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# BMJ Open

## Urban Environment and Health: a cross-sectional multiregional project based on Population Health Surveys in Spain (DAS-EP project), study protocol.

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## 170 Abstract

171 **Introduction:** The European Environment Agency estimates that 75% of the European  
172 population lives in cities. Despite the many advantages of city life, the risks and challenges to  
173 health arising from urbanization need to be addressed to tackle the growing burden of disease  
174 and health inequalities in the cities. This study, *Urban Environment and Health: a cross-*  
175 *sectional multiregional project based on Population Health Surveys in Spain* (DAS-EP project),  
176 aims to investigate the complex association between the urban environmental exposures  
177 (UrbEE) and health.

178 **Methods and analysis:** DAS-EP is a Spanish multiregional cross-sectional project that combines  
179 Population Health Surveys (PHS) and Geographical Information System (GIS) allowing to collect  
180 rich individual level data from 17,000 adult citizens participating in the PHS conducted in the  
181 autonomous communities of the Basque Country, Andalusia, and the Valencian Community,  
182 and the city of Barcelona in years 2021-2023. This study focuses on the population living in  
183 cities or metropolitan areas with more than 100,000 inhabitants. UrbEE are described by  
184 objective estimates at participants' home addresses by GIS and subjective indicators present in  
185 PHS. The health outcomes included in the PHS and selected for this study are self-perceived  
186 health (general and mental), prevalence of chronic mental disorders, health-related quality of  
187 life, consumption of medication for common mental disorders, and sleep quality. We aim to  
188 further understand the direct and indirect effect between UrbEE and health as well as to  
189 estimate the impact at the population level taking respondents' socio-demographic and socio-  
190 economic characteristics, and lifestyle into account.

### 191 **Ethics and dissemination:**

192 The study was approved by the regional Research Ethics Committee of the Basque Country  
193 (CEIm-E; PI2022138), Andalusia (CEIM GRANADA; 2078-N-22), Barcelona (CEIC-PSMar;  
194 2022/10667), and Valencian Community (CEIC DGSP/CSISP; 20221125/04). The results will be

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3 195 communicated to the general population, health professionals and institutions through  
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5 196 conferences, reports, and scientific articles.  
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9 197 **Strengths and limitations of this study**

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11 198 • The linkage of four independent population health surveys (PHS) will provide a large  
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13 199 volume of information and a large sample size of the study.  
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15 200 • The method is novel for the inclusion of objective & subjective UrbEE as well as the  
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17 201 combination of PHS from different study areas and GIS estimates.  
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19 202 • Despite the cross-sectional nature of the study, the results will ultimately help identify  
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21 203 urban indicators, increasing the capacity to detect and intervene in community health,  
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23 204 improving the routine surveillance and monitoring of the cities' health information  
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## 1. Introduction

According to World Health Organization, modifiable environmental factors are responsible for 23% and 22% of global mortality and morbidity respectively (1). As reported by the European Environment Agency, in 2021, 75% of the European population lived in urban areas including cities but also smaller urban settlements and suburban areas, developed for residential, industrial or recreational purposes (2). The conditions and quality of the local urban environment influences people's health by determining their level of urban environmental exposures (UrbEE) (3,4). The UrbEE include the totality of the surrounding natural (e.g., green and blue spaces), built (e.g., walkability, urbanisation level, traffic,) and social (e.g., security, public services) environments within which people live, move, and interact, as well as environmental stressors like air pollution and noise. Increasing evidence shows that UrbEE such as lack of greenness, air pollution and noise can impact population's mental and physical health and quality of life (5–9). The health implications of the environmental exposures become even more important in the contemporary demographic setting, given that they are perhaps starker in urban areas (10–14). Moreover, in many regions, environmental exposures are not evenly distributed across socioeconomic status and socioeconomically vulnerable populations are also affected by poorer environmental quality (10,11). In fact, this double jeopardy may make individuals from poorer socioeconomic backgrounds more significantly affected by environmental exposures (3,15).

The UrbEE, including environmental stressors, traffic-infrastructure, natural spaces, and the built environment, have all been studied in relation health. Widespread evidence in the literature shows that air pollution, noise and lack of green space are related to a range of chronic physical diseases (16–21). Recently, it has been suggested that air pollution is associated with a range of mental disorders and poorer sleep quality (16,22–25). Other recent studies observed that environmental noise has negative effects on mental health, well-being,

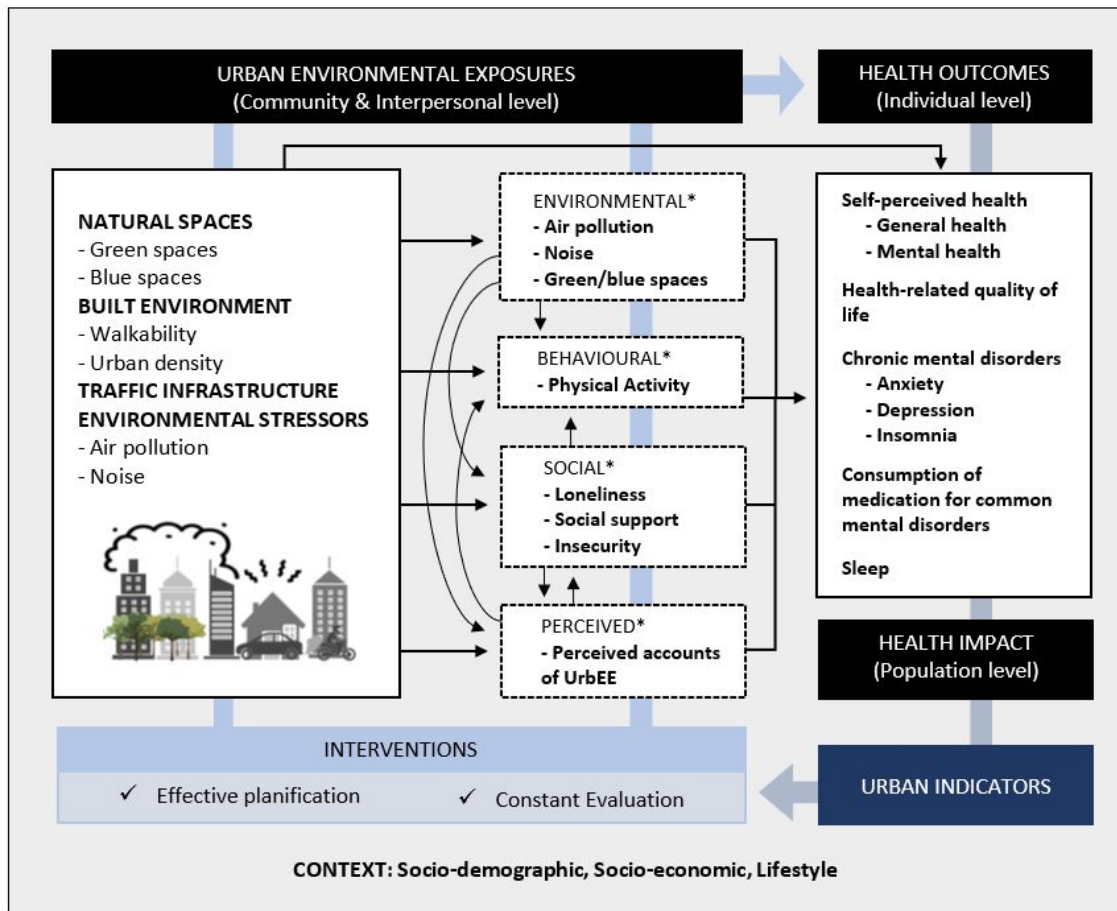
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3 231 and sleep quality (25–28), while evidence on its impact on prescriptions and consumption of  
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5 232 medication for common mental disorders has yet to be scientifically confirmed (29).  
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7 233 Otherwise, current scientific evidence indicates that residential greenness is positively  
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9 234 associated with mental health and quality of life (28,30,31), and lower consumption of  
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11 235 anxiolytics, antidepressants, and sleeping pills (25,32). Blue spaces (aquatic environments such  
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13 236 as rivers, lake, and the coast) are expected to have similar health effects to those described  
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15 237 here, however, evidence on this subject is limited (32,33). As for the built environment,  
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17 238 walkability or accessibility have also been related to reduced obesity and better cardiovascular  
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19 239 health (34), improved mental health (35,36) and well-being (37). To date, the main  
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21 240 mechanisms proposed to explain these associations are the mitigation of exposure to  
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23 241 environmental pollutants, the promotion of physical activity, and the strengthening of social  
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25 242 cohesion (30,31,34,38–40). However, these mechanisms are probably synergistic (41). The  
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27 243 correlations between several UrbEE and their relationship with behavioural exposures like  
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29 244 physical activity, and social cohesion makes the assessment of these associations and  
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31 245 pathways highly challenging (42–46). Hence, noise and air pollution could act both as  
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33 246 exposures, mediators, or potential confounders. Overall, results of previous studies are quite  
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35 247 mixed and the associations as well as the underlying mechanisms between UrbEE and mental  
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37 248 health outcomes need more robust scientific evidence (8,45,47–49).  
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44 249 This knowledge gap can be partly explained by the heterogeneity and limitations of  
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46 250 exposure and outcome metrics used in the studies (20,49,50). Moreover, there is a lack of  
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48 251 studies addressing the impact of UrbEE on health integrating objective and perceived accounts  
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50 252 of such exposures (51). Therefore, it is evident that more research is needed to determine  
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52 253 which UrbEE are associated with health, the potential mechanisms involved, and the role of  
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54 254 social aspects in those associations. Beyond this, researchers are increasingly called to provide  
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56 255 information that can guide the selection of the best and most feasible interventions to  
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58 256 improve public health in cities. In this respect, experts in the field have claimed the vital role  
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3 257 that the health impact assessment tool plays in integrating the evidence in the decision-  
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5 258 making process (52,53).  
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8 259 *Urban Environment and Health: a cross-sectional multiregional project based on*  
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10 260 *Population Health Surveys in Spain* (DAS-EP project) is a 3-year project (2023-2025) aimed at  
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13 261 further investigating the associations and underlying mechanisms, including direct and indirect  
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15 262 effects, between UrbEE and health with a health equity perspective. Five main objectives have  
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17 263 been established for this project:  
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21 264 1. To estimate, describe and compare the objective and subjective levels of UrbEE in the  
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23 265 study areas.  
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25 266 2. To describe urban environmental inequalities according to socio-demographic and  
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27 267 socio-economic variables as well as the study area.  
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29 268 3. To estimate the association between UrbEE and self-perceived general and mental  
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31 269 health, health-related quality of life, chronic mental disorders, consumption of  
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33 270 medication for common mental disorders and sleep quality (Figure 1).  
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36 271 4. To estimate the population impact of UrbEE on the health outcomes under evaluation  
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38 272 and conduct a health impact assessment.  
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40 273 5. To assess the mediating role of physical activity, social cohesion, and environmental  
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42 274 stressors on the association between UrbEE and the health outcomes under evaluation  
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44 275 (Figure 1).  
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**Figure 1.** Conceptual framework designed within the scope of this project, including potential direct and indirect effects of urban environmental exposures (UrbEE) on the health outcomes under study. \* Potential mediators on the association between UrbEE and the health outcomes under evaluation.

