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**Figure S1.** Flowchart of the study population.

Cohort with consent for follow up until age 10 years   
n=7,393

Twins and mother-child pairs without exposure data n=196

Mother-child pairs with available prenatal urban exposome   
n=7,197

Children without lung function and respiratory outcomes information at 10 years   
n=1,573

Mother-child pairs with available prenatal urban exposome and respiratory outcomes at 10 years  
n=5,624

Lung function n=4,968

Wheezing patterns n=4,197  
Current asthma n=4,698

**Figure S2.** Correlation matrix of continuous urban exposures during pregnancy.

Interfaz de usuario gráfica, Gráfico

Descripción generada automáticamente con confianza media

**Figure S3.** Directed Acyclic Graph (DAG) between the urban environment during pregnancy and childhood respiratory health.

Diagrama

Descripción generada automáticamente

\*Child’s age and height were only accounted for the construction of z-scores of lung function.

**Figure S4.** Results of the Hierarchical Clustering on Principal Components.  
A. Inter-cluster inertia gains to select the number of clusters

**Gráfico, Gráfico de barras, Histograma

Descripción generada automáticamente**

B. Dendogram of the participants distribution across clusters

**Diagrama

Descripción generada automáticamente**

**Table S1.** Urban environmental exposures description.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Exposure | Unit | Median (IQR) or  N (%) | Missing, N (%) | Transformation | Data source |
| Air pollution |  |  |  |  |  |
| NO2 | μg/m3 | 38.48 (7.48) | 12 (0.21) | Natural log | Land Use Regression (LUR) models developed within the European Study of Cohorts for Air Pollution Effects (ESCAPE) framework (1,2) |
| NOx | μg/m3 | 57.23 (21.84) | 12 (0.21) |
| PM10 | μg/m3 | 31.36 (6.14) | 12 (0.21) |
| PM2.5 | μg/m3 | 19.72 (3.83) | 12 (0.21) |
| PM2.5abs | 10-5 m-1 | 1.69 (0.39) | 12 (0.21) |
| PMcoarse | μg/m3 | 11.53 (2.42) | 12 (0.21) |
| PM2.5cu | ng/m3 | 4.64 (0.53) | 0 (0) |
| PM2.5fe | ng/m3 | 119.67 (14.87) | 0 (0) |
| PM2.5k | ng/m3 | 110.57 (5.95) | 0 (0) |
| PM2.5si | ng/m3 | 88.78 (2.75) | 0 (0) |
| PM2.5zn | ng/m3 | 18.87 (3.50) | 0 (0) |
| Noise |  |  |  |  |  |
| Day evening and night noise, Lden | dB | 54 (13) | 220 (3.91) | Natural log | Road traffic noise from European noise maps developed in 2012 for the municipalities of Rotterdam under European Environmental Noise Directive, 2002 (Directive 2002/49/EC) (3) |
| Night noise, Ln | dB | 45 (13) | 220 (3.91) |
| Traffic |  |  |  |  |  |
| Inverse distance to the nearest road | m-1 | 0.09 (0.05) | 16 (0.28) | Natural log | Dutch National Database of Road Traffic Data (Nationale Databank Wegverkeersgegevens) |
| Green spaces |  |  |  |  |  |
| NDVI within 100 m buffer from the home address | 0 to 1 | 0.37 (0.14) | 16 (0.28) | None | LANDSAT 4-5 Thematic Mapper, LANDSAT 7 Enhanced Thematic Mapper Plus, and LANDSAT 8 Operational Land Imager/Thermal infrared Sensor (OLI/TIRS) with 30 m x 30 m resolution (4) |
| NDVI within 300 m buffer from the home address | 0 to 1 | 0.39 (0.14) | 16 (0.28) | None | LANDSAT 4-5 Thematic Mapper, LANDSAT 7 Enhanced Thematic Mapper Plus, and LANDSAT 8 Operational Land Imager/Thermal infrared Sensor (OLI/TIRS) with 30 mx30 m resolution (4) |
| NDVI within 500 m buffer from the home address | 0 to 1 | 0.39 (0.15) | 16 (0.28) | None | LANDSAT 4-5 Thematic Mapper, LANDSAT 7 Enhanced Thematic Mapper Plus, and LANDSAT 8 Operational Land Imager/Thermal infrared Sensor (OLI/TIRS) with 30 m x 30 m resolution (4) |
| Size of the nearest major green space (>5000 m²) | m² | 1.38 · 1010 (1.51 · 1010) | 21 (0.37) | Natural log | Urban Atlas maps (European Environmental Protection Agency) (5) |
| Distance to the nearest major green space (>5000 m²) | m | 1.45 · 108 (1.94 · 108) | 21 (0.37) | Square root | Urban Atlas maps (European Environmental Protection Agency) (5) |
| Blue spaces |  |  |  |  |  |
| Size of the nearest major blue space (>5000 m²) | m² | 2.31· 1010 (5.08 · 1010) | 21 (0.37) | Natural log | Urban Atlas maps (European Environmental Protection Agency) (5) |
| Distance to the nearest major blue space (>5000 m²) from the home address | m | 2.43· 108 (3.51 · 108) | 21 (0.37) | Square root | Urban Atlas maps (European Environmental Protection Agency) (5) |
| Built environment |  |  |  |  |  |
| Population density | number of inhabitants/km² | 4136.41 (213.23) | 17 (0.3) | None | Global Human Settlement layer (6,7) |
| Building density within 100 m buffer from the home address | area occupied by buildings (m²)/km² | 529787.00 (178552.00) | 16 (0.28) | Squared | European Settlement Map 2017 |
| Building density within 300 m buffer from the home address | area occupied by buildings (m²)/km² | 463273.50 (154424.50) | 16 (0.28) | Squared | European Settlement Map 2017 |
| Street connectivity within 100 m buffer from the home address | number of intersections/km² | 224.26 (160.18) | 81 (1.44) | Square root | NAVTEQ (8) |
| Street connectivity within 300 m buffer from the home address | number of intersections/km² | 217.14 (121.03) | 18 (0.32) | Square root | NAVTEQ (8) |
| Facilities density within 300 m buffer from the home address | number of facilities/km²\* | 45.98 (113.18) | 16 (0.28) | Cube root | NAVTEQ (8) |
| Facilities richness within 300 m buffer from the home address | ﻿number of different facility types present/maximum potential number of facility types | 0.12 (0.14) | 16 (0.28) | None | NAVTEQ (8) |
| Land Use Mix (Shannon's Evenness Index) within 300 m buffer from the home address\*\* | 0 to 1 | 0.47 (0.13) | 21 (0.37) | None | Urban Atlas maps (European Environmental Protection Agency) (5) |
| Walkability within 300 m buffer from the home address \*\*\* | 0 to 1 | 0.35 (0.08) | 23 (0.41) | Log2 | Global Human Settlement layer, NAVTEQ, Urban Atlas maps (European Environmental Protection Agency) (5) (6,7) (8) |

\* Facilities considering all points of daily life activities (e.g., schools, medical centres, shops, restaurants, libraries).

