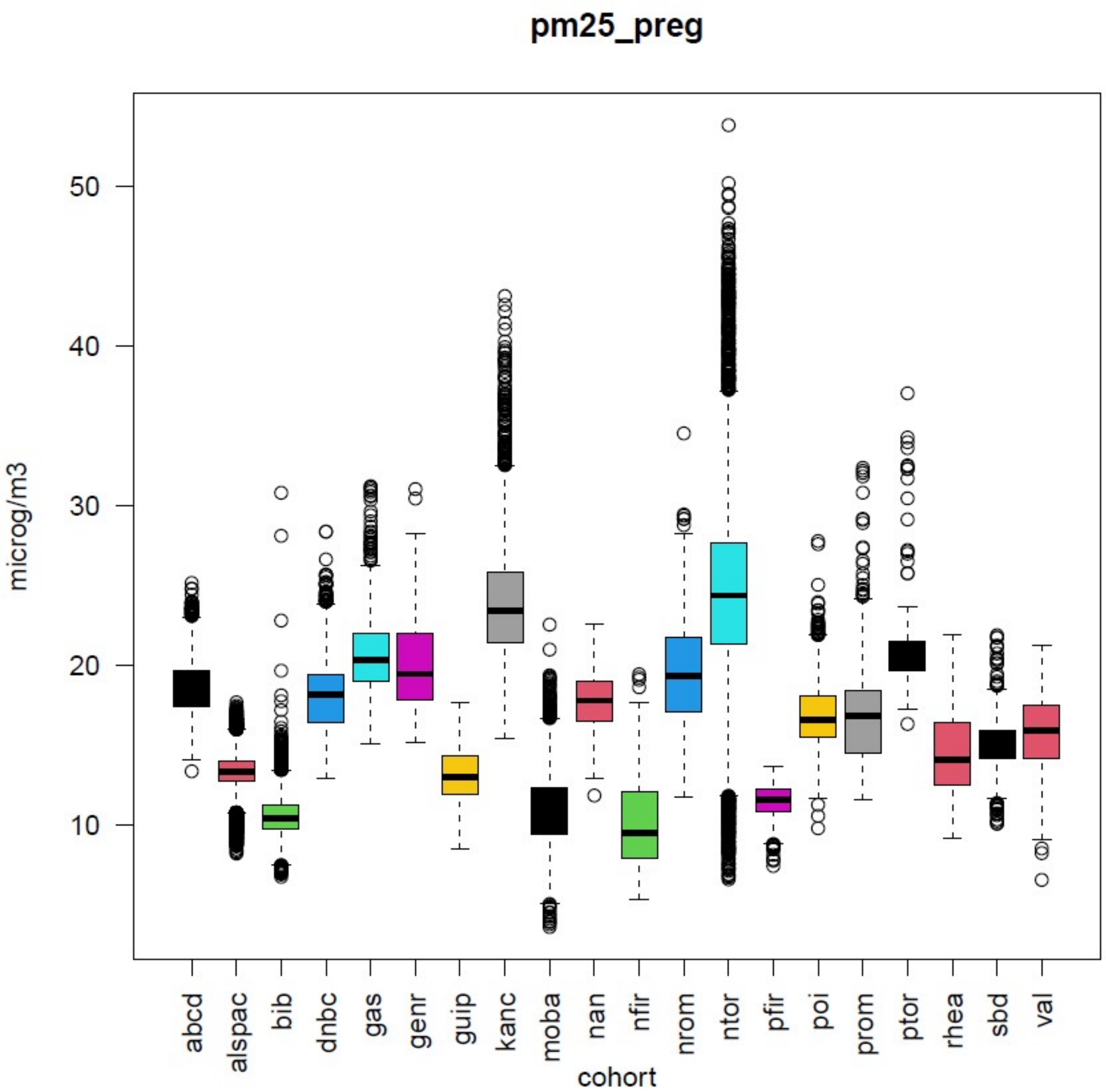


**Figure 5 $PM_{2.5absorvance}$ exposure levels during pregnancy**