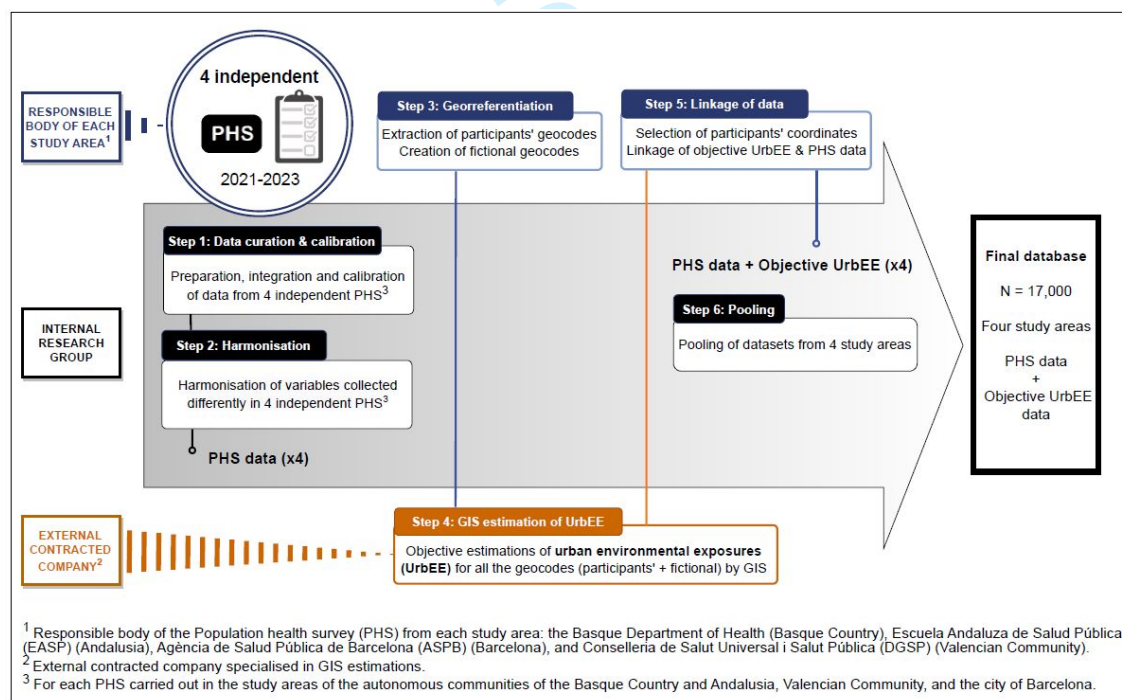
276 **2. Methods and analysis**

277 **2.1. Study design**

278 This is a cross-sectional study based on adult population data from Population Health  
 279 Surveys (PHS) that live in urban areas with more than 100,000 inhabitants in the autonomous  
 280 communities of the Basque Country and Andalusia, the Valencian Community, and the city of  
 281 Barcelona in Spain. The study integrates observational data collected within the four  
 282 independent PHS in 2021-2023 with Geographic Information System (GIS) estimations of  
 283 individual UrbEE. It entails the following research activities: 1) preparation, integration, and  
 284 calibration of PHS data from each study area, 2) harmonising the variables that have been  
 285 collected differently in the four study areas, 3) georeferencing survey respondents' home

addresses, 4) characterizing each home address in terms of UrbEE by GIS, 5) linking UrbEE estimates with PHS data, and 6) pooling of datasets from the four study areas (Figure 2). Using the final pooled database, we will analyse the association between UrbEE and health in a cross-sectional manner, taking into account sociodemographic, socioeconomic and lifestyle factors. Figure 1 shows the conceptual framework designed within the scope of this project. DAS-EP received Ethics Approval from the regional ethics committee competent at each study area (see more Supplementary file section 5). This project has received funding from the Instituto de Salud Carlos III (ISCIII) under the Strategic Action in Health with the Health Research Fund (FIS) in the call 2022 (file No. PI22/01051 and No. PI22/00512). The project runs from 2023 to 2025.

## 2.2. Study population



**Figure 2.** Summary of data management plan and the institutions involved during the development of the final database (DB) to be used by the research group in the analyses.

1  
2  
3 297 The target population is the inhabitants of the autonomous communities of the Basque  
4  
5 298 Country and Andalusia, Valencian Community, and the city of Barcelona. The sampling frames  
6  
7 299 are made up of people over 15 or 16 years of age of the respective study areas. The study  
8  
9 300 population includes the PHS' participants living in urban areas with more than 100,000  
10  
11 301 inhabitants in the autonomous communities of the Basque Country and Andalusia, the  
12  
13 302 Valencian Community, and the city of Barcelona (Figure S1, S2). The cities and metropolitan  
14  
15 303 areas participating in this study are: the city of Vitoria-Gasteiz, and the metropolitan areas of  
16  
17 304 Bilbao and Donostia-San Sebastián in the Basque Country; the cities of Almeria, Cadiz,  
18  
19 305 Cordoba, Huelva, Jaen, and the metropolitan areas of Granada, Malaga, and Seville in  
20  
21 306 Andalusia; the cities of Castellon, Valencia, Elche and Alicante in Valencian Community; and  
22  
23 307 the city of Barcelona (Table S1).

24  
25  
26  
27  
28 308 The PHS included in this project are official statistical operations that are incorporated in  
29  
30 309 the Statistical Plans of each study area. These activities are conducted by every regional or  
31  
32 310 local public administrations with competence in health and are a fundamental tool to monitor  
33  
34 311 the status and evolution of relevant health conditions in the population, their main  
35  
36 312 determinants, and the use of health services (54–57). Accordingly, these regional and local  
37  
38 313 cross-sectional epidemiological surveys are carried out by the Basque Department of Health in  
39  
40 314 the Basque Country (54), Andalusian School of Public Health (EASP) in Andalusia (55),  
41  
42 315 Barcelona Public Health Agency (ASPB) in Barcelona (56), and Foundation for the Promotion of  
43  
44 316 Health and Biomedical Research in the Valencian Region (DGSP) in Valencian Community (57).  
45  
46 317 They have been organised every 4-5 years since 1986 (Basque Country), 1999 (Andalusia),  
47  
48 318 1983 (Barcelona) and 1991 (Valencian Community). The sample design and the selection of the  
49  
50 319 sample is carried out independently by the statistical institutes (EUSTAT in the Basque Country,  
51  
52 320 Institute of Statistics and Cartography of Andalusia or IECA in Andalusia, and municipal  
53  
54 321 statistical office of the Barcelona city council in Barcelona) or health population information  
55  
56 322 systems (Valencian Community). The latest version of these surveys are included in this  
57  
58  
59  
60



1  
2  
3 323 project. After the surveys are completed, it is estimated to obtain a total sample of 16,953  
4  
5 324 individuals, with a number of 7,846 participants in the Basque Country, 3,085 in Andalusia,  
6  
7 325 3,134 in Valencian Community and 4,000 in the city of Barcelona. A more detailed information  
8  
9 326 is provided in Table S1.