\*\* Indicates the diversity and evenness of land uses. Index ranges from 0 to 1, with higher values indicating more even distribution of different types of land use.

\*\*\* Quantifies how walkable is a buffer of 300 m considering four components of the built environment: Land Use Mix (Shannon's Evenness Index), facilities richness, population density, and connectivity index. Walkability was calculated for the LifeCycle project based on previously used methods (9)

**Table S2.** Results of the Principal Component Analysis.

|  |  |  |  |
| --- | --- | --- | --- |
| **Component** | **eigen value** | **Percentage of variance** | **Cumulative percentage of variance** |
| 1 | 6.881856156 | 22.93952052 | 22.93952 |
| 2 | 4.632327051 | 15.44109017 | 38.38061 |
| 3 | 2.452455913 | 8.17485304 | 46.55546 |
| 4 | 2.058993124 | 6.86331041 | 53.41877 |
| 5 | 1.937147411 | 6.45715804 | 59.87593 |
| 6 | 1.511187507 | 5.03729169 | 64.91322 |
| 7 | 1.18774963 | 3.95916543 | 68.87239 |
| 8 | 1.115154398 | 3.71718133 | 72.58957 |
| 9 | 1.004294626 | 3.34764875 | 75.93722 |
| 10 | 0.975095263 | 3.25031754 | 79.18754 |
| 11 | 0.922680323 | 3.07560108 | 82.26314 |
| 12 | 0.854919149 | 2.8497305 | 85.11287 |
| 13 | 0.731078737 | 2.43692912 | 87.5498 |
| 14 | 0.615654374 | 2.05218125 | 89.60198 |
| 15 | 0.597278242 | 1.99092747 | 91.59291 |
| 16 | 0.485584451 | 1.61861484 | 93.21152 |
| 17 | 0.431346657 | 1.43782219 | 94.64934 |
| 18 | 0.414999834 | 1.38333278 | 96.03268 |
| 19 | 0.312158008 | 1.04052669 | 97.0732 |
| 20 | 0.171953219 | 0.5731774 | 97.64638 |
| 21 | 0.156092385 | 0.52030795 | 98.16669 |
| 22 | 0.125120388 | 0.41706796 | 98.58376 |
| 23 | 0.103031809 | 0.34343936 | 98.9272 |
| 24 | 0.099844052 | 0.33281351 | 99.26001 |
| 25 | 0.070726316 | 0.23575439 | 99.49576 |
| 26 | 0.050321205 | 0.16773735 | 99.6635 |
| 27 | 0.043767108 | 0.14589036 | 99.80939 |
| 28 | 0.039765943 | 0.13255314 | 99.94194 |
| 29 | 0.009866403 | 0.03288801 | 99.97483 |
| 30 | 0.007550318 | 0.02516773 | 100 |

**Table S3.** Maternal and child characteristics in the included and excluded populations.

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Included (n=5624)** | **Excluded (n=1766)** | **p-value** |
| **Maternal characteristics** |  |  |  |
| Age (years) | 31.00 (4.92) | 29.29 (5.43) | <0.001 |
| Pre-pregnancy BMI (kg/m2) | 23.47 (4.10) | 23.88 (4.51) | <0.001 |
| Education, low | 2,550 (49%) | 974 (64%) | <0.001 |
| Smoking |  |  |  |
| Never | 3,784 (77%) | 450 (75%) | 0.635 |
| Before pregnancy | 429 (9%) | 57 (9%) |  |
| During pregnancy | 727 (15%) | 94 (16%) |  |
| History of asthma or atopy, yes | 1,804 (37%) | 221 (38%) | 0.655 |
| Area-level SES (quintiles) |  |  |  |
| Quintile 1, least deprived | 593 (11%) | 119 (7%) | <0.001 |
| Quintile 2 | 646 (12%) | 147 (8%) |  |
| Quintile 3 | 663 (12%) | 199 (11%) |  |
| Quintile 4 | 616 (11%) | 168 (10%) |  |
| Quintile 5, most deprived | 3,087 (55%) | 1,106 (64%) |  |
| **Child characteristics** |  |  |  |
| Sex, female | 2,822 (50%) | 356 (49%) | 0.711 |
| Gestational age at birth (weeks) | 40.14 (1.86) | 39.86 (2.29) | <0.001 |
| Preterm birth | 260 (5%) | 179 (10%) | <0.001 |
| Birth weight (g) | 3,450 (690) | 3,360 (780) | <0.001 |
| Low birth weight | 239 (4%) | 170 (10%) | <0.001 |
| Season of birth |  |  |  |
| Spring | 1,333 (24%) | 405 (24%) | 0.896 |
| Summer | 1,516 (27%) | 441 (26%) |  |
| Autumn | 1,541 (27%) | 468 (28%) |  |
| Winter | 1,234 (22%) | 359 (21%) |  |
| Ethnicity |  |  |  |
| Caucasian | 4,355 (79%) | 1,241 (76%) | 0.010 |
| African/American | 402 (7%) | 149 (9%) |  |
| SE Asian | 195 (4%) | 54 (3%) |  |
| NE Asian | 137 (2%) | 44 (3%) |  |
| Other/Mixed | 406 (7%) | 152 (9%) |  |

\* Differences were calculated using Student’s t test for continuous normally distributed variables, Mann-Whitney U test for continuous non-normally distributed variables, and chi-square test for categorical variables.