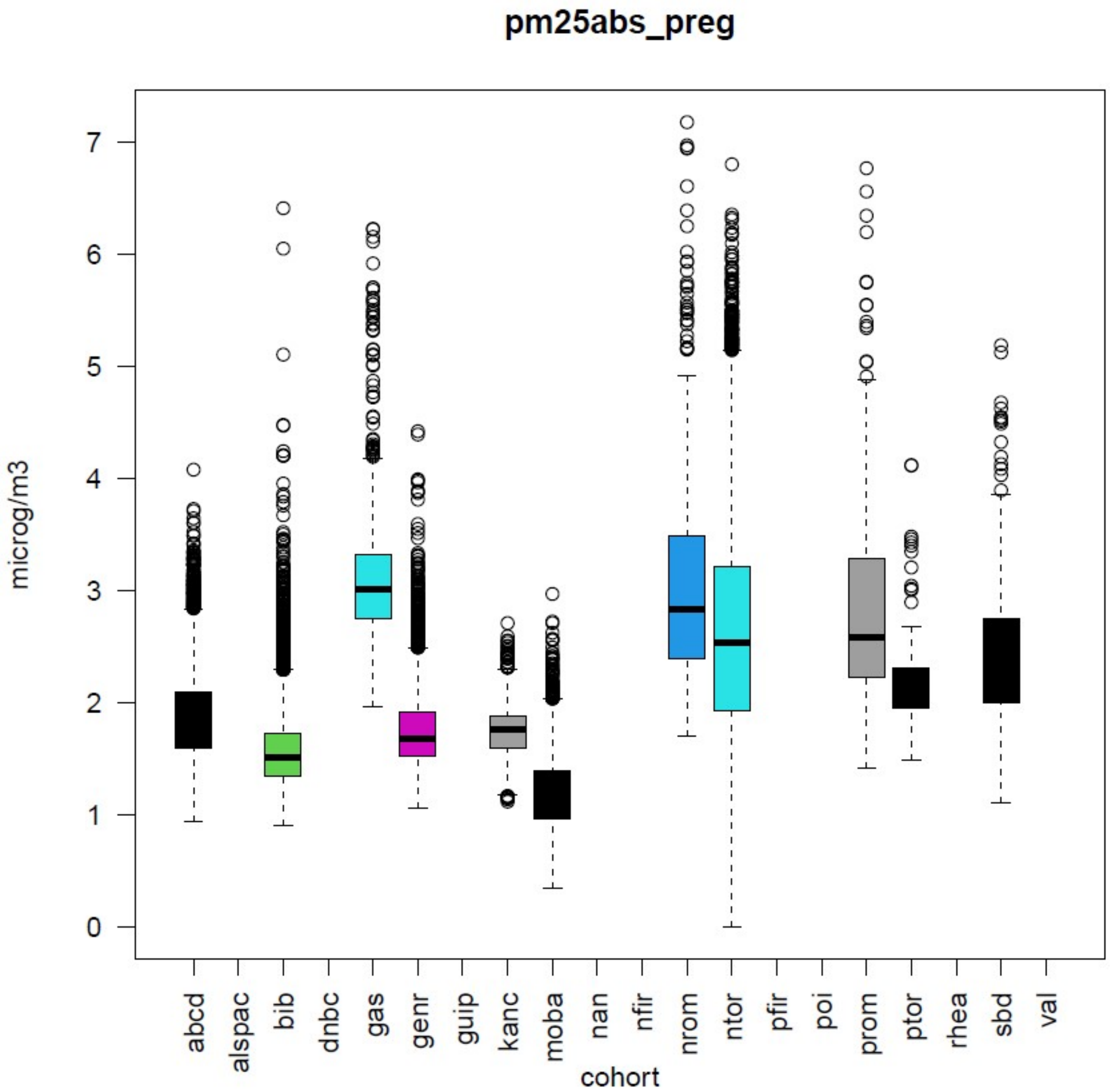


**Figure 6 $PM_{coarse}$ exposure levels during pregnancy**

