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## **Socioeconomic position and outdoor nitrogen dioxide (NO<sub>2</sub>) exposure in Western Europe: A multi-city analysis**

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1 Socioeconomic position and outdoor nitrogen dioxide (NO<sub>2</sub>) exposure in Western Europe: a  
2 multi-city analysis

3

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76

77

78 ABSTRACT

79 Background: Inconsistent associations between socioeconomic position (SEP) and outdoor air  
80 pollution have been reported in Europe, but methodological differences prevent any direct  
81 between-study comparison.

82 Objectives: Assess and compare the association between SEP and outdoor nitrogen dioxide  
83 (NO<sub>2</sub>) exposure as a marker of traffic exhaust, in 16 cities from eight Western European  
84 countries.

85 Methods: Three SEP indicators, two defined at individual-level (education and occupation)  
86 and one at neighborhood-level (unemployment rate) were assessed in three European  
87 multicenter cohorts. NO<sub>2</sub> annual concentration exposure was estimated at participants'  
88 addresses with land use regression models developed within the European Study of Cohorts  
89 for Air Pollution Effects (ESCAPE; <http://www.escapeproject.eu/>). Pooled and city-specific  
90 linear regressions were used to analyze associations between each SEP indicator and NO<sub>2</sub>.  
91 Heterogeneity across cities was assessed using the Higgins' I-squared test (I<sup>2</sup>).

92 Results: The study population included 5692 participants. Pooled analysis showed that  
93 participants with lower individual-SEP were less exposed to NO<sub>2</sub>. Conversely, participants  
94 living in neighborhoods with higher unemployment rate were more exposed. City-specific  
95 results exhibited strong heterogeneity (I<sup>2</sup>>76% for the three SEP indicators) resulting in  
96 variation of the individual- and neighborhood-SEP patterns of NO<sub>2</sub> exposure across cities.

97 The coefficients from a model that included both individual- and neighborhood-SEP  
98 indicators were similar to the unadjusted coefficients, suggesting independent associations.

99 Conclusions: Our study showed for the first time using homogenized measures of outcome  
100 and exposure across 16 cities the important heterogeneity regarding the association between  
101 SEP and NO<sub>2</sub> in Western Europe. Importantly, our results showed that individual- and  
102 neighborhood-SEP indicators capture different aspects of the association between SEP and

103 exposure to air pollution, stressing the importance of considering both in air pollution health  
104 effects studies.

105

106 Keywords: Europe, socioeconomic position, air pollution, environmental inequality

107

108 ABREVIATIONS

109 ECRHS: European Community Respiratory Health Survey

110 EGEA: French Epidemiological family-based study of the Genetics and Environment of  
111 Asthma

112 ESCAPE: European Study of Cohorts for Air Pollution Effects

113 LUR: land use regression

114 MAUP: modifiable area unit problem

115 NO<sub>2</sub>: Nitrogen dioxide

116 OC: occupational class

117 PM: Particulate matter

118 SAPALDIA: Swiss Cohort Study on Air Pollution and Lung and Heart Diseases in Adults

119 SEP: socioeconomic position

120 1. INTRODUCTION

121 Environmental inequality refers to a differential distribution of environmental hazards across  
122 socioeconomic or socio-demographic groups (1). Historically, research on environmental  
123 inequality has emerged in the United States (US) following the Environmental Justice  
124 Movement (2–5). Repeatedly, US studies reported that lower socioeconomic or minority  
125 groups were more likely to be exposed to higher traffic-related air pollution exposure such as  
126 nitrogen dioxide (NO<sub>2</sub>) or particulate matter (PM) (6). However, results from US studies  
127 cannot be extended to European countries because of very different socio-spatial  
128 characteristics, specifically in urban areas (7). For example, one of the main differences is that  
129 in general in most US cities, lower socioeconomic groups tend to live downtown when upper  
130 socioeconomic groups reside in the suburbs. In European cities, compared to US, social  
131 segregation is lower and lower socioeconomic groups rather live on the outskirts of the city  
132 (7).

133 In Europe, a rather limited number of studies compared to US had investigated the association  
134 between socioeconomic position (SEP) and air pollution, mainly in the UK first and then in  
135 other European countries (6,8). Inconsistent results have been reported in the European  
136 literature (9). Some studies reported that populations with low SEP are more exposed to  
137 outdoor air pollution (10–14) while other studies reported an inverse association (15–18).  
138 Nonlinear association (higher exposure in middle class) (19) and no association (20) were  
139 also reported. Inconsistent results were also reported within the same country, for instance in  
140 France or Spain (20–23). However, these studies were difficult to compare with each other  
141 because they used different methodologies to assess air pollution exposure or to define SEP  
142 (6,24). Moreover, most studies relied on ecological data that can raise methodological issues  
143 such as ecological fallacy, modifiable area unit problem (MAUP) or spatial autocorrelation  
144 (19,25). Few studies used individual-level data (i.e. air pollution exposure at residential

145 address and individual-level SEP) or multilevel data (i.e. SEP estimated at individual- and  
146 area-level) (15,17,26–30). Recent evidence showed the importance of considering SEP at both  
147 individual and area levels because they are independently associated with health outcomes  
148 (6,10,31–33).

149 More generally, the association between SEP and air pollution still needs to be investigated in  
150 Europe (6,24) as SEP is one of the major potential determinants of variability in the  
151 association between air pollution and health (2,34,35).

152 Within the framework of the multicenter European Study of Cohorts for Air Pollution Effects  
153 (ESCAPE) (36), we had the opportunity to tackle this research gap using outdoor NO<sub>2</sub> annual  
154 concentrations at participants' home addresses estimated from standardized procedures across  
155 a large range of European cities (36). The main objective of the present analysis was to test  
156 the environmental justice hypothesis that people with lower SEP (defined at both individual  
157 and neighborhood level) were more exposed to traffic related air pollution exposure than  
158 people with higher SEP in Western Europe.

159

## 160 2. MATERIALS AND METHODS

### 161 2.1. *Study population*

162 This cross-sectional study included participants of three multicenter epidemiological  
163 European cohorts that had previously collaborated together (37) and were involved in the  
164 ESCAPE study: the French Epidemiological family-based study of the Genetics and  
165 Environment of Asthma (EGEA2) (2003–2007) (38), and two population-based studies: the  
166 European Community Respiratory Health Survey (ECRHSII) (1999–2002) (39) and The  
167 Swiss Cohort Study on Air Pollution and Lung and Heart Diseases in Adults (SAPALDIA2)  
168 (2001–2003) (40). Details on each cohort are given elsewhere (38–40) and summarized in the



169 supplementary materials. For the three cohorts, information on participants were collected  
170 from detailed, standardized and validated questionnaires completed by face-to-face  
171 interviews.

172 Initially, the ESCAPE study included a subsample of the three cohorts (n=9556 participants,  
173 Figure 1) from 20 urban areas of eight Western European countries. Of these 20 areas, we  
174 were able to recover homogenized SEP data at individual and neighborhood level for 16  
175 (n=5692 participants: 4002, 1078 and 612 in ECRHS, EGEA and SAPALDIA respectively;  
176 Figure 1) including Norwich, Ipswich (Great Britain; GB); Antwerp (Belgium; BE); Paris,  
177 Lyon, Grenoble, Marseille (France; FR); Geneva, (Switzerland; CH); Verona, Pavia, Turin  
178 (Italy; IT); Oviedo, Galdakao, Barcelona, Albacete, Huelva (Spain; SP) (Figure S1). The  
179 areas covered by ESCAPE were of substantially different sizes (Table S1) with a range of  
180 density population from 152 to 21154 inhabitants/km<sup>2</sup> (41). Most of them could be defined as  
181 metropolitan areas (large cities with surrounding smaller suburban communities) but some  
182 areas were restricted to a single city (municipality). For purposes of clarity, we refer to these  
183 different areas as “cities”.

184

## 185 *2.2. NO<sub>2</sub> exposure assessment*

186 We considered nitrogen dioxide (NO<sub>2</sub>) as a marker of near-road traffic-related air pollution  
187 (42). The major sources of NO<sub>2</sub> are motorized road traffic, industry, shipping and heating  
188 (41). In the framework of ESCAPE, a single harmonized exposure assessment protocol has  
189 been developed to estimate the NO<sub>2</sub> annual concentrations. A common protocol described in  
190 detail in Beelen et al. was used to ensure high standardization of all procedures (i.e.  
191 measurement and estimation model) across the study areas (36). Briefly, in each city covered,  
192 two-week integrated NO<sub>2</sub> measurements at approximately 40 urban sites were made in three  
193 different seasons over a one-year period between 2008 and 2011. City-specific land use

194 regression (LUR) models (see supplementary materials) were developed to explain the spatial  
195 variation of NO<sub>2</sub> using a variety of geographical data including traffic, population and land  
196 use variables. The model explained variances ( $R^2$ ) of the LUR models ranged from 55% in  
197 Huelva to 92% in Pavia, 10 out of the 16 cities have a  $R^2$  above 75% (36). These LUR models  
198 were used to assign estimates of NO<sub>2</sub> annual average concentrations at each participant's  
199 geocoded residential address. Back-extrapolated estimates were also derived because  
200 ESCAPE measurement campaigns took place after the health surveys for the three cohorts  
201 (43). Correlations between back-extrapolated and non-back-extrapolated concentrations were  
202 high (Pearson correlation coefficient=0.95) so we only considered the non-back-extrapolated  
203 data in the present analysis.

204

### 205 *2.3. Markers of socioeconomic position*

206 We indexed SEP defined at two different levels:

#### 207 *2.3.1. Individual-level SEP*

208 We characterized individual-level SEP based on educational level and occupational class. For  
209 the three cohorts, educational level corresponded to the age at completion of full-time  
210 education. We categorized the continuous educational variable into country-specific tertiles  
211 (high, medium and low). Occupational class was based on the longest job held between  
212 baseline and follow-up (in average 10–12 years), and categorized in five classes according to  
213 the International Standard Classification of Occupation (ISCO-1988) (44): Manager and  
214 Professional (Occupational Class-I); Technician & associate (OC-II); Other non-manual (OC-  
215 III); Skilled, semi-skilled and unskilled manual (OC-IV) and “not in labor force”.