**Table S4.** Maternal and child characteristics in the complete case and imputed populations.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Missing** | **Included (n=5624)** | **Excluded (n=1766)** | **p-value** |
| **Maternal characteristics** |  |  |  |  |
| Age (years) | 0 (0%) | 31.00 (4.92) | 29.29 (5.43) | <0.001 |
| Pre-pregnancy BMI (kg/m2) | 1,359 (24.2%) | 23.47 (4.10) | 23.88 (4.51) | <0.001 |
| Education, low | 420 (7.5%) | 2550 (49%) | 974 (64%) | <0.001 |
| Smoking | 684 (12.2%) |  |  |  |
| Never |  | 3784 (77%) | 450 (75%) | 0.635 |
| Before pregnancy |  | 429 (9%) | 57 (9%) |  |
| During pregnancy |  | 727 (15%) | 94 (16%) |  |
| History of asthma or atopy, yes | 760 (13.5%) | 1,804 (37%) | 221 (38%) | 0.655 |
| Area-level SES (quintiles) | 19 (0.3%) |  |  |  |
| Quintile 1, least deprived |  | 593 (11%) | 119 (7%) | <0.001 |
| Quintile 2 |  | 646 (12%) | 147 (8%) |  |
| Quintile 3 |  | 663 (12%) | 199 (11%) |  |
| Quintile 4 |  | 616 (11%) | 168 (10%) |  |
| Quintile 5, most deprived |  | 3,087 (55%) | 1,106 (64%) |  |
| **Child characteristics** |  |  |  |  |
| Sex, female | 0 (0%) | 2,822 (50%) | 356 (49%) | 0.711 |
| Gestational age at birth (weeks) | 33 (0.6%) | 40.14 (1.86) | 39.86 (2.29) | <0.001 |
| Preterm birth | 7 (0.1%) | 260 (5%) | 179 (10%) | <0.001 |
| Birth weight (g) | 0 (0%) | 3,450 (690) | 3,360 (780) | <0.001 |
| Low birth weight | 0 (0%) | 239 (4%) | 170 (10%) | <0.001 |
| Season of birth | 33 (0.6%) |  |  |  |
| Spring |  | 1,333 (24%) | 405 (24%) | 0.896 |
| Summer |  | 1,516 (27%) | 441 (26%) |  |
| Autumn |  | 1,541 (27%) | 468 (28%) |  |
| Winter |  | 1,234 (22%) | 359 (21%) |  |
| Ethnicity | 129 (2.3%) |  |  |  |
| Caucasian |  | 4,355 (79%) | 1,241 (76%) | 0.010 |
| African/American |  | 402 (7%) | 149 (9%) |  |
| SE Asian |  | 195 (4%) | 54 (3%) |  |
| NE Asian |  | 137 (2%) | 44 (3%) |  |
| Other/Mixed |  | 406 (7%) | 152 (9%) |  |

\* Differences were calculated using Student’s t test for continuous normally distributed variables, Mann-Whitney U test for continuous non-normally distributed variables, and chi-square test for categorical variables.

**Table S5.** Single-exposure associations betweenurban environment exposures during pregnancy and lung function (n=4,968).