### 13 327 **2.3. Data collection**

#### 15 328 2.3.1. GIS estimates of urban environmental exposures (UrbEE)

18 329 Objective measures of UrbEE are estimated by a company specialised in GIS based on the  
19  
20 330 geographic coordinates of the participants' home addresses. A significant number of these  
21  
22 331 variables will be expressed in buffers around each participant's residence or at the building  
23  
24 332 level. All environmental exposures will be assessed preceding, and as close as possible to the  
25  
26 333 time the PHS are being conducted (2021-2023) in order to avoid temporal mismatch (58). The  
27  
28 334 objective UrbEE under study in this project include exposures originated from surrounding  
29  
30 335 natural spaces, built environment, traffic-infrastructure, and environmental stressors. Detailed  
31  
32 336 information on the UrbEE estimated within the scope of this project can be found in the  
33  
34 337 Supplementary file (Table S2).

#### 39 338 *Surrounding natural spaces*

- 42 339 - Green spaces. Five green space exposure metrics will be calculated in buffers of 100, 300  
43  
44 340 and 500m around each geocode: 1) percentage of green space; 2) mean Normalised  
45  
46 341 Difference Vegetation Index (NDVI) (59,60); 3) percentage of tree cover; 4) Euclidean  
47  
48 342 distance to the nearest green space larger than 5,000m<sup>2</sup> (61), and 5) presence of a major  
49  
50 343 green area (greater than 5,000 m<sup>2</sup>).
- 53 344 - Blue spaces. Any blue environment, including lake, river, or coastline will be considered as  
54  
55 345 blue space. Three blue space exposure variables will be estimated: 1) presence of water  
56  
57 346 surface; 2) percentage of water surface; and 3) Euclidean distance to nearest water surface  
58  
59  
60

1  
2  
3 347 greater than 5,000m<sup>2</sup>. The first two refer 100, 300 and 500m buffers around each geocode  
4  
5 348 (62).  
6  
7

8 349 *Built environment*  
9

10  
11 350 - Building density. The building density around each home address in 100, 300 and 500m  
12  
13 351 buffers will be estimated, accounting not only for the perimeter of the buildings but also  
14  
15 352 for their height (63).  
16  
17

18 353 - Walkability. An overall walkability index in 100, 300 and 500m buffers around the  
19  
20 354 participants' home addresses will be calculated. This index will be calculated through the  
21  
22 355 sum of the following subindices: 1) population density (referring to the census tract of the  
23  
24 356 address), 2) destination density, 3) street density, 4) street connectivity, 5) land use, 6)  
25  
26 357 facility richness, and 7) average slope (64,65).  
27  
28  
29

30 358 *Traffic infrastructure*  
31  
32

33 359 - Major road (Yes vs. No). Presence of a major road (with >3 million vehicle passages per  
34  
35 360 year) in 100, 300 and 500m buffers around the participants' home addresses (63).  
36  
37

38 361 - Distance to major road. Distance to the nearest major road (with >3 million vehicle  
39  
40 362 passages per year) from the participants home addresses (63).  
41  
42

43 363 *Environmental stressors*  
44  
45

46 364 - Air pollution. Spatiotemporal daily models at household-level for particulate matter (PM<sub>10</sub>  
47  
48 365 and PM<sub>2.5</sub>) and nitrogen dioxide (NO<sub>2</sub>) will be constructed for all study areas using  
49  
50 366 multistage mixed models. These models are known as spatiotemporal land-use random-  
51  
52 367 forest model (66) and combine ground-level and satellite measurements, land use and  
53  
54 368 meteorology. A precise daily estimate of the exposures will be obtained for all study  
55  
56 369 subjects (period 2006 to 2023). Using the daily estimates, annual average for the last five  
57  
58  
59  
60

1  
2  
3 370 years and the five-year average of NO<sub>2</sub>, PM<sub>10</sub> and PM<sub>2.5</sub> exposure levels will be calculated  
4  
5 371 at PHS respondents' home address as indicators for long-term air quality.  
6  
7 372 - Environmental noise. The Strategic Noise Maps derived under the EU Directive  
8  
9 373 2002/49/EC from the Ministry for the Ecological Transition and the Demographic Challenge  
10  
11 374 will be used. All potential sources of environmental noise at street level will be examined,  
12  
13 375 including road traffic, rail, industrial, airports and total noise (67,68). Major roads, major  
14  
15 376 railways, and major airports will be included in cities where this information is available  
16  
17 377 and not included in the agglomeration layer. Agglomerations corresponding to the closest  
18  
19 378 street to the dwelling, and major roads and airports corresponding to the closest isoline  
20  
21 379 will be used. In all cases, the Euclidean distance to each source will also be calculated. The  
22  
23 380 daytime (L<sub>d</sub>), evening (L<sub>e</sub>), night-time (L<sub>n</sub>), and total (L<sub>den</sub>) noise indices will be assigned.  
24  
25  
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28

### 29 381 2.3.2. Information collected through Population Health Surveys

30  
31  
32 382 Information from four independent PHS that represent four study areas is included in the  
33  
34 383 study. The surveys are carried out between 2021-2023, being Barcelona city the earliest in  
35  
36 384 completing the collection (2021 February – 2022 March), followed by the Valencian  
37  
38 385 Community (2022 April – 2022 December), Andalusia (2022 April – 2023 April), and the Basque  
39  
40 386 Country (2022 October – 2023 June) (Table S1). During each survey, detailed information is  
41  
42 387 collected through face-to-face interviews and self-administered questionnaires. The PHS collect  
43  
44 388 information on different health aspects, morbidity and use of health services. It also gathers  
45  
46 389 information on health determinants of health such as socio-economic status, working  
47  
48 390 conditions, social cohesion, health-related behaviours and perception on residential  
49  
50 391 environment. Most of these variables are measured with validated screening tools. The  
51  
52 392 selection of relevant variables to be included in this project was based on a literature review  
53  
54 393 and the most appropriate variables to meet the objectives of the study were selected from  
55  
56 394 among the variables collected by the PHS. All the study areas collected the main variables of  
57  
58  
59  
60

1  
2  
3 395 the study (i.e., mental health, health-related quality of life, physical activity, social cohesion,  
4  
5 396 and sleep), however, in some cases, the measuring instruments differ across the study areas.  
6  
7 397 Detailed information about the variables and the measuring instruments used in each study  
8  
9 398 area can be found in Table S3.

### 399 *Health outcomes*

400 Several health outcome variables are included in this study.

- 401 - Self-perceived general health. Self-assessment of health was measured as an ordinal  
402 response, with five categories (1, Excellent; 2, Very good; 3, Good; 4, Fair; 5, Poor).  
403 - Self-perceived mental health. This variable was collected with the Mental Health  
404 Inventory (69), the SF-12 (Short-Form Health Survey 12) scale (70) or the General Health  
405 Questionnaire (GHQ-12) (71).  
406 - Health-related quality of life. This variable was measured with the Euroqol-5D-5L-EAV scale  
407 (72) or the SF-12 (Short-Form Health Survey 12) scale (70).  
408 - Sleep duration and quality. The duration of sleep, indicated as the total number of hours  
409 per day spent on sleep including napping was calculated. The quality of sleep was collected  
410 using the SATED scale (Satisfaction Alertness Timing Efficiency and Duration Scale) (73) or  
411 discrete items.  
412 - Prevalence of chronic mental health problems. Self-reported diagnosis of anxiety,  
413 depression and sleeping disorders was collected through the PHS. These dichotomised  
414 indicators were based on the physician diagnosis or self-diagnosis for depression, anxiety  
415 and sleeping problems at any time throughout the life.  
416 - Consumption of medication for common mental disorders. Information on consumption of  
417 medication for common mental disorders, such as, anxiolytics, antidepressants and  
418 hypnotics was reported on bi-daily or bi-weekly basis depending on the study area.