#### 216 *2.3.2. Neighborhood-level SEP*

217 To characterize the socioeconomic residential environment of the participants, we used the  
218 neighborhood unemployment rate (i.e. proportion of unemployed persons of the labor force).  
219 The neighborhood level corresponded to the smallest geographical level unit (with a  
220 population size ranging from 169 to 2000 inhabitants) with census-based data available in the  
221 different countries (see Table S2 for neighborhood specific characteristics). We obtained the  
222 unemployment rate variable from 2001 national censuses (except for France: 2008 and  
223 Switzerland: 2006). As the magnitude of the unemployment rate varied across European  
224 countries, we standardized it using country-specific z-scores to take this variability into  
225 account.

226

## 227 *2.4. Strategy of analysis*

### 228 *2.4.1. Main analyses*

229 The strategy of analysis aimed to test the hypothesis that the NO<sub>2</sub> annual concentration  
230 (dependent variable) differs according to the individual- and neighborhood- SEP of the  
231 participants (explanatory variables).

232 We performed analyses considering first the pooled dataset and then each city separately, due  
233 to the heterogeneity of the associations between SEP and air pollution among the cities  
234 (assessed with the Higgins' I-squared test ( $I^2$ ) (45)) We ran several multilevel linear  
235 regression models (Table S3) with neighborhood random effects (plus city random effects for  
236 the pooled dataset) including one individual SEP indicator (education or occupation) mutually  
237 adjusted for neighborhood unemployment rate. In the supplementary materials, we present the  
238 results for the single-level linear regression models that ignore the nested structure of the  
239 observations.

240 We transformed NO<sub>2</sub> using a natural log transformation to obtain a normally distributed  
241 variable. For ease of interpretation, we converted the regression coefficients ( $\beta$ s) into percent  
242 change (and 95% Confidence Interval (CI)) per one unit increase in the explanatory factor  
243 using the formula  $[\exp(\beta)-1]*100$  (a 95% CI which does not include zero indicates the  
244 presence of significant differences). The considered unit for unemployment rate was 1  
245 standard deviation (SD). For the individual-level SEP variables, we considered each subgroup  
246 and tested the statistical differences of the coefficients against the highest group (thus  
247 reference group were high educational level and OC-I for occupational class). We deliberately  
248 did not show results for participants who were not in the labor force as this class was too  
249 heterogeneous to draw any kind of conclusion (i.e. housepersons, unemployed, not working  
250 because of poor health, full-time student and retired). This category was excluded to assess  
251 the trend across the occupational groups.

#### 252 2.4.2. *Additional analyses*

253 We ran a sensitivity analysis using logistic regression models considering high vs. low  
254 exposure (high exposure was defined as an exposure above the 75th percentile of the  
255 distribution for each city). All models were adjusted for cohort, age and sex. We checked for  
256 potential interactions between SEP and sex, SEP and age and between individual- and  
257 neighborhood-level SEP (supplementary materials). Analyses were conducted using R  
258 statistical software (Version 3.0.3) and SAS 9.3.

259 As pointed out above some “cities” included in this analysis had a wide geographic coverage.  
260 For example, the city labelled “Paris” (FR) covered actually the metropolitan area of Paris-  
261 Region (i.e. 12,000 km<sup>2</sup>). Therefore, we ran a sensitivity analysis by examining more in detail  
262 this area: instead of considering participants of Paris in only one area, we considered three  
263 distinctive areas (i.e. City of Paris, the inner-suburbs and the outer-suburbs) defined by  
264 particular sociodemographic and geographic situations that could influence the association

265 between SEP and air pollution. The methods and results are presented in detail in the  
266 supplementary materials and discussed in the main article.

267

## 268 3. RESULTS

### 269 *3.1. Study population characteristics*

270 The study population (Table 1a) was composed of 48% males, with a mean age ( $\pm$ standard  
271 deviation;  $\pm$ SD) of 44 ( $\pm$ 11) years. Regarding the NO<sub>2</sub> distribution, we found substantial  
272 variability between cities with a mean ranging from 21 ( $\pm$ 5) (Pavia; IT) to 57 ( $\pm$ 14)  $\mu\text{g m}^{-3}$   
273 (Barcelona; ES). Substantial variability was also found within cities. The average range for  
274 NO<sub>2</sub> (difference between the highest and the lowest annual average) within each area was  
275 50.3  $\mu\text{g m}^{-3}$ . The largest variation for NO<sub>2</sub> was found in the two largest cities Paris (FR)  
276 (85.0) and Barcelona (SP) (92.8).

277 Regarding the socioeconomic characteristics of the population (Table 1b), participants  
278 completed their education on average at age 20 ( $\pm$ 4) years. The proportion of manual workers  
279 ranged from 6% (Paris; FR) to 38% (Galdakao; SP) and was generally higher in the Spanish  
280 cities. On average, participants with lower educational attainment were employed in less  
281 skilled occupations (p-value for trend  $<0.001$ ) (Table S4). The neighborhood unemployment  
282 rate varied from 3% (Pavia; IT) to 22% (Huelva; SP). Participants with lower educational  
283 attainment or less skilled occupations were more likely to live in neighborhoods with higher  
284 unemployment rate. However, the associations did not reach the level of significance in 7 and  
285 6 out of the 16 cities for education and occupation respectively (Tables S5a-S5b).

286

### 287 *3.2. Pooled results*

288 Pooled results are shown in Table 2. In the model taking into account only clustering within  
289 cities, low educational level and manual occupations were associated with a lower NO<sub>2</sub>

290 exposure (Percent difference (95% CI) Low vs. high educational level= -6.9% (-9.1; -4.7);  
291 OC-IV vs. OC-I=-5.6% (-8.2; -3.0)). Conversely, higher neighborhood unemployment rate  
292 was associated with higher NO<sub>2</sub> exposure (7.3% (6.2; 8.5) per 1 SD increase in the  
293 unemployment rate). The introduction of individual- and neighborhood-SEP in the same  
294 model did not substantially alter effect estimates (Low vs. High educational level= -8.7% (-  
295 10.8; -6.5) and 7.8% (6.7; 8.9) per 1 SD increase in the unemployment rate). Accounting for  
296 both city and neighborhood clustering decreased the effect size of both the individual- and  
297 neighborhood-SEP. Associations remained significant for educational level and the  
298 unemployment rate.

299

### 300 *3.3. City-specific results*

301 In the city-specific analyses using standard linear regression models (Table S4), associations  
302 with NO<sub>2</sub> were highly heterogeneous for all SEP indicators ( $I^2 > 76\%$ ,  $p < 0.001$ ). Using  
303 multilevel linear regression models, individual-SEP was weakly or not associated with NO<sub>2</sub>  
304 exposure for most cities (14 out of 16 cities). For educational level (Table 3a), significant  
305 associations were only found in Lyon (FR) (Low vs. High = -3.6 (-12.3; -5.9)) and Verona  
306 (IT) (-16.1 (-26.5; -4.3)). For occupational class (Table 3b), significant associations were  
307 found for the middle class in Paris (FR) (OC-III vs. OC-I= -3.3 (-6.4; -0.1) and Oviedo (-8.7  
308 (-15.7; -1.2). Living in a neighborhood with higher unemployment rate was associated with  
309 higher NO<sub>2</sub> exposure (regardless of the individual-SEP marker included in the model) in 11  
310 out of 16 cities. In Oviedo (ES) and Barcelona (ES) an inverse association was observed.

### 311 *3.4. Additional analyses*

312 Results from the logistic regression models (high vs. low exposure) were consistent with the  
313 linear regression ones for the educational level (Table S6a) as well for occupational class  
314 (Table S6b).

315 In Paris-Region (FR), when considering participants in three distinctive areas (i.e. city of  
316 Paris, inner suburbs and outer suburbs; supplementary materials), participants with lower  
317 educational level or occupational class were less exposed to air pollution (not significant) but  
318 those living in neighborhood with higher unemployment rate were more exposed. These  
319 results are consistent with those observed when considering participants in one area.

320

#### 321 4. DISCUSSION

322 We investigated, in three European cohorts, whether SEP evaluated at both individual- and  
323 neighborhood-level was associated with traffic related air pollution exposure across sixteen  
324 Western European cities. The pooled analyses masked important heterogeneity across the  
325 cities showing that city appeared to be the major predictor of the association between SEP and  
326 NO<sub>2</sub> exposure.

327 The associations between individual-SEP and NO<sub>2</sub> were generally weak and inconsistent  
328 across the cities. This is in accordance with those of the three studies that used a comparable  
329 approach to ours (17,20,46). Education and occupation showed the same pattern with NO<sub>2</sub> in  
330 the pooled data and in most cities, in the city specific analyses, showing that both indicators  
331 measured the same concept (47,48). The associations between neighborhood-SEP and NO<sub>2</sub>  
332 were in the opposite direction (higher exposure in lower neighborhood-SEP) compared to the  
333 individual-SEP variables, both in the pooled data and in most cities in the city-specific  
334 models. This has also been observed in other studies in Europe (30) and in Montreal, Canada  
335 (49).

336 One possible explanation for the difference in direction is that the neighborhood-SEP is  
337 capturing aspects beyond the SEP of the population living in that area, such as how  
338 industrialized the neighborhood may be. Moreover, NO<sub>2</sub> variability was relatively small  
339 across the individual-SEP groups, and after adjusting for neighborhood-SEP there was little  
340 evidence of potential confounding by individual-SEP. Place of residence is strongly patterned  
341 by social position and outdoor air pollution is spatially located within cities, therefore the  
342 degree to which air pollution is socially patterned is likely to occur more at area-level as well  
343 (33).

344 Accounting for both city and neighborhood clustering using a two level random intercept  
345 model drastically decreased the size effects of the associations for both individual- and area-  
346 SEP markers compared to the single level linear regression model (Table S7). This has been  
347 observed in other studies (30,35,50) showing the importance to accounting for clustering in  
348 analyses including spatially nested data. With the multilevel approach the effect of  
349 unemployment rate remained in all cities but the effect of the individual-SEP decreased and  
350 even became null for several cities showing that variability was mainly explained by the city  
351 first then by the neighborhoods and for a smaller part by the individual-SEP. We looked at  
352 some socioeconomic variables at city level (e.g. population density, gross domestic product,  
353 etc.) to try to explain the heterogeneity of the association between SEP and NO<sub>2</sub> among the  
354 cities using a meta-regression. However, none of the tested variables explained this  
355 heterogeneity (not shown).