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **FEV1** |  | **FVC** |  | **FEV1/FVC** |  | **FEF25-75%** |  |
|  | z-score change (95%CI) | p-value | z-score change (95%CI) | p-value | z-score change (95%CI) | p-value | z-score change (95%CI) | p-value |
| Air pollution |  |  |  |  |  |  |  |  |
| NO2 | 0.02 (-0.01, 0.05) | 0.304 | 0.01 (-0.02, 0.04) | 0.439 | 0.00 (-0.03, 0.03) | 0.841 | -0.04 (-0.07, 0.00) | 0.034 |
| NOx | 0.01 (-0.02, 0.04) | 0.656 | 0.00 (-0.02, 0.03) | 0.797 | 0.00 (-0.03, 0.03) | 0.932 | -0.01 (-0.04, 0.02) | 0.448 |
| PM10 | 0.04 (0.01, 0.07) | 0.004 | 0.05 (0.02, 0.08) | <0.001 | -0.02 (-0.05, 0.00) | 0.107 | -0.06 (-0.09, -0.03) | <0.001 |
| PM25 | 0.05 (0.02, 0.08) | 0.001 | 0.06 (0.03, 0.08) | <0.001 | -0.02 (-0.05, 0.01) | 0.148 | -0.06 (-0.09, -0.03) | <0.001 |
| PM25abs | 0.02 (-0.01, 0.05) | 0.209 | 0.02 (0.00, 0.05) | 0.098 | -0.01 (-0.04, 0.01) | 0.323 | -0.03 (-0.07, 0.00) | 0.033 |
| PMcoarse | 0.04 (0.01, 0.07) | 0.006 | 0.04 (0.01, 0.07) | 0.003 | -0.01 (-0.03, 0.02) | 0.684 | -0.03 (-0.06, 0.00) | 0.067 |
| PM25cu | -0.01 (-0.03, 0.02) | 0.683 | -0.01 (-0.03, 0.02) | 0.625 | 0.00 (-0.03, 0.03) | 0.964 | -0.02 (-0.05, 0.01) | 0.238 |
| PM25fe | 0.00 (-0.03, 0.02) | 0.807 | -0.01 (-0.04, 0.01) | 0.402 | 0.01 (-0.01, 0.04) | 0.329 | -0.01 (-0.04, 0.02) | 0.633 |
| PM25k | -0.02 (-0.05, 0.01) | 0.139 | -0.01 (-0.04, 0.01) | 0.371 | -0.02 (-0.05, 0.01) | 0.195 | -0.02 (-0.05, 0.01) | 0.126 |
| PM25si | 0.00 (-0.03, 0.03) | 0.909 | -0.01 (-0.03, 0.02) | 0.488 | 0.02 (-0.01, 0.05) | 0.163 | 0.02 (-0.01, 0.05) | 0.256 |
| PM25zn | -0.02 (-0.05, 0.01) | 0.161 | -0.01 (-0.04, 0.02) | 0.468 | -0.02 (-0.05, 0.01) | 0.159 | -0.02 (-0.06, 0.01) | 0.110 |
| Noise |  |  |  |  |  |  |  |  |
| Lden | 0.00 (-0.03, 0.03) | 0.895 | -0.01 (-0.03, 0.02) | 0.695 | 0.01 (-0.02, 0.04) | 0.462 | 0.00 (-0.03, 0.03) | 0.973 |
| Night noise, Ln | 0.00 (-0.02, 0.03) | 0.780 | 0.00 (-0.03, 0.02) | 0.756 | 0.01 (-0.02, 0.04) | 0.396 | 0.00 (-0.03, 0.03) | 0.894 |
| Traffic |  |  |  |  |  |  |  |  |
| Inverse distance to nearest road | 0.02 (-0.01, 0.05) | 0.121 | 0.02 (-0.01, 0.04) | 0.217 | 0.01 (-0.02, 0.03) | 0.592 | 0.00 (-0.03, 0.03) | 0.782 |
| Green spaces |  |  |  |  |  |  |  |  |
| NDVI within 100 m buffer | 0.01 (-0.01, 0.04) | 0.324 | 0.01 (-0.01, 0.04) | 0.302 | 0.00 (-0.03, 0.02) | 0.845 | 0.00 (-0.03, 0.03) | 0.753 |
| NDVI within 300 m buffer | 0.00 (-0.03, 0.03) | 0.904 | 0.01 (-0.02, 0.03) | 0.622 | -0.01 (-0.04, 0.02) | 0.530 | -0.02 (-0.05, 0.01) | 0.181 |
| NDVI within 500 m buffer | 0.00 (-0.03, 0.02) | 0.737 | 0.00 (-0.03, 0.02) | 0.917 | -0.01 (-0.03, 0.02) | 0.681 | -0.01 (-0.04, 0.02) | 0.400 |
| Size of nearest major green space (>5000 m²) | 0.00 (-0.03, 0.03) | 0.910 | 0.00 (-0.03, 0.02) | 0.785 | 0.01 (-0.02, 0.04) | 0.449 | 0.00 (-0.03, 0.03) | 0.790 |
| Distance nearest major green space (>5000 m²) | -0.01 (-0.04, 0.02) | 0.451 | 0.00 (-0.03, 0.03) | 0.972 | -0.02 (-0.04, 0.01) | 0.267 | 0.00 (-0.03, 0.03) | 0.815 |
| Blue spaces |  |  |  |  |  |  |  |  |
| Size of nearest major blue space (>5000 m²) | 0.04 (0.01, 0.06) | 0.009 | 0.03 (0.00, 0.05) | 0.039 | 0.02 (-0.01, 0.04) | 0.219 | 0.02 (-0.01, 0.05) | 0.105 |
| Distance nearest major blue space (>5000 m²) | 0.00 (-0.03, 0.03) | 0.906 | 0.00 (-0.02, 0.03) | 0.939 | 0.01 (-0.02, 0.03) | 0.616 | 0.01 (-0.02, 0.04) | 0.489 |
| Built environment |  |  |  |  |  |  |  |  |
| Population density | 0.02 (-0.01, 0.05) | 0.130 | 0.00 (-0.02, 0.03) | 0.889 | 0.04 (0.01, 0.06) | 0.009 | 0.01 (-0.02, 0.04) | 0.488 |
| Building density within 100 m buffer | -0.01 (-0.04, 0.02) | 0.402 | -0.01 (-0.04, 0.02) | 0.464 | 0.00 (-0.02, 0.03) | 0.769 | 0.00 (-0.03, 0.03) | 0.911 |
| Building density within 300 m buffer | 0.01 (-0.01, 0.04) | 0.355 | 0.00 (-0.02, 0.03) | 0.934 | 0.02 (0.00, 0.05) | 0.080 | 0.01 (-0.02, 0.04) | 0.428 |
| Street connectivity within 300 m buffer | -0.01 (-0.04, 0.02) | 0.500 | -0.01 (-0.03, 0.02) | 0.589 | -0.01 (-0.03, 0.02) | 0.570 | 0.00 (-0.03, 0.03) | 0.755 |
| Street connectivity within 100 m buffer | -0.03 (-0.06, 0.00) | 0.022 | -0.02 (-0.04, 0.01) | 0.182 | -0.02 (-0.05, 0.00) | 0.070 | 0.00 (-0.03, 0.03) | 0.790 |
| Facilities density within 300 m buffer | 0.01 (-0.02, 0.04) | 0.511 | 0.00 (-0.03, 0.03) | 0.971 | 0.02 (-0.01, 0.04) | 0.199 | -0.01 (-0.04, 0.02) | 0.358 |
| Facilities richness within 300 m buffer | 0.01 (-0.02, 0.03) | 0.690 | 0.00 (-0.03, 0.03) | 0.946 | 0.02 (-0.01, 0.04) | 0.267 | -0.02 (-0.05, 0.01) | 0.226 |
| Land Use Mix (Shannon’s Evenness Index) within 300 m buffer | 0.01 (-0.01, 0.04) | 0.317 | 0.03 (0.00, 0.05) | 0.050 | -0.03 (-0.05, 0.00) | 0.042 | 0.01 (-0.02, 0.04) | 0.476 |
| Walkability | -0.01 (-0.03, 0.02) | 0.600 | 0.00 (-0.03, 0.03) | 0.994 | -0.01 (-0.04, 0.01) | 0.288 | -0.01 (-0.04, 0.02) | 0.636 |

\*Models adjusted for maternal education, pre-pregnancy BMI, age, smoking during pregnancy, history of asthma or atopy, area-level SES, and child’s ethnicity and season of birth.