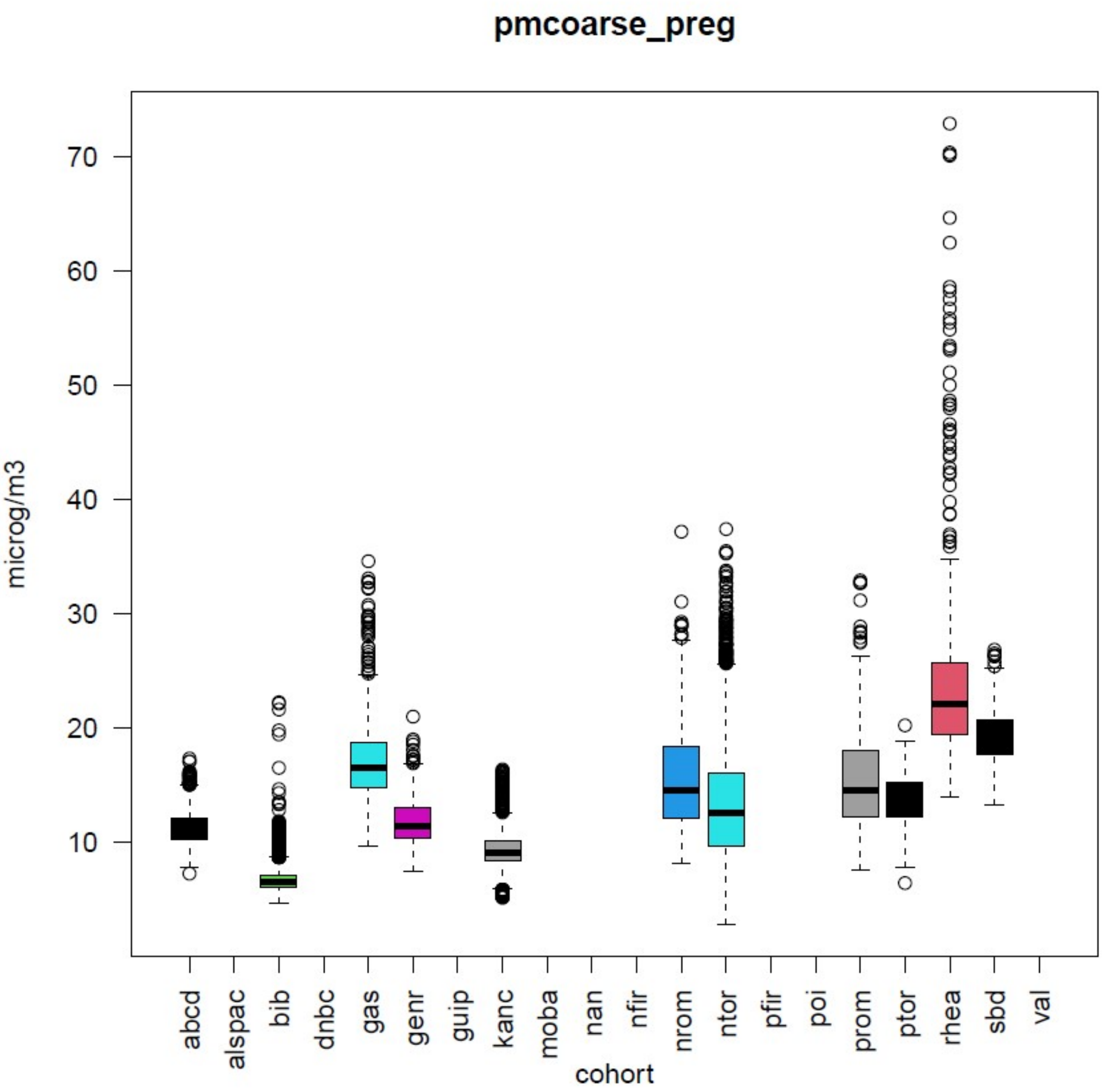


**Figure 7 NDVI exposure levels at pregnancy**