356 To the best of our knowledge this is the first study including a large sample of cities  
357 geographically representative of Western Europe, with important within- and between-area  
358 variability of air pollution exposure. We used NO<sub>2</sub> as a traffic-related pollutant known to have  
359 a great intra-urban variability and thus was the most appropriate to study socioeconomic  
360 differences at individual-level (10,41,51). The NO<sub>2</sub> annual concentrations have been



361 estimated at participant's residential address with a single harmonized exposure assessment  
362 protocol across the cities. The measurement time of NO<sub>2</sub> does not overlap with the  
363 questionnaire data from the cohorts. However, we assume that spatial contrasts in outdoor  
364 NO<sub>2</sub> pollution were stable over time; an assumption supported from observations in different  
365 settings in European countries (52,53). We used homogenized SEP indicators at both  
366 individual- and neighborhood-level. Recent evidence showed the importance of accounting  
367 SEP at both levels because they were independently associated with health outcomes (32–  
368 34,46,54,55) but this had rarely been investigated with air pollution exposure (10,28,29). We  
369 used an area-based indicator defined at the smallest geographical unit available in each  
370 country to avoid MAUP as recommended (49,56–58).

371 Our study has some limitations. Due to data confidentiality, we did not have access to  
372 participants' geographical coordinates for the present analysis and we were not able to analyze  
373 their spatial distribution. We applied an aspatial multilevel model to take into account the  
374 clustering of the participants within neighborhoods (46,59) but the proportion of  
375 neighborhoods containing only one participant was relatively high in some cities (60). This  
376 highlights a common problem in studies that were not originally designed to study area-level  
377 determinants. We compared a large number of European cities, but the sample in some cities  
378 was quite small and could explain the absence of associations and large confidence intervals.  
379 The different areas were also of different sizes and with different population density.  
380 However, the additional analysis performed for the Paris-Region suggested that the results  
381 were not sensitive to this aspect.

382 We considered the unemployment rate, the sole indicator of neighborhood SEP uniformly  
383 available for most of the cities with ESCAPE NO<sub>2</sub> estimates. This single indicator does not  
384 fully describe participants' neighborhood-SEP (33) but has been used in other studies that  
385 compared different countries regarding air pollution (61) and has been associated with

386 adverse health outcomes neighborhood level (61–64). We performed additional analyses with  
387 country-specific deprivation indices that were available at neighborhood level only for 12 out  
388 of the 16 cities (65–68) and we found consistent results compared to the ones with the  
389 neighborhood unemployment rate (Table S8).

390 Finally, we did not have information on other type of exposures such as occupational and  
391 indoor exposures or time-activity patterns (69) which could contribute to create or reinforce  
392 environmental inequalities.

393

## 394 5. CONCLUSIONS

395 Unequal distribution to air pollution exposure according to SEP groups is complex in  
396 European cities and no general pattern exists across cities, but rather inequalities need to be  
397 specifically assessed in each city. Importantly, our results highlighted the importance of  
398 taking into account both individual- and neighborhood-SEP in order to fully describe and  
399 understand the complexity of current patterns of social inequalities relating to air pollution.

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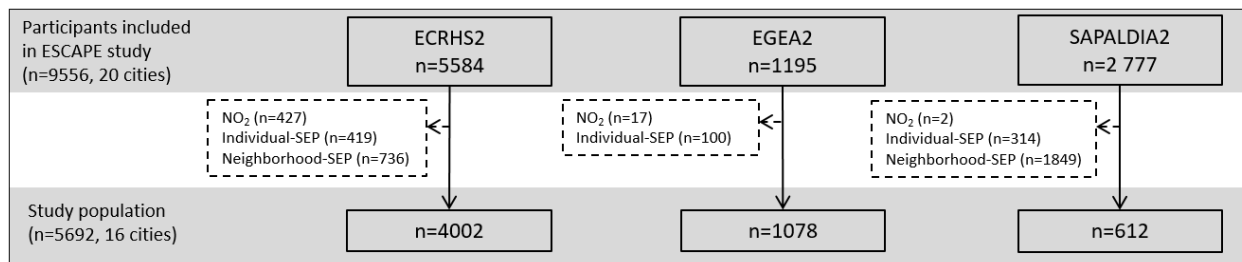
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- 603

604 Figure 1: Flow chart of the study population



605

606 Dotted frame: missing data

607 ESCAPE: European Study of Cohorts for Air Pollution Effects

608 ECRHS: European Community Respiratory Health Survey (1999-2002)

609 EGEA: Epidemiological study on Genetics and Environment of Asthma (2003-2007)

610 SAPALDIA: Swiss Cohort Study on Air Pollution and Lung and Heart Diseases in Adults (2001-2003)



611 Table 1a: Characteristics of the population (by city and data pooled)  
 612

City	Country	n	Sex	Age	NO <sub>2</sub> (µg*m <sup>-3</sup> )	
			Men, %	mean ±sd	mean ±sd	Q1 – Q3
Norwich <sup>a</sup>	UK	242	43.0	43.6 ±6.5	25.6 ±5.7	22.8 – 28.7
Ipswich <sup>a</sup>	UK	338	42.3	42.4 ±6.8	24.2 ±4.0	22.7 – 26.0
Antwerp <sup>a</sup>	Belgium	500	49.9	42.7 ±6.9	39.4 ±9.0	32.7 – 45.6
Paris <sup>a,b</sup>	France	785	48.3	41.7 ±12.9	36.4 ±13.4	27.4 – 42.6
Lyon <sup>a</sup>	France	210	46.7	48.4 ±15.3	28.7 ±13.5	16.9 – 40.6
Grenoble <sup>a,b</sup>	France	690	52.9	44.9 ±13.4	27.5 ±8.2	20.8 – 32.9
Marseille <sup>b</sup>	France	119	43.7	49.2 ±15.8	26.1 ±8.2	21.4 – 31.1
Geneva <sup>c</sup>	Switzerland	612	49.4	52.1 ±11.3	26.5 ±7.0	21.1 – 31.3
Verona <sup>a</sup>	Italy	179	44.1	42.6 ±7.1	30.7 ±13.8	22.6 – 40.2
Pavia <sup>a</sup>	Italy	188	53.7	44.2 ±6.6	20.5 ±4.8	17.6 – 21.8
Turin <sup>a</sup>	Italy	170	46.6	42.9 ±7.0	54.9 ±10.1	49.2 – 61.9
Oviedo <sup>a</sup>	Spain	315	49.8	42.9 ±7.1	36.6 ±12.5	29.3 – 43.9
Galdakao <sup>a</sup>	Spain	408	48.5	40.7 ±7.3	23.9 ±6.6	18.6 – 28.3
Barcelona <sup>a</sup>	Spain	284	44.4	41.9 ±7.1	57.4 ±14.1	49.6 – 62.4
Albacete <sup>a</sup>	Spain	419	46.8	40.8 ±7.3	28.6 ±14.8	19.5 – 38.1
Huelva <sup>a</sup>	Spain	233	50.2	41.1 ±7.2	25.2 ±6.4	20.6 – 29.8
Pooled data		5692	48.2	43.9 ±10.6	31.8 ±13.6	22.4 – 38.6

613 Cities are sorted from north to south.

614 Participants were from <sup>a</sup>ECRHS, <sup>b</sup>EGEA, <sup>c</sup>SAPALDIA; Paris: ECRHS n=386, EGEA n=399, Grenoble: ECRHS  
 615 n=350, EGEA n=340.

616 Table1b: Socioeconomic characteristics of the population (by city and data pooled)

City	n	Age at end of school mean $\pm$ SD	Individual-level SEP				Neighborhood-level SEP	
			Occupational Class, %				Unemployment rate*	
			Managers and Professionals (OC-I)	Technicians & Associate Professionals (OC-II)	Other non-manuals (OC-III)	Manuals (OC-IV)	<i>Not in labor force</i>	mean $\pm$ SD (min-max)
Norwich <sup>a</sup>	242	17.6 $\pm$ 3.1	25.6	19.4	27.3	24.0	3.7	11.1 $\pm$ 7.2 (2.1-34.1)
Ipswich <sup>a</sup>	338	17.1 $\pm$ 2.6	22.5	16.6	30.8	22.2	8.0	10.4 $\pm$ 6.6 (2.4-32.0)
Antwerp <sup>a</sup>	500	20.2 $\pm$ 3.1	33.0	18.6	31.0	16.8	0.7	8.2 $\pm$ 5.9 (0.8-31.2)
Paris <sup>a,b</sup>	785	21.3 $\pm$ 3.6	41.7	23.6	18.5	6.2	10.1	10.6 $\pm$ 4.0 (3.0-28.0)
Lyon <sup>a</sup>	210	19.5 $\pm$ 3.7	20.5	24.8	26.2	21.0	7.6	9.1 $\pm$ 3.8 (3.4-25.1)
Grenoble <sup>a,b</sup>	690	20.8 $\pm$ 3.8	37.5	20.1	17.4	13.9	11.0	9.8 $\pm$ 4.5 (3.4-31.3)
Marseille <sup>b</sup>	119	20.6 $\pm$ 3.4	46.2	20.2	14.3	9.3	10.1	12.1 $\pm$ 5.5 (4.9-35.0)
Geneva <sup>c</sup>	612	20.5 $\pm$ 4.3	32.4	20.4	24.8	11.4	11.0	4.3 $\pm$ 1.4 (0.7-9.1)
Verona <sup>a</sup>	179	19.0 $\pm$ 4.7	25.8	13.7	29.0	23.7	7.9	4.5 $\pm$ 3.0 (1.0-15.4)
Pavia <sup>a</sup>	188	18.7 $\pm$ 4.6	25.8	13.7	29.0	23.7	7.9	3.4 $\pm$ 2.5 (0.7-14.3)
Turin <sup>a</sup>	170	19.5 $\pm$ 5.2	21.6	13.1	36.4	22.1	6.8	7.4 $\pm$ 4.1 (1.4-21.7)
Oviedo <sup>a</sup>	315	19.3 $\pm$ 4.6	26.7	10.8	29.2	28.6	4.8	14.0 $\pm$ 3.0 (7.5-33.3)
Galdakao <sup>a</sup>	408	18.2 $\pm$ 4.1	17.9	8.6	25.3	37.7	10.5	10.7 $\pm$ 3.5 (3.1-21.9)
Barcelona <sup>a</sup>	284	18.8 $\pm$ 4.9	28.9	14.4	29.6	21.1	6.0	10.9 $\pm$ 3.3 (4.1-26.4)
Albacete <sup>a</sup>	419	17.7 $\pm$ 4.9	17.0	10.0	29.4	33.2	10.5	14.6 $\pm$ 5.3 (7.7-60.4)
Huelva <sup>a</sup>	233	18.0 $\pm$ 4.6	17.6	9.4	27.9	30.5	14.6	21.8 $\pm$ 6.7 (10.7-41.4)
Pooled data	5692	19.5 $\pm$ 4.3	29.1	17.0	25.6	19.6	8.7	10.0 $\pm$ 6.0 (0.7-60.4)

617 Cities are sorted from north to south

618 SD=standard deviation

619 Participants were from <sup>a</sup> ECRHS, <sup>b</sup> EGEA, <sup>c</sup> SAPALDIA; Paris: ECRHS n=386, EGEA n=399, Grenoble: ECRHS n=350, EGEA n=340

620 OC= Occupational class. Not in labor force participants (in italics) included unemployed, retired, housepersons and students

621 \* The neighborhood unemployment rate has been assigned individually to participants using their residential addresses.