**Table S6.** Single-exposure associations ofurban environment exposures during pregnancy with preschool wheezing (n=4,197) and school asthma (n=4,698).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Preschool wheezing** |  | **School asthma** |  |
|  | OR (95%CI) | p-value | OR (95%CI) | p-value |
| Air pollution |  |  |  |  |
| NO2 | 1.08 (1.01, 1.16) | 0.024 | 1.04 (0.91, 1.19) | 0.526 |
| NOx | 1.08 (1.01, 1.15) | 0.018 | 1.10 (0.97, 1.25) | 0.145 |
| PM10 | 0.97 (0.91, 1.03) | 0.311 | 0.98 (0.86, 1.11) | 0.738 |
| PM25 | 0.95 (0.89, 1.01) | 0.111 | 0.96 (0.85, 1.09) | 0.531 |
| PM25abs | 1.01 (0.95, 1.08) | 0.719 | 1.06 (0.93, 1.20) | 0.404 |
| PMcoarse | 0.96 (0.90, 1.02) | 0.222 | 0.98 (0.87, 1.12) | 0.807 |
| PM25cu | 1.05 (0.99, 1.12) | 0.096 | 1.06 (0.94, 1.19) | 0.293 |
| PM25fe | 1.04 (0.98, 1.11) | 0.168 | 1.04 (0.92, 1.17) | 0.515 |
| PM25k | 1.03 (0.97, 1.10) | 0.293 | 1.10 (0.98, 1.22) | 0.100 |
| PM25si | 1.01 (0.94, 1.07) | 0.870 | 1.05 (0.92, 1.18) | 0.425 |
| PM25zn | 1.02 (0.96, 1.08) | 0.496 | 1.10 (0.98, 1.23) | 0.107 |
| Noise |  |  |  |  |
| Lden | 1.05 (0.99, 1.12) | 0.093 | 1.05 (0.93, 1.19) | 0.418 |
| Night noise, Ln | 1.06 (0.99, 1.12) | 0.079 | 1.03 (0.91, 1.17) | 0.611 |
| Traffic |  |  |  |  |
| Inverse distance to nearest road | 1.02 (0.95, 1.08) | 0.623 | 0.97 (0.85, 1.09) | 0.591 |
| Green spaces |  |  |  |  |
| NDVI within 100 m buffer | 0.98 (0.93, 1.05) | 0.621 | 0.99 (0.88, 1.13) | 0.936 |
| NDVI within 300 m buffer | 0.96 (0.90, 1.02) | 0.226 | 0.99 (0.87, 1.12) | 0.817 |
| NDVI within 500 m buffer | 0.96 (0.90, 1.02) | 0.157 | 1.00 (0.89, 1.14) | 0.942 |
| Size of nearest major green space (>5000 m²) | 1.01 (0.95, 1.07) | 0.745 | 1.09 (0.96, 1.24) | 0.192 |
| Distance nearest major green space (>5000 m²) | 1.02 (0.96, 1.08) | 0.550 | 1.03 (0.91, 1.16) | 0.660 |
| Blue spaces |  |  |  |  |
| Size of nearest major blue space (>5000 m²) | 0.97 (0.91, 1.03) | 0.298 | 0.87 (0.75, 0.99) | 0.036 |
| Distance nearest major blue space (>5000 m²) | 1.01 (0.95, 1.07) | 0.824 | 1.04 (0.92, 1.18) | 0.519 |
| Built environment |  |  |  |  |
| Population density | 0.99 (0.93, 1.05) | 0.787 | 0.98 (0.88, 1.12) | 0.792 |
| Building density within 100 m buffer | 1.04 (0.98, 1.11) | 0.202 | 1.03 (0.91, 1.17) | 0.621 |
| Building density within 300 m buffer | 1.05 (0.99, 1.12) | 0.122 | 1.05 (0.93, 1.19) | 0.420 |
| Street connectivity within 300 m buffer | 0.99 (0.93, 1.05) | 0.777 | 1.04 (0.92, 1.18) | 0.542 |
| Street connectivity within 100 m buffer | 1.04 (0.97, 1.10) | 0.248 | 1.01 (0.89, 1.14) | 0.912 |
| Facilities density within 300 m buffer | 1.07 (1.01, 1.14) | 0.028 | 1.09 (0.96, 1.23) | 0.168 |
| Facilities richness within 300 m buffer | 1.07 (1.00, 1.14) | 0.039 | 1.10 (0.97, 1.24) | 0.124 |
| Land Use Mix (Shannon's Evenness Index) within 300 m buffer | 1.01 (0.94, 1.07) | 0.859 | 0.94 (0.83, 1.07) | 0.369 |
| Walkability | 1.08 (1.01, 1.15) | 0.019 | 1.04 (0.92, 1.18) | 0.537 |

\*Models adjusted for maternal education, pre-pregnancy BMI, age, smoking during pregnancy, history of asthma or atopy, area-level SES, and child’s sex, ethnicity, and season of birth.

**Table S7.** Maternal and child characteristics in the clusters of urban exposures.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Cluster 1 (n=1,598)** | **Cluster 2 (n=2,835)** | **Cluster 3 (n=1,191)** | **p-value** |
| **Maternal characteristics** |  |  |  |  |
| Age (years) | 31.10 (4.93) | 30.84 (5.04) | 31.20 (4.59) | 0.046 |
| Pre-pregnancy BMI (kg/m2) | 23.55 (4.19) | 23.53 (4.16) | 23.17 (3.87) | 0.022 |
| Education, low | 860 (54%) | 1386 (49%) | 527 (44%) | <0.001 |
| Smoking, % |  |  |  |  |
| Never | 1214 (76%) | 2175 (77%) | 900 (76%) | 0.635 |
| Before pregnancy | 138 (9%) | 237 (8%) | 117 (10%) |  |
| During pregnancy | 246 (15%) | 423 (15%) | 174 (15%) |  |
| History of asthma or atopy, yes | 587 (37%) | 1018 (36%) | 435 (37%) | 0.843 |
| **Child characteristics** |  |  |  |  |
| Sex, female | 792 (50%) | 1417 (50%) | 593 (50%) | 0.964 |
| Preterm birth, yes | 69 (4%) | 143 (5%) | 49 (4%) | 0.339 |
| Low birth weight, % | 63 (4%) | 133 (5%) | 43 (4%) | 0.232 |
| Season of birth |  |  |  |  |
| Spring | 358 (22%) | 629 (22%) | 346 (29%) | <0.001 |
| Summer | 397 (25%) | 771 (27%) | 348 (29%) |  |
| Autumn | 494 (31%) | 800 (28%) | 247 (21%) |  |
| Winter | 349 (22%) | 635 (22%) | 250 (21%) |  |
| Ethnicity, % |  |  |  |  |
| Caucasian | 1286 (80%) | 2190 (77%) | 979 (82%) | 0.001 |
| African/American | 106 (7%) | 242 (9%) | 67 (6%) |  |
| Asian | 108 (7%) | 168 (6%) | 64 (5%) |  |
| Other/Mixed | 98 (6%) | 235 (8%) | 81 (7%) |  |
| Age (years) | 9.78 (0.35) | 9.80 (0.36) | 9.78 (0.34) | 0.081 |
| FEV1 (z-score) | 0.17 (0.97) | 0.17 (0.99) | 0.14 (0.97) | 0.736 |
| FVC (z-score) | 0.21 (0.91) | 0.20 (0.97) | 0.19 (0.92) | 0.893 |
| FEV1/FVC (z-score) | -0.10 (0.96) | -0.09 (0.97) | -0.13 (0.96) | 0.448 |
| FEF25-75% (z-score) | 0.46 (1.10) | 0.46 (1.10) | 0.39 (1.07) | 0.216 |
| Preschool wheezing | 494 (35%) | 937 (37%) | 434 (39%) | 0.043 |
| School asthma, % | 69 (5%) | 147 (6%) | 52 (5%) | 0.220 |

\* Differences were calculated using Student’s t test for continuous normally distributed variables, Mann-Whitney U test for continuous non-normally distributed variables, and chi-square test for categorical variables.