### 419 *Covariates*

- 1  
2  
3 420 A set of individual level variables will be used as control variables in the statistical analyses.  
4  
5  
6 421 - Anthropometric variables. The surveys collect information on sex, age, weight, and height  
7  
8 422 of individuals. A Body Mass Index (BMI) (kg/m<sup>2</sup>) will be calculated using information given  
9  
10 423 by the participants about their height and weight at the moment of filling the  
11  
12 424 questionnaire.  
13  
14 425 - Socio-demographic and socio-economic variables. To describe respondents' individual-  
15  
16 426 level socioeconomic status (SES), seven variables will be selected: country of birth,  
17  
18 427 household size, level of education, employment and occupational status, reported  
19  
20 428 household income, and economic difficulty of the household. Further, neighbourhood-  
21  
22 429 level SES will be calculated based on the deprivation index by census tract in 2021 from the  
23  
24 430 MEDEA project (forthcoming paper).  
25  
26 431 - Lifestyle factors. These will include consumption habits such as alcohol consumption,  
27  
28 432 passive smoking at home and tobacco use.  
29  
30 433 - Physical health. A chronicity index will be calculated based on presence of one or more  
31  
32 434 non-psychological chronic conditions (e.g., diabetes, heart disease, cancer, etc.).  
33  
34  
35  
36  
37 435 The following social and behavioural variables will be treated as potential mediators.  
38  
39  
40 436 - Social cohesion and loneliness. Social cohesion is measured with the Duke-UNC-11 scale  
41  
42 437 (74) or the OSLO-3 tool (75). While perceived loneliness is collected with a single item.  
43  
44 438 - Physical activity. The International Physical Activity Questionnaire (IPAQ) (76) to measure  
45  
46 439 the physical activity performed by the participants. Days per week and time spent in  
47  
48 440 vigorous physical activity, in moderate physical activity, and walking more than 10  
49  
50 441 minutes, and time spent sitting on a normal day will be available.  
51  
52  
53  
54 442 *Perception of the neighbourhood*  
55  
56  
57 443 Perceived accounts of UrbEE are collected through PHS employing 3-point or 5-point  
58  
59 444 Likert format questions depending on the study area. These include: 1) perception of noise

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3 445 outside the dwelling, 2) perception of shortage of green areas in the residential environment,  
4  
5 446 3) perception of air pollution in the residential environment, and 4) perception of insecurity in  
6  
7 447 the neighbourhood.  
8  
9

#### 10 448 **2.4. Data analysis**

11  
12  
13  
14 449 Initially, all databases will be cleaned. The variables will be harmonised, when needed,  
15  
16 450 following the Maelstrom Research Guidelines for rigorous harmonisation of retrospective data  
17  
18 451 (77). Nonetheless, because most variables have already been collected consistently in the  
19  
20 452 respective Population Health Surveys, few variables will require harmonisation (see  
21  
22 453 Supplementary file Section 3). Among the few variables requiring harmonisation, most will be  
23  
24 454 re-categorised. For more information, see Supplementary file Section 4. Subsequently, both  
25  
26 455 exploratory and descriptive analysis will be applied using numerical and graphical techniques  
27  
28 456 (78). Before proceeding to inference, sample weights for each survey will be adjusted through  
29  
30 457 calibration (79), so that we may compensate for non-response and coverage biases as well as  
31  
32 458 to improve accuracy. This calibration will be carried out separately for each study area, so that  
33  
34 459 region-level estimates are obtained first, and then harmonized to obtain estimates at  
35  
36 460 population level.  
37  
38  
39  
40

41  
42 461 The relationships between the various UrbEE and health outcomes will be analysed  
43  
44 462 according to the multilevel, or hierarchical structure (80) that the data will possess, as census  
45  
46 463 tracts are nested within cities, and cities are nested within autonomous communities.  
47  
48 464 Generalised linear mixed models (GLMMs) will be applied to investigate the relationship  
49  
50 465 between urban environment and health. The sets of adjustment covariates used in these  
51  
52 466 models will be chosen by applying robust causal inference techniques based on directed  
53  
54 467 acyclic graphs (DAGs) (81), both for the estimation of direct effects and hypothetical indirect  
55  
56 468 effects mediated by air pollution, environmental noise, physical activity, and social cohesion.  
57  
58 469 This will imply the prior design of a DAG describing the relationships between UrbEE, health  
59  
60

1  
2  
3 470 outcomes and other potentially implicated variables (82; 83). The testable implications derived  
4  
5 471 from this DAG will be checked following the procedure described by Ankan and colleagues  
6  
7 472 (84), thereby updating the DAG if needed (85,86). The length of time living in the same  
8  
9 473 home/place will be taken into account by excluding individuals living at the same place of  
10  
11  
12 474 residence for less than one and less than five years in separate models.  
13  
14

15 475 In case of demonstrating a significant relationship between a given exposure and a certain  
16  
17 476 outcome, we also intend to identify the specific exposures that cause most disease in the  
18  
19 477 populations of interest via the population attributable fraction (PAF) (87). To estimate the PAF  
20  
21  
22 478 we will require previous estimations of relative risk (RR) and either the prevalence of exposure  
23  
24 479 in the population or the prevalence of exposure among the cases of disease. All these previous  
25  
26 480 estimates will be available. The possible existence of spatial clusters in the UrbEE distribution  
27  
28 481 will also be studied using the standard spatial scan statistic method (88) and calculating the  
29  
30 482 posteriori probabilities for the smoothed standardised ratios to be greater than unity, in the  
31  
32  
33 483 general framework of Bayesian hierarchical standardised ratio smoothing models.  
34  
35

36 484 The analyses will be implemented using the latest version of the R software packages  
37  
38 485 *dagitty* (89), *DClusterm* (90,91), *R INLA* (92), *Sampling* (93) and others.  
39  
40

## 41 486 **2.5. Data Management Plan**

42  
43  
44 487 The data management plan can be found in the Supplementary file Section 4. The source and  
45  
46 488 type of data that will be collected within the scope of this project is described in this plan,  
47  
48 489 together with the accessibility and ownership of data. Data storage and processing, as well as  
49  
50 490 the procedure to guarantee the specific ethical and legal requirements, are likewise explained.  
51  
52  
53

## 54 491 **2.6. Patient and Public Involvement**

55  
56 492 Patients and the public will not be involved in the design, or conduct, or reporting, or  
57  
58 493 dissemination plans of our research.  
59  
60

### 494 3. Discussion

495 The present study is a clear commitment to the generation of urban environmental  
496 indicators potentially explanatory of self-perceived health (physical and mental), chronic  
497 mental disorders, health-related quality of life, consumption of medication for common  
498 mental disorders and sleep quality with a health equity perspective. This project responds to  
499 the national Spanish Strategic Plan for Health and the Environment (PESMA) 2022-2026 (94),  
500 to the local implementation of the Strategy for Health Promotion and Prevention in the  
501 National Health System (NHS) (95) as well as to the main objective of the Spanish Urban  
502 Agenda 2019 (96) that cities should have a global vision that takes into account the physical,  
503 mental, and social well-being of their inhabitants. Likewise, it is aligned with three of the  
504 Sustainable Development Goals (SDG) of the World Health Organization (SDG.3 - Good Health  
505 and Well-being, SDG.10 – Reduced Inequalities, and SDG.11 – Sustainable Cities and  
506 Communities) (97,98).

507 When it comes to health-promoting urban and transport design, there is a lack of  
508 standardized, quantitative indicators to guide the integration of health components right from  
509 the outset (53,100). In this context, the DAS-EP project not only aims to obtain individual  
510 UrbEE estimates but also to assess their association with and impact on various health  
511 outcomes. By means of PHS, the health effects to be studied in this study are derived from an  
512 unbiased population, which allows to obtain an approximate estimate of the impact at  
513 population level. Moreover, it is important to identify the precise routes that connect urban  
514 environment to health because they can guide the most efficient interventions, allowing us to  
515 design healthy(er) cities (52,101). In this sense, the DAS-EP project investigates various  
516 components of the urban environment and health at individual level. Besides using  
517 complementary indicators that describe both the physical and the social urban environment  
518 (e.g., neighbourhood insecurity), combines objective and perceived indicators to deepen the



1  
2  
3 519 characterization of the urban environment. By combining these data, it is possible to develop a  
4  
5 520 more precise understanding of the effects of urban environment on health, while describing  
6  
7 521 the complexity of the relationship influenced by neighbourhood environmental and individual  
8  
9 522 characteristics (99,102,103).