622 Table 2: Pooled results for the association between NO<sub>2</sub> concentration (µg\*m-3) and SEP markers (n=5692) in percent change (95%CI)

			Multilevel model with city at level*			Multilevel model with neighborhood (level 2) and city (level 3)†		
			Adjusted for individual factors	Mutually adjusted for individual and neighborhood SEP		Adjusted for individual factors	Mutually adjusted for individual and neighborhood SEP	
Individual-level SEP								
Educational level	High (ref)	1917	-	-	-	-	-	-
	Medium	2001	-4.5 (-6.6; -2.3)	-5.1 (-7.1; -3.0)	-	-1.3 (-2.7; -0.2)	-1.3 (-2.7; 0.2)	-
	Low	1774	-6.9 (-9.1; -4.7)	-8.7 (-10.8; -6.5)	-	-1.7 (-3.2; -0.1)	-1.8 (-3.3; -0.2)	-
	p-value for trend‡		<0.0001	<0.0001		0.04	0.03	
Occupational class								
	OC-I (ref)	1657	-	-	-	-	-	-
	OC-II	967	-2.6 (-5.3; 0.2)	-2.7 (-5.4; 0.01)		1.0 (-0.8; 2.9)	1.0 (-0.8; 2.9)	
	OC-III	1457	-1.0 (-3.5; 1.6)	-2.0 (-4.1; 0.5)		-0.6 (-2.3; 1.0)	-0.7 (-2.3; 1.0)	
	OC-IV	1118	-5.6 (-8.2; -3.0)	-7.9 (-10.4; -5.3)		-0.6 (-2.5; 1.2)	-0.8 (-2.6; 1.1)	
	p-value for trend‡		0.001	<0.0001		0.03	0.03	
Neighborhood-level SEP								
	Unemployment rate§	5692	7.3 (6.2; 8.5)	7.8 (6.7; 8.9)¶	7.7 (6.6; 8.8)#	3.33 (0.71; 6.01)	3.2 (1.5; 5.0)¶	3.3 (1.5; 5.1)#

623 \* A multilevel model was performed with city at level-2 (random intercept for city level).

624 † A multilevel model was performed with neighborhood at level-2 and city at level-3 (random intercept for city and neighborhood levels).

625 ‡ The unemployment rate has been transformed in z-score, the change in NO<sub>2</sub> is showed for 1 standard deviation.

626 ¶ Mutually adjusted for educational level and neighborhood unemployment rate.

627 # Mutually adjusted for occupational class and neighborhood unemployment rate.

628 All models are adjusted for cohort, age and sex.

629 Results are expressed in percent change in NO<sub>2</sub> (µg\*m-3) concentration adjusted for cohort, age, sex. Negative value means a decrease in NO<sub>2</sub> (in percent) compared to the  
630 reference class for categorical variable and for 1SD increase for the continuous variable; p-value for trend were calculated by introducing the categorical variables in  
631 continuous.

632 Occupational class (OC): OC-I: Managers and Professionals, OC-II: Technician and associate professionals, OC-III: other non-manuals, OC-IV: skilled, semi-skilled and  
633 unskilled manual.

634 Table 3a: Percent change (95%CI) in NO<sub>2</sub> concentration (µg\*m-3) in association to educational level mutually adjusted for neighborhood  
 635 unemployment rate (n=5692)

City	n	Educational level (ref=high)			P-value for trend	Neighborhood Unemployment rate*
		Medium	Low			
Norwich	242	-0.9 (-5.7; 4.3)	-1.1 (-7.7; 6.0)	0.71	9.4 (5.1; 13.8)	
Ipswich	338	2.0 (-0.6; 4.7)	0.5 (-2.8; 3.8)	0.69	4.9 (1.0; 8.9)	
Antwerp	500	0.6 (-2.2; 3.4)	1.2 (-1.9; 4.3)	0.45	14.9 (11.8; 18.2)	
Paris	785	0.1 (-2.6; 2.9)	-0.3 (-3.1; 2.6)	0.84	13.7 (9.7; 17.8)	
Lyon	210	-9.4 (-17.0; -0.9)	-3.6 (-12.3; -5.9)	0.58	12.6 (2.2; 24.0)	
Grenoble	690	0.5 (-2.1; 3.0)	0.8 (-1.9; 3.7)	0.56	9.3 (5.1; 13.7)	
Marseille	119	-1.9 (-10.4; 7.3)	-7.1 (-16.1; 2.9)	0.13	12.1 (7.1; 17.4)	
Geneva	612	-2.0 (-4.5; 0.6)	-1.8 (-4.4; 0.9)	0.18	9.5 (4.7; 14.6)	
Verona	179	-0.9 (-15.8; 16.8)	-16.1 (-26.5; -4.3)	0.01	14.0 (3.6; 25.3)	
Pavia	188	0.1 (-4.2; 4.6)	-1.4 (-5.4; 2.6)	0.48	2.6 (-1.0; 6.4)	
Turin	170	2.8 (-5.9; 12.3)	5.9 (-3.9; 16.6)	0.22	2.3 (-1.4; 6.1)	
Oviedo	315	-0.4 (-7.2; 7.0)	-5.0 (-12.3; 3.0)	0.25	-14.1 (-23.6; -3.3)	
Galdakao	408	-1.3 (-5.1; 2.8)	-3.3 (-7.8; 1.5)	0.18	21.8 (14.1; 30.1)	
Barcelona	284	3.3 (-2.7; 9.7)	3.7 (-3.3; 11.2)	0.28	-7.7 (-12.7; -2.4)	
Albacete	419	-10.3 (-21.1; 1.9)	-8.4 (-18.4; 2.9)	0.11	-7.9 (-17.5; 2.9)	
Huelva	233	-1.0 (-6.1; 4.3)	-2.6 (-8.5; 3.6)	0.39	1.9 (-2.3; 6.4)	

636 Cities are sorted from north to south.

637 A multilevel linear regression model (PROC MIXED) was performed with neighborhood at level-2 (random intercept for neighborhood level); adjusted for cohort, age and  
 638 sex.

639 Results are expressed in percent change in NO<sub>2</sub> (µg\*m-3) concentration. Negative value means a decrease in NO<sub>2</sub> (in percent) compared to the reference class for the  
 640 categorical variable; p-value for trend were calculated by introducing the categorical variables in continuous. The unemployment rate has been transformed in z-score, the  
 641 change in NO<sub>2</sub> is showed for 1 standard deviation.

642 Table 3b: Percent change (95%CI) in NO<sub>2</sub> concentration (µg\*m-3) in association to occupational class mutually adjusted for neighborhood  
 643 unemployment rate (n=5692)

City	n	Occupational class (ref=OC-I)			P-value for trend	Neighborhood Unemployment rate*
		OC-II	OC-III	OC-IV		
Norwich	242	-0.1 (-6.1; 6.2)	0.1 (-6.1; 6.7)	4.9 (-1.5; 11.8)	0.45	9.7 (5.3; 14.3)
Ipswich	338	2.3 (-1.2; 5.8)	1.6 (-1.4; 4.7)	0.6 (-2.5; 3.7)	0.99	5.0 (1.2; 9.1)
Antwerp	500	0.9 (-2.5; 4.4)	1.6 (-1.4; 4.6)	-1.7 (-5.0; 1.7)	0.63	15.1 (11.9; 8.3)
Paris	785	-2.3 (-5.0; 0.6)	-3.3 (-6.4; -0.01)	-4.8 (-9.5; 0.1)	0.03	13.7 (9.7; 17.8)
Lyon	210	3.2 (-5.7; 12.9)	-3.9 (-12.5; 5.5)	-2.1 (-11.7; 8.6)	0.78	13.0 (2.5; 24.6)
Grenoble	690	1.8 (-1.1; 4.8)	1.1 (-2.1; 4.3)	3.1 (-0.4; 6.7)	0.20	9.1 (4.9; 13.5)
Marseille	119	-8.6 (-16.6; 0.1)	-6.9 (-15.2; 2.2)	-4.8 (-15.8; 7.7)	0.07	12.1 (7.0; 17.3)
Geneva	612	1.7 (-1.3; 4.8)	-1.0 (-3.7; 1.9)	-0.7 (-4.1; 2.8)	0.72	9.3 (4.4; 14.3)
Verona	179	1.9 (-20.8; 31.0)	-2.7 (-18.3; 15.8)	-12.9 (-28.1; 5.4)	0.07	13.3 (2.9; 4.7)
Pavia	188	-2.6 (-8.2; 3.4)	-3.7 (-7.8; 0.7)	-2.5 (-7.6; 2.8)	0.17	2.7 (-0.9; 6.4)
Turin	170	9.5 (-3.6; 24.4)	9.6 (-0.6; 20.8)	11.7 (-0.1; 25.0)	0.07	2.3 (-1.3; 6.1)
Oviedo	315	0.8 (-9.5; 12.3)	-8.7 (-15.7; -1.2)	-5.9 (-13.2; 2.1)	0.07	-13.7 (-23.6; -2.8)
Galdakao	408	3.9 (-3.1; 11.4)	3.6 (-1.6; 9.0)	3.3 (-1.8; 8.6)	0.67	21.4 (13.6; 29.6)
Barcelona	284	3.4 (-4.8; 12.2)	3.4 (-2.8; 10.1)	4.1 (-2.6; 11.2)	0.16	-7.7 (-12.7; -2.5)
Albacete	419	-3.7 (-18.2; 13.5)	-6.1 (-18.2; 7.8)	-4.6 (-16.5; 9.1)	0.34	-8.3 (-18.0; 2.6)
Huelva	233	8.5 (-0.1; 17.9)	4.1 (-2.1; 10.8)	6.8 (0.1; 13.8)	0.15	1.0 (-3.2; 5.3)

644 Cities are sorted from north to south.

645 A multilevel linear regression model (PROC MIXED) was performed with neighborhood at level-2 (random intercept for neighborhood level); adjusted for cohort, age and  
 646 sex. Results are expressed in percent change in NO<sub>2</sub> (µg\*m-3) concentration. Negative value means a decrease in NO<sub>2</sub> (in percent) compared to the reference class for the  
 647 categorical variable; p-value for trend were calculated by introducing the categorical variables in continuous. The unemployment rate has been transformed in z-score, the  
 648 change in NO<sub>2</sub> is showed for 1 standard deviation.