**Table S8.** Distribution of exposures and outcomes across area-level SES quintiles.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Overall** | **Quintile 1 (least deprived)** | **Quintile 2** | **Quintile 3** | **Quintile 4** | **Quintile 5 (most deprived)** | **p-value** |
|  | n=5,605 | n=593 | n=646 | n=663 | n=616 | n=3,087 |
| NO2 | 38.48 (7.47) | 36.29 (8.41) | 40.05 (7.09) | 36.24 (6.90) | 40.54 (10.32) | 38.80 (6.72) | < 0.001 |
| PM2.5 | 19.72 (3.83) | 19.17 (3.77) | 20.01 (3.91) | 19.45 (3.39) | 20.05 (3.85) | 19.71 (3.84) | < 0.001 |
| Day evening and night noise, Lden | 54.00 (13.00) | 53.00 (10.00) | 52.00 (12.00) | 52.00 (9.00) | 58.00 (13.00) | 55.00 (14.00) | < 0.001 |
| Night noise, Ln | 45.00 (13.00) | 44.00 (10.00) | 44.00 (11.00) | 43.00 (8.00) | 48.00 (12.00) | 46.00 (14.00) | < 0.001 |
| Inverse distance to nearest road | 0.09 (0.05) | 0.08 (0.05) | 0.09 (0.06) | 0.08 (0.05) | 0.10 (0.05) | 0.09 (0.06) | < 0.001 |
| NDVI within 300 m buffer | 0.39 (0.14) | 0.48 (0.11) | 0.42 (0.09) | 0.49 (0.09) | 0.36 (0.18) | 0.35 (0.10) | < 0.001 |
| Size of nearest major blue space (>5000 m²) | 2.3 x 1010 (5.1 x 1010 ) | 2.3 x 1010 (1.8 x 1011) | 2.3 x 1010 (3.5 x 1011) | 1.6 x 1010 (3.8 x 1010) | 2.3 x 1010 (1.9 x 1010) | 2.1 x 1010 (5.0 x 1010) | < 0.001 |
| Building density within 300 m buffer | 4.6 x 105 (1.5 x 105) | 3.8 x 105 (1.9 x 105) | 4.6 x 105 (1.8 x 105) | 4 x 105 (1.3 x 105) | 4.6e x 105 (1.3 x 105) | 4.9 x 105 (1.4 x 105) | < 0.001 |
| FEV1 (z-score) | 0.16 (0.98) | 0.01 (0.94) | 0.11 (0.96) | 0.15 (0.95) | 0.16 (0.93) | 0.20 (1.00) | 0.001 |
| FVC (z-score) | 0.20 (0.94) | 0.09 (0.89) | 0.17 (0.92) | 0.22 (0.91) | 0.22 (0.90) | 0.22 (0.97) | 0.034 |
| FEV1/FVC (z-score) | -0.10 (0.96) | -0.19 (0.94) | -0.15 (0.96) | -0.15 (0.91) | -0.15 (0.93) | -0.05 (0.98) | 0.003 |
| FEF25-75% (z-score) | 0.45 (1.09) | 0.35 (1.09) | 0.45 (1.07) | 0.36 (1.10) | 0.47 (1.09) | 0.48 (1.10) | 0.035 |
| Preschool wheezing | 1865 (37%) | 230 (40%) | 265 (42%) | 238 (38%) | 195 (35%) | 930 (35%) | 0.009 |
| School asthma | 266 (6%) | 24 (4%) | 21 (4%) | 32 (5%) | 21 (4%) | 168 (7%) | 0.002 |

**Table S9.** Single-exposure associations between urban environment exposures during pregnancy and lung function including only children with reproducible spirometries (n=4,574).