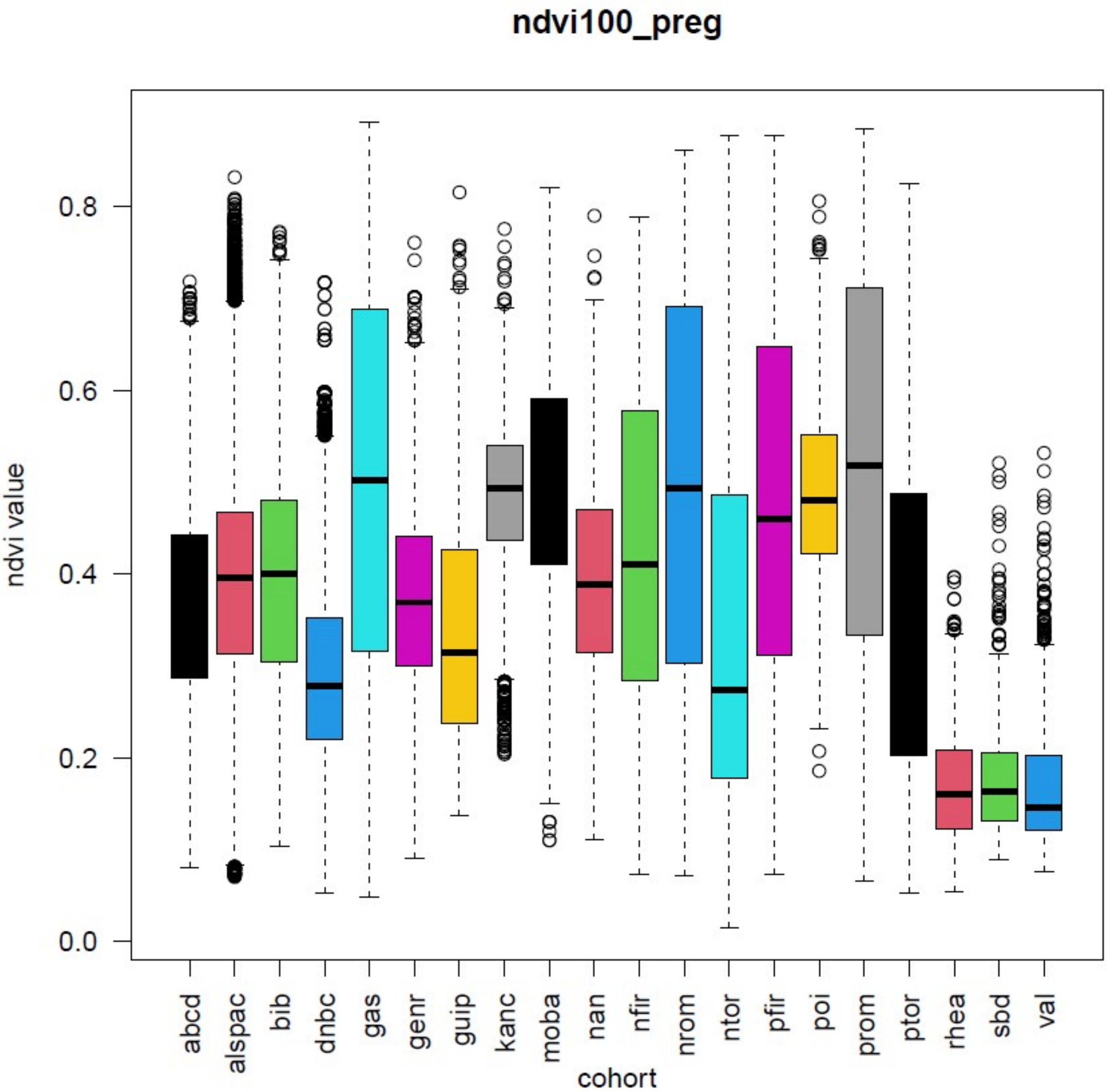


Figure 8 Walkability index (mean values) at pregnancy