649 Occupational class (OC): OC-I: Managers and Professionals (ref), OC-II: Technicians and associate professionals, OC-III: other non-manuals, OC-IV: skilled, semi-skilled  
 650 and unskilled manual. P-value for trend were calculated by introducing the categorical variables in continuous.

651

## Supplementary materials

Socioeconomic position and outdoor nitrogen dioxide (NO<sub>2</sub>) exposure in Western Europe: a multi-city analysis

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## Methods

### Study population

ECRHS is a population-based cohort study. About 18,000 young adults aged 20-44 were recruited mainly across Europe in 1991 – 1993 (ECRHS I) and 10,364 participated to the first follow-up (ECRHS II) between 1999 – 2002. 4738 follow-up participants were included in the ESCAPE project from Umea (Sweden), Norwich, Ipswich (United Kingdom); Erfurt (Germany); Antwerp (Belgium); Paris-Region, Grenoble (France); Verona, Pavia, Turin (Italy); Oviedo, Galdakao, Barcelona, Albacete, Huelva (Spain) (Jarvis & ECRHS 2002).

EGEA is a French case-control and family-based study including 2047 participants aged 7-65 recruited between 1991 – 1995 (EGEA1). At the first follow-up (EGEA2), 1922 participants provided a questionnaire between 2003 – 2007. 1078 follow-up participants were included in the ESCAPE project from Paris-Region, Grenoble, Lyon and Marseille (Siroux et al. 2011).

SAPALDIA is a cohort study in Switzerland. In 1991, 9651 participants aged 20-65 were recruited for a detailed interview and health examination (SAPALDIA1). The follow-up (SAPALDIA2) was conducted in 2001-2003 at which 8047 participants provided health information. 2461 follow-up participants were included in the ESCAPE project from Basel, Geneva and Lugano (Ackermann-Lieblich et al. 2005).

### NO<sub>2</sub> exposure assessment

Definition of the Land-use regression (LUR) methods: a LUR combines monitoring of air pollution at a small number of locations and development of stochastic models using predictor variables usually obtained through geographic information systems (GIS). The model is then applied to a large number of unsampled locations in the study area (Hoek et al. 2008). To avoid the exaggerated influence of a high NO<sub>2</sub> point in the models validation process, the predictor variables were truncated. All the details of the development of the models are described in a previous publication (Beelen et al. 2013) and more general information on LUR can be found in Hoek et al. 2008.

Figure S1 Study areas (in brackets: number of participants including in the present analysis)

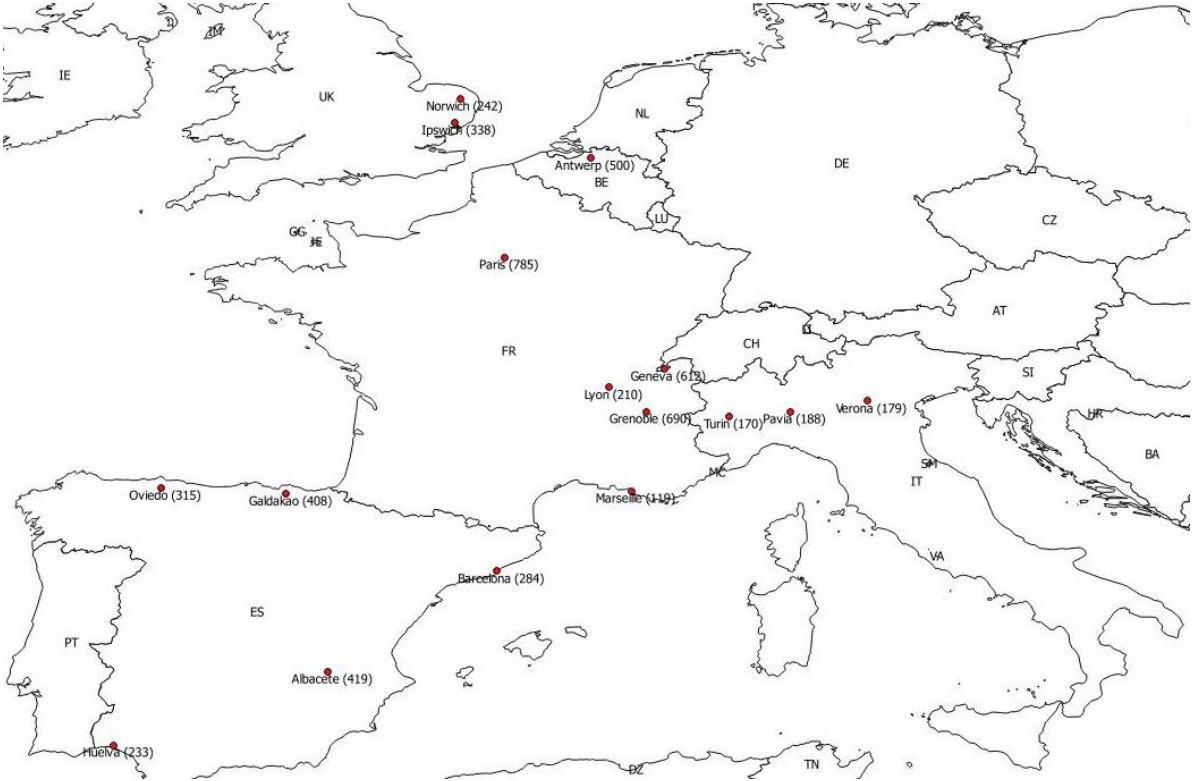


Table S1 Description of the study areas and population density

Study area	Country	Study area description; major city	Population density of the major city (inhabitants/km <sup>2</sup> )
Norwich	United Kingdom	Norwich and surrounding areas	4 129
Ipswich	United Kingdom	Ipswich and surrounding areas	3 247
Antwerp	Belgium	Antwerp and surrounding areas	2 479
Paris	France	Paris and suburban areas	21 154
Lyon	France	Lyon and suburban areas	10 460
Grenoble	France	Grenoble and suburban areas	8 837
Marseille	France	Marseille city	3 555
Geneva	Switzerland	Geneva city and surrounding smaller towns	12 628
Verona	Italy	City of Verona and surrounding areas	1 277
Pavia	Italy	City of Pavia and surrounding areas	1 147
Turin	Italy	Turin city and five smaller municipalities	6 902
Oviedo	Spain	Oviedo city	1 186
Galdakao	Spain	Galdakao and surrounding smaller towns	923
Barcelona	Spain	Barcelona city	15 982
Albacete	Spain	Albacete city	152
Huelva	Spain	Huelva city	987

Adapted from Cyrus et al., *Atmospheric Environment*, 2012 (Cyrus et al. 2012)

Table S2: Definition of neighborhood and distribution of the study population by neighborhood and city

City	Type of neighborhood (average population size)	Study participants by neighborhood mean (min-max)	Neighborhoods with one participant (%)
Norwich	LSOA <sup>a</sup> (1200)	2.3 (1 – 6)	18
Ipswich		3.0 (1 – 11)	11
Antwerp	Statistical sector (670)	2.1 (1 – 9)	27
Paris		1.9 (1 – 10)	37
Lyon		2.1 (1 – 10)	25
Grenoble		4.6 (1 – 16)	4
Marseille		1.7 (1 – 6)	35
Geneva	Sous-secteur (2000)	4.0 (1 – 18)	25
Verona	Sezione di censimento (169)	1.1 (1 – 3)	80
Pavia		1.4 (1 – 7)	56
Turin		1.0 (1 – 2)	89
Oviedo	Secciones censales (1000)	2.4 (1 – 8)	14
Galdakao		2.6 (1 – 12)	14
Barcelona		1.1 (1 – 3)	77
Albacete		4.3 (1 – 13)	2
Huelva		2.7 (1 – 8)	8

<sup>a</sup> Lower layer Super Output Area

<sup>b</sup> IRIS is a French acronym for ‘aggregated units for statistical information’.

Table S3 Description of the main analysis

Model	Type of linear regression	Random effect	SEP	Table (column)
<b>Pooled data</b>				
Model 1	Multi-level	City	Each SEP indicator separately	2 (1)
Model 2			Education level mutually adjusted for unemployment	2 (2)
Model 3			Occupation class mutually adjusted for unemployment	2 (3)
Model 4	Multi-level	City + neighborhood	Each SEP indicator separately	2 (4)
Model 5			Education level mutually adjusted for unemployment	2 (5)
Model 6			Occupation class mutually adjusted for unemployment	2 (6)
<b>City-specific</b>				
Model 7	Multi-level	Neighborhood	Education level mutually adjusted for unemployment	3a
Model 8			Occupation class mutually adjusted for unemployment	3b
Model 9	Single-level	-	Each SEP indicator separately	S6

## Results

### Supplementary analysis

We found an interaction between education and unemployment for only 4 cities (Norwich, Antwerp, Verona and Paris). We found an interaction between occupational class and sex only in Pavia (women in lower occupational class were more exposed than men). Finally, we found an interaction between unemployment and age in Grenoble (younger participants living in neighborhoods with higher unemployment rate were more exposed to NO<sub>2</sub>) and in Huelva (only older participants living in neighborhoods with higher unemployment were exposed to NO<sub>2</sub>).

Table S4: Mean age at completed education by occupational class (crude)

Cities	N	Occupational class				
		OC-I	OC-II	OC-III	OC-IV	Not in labor force*
Norwich	242	20.0	18.0	16.6	16.0	16.0
Ipswich	338	18.7	18.6	16.2	15.9	16.1
Antwerp	539	21.8	20.9	19.6	17.5	16.5
Paris	785	23.0	20.9	19.1	18.2	20.8
Lyon	210	22.3	20.2	18.9	16.3	20.0
Grenoble	690	23.2	20.5	19.0	17.5	20.1
Marseille	119	22.5	19.6	18.8	16.7	19.7
Geneva	612	23.0	21.0	18.9	17.4	19.1
Verona	179	22.5	21.4	18.6	16.3	16.4
Pavia	190	21.8	20.6	18.4	15.2	17.4
Turin	176	23.4	21.9	18.6	17.1	14.8
Oviedo	315	21.5	21.5	19.8	16.5	16.2
Galdakao	408	22.0	20.0	18.6	16.6	15.1
Barcelona	284	21.8	19.7	17.9	16.1	16.2
Albacete	419	20.9	19.8	18.7	15.7	14.5
Huelva	233	22.0	19.0	18.6	16.1	15.4
Pooled cities	5692	22.2	20.4	18.6	16.5	17.8

Occupation class (OC): OC-I: Managers and Professionals, OC-II: Technicians and associate professionals, OC-III: other non-manuals, OC-IV: skilled, semi-skilled and unskilled manual.