10  
11  
12  
13 523 The main limitation of this study is its cross-sectional nature. Due to the chronic  
14  
15 524 character of the health conditions included in the study (e.g., depression, insomnia) and the  
16  
17 525 possible long-term effects of UrbEE, a longitudinal design would be more informative and  
18  
19 526 appropriate. Although PHS have a cross-sectional approach, the question "since when have  
20  
21 527 you been living at your current address" enables to account for the extent of exposures.  
22  
23  
24 528 Drawing on this mobility data, sensitivity analysis of the models will be fitted reducing the risk  
25  
26 529 of exposure misclassification. Another limitation is that the samples from the study areas of  
27  
28 530 the Basque Country, Andalusia, and Valencian community, although representative of the  
29  
30 531 study population (considering the inclusion criteria) may not be representative of the  
31  
32 532 autonomous communities from which they come as we are not considering the non-urban  
33  
34 533 municipalities (<100,000 inhabitants). Despite the weight calibration will be conducted to  
35  
36 534 reduce coverage and representativeness biases, the reweighting procedure will not guarantee  
37  
38 535 the elimination of other response biases that may affect data collection from PHS (as  
39  
40 536 acquiescence, social desirability, etc.) that could affect the validity of the results (104,105).  
41  
42  
43 537 Further, the project is subject to residual confounding which in turn implies confounders that  
44  
45 538 could not be controlled and, importantly, measurement errors in the confounders that have  
46  
47 539 been included. In this regard, the estimation UrbEE by GIS is affected by the problem of  
48  
49 540 uncertainty of the temporal and geographical context (106). Finally, the heterogeneity across  
50  
51 541 study areas in terms of geographic scale (autonomous communities vs. city) may be a source of  
52  
53 542 information bias. In this vein, the majority but not all the scales and variables are included in  
54  
55 543 the different PHS are identical. These minor differences in data collection across PHS may lead  
56  
57 544 to additional information biases hindering the comparability of the data. To minimize this  
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1  
2  
3 545 problem, special attention will be paid to the selection and harmonization of the variables to  
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5 546 be included in order to ensure the consistency of data before making the comparisons across  
6  
7 547 study areas.  
8  
9

10  
11 548 As for the strengths of this project, pooling linked surveys across study areas will make  
12  
13 549 it possible to compare the results in different populations, providing a comprehensive dataset  
14  
15 550 that is larger than most existing cohort studies, and that have an unique national and  
16  
17 551 population perspective. The results will be novel in terms of their thematic (objective &  
18  
19 552 subjective UrbEE) and methodological approach (combination of PHS from different study  
20  
21 553 areas and GIS estimates), as well as in terms of the large volume of information that will be  
22  
23 554 handled and the large sample size of the study. Beyond that, the standardization of the  
24  
25 555 procedure here described will generate useful information to assist in the planning of national  
26  
27 556 health surveillance programs, research studies and, more importantly, interventions to  
28  
29 557 strengthen population's health.  
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34 558 In short, the results and products (i.e., databases, computer codes) of this project will  
35  
36 559 greatly contribute to estimate the proportion of the population exposed to different UrbEE,  
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38 560 identify health disparities while considering UrbEE, estimate how these exposures relate to  
39  
40 561 and affect various health variables, and conduct a health impact assessment of UrbEE. We will  
41  
42 562 have taken a further step towards understanding and improving the urban environment and  
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44 563 being able to establish corrective measures in the urban development plans of the cities.  
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## 564 **Declarations**

### 565 **Ethics and dissemination**

566 The study was approved by the regional Research Ethics Committee of the **Basque Country**,  
567 ETHICS COMMITTEE FOR RESEARCH INVOLVING MEDICINAL PRODUCTS IN THE BASQUE  
568 COUNTRY (*CEIm-E*) (protocol code PI2022138, dated 9<sup>th</sup> November 2022); **Andalusia**,  
569 BIOMEDICAL RESEARCH ETHICS COMMITTEE OF THE PROVINCE OF GRANADA (CEI/CEIM  
570 GRANADA) (protocol code 2078-N-22, dated 27<sup>th</sup> December 2022); **Barcelona**, PARC DE SALUT  
571 MAR CLINICAL RESEARCH ETHICS COMMITTEE (CEIm) (protocol code 2022/10667, dated 2<sup>nd</sup>  
572 December 2022); **Valencian Community**, ETHICS COMMITTEE FOR CLINICAL RESEARCH OF THE  
573 DIRECTORATE GENERAL OF PUBLIC HEALTH AND CENTER FOR ADVANCED RESEARCH IN PUBLIC  
574 HEALTH (CEIC DGSP / CSISP) (protocol code 20221125/04, dated 25<sup>th</sup> November 2022). The  
575 results will be communicated to the general population, health professionals and institutions  
576 through conferences, reports, and scientific articles.

### 577 **Competing interests**

578 The authors declare that they have no competing interests.

### 579 **Funding statement**

580 This project was supported by the Instituto de Salud Carlos III (ISCIII) under the Strategic Action  
581 in Health with the Health Research Fund (FIS) in the call 2022 (file No. PI22/01051 and No.  
582 PI22/00512). Data collection is funded by the various agencies responsible for the included  
583 health surveys. In addition to the FIS funding, the group has its own financial means for other  
584 expenses including publication and dissemination of results, travel expenses and conference  
585 registrations related to the study.

### 586 **Authors' contributions**

1  
2  
3 587 Conceptualisation, A.L., A.C.-L., M.S-P  
4  
5 588 Methodology, A.L., A.C.-L., M.S-P  
6  
7 589 Writing, original draft preparation, A.B., A.L., M.S-P., A.C-L  
8  
9  
10 590 Writing, review and editing, A.B., A.L., M.S-P., A.C-L., S.C.G., G.G-B., S.D.G., F.B., M.E., A.M.,  
11  
12 591 A.E., M.A.I., C.B., R.M., L.F-R., X.B., K.P., L.O., A-C.B., A.D., L.G., H.G.C., M.L.N., R.C., M.M.R.,  
13  
14 592 M.S  
15  
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3 1 Supplementary file  
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6 2 **File name:** Supplementary file\_DAS-EP  
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9 3 **File format:** Word document (.docx)  
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12 4 **Title of data:** Supplementary data of Urban Environment and Health: a cross-sectional  
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14 5 multiregional project based on Population Health Surveys in Spain (DAS-EP project), study  
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16 6 protocol.  
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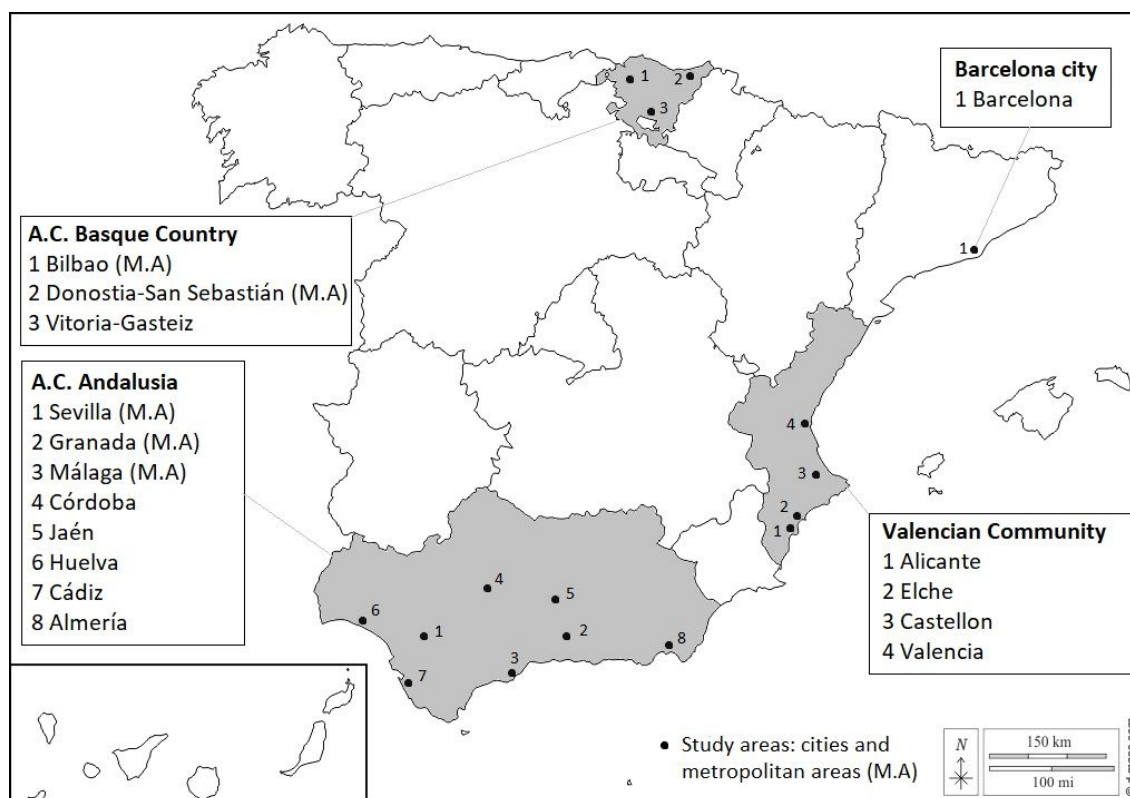
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## 23 Section 1. GENERAL CHARACTERISTICS OF THE STUDY AREAS



**Figure S1.** Study areas of the project, being the cities and metropolitan areas (M.A) with more than 100,000 inhabitants from the autonomous communities of the Basque Country and Andalusia, Valencian Community, and the city of Barcelona. Figure edited from Daniel Dalet / d-maps.com.