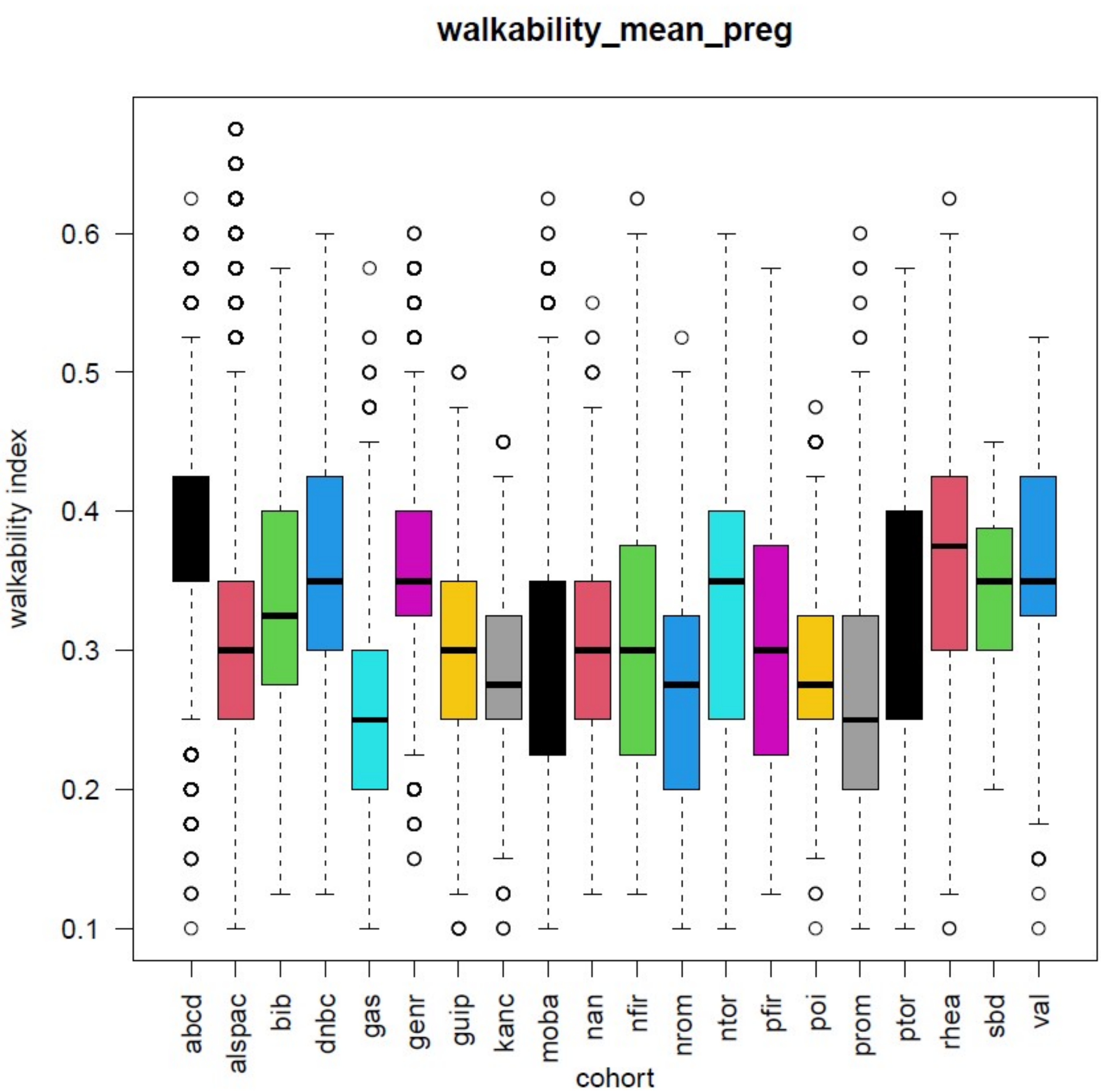
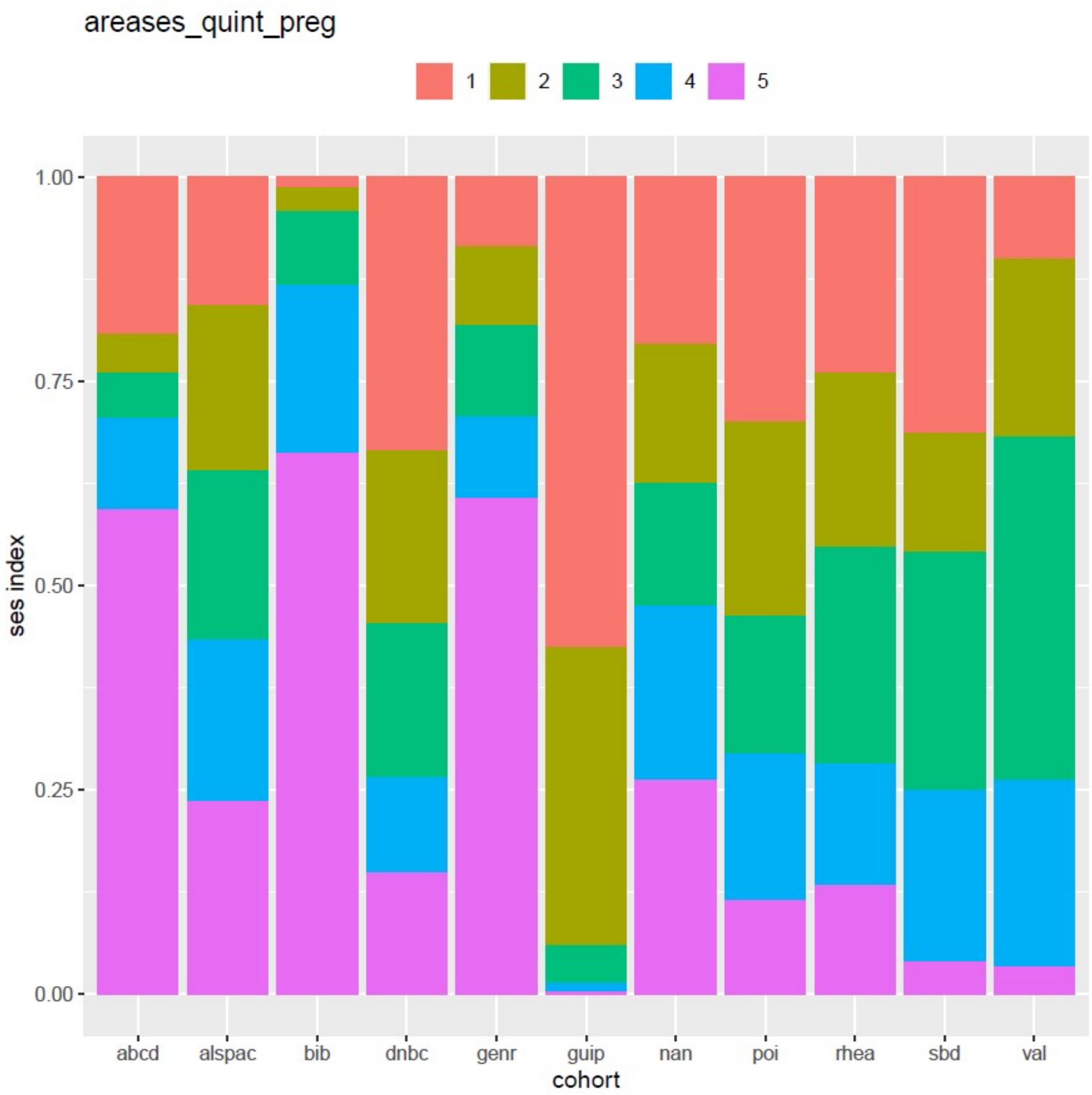
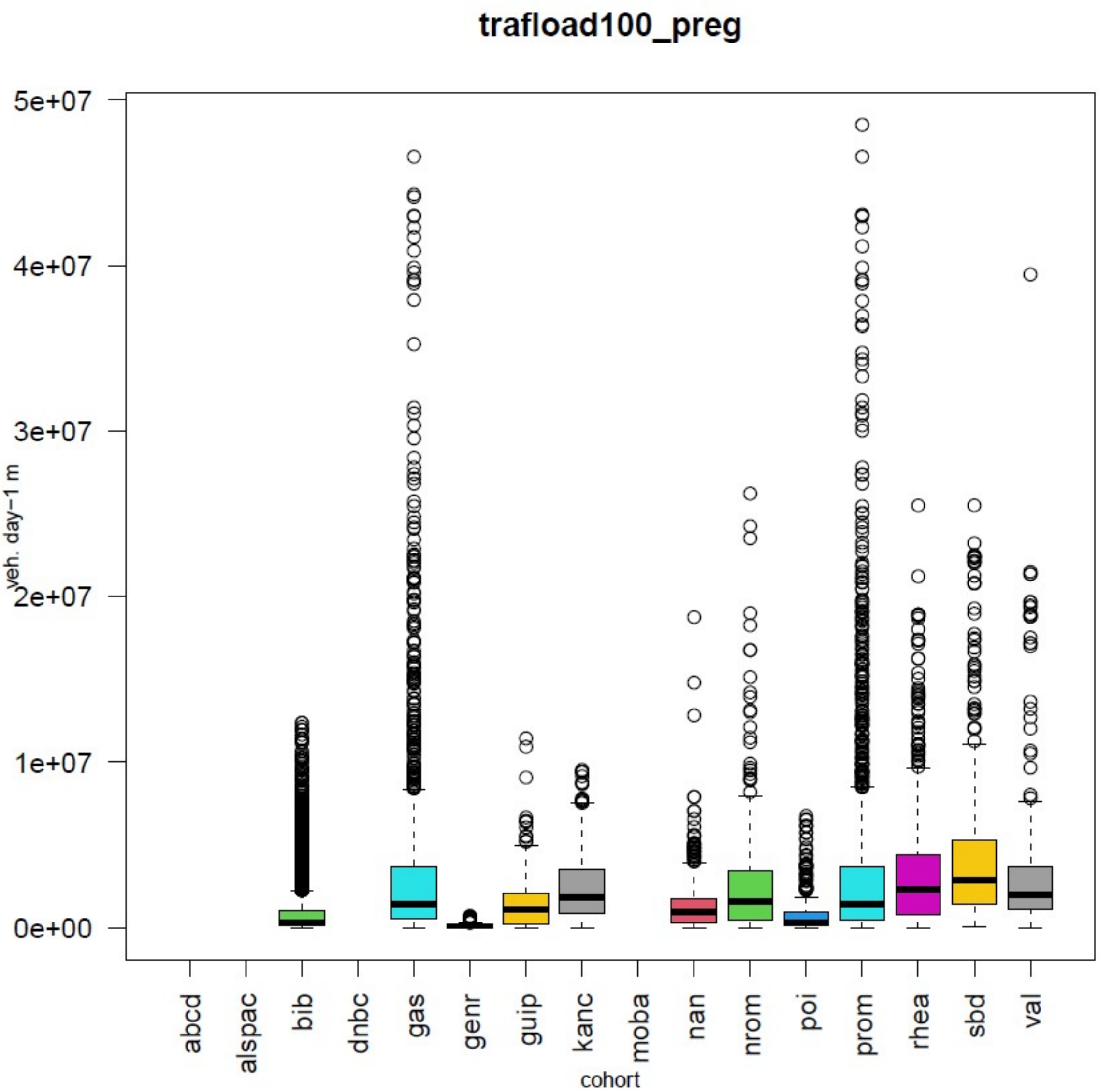