\*Category “not in the labor force” was excluded to calculate the p-value for trend.

All p-values for trend across the occupational classes were significant ( $p < 0.0001$ )

Table S5a: Mean unemployment rate (%) by education level (crude)

	n	High	Medium	Low	P-value for trend
Norwich	242	10.0	10.6	13.9	0.004
Ipswich	338	8.1	10.8	12.1	<0.0001
Antwerp	500	8.4	7.2	9.0	0.41
Paris	785	10.3	10.3	11.1	0.05
Lyon	210	9.4	9.1	8.9	0.47
Grenoble	690	9.6	9.6	10.1	0.21
Marseille	119	12.8	11.3	12.3	0.74
Geneva	612	4.1	4.3	4.6	<0.0001
Verona	179	4.4	4.9	4.5	0.89
Pavia	188	3.3	3.6	3.3	0.99
Turin	170	6.1	8.0	8.4	0.001
Oviedo	315	13.5	14.2	14.6	0.01
Galdakao	408	10.5	10.6	10.9	0.27
Barcelona	284	10.3	10.8	11.9	0.001
Albacete	419	13.3	14.5	15.4	0.001
Huelva	233	18.9	22.1	24.1	<0.0001
Pooled cities	5692	9.4	10.1	10.7	<0.0001

The neighborhood unemployment rate has been assigned individually to participants using their residential addresses.



Table S5b: Mean unemployment rate (%) by occupational class (crude)

Cities	N	Occupational class				Not in labor force*	P-value for trend
		OC-I	OC-II	OC-III	OC-IV		
Norwich	242	8.9	9.2	13.4	12.6	10.6	0.0002
Ipswich	338	9.1	8.9	10.7	11.1	13.9	0.02
Antwerp	500	8.0	6.9	8.3	9.7	7.3	0.03
Paris	785	10.6	10.5	10.9	11.1	9.0	0.36
Lyon	210	9.5	9.2	9.5	7.7	9.8	0.06
Grenoble	690	9.4	9.6	9.8	11.6	10.0	0.0003
Marseille	119	12.2	10.9	12.8	13.2	11.6	0.66
Geneva	612	4.1	4.3	4.4	4.8	4.5	0.0001
Verona	179	4.8	4.8	4.9	3.5	4.5	0.15
Pavia	188	3.2	3.8	3.0	3.7	3.5	0.69
Turin	170	6.8	6.6	7.5	8.1	8.2	0.12
Oviedo	315	13.2	13.6	13.8	15.0	14.8	0.0002
Galdakao	408	10.1	10.7	10.6	11.2	10.0	0.04
Barcelona	284	10.2	10.3	10.4	11.6	11.3	0.004
Albacete	419	13.4	13.7	13.8	16.0	14.7	0.0005
Huelva	199	18.5	20.1	20.9	24.8	22.5	<0.0001
Pooled cities	5692	9.2	9.1	10.1	11.8	10.1	<0.0001

Occupation class (OC): OC-I: Managers and Professionals, OC-II: Technicians and associate professionals, OC-III: other non-manuals, OC-IV: skilled, semi-skilled and unskilled manual.

The neighborhood unemployment rate has been assigned individually to participants using their residential addresses.

\*Category “not in the labor force” was excluded to calculate the p-value for trend.

Table S6a: Odd ratios (OR) for high exposure (95% CI) in association to educational level mutually adjusted for neighborhood unemployment rate (n=5692)

City	n	Educational level (ref=high)			Neighborhood Unemployment*
		Medium	Low	P-value for trend	
Norwich	242	0.45 (0.21; 1.00)	0.44 (0.17; 1.15)	0.05	1.59 (1.11; 2.62)
Ipswich	338	1.04 (0.49; 2.18)	0.57 (0.19; 1.67)	0.36	1.21 (0.78; 1.86)
Antwerp	500	0.72 (0.40; 1.31)	0.69 (0.36; 1.32)	0.23	3.68 (2.49; 5.44)
Paris	785	1.00 (0.64; 1.55)	0.47 (0.29; 0.75)	0.002	1.33 (1.04; 1.69)
Lyon	210	0.49 (0.20; 1.17)	0.37 (0.14; 0.95)	0.04	1.95 (1.07; 3.56)
Grenoble	690	0.83 (0.42; 1.63)	0.51 (0.30; 0.89)	0.64	1.63 (1.17; 2.26)
Marseille	119	0.57 (0.15; 2.14)	0.20 (0.04; 0.96)	0.05	2.19 (1.23; 3.88)
Geneva	612	0.80 (0.42; 1.51)	0.87 (0.48; 1.56)	0.62	1.60 (1.04; 2.45)
Verona	179	0.60 (0.23; 1.54)	0.23 (0.08; 0.68)	0.009	1.38 (0.96; 2.00)
Pavia	188	0.65 (0.29; 1.44)	0.35 (0.15; 0.81)	0.02	1.37 (0.89; 2.09)
Turin	170	0.68 (0.24; 1.91)	1.41 (0.51; 3.89)	0.55	1.03 (0.68; 1.56)
Oviedo	315	0.77 (0.45; 1.32)	0.36 (0.16; 0.83)	0.02	0.52 (0.27; 1.01)
Galdakao	408	0.75 (0.41; 1.38)	0.49 (0.24; 0.97)	0.04	2.80 (1.53; 5.11)
Barcelona	284	0.87 (0.45; 1.69)	0.77 (0.35; 1.68)	0.48	0.53 (0.29; 0.95)
Albacete	419	0.74 (0.39; 1.42)	0.63 (0.31; 1.28)	0.21	0.39 (0.22; 0.72)
Huelva	233	1.16 (0.49; 2.75)	0.65 (0.20; 2.09)	0.43	2.06 (1.16; 3.65)

Cities are sorted from north to south.

A multilevel logistic regression model (PROC GLIMMIX) was performed with neighborhood at level-2 (random intercept for neighborhood level); adjusted for cohort, age, sex. High exposure (reference category) was defined as a concentration above the 75th percentile of the distribution by cities; p-value for trend were calculated by introducing the categorical variables in continuous.

Table S6b: Odd ratios (OR) for high exposure (95% CI) in association to occupational class mutually adjusted for neighborhood unemployment rate (n=5692)

City	n	Occupational class (ref=OC-I)			P-value for trend	Neighborhood Unemployment t <sub>00</sub>
		OC-II	OC-III	OC-IV		
Norwich	242	1.02 (0.39; 2.68)	0.43 (0.16; 1.12)	0.42 (0.15; 1.20)	0.09	1.71 (1.17; 2.51)
Ipswich	338	1.91 (0.79; 4.62)	1.23 (0.54; 2.81)	0.81 (0.17; 1.50)	0.27	1.23 (0.81; 1.86)
Antwerp	500	1.00 (0.49; 2.04)	1.23 (0.75; 2.03)	0.45 (0.18; 1.08)	0.34	3.96 (2.65; 5.90)
Paris	785	0.91 (0.58; 1.41)	0.88 (0.53; 1.46)	0.68 (0.30; 1.56)	0.24	1.33 (1.04; 1.69)
Lyon	210	0.41 (0.16; 1.08)	0.42 (0.16; 1.11)	0.45 (0.15; 1.36)	0.65	1.94 (1.05; 3.59)
Grenoble	690	1.19 (0.66; 2.15)	0.89 (0.44; 1.81)	1.07 (0.50; 2.27)	0.75	1.60 (1.15; 2.23)
Marseille	119	0.43 (0.10; 1.77)	0.06 (0.01; 0.48)	0.50 (0.10; 2.64)	0.08	2.40 (1.34; 4.31)
Geneva	612	0.93 (0.45; 1.92)	0.88 (0.45; 1.73)	0.55 (0.28; 1.12)	0.68	1.62 (1.06; 2.48)
Verona	179	1.31 (0.38; 4.49)	1.07 (0.38; 3.03)	0.14 (0.03; 0.83 )	0.06	1.28 (0.87; 1.87)
Pavia	188	1.58 (0.59; 4.21)	0.25 (0.10; 0.65)	0.22 (0.07; 0.69)	0.004	1.36 (0.88; 2.10)
Turin	170	0.34 (0.06; 1.93)	0.84 (0.29; 2.45)	0.83 (0.24; 2.86)	0.84	1.02 (0.70; 1.49)
Oviedo	315	0.30 (0.10; 0.93)	0.53 (0.29; 0.99)	0.52 (0.24; 1.12)	0.20	0.49 (0.25; 0.96)
Galdakao	408	0.50 (0.20; 1.24)	0.64 (0.31; 1.33)	0.63 (0.31; 1.30)	0.35	2.71 (1.49; 4.91)
Barcelona	284	1.69 (0.69; 4.15)	0.96 (0.45; 2.04)	0.91 (0.40; 2.07)	0.74	0.52 (0.29; 0.93)
Albacete	419	0.93 (0.37; 2.36)	0.38 (0.16; 0.90)	0.54 (0.27; 1.09)	0.19	0.38 (0.21; 0.69)
Huelva	233	1.13 (0.33; 3.87)	1.27 (0.47; 3.39)	1.64 (0.57; 4.78)	0.42	1.08 (1.04; 3.26)

Cities are sorted from north to south.

A multilevel logistic regression model (PROC GLIMMIX) was performed with neighborhood at level-2 (random intercept for neighborhood level); adjusted for cohort, age, sex. High exposure (reference category) was defined as a concentration above the 75th percentile of the distribution by cities; p-value for trend were calculated by introducing the categorical variables in continuous.

Occupational class (OC): OC-I: Managers and Professionals (ref), OC-II: Technicians and associate professionals, OC-III: other non-manuals, OC-IV: skilled, semi-skilled and unskilled manual. P-value for trend were calculated by introducing the categorical variables in continuous.