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **FEV1** |  | **FVC** |  | **FEV1/FVC** |  | **FEF25-75%** |  |
|  | z-score change (95%CI) | p-value | z-score change (95%CI) | p-value | z-score change (95%CI) | p-value | z-score change (95%CI) | p-value |
| Air pollution |  |  |  |  |  |  |  |  |
| NO2 | 0.01 (-0.02, 0.04) | 0.564 | 0.00 (-0.03, 0.03) | 0.798 | 0.01 (0.66, 0.04) | 0.660 | -0.04 (-0.07, 0.00) | 0.027 |
| NOx | 0.00 (-0.03, 0.03) | 0.957 | 0.00 (-0.03, 0.03) | 0.847 | 0.00 (0.81, 0.03) | 0.807 | -0.02 (-0.05, 0.02) | 0.308 |
| PM10 | 0.03 (0.00, 0.06) | 0.034 | 0.04 (0.01, 0.06) | 0.007 | -0.01 (0.34, 0.01) | 0.342 | -0.06 (-0.10, -0.03) | 0.000 |
| PM25 | 0.04 (0.01, 0.06) | 0.009 | 0.04 (0.02, 0.07) | 0.002 | -0.01 (0.49, 0.02) | 0.486 | -0.06 (-0.09, -0.03) | 0.000 |
| PM25abs | 0.01 (-0.02, 0.04) | 0.620 | 0.01 (-0.02, 0.04) | 0.391 | -0.01 (0.40, 0.02) | 0.397 | -0.04 (-0.07, -0.01) | 0.016 |
| PMcoarse | 0.03 (0.00, 0.06) | 0.042 | 0.03 (0.00, 0.05) | 0.047 | 0.00 (0.83, 0.03) | 0.827 | -0.03 (-0.06, 0.00) | 0.037 |
| PM25cu | -0.01 (-0.04, 0.02) | 0.467 | -0.01 (-0.04, 0.02) | 0.454 | 0.00 (0.90, 0.03) | 0.900 | -0.03 (-0.06, 0.01) | 0.109 |
| PM25fe | -0.01 (-0.03, 0.02) | 0.687 | -0.01 (-0.04, 0.01) | 0.325 | 0.01 (0.31, 0.04) | 0.309 | -0.01 (-0.04, 0.02) | 0.571 |
| PM25k | -0.03 (-0.05, 0.00) | 0.062 | -0.02 (-0.04, 0.01) | 0.227 | -0.02 (0.16, 0.01) | 0.162 | -0.03 (-0.06, 0.01) | 0.109 |
| PM25si | 0.00 (-0.03, 0.03) | 0.877 | -0.02 (-0.04, 0.01) | 0.231 | 0.03 (0.06, 0.05) | 0.057 | 0.01 (-0.02, 0.05) | 0.345 |
| PM25zn | -0.02 (-0.05, 0.00) | 0.083 | -0.01 (-0.04, 0.01) | 0.323 | -0.02 (0.14, 0.01) | 0.138 | -0.03 (-0.06, 0.00) | 0.094 |
| Noise |  |  |  |  |  |  |  |  |
| Lden | 0.00 (-0.03, 0.02) | 0.816 | -0.01 (-0.04, 0.02) | 0.486 | 0.01 (0.48, 0.04) | 0.480 | 0.00 (-0.03, 0.03) | 0.912 |
| Night noise, Ln | 0.00 (-0.03, 0.03) | 0.863 | -0.01 (-0.03, 0.02) | 0.542 | 0.01 (0.52, 0.04) | 0.518 | 0.00 (-0.04, 0.03) | 0.775 |
| Traffic |  |  |  |  |  |  |  |  |
| Inverse distance to nearest road | 0.03 (0.00, 0.06) | 0.036 | 0.02 (0.00, 0.05) | 0.072 | 0.01 (0.64, 0.03) | 0.641 | 0.01 (-0.02, 0.04) | 0.421 |
| Green spaces |  |  |  |  |  |  |  |  |
| NDVI within 100 m buffer | 0.02 (-0.01, 0.05) | 0.202 | 0.01 (-0.01, 0.04) | 0.275 | 0.00 (0.80, 0.03) | 0.802 | 0.01 (-0.02, 0.04) | 0.710 |
| NDVI within 300 m buffer | 0.01 (-0.02, 0.03) | 0.599 | 0.01 (-0.02, 0.04) | 0.471 | 0.00 (0.73, 0.02) | 0.731 | -0.02 (-0.05, 0.01) | 0.220 |
| NDVI within 500 m buffer | 0.00 (-0.03, 0.03) | 0.904 | 0.00 (-0.02, 0.03) | 0.863 | 0.00 (0.90, 0.03) | 0.899 | -0.01 (-0.04, 0.02) | 0.472 |
| Size of nearest major green space (>5000 m²) | -0.01 (-0.04, 0.02) | 0.443 | -0.02 (-0.04, 0.01) | 0.209 | 0.01 (0.38, 0.04) | 0.384 | 0.00 (-0.04, 0.03) | 0.793 |
| Distance nearest major green space (>5000 m²) | -0.02 (-0.05, 0.01) | 0.170 | -0.01 (-0.03, 0.02) | 0.697 | -0.02 (0.16, 0.01) | 0.161 | -0.01 (-0.04, 0.02) | 0.647 |
| Blue spaces |  |  |  |  |  |  |  |  |
| Size of nearest major blue space (>5000 m²) | 0.03 (0.00, 0.06) | 0.053 | 0.02 (0.00, 0.05) | 0.100 | 0.01 (0.43, 0.04) | 0.426 | 0.03 (0.00, 0.06) | 0.073 |
| Distance nearest major blue space (>5000 m²) | -0.01 (-0.03, 0.02) | 0.674 | -0.01 (-0.04, 0.02) | 0.415 | 0.02 (0.21, 0.04) | 0.208 | 0.00 (-0.03, 0.03) | 0.991 |
| Built environment |  |  |  |  |  |  |  |  |
| Population density | 0.02 (0.00, 0.05) | 0.097 | 0.01 (-0.02, 0.03) | 0.655 | 0.03 (0.02, 0.06) | 0.024 | 0.01 (-0.02, 0.04) | 0.645 |
| Building density within 100 m buffer | -0.01 (-0.04, 0.01) | 0.325 | -0.01 (-0.03, 0.02) | 0.543 | 0.00 (0.87, 0.02) | 0.875 | -0.01 (-0.04, 0.02) | 0.618 |
| Building density within 300 m buffer | 0.01 (-0.01, 0.04) | 0.324 | 0.00 (-0.02, 0.03) | 0.720 | 0.02 (0.15, 0.05) | 0.153 | 0.01 (-0.02, 0.04) | 0.681 |
| Street connectivity within 300 m buffer | -0.01 (-0.03, 0.02) | 0.611 | -0.01 (-0.04, 0.02) | 0.528 | 0.00 (0.85, 0.02) | 0.855 | 0.00 (-0.03, 0.04) | 0.772 |
| Street connectivity within 100 m buffer | -0.02 (-0.05, 0.00) | 0.107 | -0.01 (-0.04, 0.02) | 0.393 | -0.02 (0.13, 0.01) | 0.131 | -0.01 (-0.04, 0.02) | 0.649 |
| Facilities density within 300 m buffer | 0.01 (-0.02, 0.03) | 0.682 | 0.00 (-0.03, 0.03) | 0.966 | 0.01 (0.41, 0.04) | 0.414 | -0.01 (-0.04, 0.02) | 0.449 |
| Facilities richness within 300 m buffer | 0.00 (-0.03, 0.03) | 0.906 | 0.00 (-0.03, 0.03) | 0.941 | 0.01 (0.58, 0.03) | 0.584 | -0.02 (-0.05, 0.01) | 0.269 |
| Land Use Mix (Shannon's Evenness Index) within 300 m buffer | 0.01 (-0.01, 0.04) | 0.369 | 0.02 (0.00, 0.05) | 0.070 | -0.03 (0.04, 0.00) | 0.042 | 0.02 (-0.01, 0.05) | 0.311 |
| Walkability | -0.01 (-0.03, 0.02) | 0.685 | 0.00 (-0.02, 0.03) | 0.842 | -0.02 (0.19, 0.01) | 0.186 | 0.00 (-0.04, 0.03) | 0.757 |

\*Models adjusted for maternal education, pre-pregnancy BMI, age, smoking during pregnancy, history of asthma or atopy, area-level SES, and child’s ethnicity and season of birth.