Figure 9 Social context at first year (1 = less deprived, 5 = most deprived)



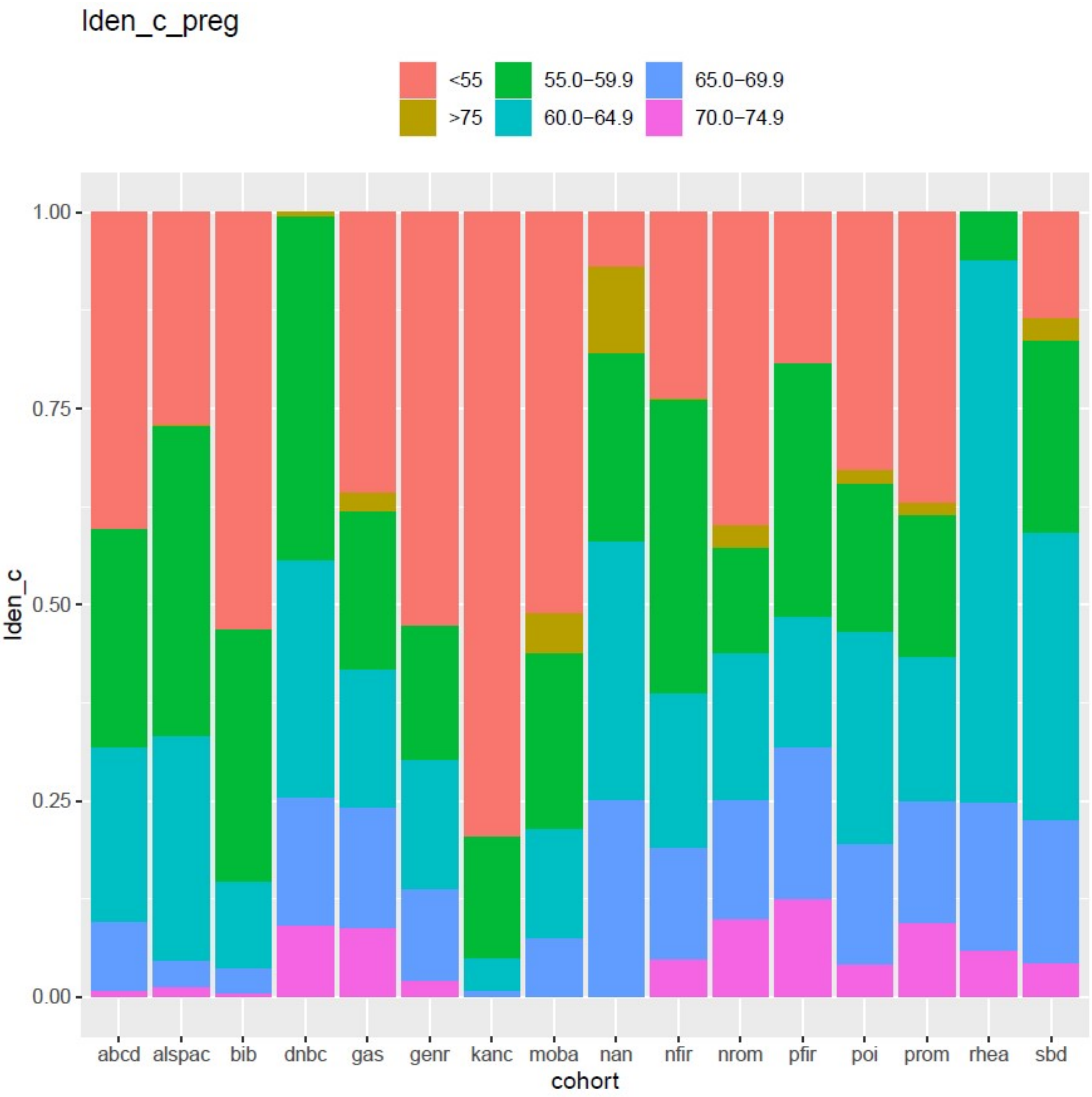

Note: exposure for NINFEA, Gaspii and Piccolipiù is calculated by University of Turin and will be directly uploaded to Opal by the cohort.