Table S7: Association between individual- and neighborhood SEP and NO<sub>2</sub> (µg m<sup>-3</sup>) using a single-level linear regression model (each SEP variable considered separately; n=5692)

City	n	Educational level (ref=high)			Occupational class (ref=OC-I)				Neighborhood unemployment rate
		Medium	Low	P-value for trend	OC-II	OC-III	OC-IV	p-value for trend	
Norwich	242	-3.0 (-9.3;3.8)	2.4 (-5.7; 11.3)	0.77	0.3 (-8.1; 9.4)	-1.4 (-9.2; 7.1)	-3.9 (-12.2; 5.1)	0.83	9,4 (5,1; 13,8)
Ipswich	338	3.8 (-0.9; 8.7)	2.7 (-3.1; 8.7)	0.28	1.3 (-4.4; 7.4)	7.2 (1.5; 13.2)	3.6 (-2.6; 10.3)	0.28	5,0 (1,1; 9,0)
Antwerp	500	-4.4 (-8.6; -0.04)	-1.5 (-6.1; 3.3)	0.44	-1.7 (-7.1; 4.0)	2.1 (-2.6; 7.1)	-3.0 (-8.1; 2.4)	0.90	15,0 (11,8; 18,2)
Paris	785	-7.5 (-13.0; -1.7)	-4.2 (-10.1; 2.2)	0.12	-3.6 (-13.7;7.7)	-1.3 (-8.2; 6.2)	-4.1 (-10.2;2.5)	0.46	13,7 (9,7; 17,8)
Lyon	210	-16.5 (-29.9; -0.6)	-28.1 (-40.2; -13.4)	0.001	-25.5 (-39.2; -8.9)	-7.3 (-23.2; 11.8)	-12.7 (-27.7; 5.3)	0.02	12,8 (2,3; 24,4)
Grenoble	690	1.1 (-4.3; 6.8)	1.2 (-4. 4; 7.1)	0.68	2.8 (-4.3; 10.5)	0.9 (-5.7; 8.0)	-0.6 (-6.7; 5.8)	0.44	9,3 (5,1; 13,7)
Marseille	119	-14.9 (-25.4; -2.8)	-19.2 (-29.9; -6.9)	0.004	-2.4 (-20.2; 19.4)	-10.4 (-24.4; 6.2)	-6.1 (-19.1; 8.9)	0.37	12,2 (7,1; 17,6)
Geneva	612	-0.5 (-5.8; 5.1)	-3.6 (-8.9; 2.1)	0.22	2.4 (-5.1; 10.5)	-0.5 (-6.4; 5.7)	-0.5 (-6.5; 5.9)	0.71	9,3 (4,5; 14,3)
Verona	179	-12.9 (-31.1; 10.1)	-25.1 (-39.8; -6.7)	0.01	-32.8 (-49.8; -10.0)	-6.9 (-27.7; 20.0)	0.4 (-27.0; 37.9)	0.008	14,0 (3,7; 25,5)
Pavia	188	-2.2 (-9.1; 5.3)	-6.1 (-12.4; 0.7)	0.08	-9.5 (-16.7; -1.6)	-9.3 (-16.0; -2.1)	2.1 (-7.3; 12.5)	0.003	2,7 (-0,9; 6,4)
Turin	170	4.5 (-3.4; 13.0)	8.2 (-0.6; 17.8)	0.06	12.1 (1.5; 23.8)	10.0 (0.8; 20.1)	9.6 (-2.1; 22.7)	0.02	2,8 (-0,7; 6,5)
Oviedo	315	-9.6 (-19.0; 0.9)	-22.3 (-31.1; -12.3)	<0.0001	-27.2 (-35.7; -17.7)	-13.3 (-23.4; -1.7)	-17.1 (-29.8; -2.1)	<0.0001	-14,4 (-24,0; -3,6)
Galdakao	408	-2.6 (-9.4; 4.8)	-1.5 (-9.4; 7.1)	0.70	3.7 (-4.9; 13.1)	8.1 (-1.6; 18.7)	3.8 (-8.4; 17.6)	0.39	21,5 (13,8; 29,7)
Barcelona	284	0.3 (-6.7; 7.7)	-5.0 (-12.5; 3.2)	0.25	-2.2 (-10.2; 6.4)	2.7 (-5.1; 11.0)	4.4 (-5.1; 14.9)	0.71	-7,2 (-12,1; -2,0)
Albacete	419	-20.4 (-32.3; -6.2)	-29.6 (-40.5; -16.7)	<0.0001	-21.0 (-34.3; -5.0)	-14.9 (-29.7; 3.2)	-11.4 (-30.7; 13.3)	0.007	-8,3 (-18,1; 2,6)
Huelva	233	-0.5 (-8.4; 8.29)	-1.1 (-10.0; 8.6)	0.82	19.6 (8.3; 32.1)	8.6 (-1.9; 20.2)	10.8 (-3.0; 26.6)	0.001	1,6 (-2,6; 5,9)

Cities are sorted from north to south.

Each SEP variables were considered separately, adjusted for cohort, age and sex.

Results are expressed in percent change in NO<sub>2</sub> (µg\*m<sup>-3</sup>) concentration. Negative value means a decrease in NO<sub>2</sub> (in percent) compared to the reference class for the categorical variable; p-value for trend were calculated by introducing the categorical variables in continuous. The unemployment rate has been transformed in z-score, the change in NO<sub>2</sub> is showed for 1 standard deviation.

Occupation class (OC): OC-I: Managers and Professionals, OC-II: Technicians and associate professionals, OC-III: other non-manuals, OC-IV: skilled, semi-skilled and unskilled manual.

Table S8: Percent change (95% CI) in NO<sub>2</sub> concentration ( $\mu\text{g m}^{-3}$ ) in association neighborhood deprivation (alone and mutually adjusted for either educational level or occupational class)

Cities	n	Alone	Adjusted for educational level	Adjusted for occupational class
Norwich	242	6.8 (3.3; 10.4)	7.2 (3.6; 10.9)	7.1 (3.5; 10.9)
Ipswich	338	1.2 (-0.4; 2.7)	1.1 (-0.5; 2.6)	1.2 (-0.4; 2.8)
Paris	782	19.4 (15.7; 23.1)	19.4 (15.7; 23.1)	19.4 (15.7; 23.1)
Lyon	206	26.4 (12.4; 42.1)	26.1 (12.3; 41.7)	26.9 (12.9; 42.7)
Grenoble	690	15.0 (9.4; 20.9)	14.9 (9.3; 20.8)	14.8 (9.2; 20.7)
Marseille	119	18.3 (9.7; 27.5)	18.4 (9.9; 27.6)	18.1 (9.7; 27.2)
Verona	176	3.2 (-7.5; 15.1)	3.2 (-7.5; 15.2)	2.1 (-8.6; 14.0)
Pavia	188	-0.5 (-3.6; 2.8)	-0.5 (-3.6; 2.8)	-0.4 (-3.6; 2.8)
Oviedo	315	-12.2 (-17.8; -6.1)	-11.8 (-17.5; -5.8)	-11.9 (-17.7; -5.8)
Galdakao	408	1.3 (-3.4; 6.2)	2.4 (-3.7; 8.9)	1.2 (-3.5; 6.0)
Barcelona	284	2.7 (-0.2; 5.7)	2.7 (-0.2; 5.8)	2.5 (-0.4; 5.6)
Albacete	419	-13.7 (-24.7; -1.2)	-12.7 (-23.7; -0.2)	-13.4 (-24.4; -0.9)
Huelva	233	-1.1 (-6.6; 4.6)	-0.9 (-6.4; 4.8)	-1.8 (-7.1; 3.8)

A multilevel linear regression model (PROC MIXED) was performed with neighborhood at level-2 (random intercept for neighborhood level); adjusted for cohort, age and sex.

Results are expressed in percent change in NO<sub>2</sub> ( $\mu\text{g m}^{-3}$ ) concentration. The deprivation indices have been transformed in country-specific z-scores, the change in NO<sub>2</sub> is showed for 1 standard deviation. Positive value means higher exposition to NO<sub>2</sub>. A 95% confidence interval (CI) that does not include zero indicates the presence of significant differences. Deprivation index corresponds to the Carstairs Index for GB cities (Carstairs, 1995); The French European Deprivation Index for the French cities (Pornet et al. 2012); Italian Deprivation Index for Italian cities (Caranci et al. 2010) and Index of vulnerability for the Spanish cities (Alguacil Gómez et al. 2013). Deprivation index (DI) information were not available for Antwerp, Turin and Geneva

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## Annex 1: Paris-Region: a case study

### Methods:

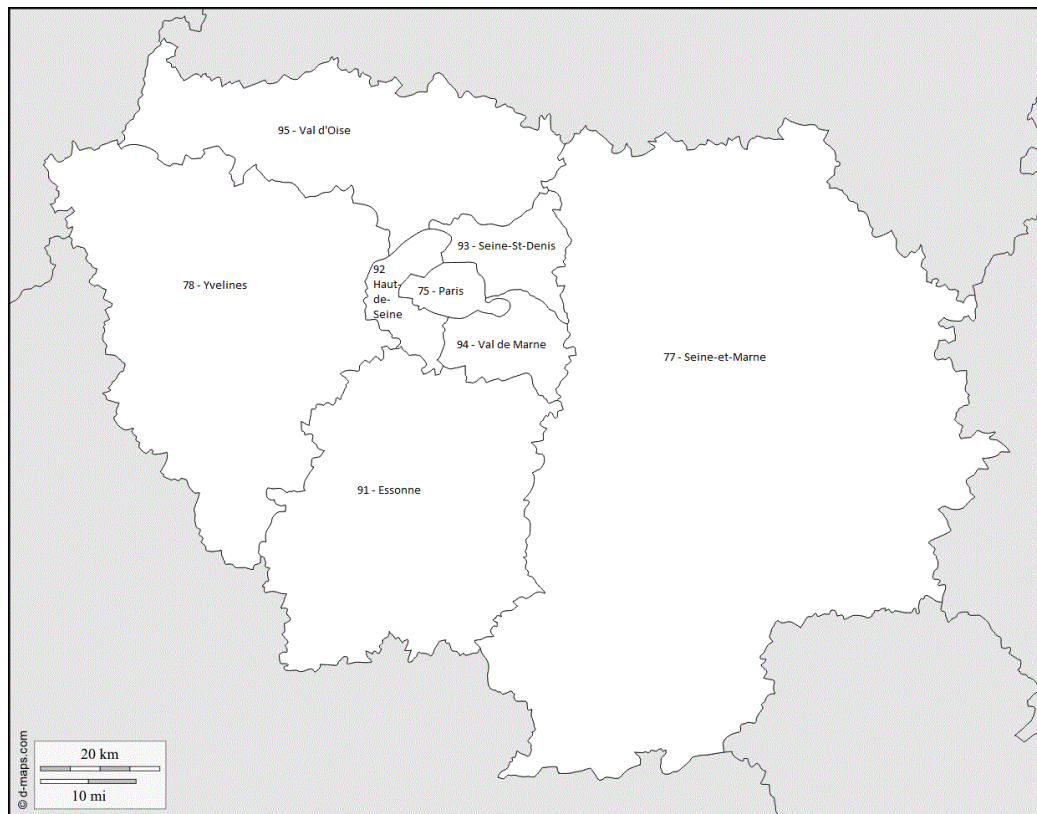
We described the departments regarding their geographical characteristics (population density, green areas) and socioeconomic indicators (unemployment, poverty, Gini index).