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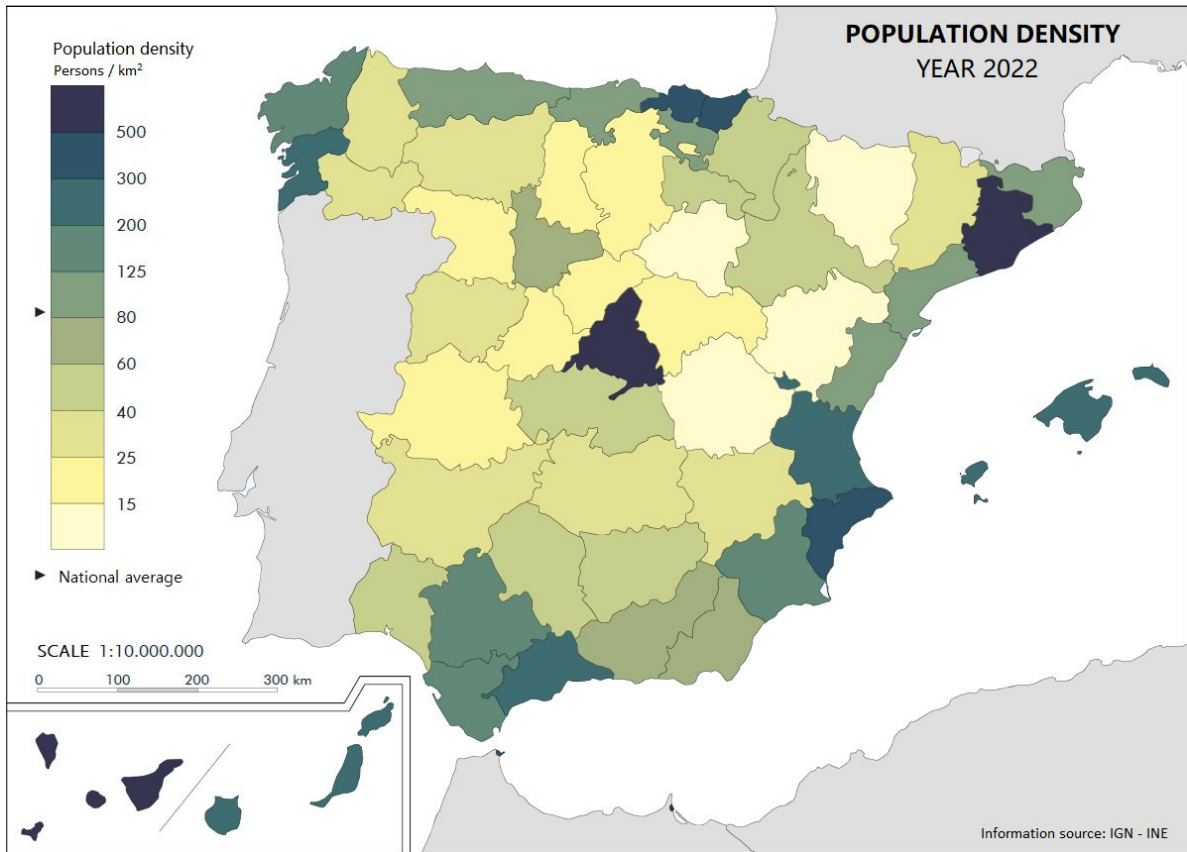
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**Figure S2.** Population density of Spanish provinces in 2022. Figure edited from Instituto Geográfico Nacional, *La población en España 2022*. Accessed through: <https://www.ign.es/pobesp/pe1.htm>

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36 **Section 2. GENERAL CHARACTERISTICS OF THE POPULATION HEALTH SURVEYS**

38 **Table S1.** Characteristics of the study areas and the population health surveys comprised in the project.

Study area	Cities and areas of influence	Population health survey	Responsible body	Sample size	Data collection period
A.C. Basque Country	Vitoria-Gasteiz Donostia-San Sebastián (M.A) Bilbao (M.A)	Encuesta de Salud de la Comunidad Autónoma País Vasco (ESCAV)	✓ Basque Department of Health	7,846	2022 October – 2023 June
A.C. Andalusia	Almería Cádiz Córdoba Huelva Jaén Granada (M.A) Malaga (M.A) Sevilla (M.A)	Encuesta Andaluza de Salud (EAS)	✓ Andalusian School of Public Health (EASP)	3,085	2022 April – 2023 April
Barcelona city	Barcelona	Encuesta de Salud de Barcelona (ESB)	✓ Barcelona Public Health Agency (ASPB)	4,000	2021 February – 2022 March
Valencian Community	Castellon Valencia Elche Alicante	Encuesta Salud Comunidad Valenciana (ESCV)	✓ Foundation for the Promotion of Health and Biomedical Research in the Valencian Region (DGSP)	3,134	2022 April – 2022 December

Abbreviations: A.C., Autonomous community; M.A, Metropolitan Area.

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41 **Section 3. OVERVIEW OF THE VARIABLES OF THE STUDY PER STUDY AREA**

42 **Table S2.** Objective urban environmental exposures obtained through GIS estimations.

GIS Variables	Study areas: A.C. s of the Basque Country and Andalusia, Valencian Community & the city of Barcelona	
OBJECTIVE URBAN ENVIRONMENTAL EXPOSURES	Scale	Variable
<b>a) Surrounding natural spaces</b>		
<b>Green Spaces</b>		
	100, 300, 500m	
Green space percentage	buffers	Percentage of green space.
NDVI	100, 300, 500m buffers	Annual mean Normalised Difference Vegetation Index (NDVI) of the year when the surveys were conducted and the mean NDVI of the last 5 years previous to the surveys.
	100, 300, 500m	
Tree percentage	buffers	Percentage of tree cover based on Growing stock volume (GSV) data.
Distance to green space		Euclidean distance to the nearest major green space (green surface over 5,000m <sup>2</sup> ).
Green spaces Yes (vs. No)	100, 300, 500m buffers	Dichotomous variable of presence of major green spaces (green surface over 5,000m <sup>2</sup> ) from local topographical or Europe-wide maps (Urban atlas).
<b>Blue spaces</b>		
	100, 300, 500m	
Blue spaces Yes (vs. No)	buffers	Dichotomous variable of presence of water surfaces. Based on Urban Atlas.
	100, 300, 500m	
Blue space percentage	buffers	Percentage of water surface. Based on Urban Atlas.
Distance to blue space		Euclidean distance to the nearest water surface over 5,000m <sup>2</sup> . Based on Urban



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Atlas.		
<b>b) Built environment</b>		
Building density	100, 300, 500m buffers	The building density around each household will be calculated accounting for the perimeter and height of the buildings from local cadastre data or Europe-wide maps (Urban Atlas).
Population density	100, 300, 500m buffers	The number of inhabitants (per km <sup>2</sup> ) surrounding the home addresses.
Street connectivity	100, 300, 500m buffers	Using data from OpenStreetMap® .
Accessibility (bus lines)	100, 300, 500m buffers	Access to public transport bus lines from local topographical maps or OpenStreetMap®.
Accessibility (bus stops)	100, 300, 500m buffers	Access to public transport bus stops from local topographical maps or OpenStreetMap®.
Facility richness	100, 300, 500m buffers	Using local topographical maps or OpenStreetMap®.
Facility density	100, 300, 500m buffers	Using local topographical maps or OpenStreetMap®.
Land use	100, 300, 500m buffers	Mixed land use will be estimated by Shannon's Evenness Index based on Urban Atlas data.
Walkability index	100, 300, 500m buffers	Index constructed from seven indicators: population density, street connectivity, facility richness, land use, destination density, street density, and average slope.
<b>c) Traffic infrastructure</b>		
Major road Yes (vs. No)	100, 300, 500m buffers	Dichotomous variable of presence of a major road (OpenStreetMap®).

Inverse distance

Inverse distance to the nearest major road (OpenStreetMap®).