Figure 10 Total traffic load of all roads within a buffer of 100 m at pregnancy



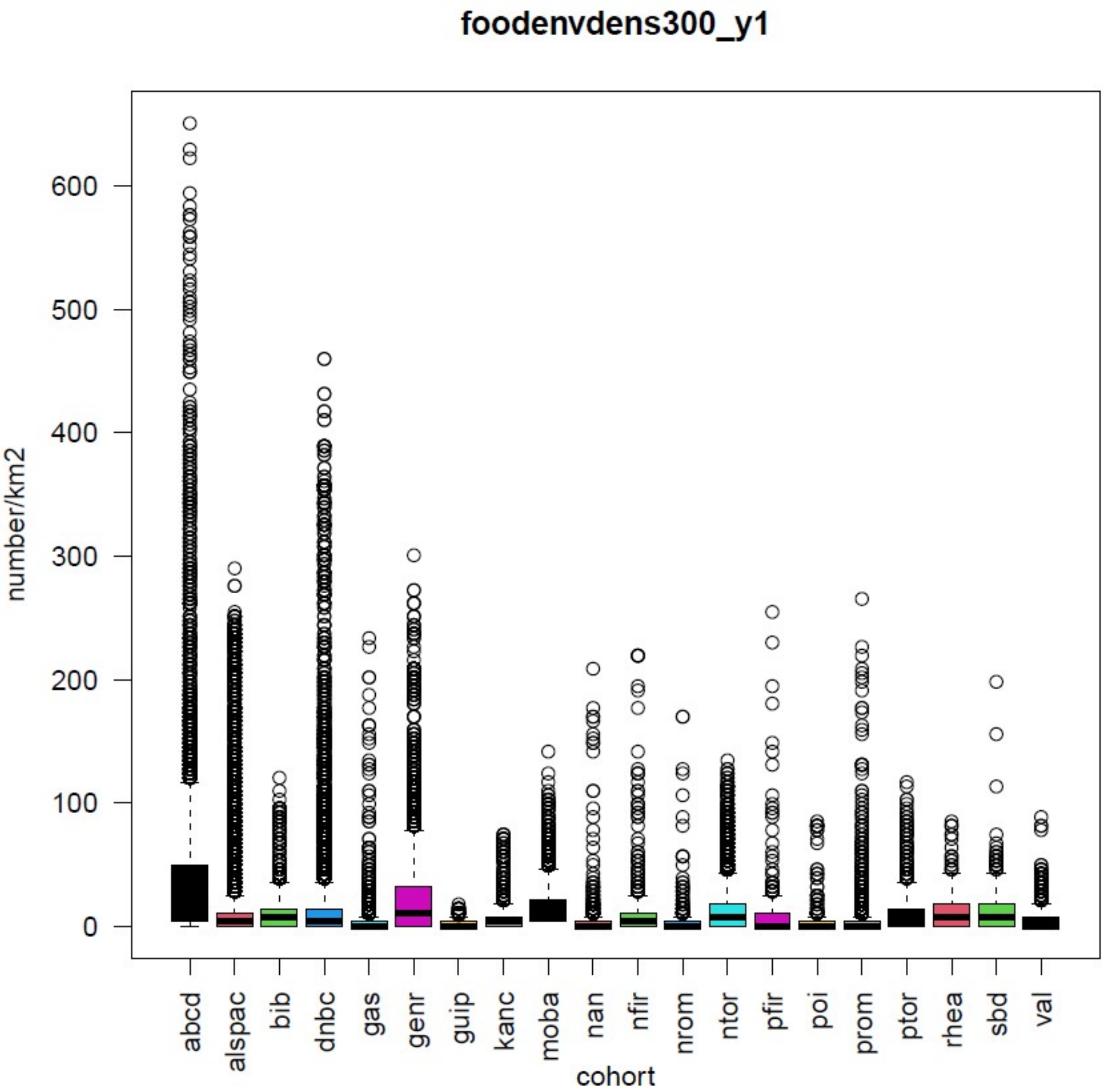

Note: exposure for NINFEA Turin and Piccolipiù Turin is calculated by University of Turin and will be directly uploaded to Opal by the cohort. Traffic load could not be calculated for DNBC, ABCD, ALSPAC, MoBa, NINFEA Florence, and Piccolipiù Florence.

Figure 11 Noise exposure levels (Lden) at pregnancy




Note: exposure for NINFEA Turin and Piccolipiù Turin is calculated by University of Turin and will be directly uploaded to Opal by the cohort. Noise could not be calculated for INMA Valencia, INMA Gipuzkoa.