We ran a standard multilevel linear regression model with random effects that takes into account the hierarchical structure of the data by disentangling the residual variability at the individual, neighborhood level. We presented the results for the model including simultaneously the individual- and area-SEP markers and accounting for the neighborhood clustering. As NO<sub>2</sub> concentrations were positively skewed, we transformed the variables using natural log transformation. For ease of interpretation, we converted the regression coefficients ( $\beta$ s) into percent increase (95% CI) per unit change in the explanatory factor using the formula  $[\exp(\beta)-1]*100$ .

For the categorical variable, we calculated the percent increase (95% CI) for each SEP indicator's subgroup (i.e. low, medium and high for educational level) and tested the statistical differences of the coefficients against the highest SEP group (reference group). We considered three sub-regions rather than the departments as they present particular sociodemographic and geographic situations and also to have enough participants in each categories.

### Results:

Figure A: Maps of Paris-Region



Paris Region is organized in three principal geographic areas: City of Paris (75), the inner suburbs (composed of three administrative “departments”: Hauts-de-Seine (92), Seine-St-Denis (93) and Val de Marne (94)) and the outer suburbs (composed of four departments: Seine-et-Marne (77), Yvelines (78), Essonne (91) and Val d’Oise (95)).

Table A. Characteristics of the departments in Paris-Region

	Department-level				Neighborhood-level			Individual-level data			
	Department	N	Population density	% of green areas	% of unemployment	% Poverty rate	Gini index	Neighborhood Unemployment	NO <sub>2</sub> mean $\pm$ sd	% of participants with high Education	% of participants with high Occupation
City of Paris	75	389	21347	21	8	16	0.45	11.9	42.7 $\pm$ 8.9	58.9	50.1
Inner suburbs	92	76	11315	18	6.2	12.0	0.40	9.2	35.9 $\pm$ 14.2	47.4	47.4
	93	35	7892	12	10.2	27.0	0.33	15.4	41.8 $\pm$ 20.1	37.1	37.1
	94	32	9833	9	6.7	15.0	0.35	9.4	33.7 $\pm$ 12.0	46.9	59.4
Total inner suburbs		143	10,146 $\pm$ 1416	14.5	7.3	16.3	0.37	10.8	37.2 $\pm$ 15.8	44.8	47.6
Outer suburbs	77	28	1761	59	5.1	11	0.32	9.7	19.8 $\pm$ 5.6	14.3	28.6
	78	63	2400	54	4.9	9	0.36	7.1	21.7 $\pm$ 7.4	39.7	34.9
	91	48	1856	48	4.8	12.0	0.33	7.5	24.4 $\pm$ 7.6	35.4	43.8
	95	35	3511	35	6.7	16.0	0.32	9.3	27.5 $\pm$ 12.1	34.3	37.1
Total outer suburbs		174	2371 $\pm$ 630	49.3	5.3	11.6	0.34	8.1	23.7 $\pm$ 9.0	33.3	36.8
Paris Region		706	14,401 $\pm$ 8156	26.7	7.2	15.0	0.41	10.7	36.4 $\pm$ 13.4	42.1	46.3

Table A: The sub-regions of Paris-Region are characterized by specific sociodemographic and socioeconomic situations. The outer suburbs are characterized globally by a low population density and high superficies of green areas. The unemployment (at department level and neighborhood level) and poverty rate are also less marked in this area compared to Paris or the inner suburbs. Regarding the participants, those living in the outer suburbs have lower education level and held less skilled occupations compared to Paris or the inner suburbs.

As expected, the more the participants lived far from Paris, the less they were exposed to NO<sub>2</sub>. They were twice less exposed than those residing within Paris city (23.7 vs. 42.7). That is to say, even if Paris and its inner suburbs are more polluted areas they concentrate the most educated participants with the higher skills. This could explain the reverse association between education/occupation and NO<sub>2</sub> exposure.

Neighborhood unemployment is higher than unemployment measured at department level, however its distribution is the same (higher in Paris and inner suburbs than in the outer suburbs). At department level, NO<sub>2</sub> mean increases as expected with higher density and decreases with higher green areas.

Regarding, the socioeconomics characteristics, the NO<sub>2</sub> increases with higher unemployment and higher poverty rate.



Table B: Pearson correlation between individual, neighborhood and “department” characteristics

		Individual-level			Neighborhood-level		Department-level			
		NO <sub>2</sub>	Individual Education level	Individual Occupation class	Unemployment rate	Population density	Green areas	Unemployment rate	Poverty rate	Gini index
Individual-level	NO <sub>2</sub>	0								
	Education level	0.03 <i>ns</i>	0							
	Occupation class	0.05 <i>ns</i>	0.46*	0						
Neighborhood-level	Unemployment	0.39*	-0.08°	-0.03 <i>ns</i>	0					
	Population density	0.66*	0.08°	0.12”	0.35*	0				
	Green areas	-0.62*	-0.11”	-0.12”	-0.35*	-0.69*	0			
Department-level	Unemployment rate	0.62*	0.07 <i>ns</i>	0.06 <i>ns</i>	0.49*	0.73*	0.79*	0		
	Poverty rate	0.45*	0.04 <i>ns</i>	0.02 <i>ns</i>	0.45*	0.39*	-	0.90*	0	
							0.65*			

*P*-value: *NS* non-significant, ° [0.05-0.01]; “ [0.01-0.001]; \**p*<10-5

Table B: As expected, mean NO<sub>2</sub> concentrations exposure estimated at residential address increased with higher population density and less greens areas at department level in the Paris-Region. At department level, participants with higher education level or higher occupation class appeared to live in higher density areas with less green spaces. At this level, there was no correlation between NO<sub>2</sub> and education level or occupation class. Unemployment rate at neighborhood level was positively correlated with unemployment (<0.0001) and poverty rate (<0.0001) at department level. Green areas was positively associated to unemployment at department (not at neighborhood level). Unlike in the US, wealthier people generally live in more urban areas. Individual-SEP markers were relatively well correlated to each other (r=0.46, p<0.0001), but they were weakly or not correlated to area-SEP (i.e. unemployment (both at neighborhood and department level) and poverty rate. This discrepancy could suggest a selection bias where only the high-SEP person living in disadvantaged neighborhood participated to the study. However, low correlation between individual- and area-SEP has been also found in other European studies, suggesting that, unlike in the US, the urban segregation that could explain environmental health inequalities at individual-level was not verified in Europe.

Table C: Percent increase in NO<sub>2</sub> (µg m<sup>-3</sup>) concentration (95%CI) in relation to educational level with adjustment for neighborhood unemployment rate in Paris-Region (n=706)

		n	Educational level (ref=high)		Neighborhood Unemployment t∞
			Medium	Low	P-value for trend
Paris-Region	785	0.1 (-2.6; 2.9)	-0.3 (-3.1; 2.6)	0.84	13.7 (9.7; 17.8)
City of Paris	420	1.5 (-2.0; 5.2)	1.0 (-2.5; 4.6)	0.53	4.8 (1.5; 8.2)
Inner Suburbs	156	0.3 (-1.7; 2.4)	0.3 (-1.7; 2.4)	0.67	7.3 (1.1; 13.9)
Outer suburbs	209	-1.2 (-5.9; 3.8)	-2.0 (-7.5; 3.8)	0.48	5.4 (-1.7; 13.0)

A multilevel linear regression model (PROC MIXED) was performed with neighborhood at level-2 (random intercept for neighborhood level); adjusted for study, age, sex  
Reference= High education level, p-value for trend were calculated by introducing the categorical variables in continuous.  
∞ Unemployment has been transformed in z-score, the increase/decrease in NO<sub>2</sub> is showed for 1 standard deviation in the unemployment rate

We found the similar results by pooling participants in Paris-Region compared to pooling them by sub-regions that were not artefacts and with characteristics that could influence the association. The unemployment rate however became no longer significant in the outer suburbs.

Table D: Percent increase in NO<sub>2</sub> (µg m<sup>-3</sup>) concentration (95%CI) in relation to occupational class with adjustment for neighborhood unemployment rate in Paris-Region (n=706)

City	n	Occupational class (ref=OC-I)			P-value for trend	Neighborhood Unemployment <sup>∞</sup>
		OC-II	OC-III	OC-IV		
Paris-Region	785	-2.3 (-5.0; 0.6)	-3.3 (-6.4; -0.01)	-4.8 (-9.5; 0.1)	0.03	13.7 (9.7; 17.8)
City of Paris	420	-1.5 (-5.0; 2.1)	-3.4 (-7.3; 0.7)	-3.1 (-9.2; 3.5)	0.16	5.0 (1.7; 8.4)
Inner Suburbs	156	-0.3 (-1.8; 1.3)	1.5 (-0.4; 3.5)	-0.9 (-3.5; 1.8)	0.35	7.2 (1.0; 13.8)
Outer suburbs	209	-3.2 (-8.4; 2.3)	-4.4 (-10.6; 2.2)	-2.8 (-11.4; 6.6)	0.34	5.4 (-1.7; 13.0)

A multilevel linear regression model (PROC MIXED) was performed with neighborhood at level-2 (random intercept for neighborhood level); adjusted for study, age, sex

Occupation class (OC): OC-I: Manager and Professional, OC-II: Technician and associate professional, OC-III: other non-manual, OC-IV: skilled manual, semi-skilled or unskilled manual

<sup>∞</sup> Unemployment has been transformed in z-score, the increase/decrease in NO<sub>2</sub> is showed for 1 standard deviation in the unemployment rate

We found the similar results by pooling participants in Paris-Region compared to pooling them by sub-regions that were not artefacts and with characteristics that could influence the association. However, the associations were no longer significant.