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**GIS Variables** Study areas: A.C. s of the Basque Country and Andalusia, Valencian Community & the city of Barcelona

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OBJECTIVE URBAN ENVIRONMENTAL EXPOSURES	Scale	Variable
<b>d) Environmental stressors</b>		
<b>Air pollution</b>		
PM <sub>2.5</sub>	Street level (at residential address)	PM <sub>2.5</sub> exposure indicators include: a) the annual average for the last five years, and b) the five-year average for the last five years based on spatiotemporal land-use random-forest models.
PM <sub>10</sub>	Street level (at residential address)	PM <sub>10</sub> exposure indicators include: a) the annual average for the last five years, and b) the five-year average for the last five years based on spatiotemporal land-use random-forest models.
NO <sub>2</sub>	Street level (at residential address)	NO <sub>2</sub> exposure indicators include: a) the annual average for the last five years, and b) the five-year average for the last five years based on spatiotemporal land-use random-forest models.
<b>Noise</b>		
Day (L <sub>d</sub> )	Street level (at residential address)	Exposition to environmental noise at street level during the day indicated as: a) the annual average for the last five years, and b) the five-year average for the last five years based on Strategic Noise Maps derived under the EU Directive 2002/49/EC from the Ministry for the Ecological Transition and the Demographic Challenge.
Evening (L <sub>e</sub> )	Street level (at residential address)	Exposition to environmental noise at street level during the evening indicated as: a) the annual average for the last five years, and b) the five-year average for the last five years based on Strategic Noise Maps derived under the EU Directive

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2002/49/EC from the Ministry for the Ecological Transition and the Demographic Challenge.

Night ( $L_n$ )	Street level (at residential address)	Exposition to environmental noise at street level during the night indicated as: a) the annual average for the last five years, and b) the five-year average for the last five years based on Strategic Noise Maps derived under the EU Directive 2002/49/EC from the Ministry for the Ecological Transition and the Demographic Challenge.
Total ( $L_{den}$ )	Street level (at residential address)	Total exposition to environmental noise at street level indicated as: a) the annual average for the last five years, and b) the five-year average for the last five years based on Strategic Noise Maps derived under the EU Directive 2002/49/EC from the Ministry for the Ecological Transition and the Demographic Challenge.

Abbreviations: A.C., Autonomous community; NDVI, Normalised Difference Vegetation Index; GSV, Growing stock volume;  $PM_{2.5}$ , Fine particulate matter with a diameter of 2.5 $\mu$ m or less;  $PM_{10}$ , Fine particulate matter with a diameter of 10 $\mu$ m or less;  $NO_2$ , Nitrogen dioxide

44 **Table S3.** Variables collected through Population Health Surveys.

Population Health Survey Variables	Study areas			
	A.C. Basque Country	A.C. Andalusia	Barcelona city	Valencian Community
<b>OUTCOMES</b>				
<b>a) Self-perceived health</b>				
General Health	Ordinal 1-5	Ordinal 1-5	Ordinal 1-5	Ordinal 1-5
Mental Health	Ordinal 1-5 [Mental Health Inventory /5 items]	Ordinal 1-6 [SF-12 / 3 items]	Ordinal 1-4 [GHQ-12/ 12 items]	Ordinal 1-4 [GHQ-12 / 12 items]
<b>b) Quality of life</b>				
Health-related quality of life	Ordinal 1-5 [EuroQoL / 5 items]	Ordinal 1-6/1-5 [SF-12 / 5 items]	Ordinal 1-5 [EuroQoL / 5 items]	Ordinal 1-5 [EuroQoL / 5 items]
<b>c) Sleep</b>				
Sleep duration	Continuous - Total hours/day	Continuous - Total hours/day	Continuous - Total hours/day	Continuous - Total hours/day
Quality of sleep	Ordinal 1-5 [SATED / 5 items]	yes/no & Ordinal 1-4 [4 items]	Ordinal 1-10	Ordinal 1-5 [SATED / 5 items]
<b>d) Consumption of medication for common mental disorders<sup>1</sup></b>				
Antidepressants	yes/no – reference 2 days	yes/no – reference 2 weeks	yes/no - reference 2 days	yes/no - reference 2 weeks
Hypnotics	yes/no - reference 2 days	yes/no - reference 2 weeks	yes/no - reference 2 days	yes/no – reference 2 weeks
Anxiolytics	yes/no - reference 2 days	yes/no - reference 2 weeks	yes/no - reference 2 days	yes/no - reference 2 weeks
<b>e) Chronic mental health problems<sup>2</sup></b>				
Anxiety	yes/no - reference ever	yes/no – reference present	yes/no - reference ever	yes/no – reference ever
Depression	yes/no - reference ever	yes/no - reference present	yes/no - reference ever	yes/no - reference ever

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Insomnia	yes/no - reference ever	-	-	yes/no - reference ever
Other	yes/no - reference ever	-	yes/no - reference ever	yes/no - reference ever
<b>COVARIATES</b>				
<b>a) Anthropometric variables</b>				
Age	Discrete	Discrete	Discrete	Discrete
Weight	Continuous	Continuous	Continuous	Continuous
Height	Continuous	Continuous	Continuous	Continuous
BMI	Continuous	Continuous	Continuous	Continuous
Biologic sex	Categorical - 3 conditions	Categorical - 2 conditions	Categorical - 2 conditions	Categorical - 2 conditions
Gender identity	Categorical - 3 conditions	-	Categorical - 3 conditions	-
<b>b) Socioeconomic variables</b>				
Education level	Categorical - 9 conditions	Categorical - 13 conditions	Categorical - 11 conditions	Categorical - 9 conditions
Occupational status	Categorical [CNO11]	Categorical [CNO11]	Categorical [CNO11]	Categorical [CNO11]
Household size	Discrete	Discrete	Discrete	Discrete
<b>Population Health Survey</b>		<b>Study areas</b>		
<b>Variables</b>	<b>A.C. Basque Country</b>	<b>A.C. Andalusia</b>	<b>Barcelona city</b>	<b>Valencian Community</b>
Household income	Categorical - 11 conditions	-	-	Categorical - 8 conditions
Economic difficulty	Categorical - 6 conditions	Categorical - 6 conditions	Categorical - 6 conditions	Categorical - 6 conditions
Employment status	yes/no	yes/no	yes/no	yes/no
Country of birth	Categorical & Open	Categorical & Open	Categorical & Open	Categorical & Open
Marital status	Categorical - 6 conditions	Categorical - 5 conditions	Categorical - 5 conditions	Categorical - 5 conditions
<b>c) Lifestyle factors</b>				
Alcohol consumption	Categorical - 8 conditions	Categorical - 10 conditions	Categorical - 4 conditions	Categorical - 8 conditions
Passive smoking at home	Likert 1-5	yes/no	Discrete (N° smokers)	yes/no

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Daily tobacco consumption	yes/no	Categorical - 4 conditions	Categorical - 3 conditions	Categorical - 4 conditions
<b>e) Physical Health</b>				
Non-mental chronic health problems	Categorical - 38 conditions	Categorical - 25 conditions	Categorical - 25 conditions	Categorical - 21 conditions
<b>d) Mobility</b>				
Years at household	Discrete	-	Discrete	Discrete
<b>MEDIATORS</b>				
<b>a) Physical activity</b>				
Physical activity	Discrete - IPAQ	Discrete - IPAQ	Discrete - IPAQ	Discrete - IPAQ
- Vigorous	MET-min/week	MET-min/week	MET-min/week	MET-min/week
- Moderate	MET-min/week	MET-min/week	MET-min/week	MET-min/week
- Walking	MET-min/week	MET-min/week	MET-min/week	MET-min/week
- Sitting	Time spent (hours + minutes)	Time spent (hours + minutes)	Time spent (hours + minutes)	Time spent (hours + minutes)
<b>b) Social cohesion</b>				
Social support	Ordinal 1-5 [Duke / 11 items]	Ordinal 1-5 [Duke / 11 items]	Ordinal 1-5/1-4 [OSLO/ 3 items]	Ordinal 1-5 [Duke / 11 items]
Loneliness	Ordinal 1-4	Ordinal 1-4	Ordinal 1-4	Ordinal 1-4
<b>SUBJECTIVE URBAN ENVIRONMENTAL EXPOSURES</b>				
<b>a) Perception of the neighbourhood</b>				
Noise outside dwelling	Likert 1-3	Likert 1-3	Likert 1-5	Likert 1-3
Neighbourhood air pollution	Likert 1-3	Likert 1-3	-	Likert 1-3

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Shortage of green spaces	Likert 1-3	Likert 1-3	-	Likert 1-3
Insecurity	Likert 1-3	Likert 1-3	Likert 1-5	Likert 1-3

<sup>1</sup> The subjects are provided with a list of medications and are asked if they have consumed any of them in the last 2 days or 2 weeks depending on the study area.