**Figure 12 Unhealthy food environment (number of facilities related to unhealthy food divided by the area of the 300 meters buffer) at first year**



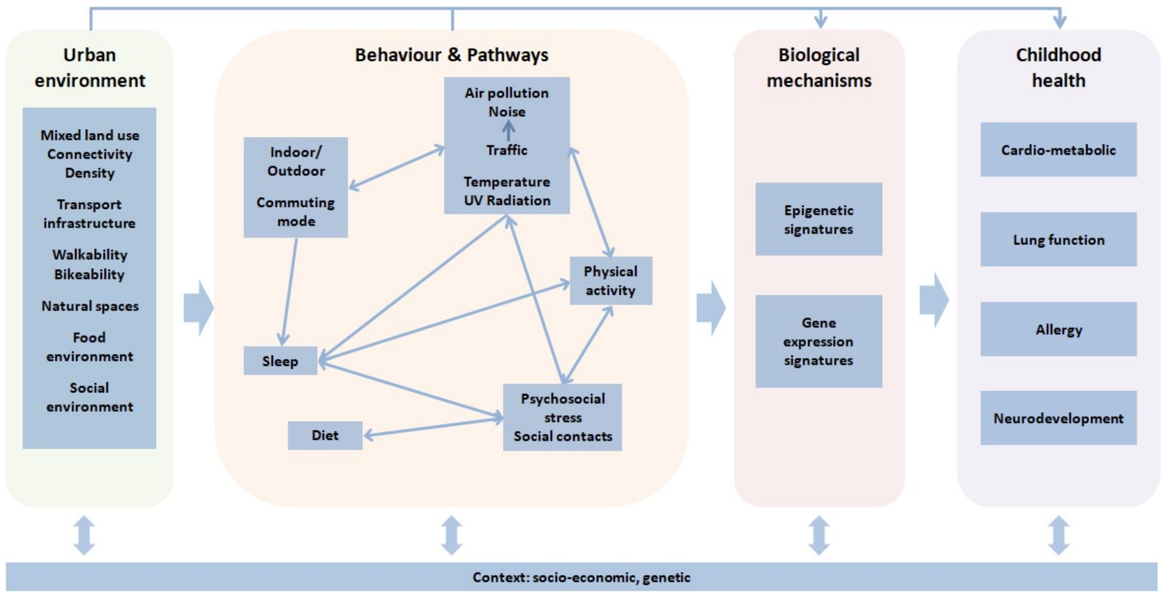
# 3 Papers

## *3.1 Conceptual framework*

The urban environment has been shown to affect health in children in some specific geographic areas, but a more consistent approach across Europe is needed to develop community level intervention and prevention strategies.

We built a conceptual framework for the subtask 3.1.3 as shown in Figure 1, based on the framework proposed by Nieuwenhuijsen (2016)[21], trying to encompass the different domains of the urban environment and their relationship with health outcomes during childhood, taking into account the role of behaviors and possible pathways.

**Figure 1 Task conceptual framework (adapted from Nieuwenhuijsen 2016)**



### *3.2 Planned papers*

As part of LifeCycle, papers have been planned within WP3 and also by linking WP3 with WP 4, 5, 6, and 8.

- Papers focusing on the association between the **urban environment** and **behavioral/lifestyle exposures and patterns** (commuting mode, physical activity, diet, sleep, social) – with 3.1.1, 3.1.4 and 3.2.
  - Proposals submitted:
    - Built environment and health behaviours in the 6 HELIX cohorts (Silvia Fernandez, ISGlobal)
  - Other potential papers
    - Social deprivation?
- Association with **outcomes**. Depending on the outcome, this will include behaviors and pathways as mediators, and/or interactions between exposures and behaviors and pathways (e.g. air pollution and physical activity interaction)
  - Proposals submitted:
    - Air pollution exposure and childhood obesity (Serena Fossati, ISGlobal) (with WP4)
    - Exposure to green spaces and child health (Amanda Fernandes, ISGlobal) (with WP4, 5 and 6)
    - The effect of early life exposures on body mass index from early childhood to early adulthood (Tim Cadman, University of Bristol) (with WP1 and 4)
    - Exposure to natural spaces and birth outcomes (Maria Torres, ISGlobal) (with WP1)
  - Other potential papers
    - Neurodevelopment – WP6 (interested researcher: Mònica Guxens, ISGlobal)
    - Mental health – WP6 (interested researcher: Aasleigh Lin, RAINE; and Nina Rautio, NFBC)
    - Respiratory health – WP5 (interested researchers: Tiffany Yang, BiB; Marie Pedersen, DNBC; Rachel Foong, Australia - RAINE)
- **Omic signatures related to the urban environment** (with WP8) (interested researcher: Lea Maitre, ISGlobal)

## 3.3 IMPORTANT: Specific requirements for publications

### 3.3.1 Requirement for DNBC air pollution data

These exposures were generated using data provided by Matthias Ketzel group. Please contact him for discussing co-authorship in publications involving these data.

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### 3.3.2 Requirement for NINFEA meteorological data (Florence and Turin)

Pleace include the following reference in publications making use of meteorological data for NINFEA Florence and Turin:

*"Morabito, Marco, & Crisci, Alfonso. (2018, September 14). Torino and Firenze weather data code retrieve (Version 0.1). Zenodo. http://doi.org/10.5281/zenodo.1418672".*

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