**Table S10.** Associations of urban exposure clusters during pregnancy with lung function including only children with reproducible spirometries (n=4,574) a.

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Cluster 1 (n=1,312)** | **Cluster 2**  **n=2,314** | **Cluster 3**  **n=948** |
|  |  | z-score change (95%CI) | z-score change (95%CI) |
| Lung function | *Reference* |  |  |
| FEV1 |  | -0.01 (-0.08, 0.05) | -0.06 (-0.14, 0.02) |
| FVC |  | -0.00 (-0.07, 0.06) | -0.043 (-0.11, 0.04) |
| FEV1/FVC |  | -0.01 (-0.07, 0.06) | -0.03 (-0.11, 0.05) |
| FEF25-75% |  | -0.02 (-0.09, 0.05) | -0.08 (-0.17, 0.00) |

a Associations are compared to the reference Cluster 1 (n=1,312).

Models were adjusted for maternal education, pre-pregnancy BMI, age, smoking during pregnancy, history of asthma or atopy, and child’s ethnicity and season of birth.

**Table S11.** Associations of urban exposure clusters during pregnancy with lung function, preschool wheezing, and school asthma excluding preterm and low birth weight born children (n=4,645)a.

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Cluster 1 n=1,508** | **Cluster 2**  **n=2,638** | **Cluster 3**  **n=1,118** |
|  |  | Estimate (95%CI) | Estimate (95%CI) |
| Lung function (z-score change) | *Reference* |  |  |
| FEV1 |  | -0.01 (-0.08, 0.05) | -0.04 (-0.12, 0.04) |
| FVC |  | -0.02 (-0.08, 0.04) | -0.03 (-0.11, 0.05) |
| FEV1/FVC |  | 0.02 (-0.04, 0.08) | -0.02 (-0.10, 0.06) |
| FEF25-75% |  | -0.02 (-0.10, 0.05) | -0.11 (-0.20, -0.02) |
| Wheezing and asthma (OR) | *Reference* |  |  |
| Preschool wheezing |  | 1.14 (0.99, 1.31) | 1.20 (1.01, 1.42) |
| School asthma |  | 1.27 (0.94, 1.75) | 1.03 (0.70, 1.53) |

a Associations are compared to the reference Cluster 1 (n=1,508).

Lung function models were adjusted for maternal education, pre-pregnancy BMI, age, smoking during pregnancy, history of asthma or atopy, and child’s ethnicity and season of birth. Wheezing and asthma models were additionally adjusted for child’s sex.

**Table S12.** Associations of urban exposure clusters during pregnancy with preschool wheezing present at 1 or ≥2 ages and by age from 1 to 5 yearsa.

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Cluster 1** | **Cluster 2** | **Cluster 3** |
|  |  | OR (95%CI) | OR (95%CI) |
| Preschool wheezing | *Reference* |  |  |
| Present at 1 age (vs never) |  | 1.13 (0.96, 1.34) | 1.23 (1.00, 1.50) |
| Present at ≥2 ages (vs never) |  | 1.12 (0.93, 1.35) | 1.20 (0.96, 1.50) |
| Preschool wheezing by age | *Reference* |  |  |
| 1 year |  | 1.02 (0.86, 1.22) | 1.07 (0.87, 1.32) |
| 2 years |  | 1.21 (0.98, 1.50) | 1.19 (0.93, 1.53) |
| 3 years |  | 0.95 (0.75, 1.20) | 0.97 (0.74, 1.28) |
| 4 years |  | 0.91 (0.73, 1.15) | 0.82 (0.62, 1.09) |
| 5 years |  | 1.07 (0.83, 1.38) | 1.03 (0.76, 1.40) |

a Associations are compared to the reference Cluster 1. Models were adjusted for maternal education, pre-pregnancy BMI, age, smoking during pregnancy, history of asthma or atopy, and child’s ethnicity, season of birth, and child’s sex.

b Sample size for preschool wheezing was 5041, at 1 year was 3687, at 2 years 3396, at 3 years 3730, at 4 years 3824, and at 5 years 4221.

**References**

1. Beelen R, Hoek G, Vienneau D, Eeftens M, Dimakopoulou K, Pedeli X, et al. Development of NO2 and NOx land use regression models for estimating air pollution exposure in 36 study areas in Europe - The ESCAPE project. Atmos Environ. 2013 Jun 1;72:10–23.

2. Eeftens M, Beelen R, De Hoogh K, Bellander T, Cesaroni G, Cirach M, et al. Development of land use regression models for PM2.5, PM 2.5 absorbance, PM10 and PMcoarse in 20 European study areas; Results of the ESCAPE project. Environ Sci Technol. 2012 Oct 16;46(20):11195–205.

3. EN Directive. Directive 2002/49/EC of the European Parliament and the European Parliament and of the Council of 25 June 2002 Relating to the Assessment and Management of Environmental Noise. 2002.

4. National Aeronautics and Space Administration. The Thematic Mapper | Landsat Science [Internet]. Available from: https://landsat.gsfc.nasa.gov/landsat-4-5/tm

5. Meirich S. Mapping guide for a European urban atlas - Google Scholar. GSE Land Information Services GSE Land Consortium. 2008;

6. European Commission. GHS-POP R2015A - GHS population grid, derived from GPW4, multitemporal (1975, 1990, 2000, 2015) [Internet]. Mapping and Assessment of Ecosystems and their Services. 2020. Available from: https://data.jrc.ec.europa.eu/dataset/jrc-ghsl-ghs\_pop\_gpw4\_globe\_r2015a

7. European Commission. Commission Regulation (EU) No 1089/2010 of 23 November 2010 implementing Directive 2007/2/EC of the European Parliament and of the Council as regards interoperability of spatial data sets and services. Official Journal of the European Union. 2010;

8. HERE WeGo [Internet]. Available from: https://wego.here.com/

9. Frank LD, Sallis JF, Conway TL, Chapman JE, Saelens BE, Bachman W. Many pathways from land use to health: Associations between neighborhood walkability and active transportation, body mass index, and air quality. Journal of the American Planning Association. 2006 Dec;72(1):75–87.