<sup>2</sup> The subjects are provided with a list of chronic health problems and are asked if they currently suffer or have ever suffered (depending on the study area) from any of them.

For peer review only

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4 46 **Section 4. DATA MANAGEMENT PLAN**  
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7 47 A) RESEARCH ACTIVITIES  
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10 48 Step 1. Population Health Surveys' (PHS) data curation and calibration  
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13 49 The selected individuals were contacted by a phone call, SMS, or letter to arrange an  
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15 50 appointment for a face-to face interview for the purpose of the survey. The database produced  
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17 51 with the interviews will be pseudonymised from that with the personal data for the contact by  
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19 52 assigning a unique code for each participant and remains under the custody of the responsible  
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21 53 body in each study area; the Basque Department of Health in the Basque Country, Escuela  
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23 54 Andaluza de Salud Pública (EASP) in Andalusia, Agència de Salut Pública de Barcelona (ASPB) in  
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25 55 Barcelona, and Conselleria de Salut Universal i Salut Pública (DGSP) in Valencian Community.  
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30 56 Step 2. Harmonisation  
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33 57 Initially, the databases of each study area will be cleaned, and the variables that require it  
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35 58 will be harmonised. The vast majority of the variables to be used in the project have been  
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37 59 collected identically in the Population Health Surveys of the study areas included. The variables  
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39 60 to be harmonized are listed below and the measures used in each study area can be found in  
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41 61 Table S2.  
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45 62 The variables that need harmonisation can be distinguished between simple or complex  
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47 63 variables, depending on the level of difficulty and the manipulation of data that require the  
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49 64 harmonisation of the respective variable:

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53 65 - Simple variables: Chronic mental health problems, Educational level, Occupation  
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55 66 status, Household income, Loneliness, Noise outside dwelling, and Insecurity.  
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3 67 - Complex variables: mental health, health-related quality of life, sleep quality,  
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5 68 consumption of medication for common mental disorders, alcohol consumption,  
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7 69 passive smoking at home, tobacco consumption, physical health, and social support.  
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11 70 The Maelstrom Research Guidelines for the rigorous harmonisation of retrospective data  
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13 71 (77) will be applied. Among the variables that need harmonisation, the majority can be easily  
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15 72 re-categorised (simple variables). For instance, in the case of scales with different score ranges  
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17 73 (e.g., Likert scale levels), standardised scores will be calculated, or other procedures will be  
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19 74 followed to ensure comparability. The procedure to follow with variables measured with  
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21 75 different scales will be more complex (complex variables). For these, the content of each  
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23 76 variable will be studied to detect the common content (e.g., items) in each of the study areas.  
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25 77 Once detected, aggregate scores will be calculated for the common items, and these scores  
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27 78 will be used for statistical analyses. The remaining non-harmonizable variables will be assessed  
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29 79 for their potential for performing separate statistical analysis for each study area.  
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### 34 80 Step 3. Georeferentiation

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37 81 The responsible bodies, in collaboration with regional Statistical Institutes or  
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39 82 Population Registers, will link the health survey data to the geographical coordinates of each  
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41 83 respondent's home address. The geographical coordinates will also be pseudonymised and  
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43 84 sent this way to the research group specialised in Geographic Information System (GIS)  
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45 85 estimations that will calculate UrbEE. In order to further ensure the protection of the personal  
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47 86 data of the survey participants and enhance their anonymity, fictional coordinates will be  
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49 87 created in a number five times the number of participants selected for the study in each study  
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51 88 area and sent to the research group specialised in GIS estimations together with the real  
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53 89 coordinates.  
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### 58 90 Step 4. GIS estimation of Urban Environmental Exposures (UrbEE)

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3 91 A company specialised in GIS estimations will calculate the objective urban  
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5 92 environmental exposures (UrbEE) of all the geocodes, including the participants' coordinates  
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7 93 and the fictional coordinates by GIS.  
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11 94 Step 5. Selection and linkage of data  
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14 95 After the estimations are finalised, the responsible bodies of the surveys in each study  
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16 96 area will re-select the geocodes of the participants and add the new urban environmental  
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18 97 variables to the database with the PHS data. The researchers will be provided with the  
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20 98 resultant database of each study area composed by the PHS data and the UrbEE (without  
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22 99 geocodes and personal data of the participants). This guarantees that the data supplied are  
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24 100 protected by statistical secrecy, not misused and treated anonymously and globally at all  
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31 102 Step 6. Pooling  
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34 103 Finally, the final databases of all the study areas will be pooled, creating the final  
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36 104 pooled database to be used in the planned analyses.  
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39 105 **B) DATA STORAGE AND PROCESSING**  
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42 106 Data will be kept at all times on servers located in the responsible centre of this project. This  
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44 107 way, data will be stored on the University of the Basque Country UPV/EHU's own servers,  
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46 108 complying with the greater security and privacy requirements of the LOPD as the data is not  
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48 109 sent to external servers. The entire process of recording, dumping and storage of the data will  
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50 110 be anonymised, with the data collected being exclusively linked to a sample unit code. Access  
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52 111 to the anonymised microdata will be limited to technicians from the responsible centres of  
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54 112 each study area through profiles with regulated permissions that allow for supervising and  
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56 113 controlling access to the information. Supervision of the data management will be assigned to  
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3 114 the principal investigators with expert advice, and to the data protection officer of the centre  
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5 115 responsible for the project.  
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9 116 C) ETHICAL CONSIDERATIONS AND ACCOUNTABILITY  
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12 117 The study was approved by the regional Research Ethics Committee of the **Basque Country**,  
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14 118 ETHICS COMMITTEE FOR RESEARCH INVOLVING MEDICINAL PRODUCTS IN THE BASQUE  
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16 119 COUNTRY (CEIm-E) (protocol code PI2022138, dated 9th November 2022); **Andalusia**,  
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18 120 BIOMEDICAL RESEARCH ETHICS COMMITTEE OF THE PROVINCE OF GRANADA (CEI/CEIM  
19  
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22  
23 122 MAR CLINICAL RESEARCH ETHICS COMMITTEE (CEIm) (protocol code 2022/10667, dated 2nd  
24  
25 123 December 2022); **Valencian Community**, ETHICS COMMITTEE FOR CLINICAL RESEARCH OF THE  
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27 124 DIRECTORATE GENERAL OF PUBLIC HEALTH AND CENTER FOR ADVANCED RESEARCH IN PUBLIC  
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29 125 HEALTH (CEIC DGSP / CSISP) (protocol code 20221125/04, dated 25th November 2022).  
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32  
33 126 This study is based on secondary data obtained from four independent Population  
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35 127 Health Surveys (PHS) from Spain. Since the present study does not involve the activity of data  
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37 128 collection, to obtain the informed consent from the subjects is not applicable for this study.  
38  
39 129 However, the PHS included this project are official statistical operations included in the  
40  
41 130 respective Statistical Plans of each study area. This ensures that the data provided is protected  
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43 131 by statistical confidentiality, it is not misused, its treatment is anonymous and global at all  
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45 132 times, and that indirect identification is impossible. Data are collected and processed in  
46  
47 133 accordance with the provisions of the General Data Protection Regulation (GDPR) and in  
48  
49 134 accordance with the provisions of Article 5 of the Organic Law 3/2018 of 5 December on the  
50  
51 135 Protection of Personal Data and the guarantee of digital rights (Regulation (EU) 2016/679),  
52  
53 136 they will be treated confidentially, with access to them being granted to personnel who strictly  
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55 137 need to process them in the framework of the study.  
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3 138 Furthermore, the transfer of data occurs between organisations within the Public  
4  
5 139 Health System of each region and the regional or local government itself. This is done in the  
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7 140 context of a research project conducted exclusively in the public sphere and with the  
8  
9 141 legitimacy of the use of administrative records as research infrastructures in accordance with  
10  
11 142 the General Health Act, the Biomedical Research Act and the General Law on Public Health.  
12  
13  
14 143 The results of the study will provide information at a sufficiently aggregated territorial level to  
15  
16 144 prevent indirect identification. Furthermore, the project's results will be beneficial to the  
17  
18 145 general population in a holistic way, thanks to its socioeconomic and environmental context,  
19  
20 146 and its evolution over several years from the onset of the COVID-19 pandemic. Therefore, the  
21  
22 147 risk to the privacy of the study population is minimal compared to the potential benefits the  
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24 148 results will bring.  
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For review only

# BMJ Open

## Urban Environment and Health: a cross-sectional multiregional project based on Population Health Surveys in Spain (DAS-EP project), study protocol.

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## Abstract

**Introduction:** The European Environment Agency estimates that 75% of the European population lives in cities. Despite the many advantages of city life, the risks and challenges to health arising from urbanization need to be addressed in order to tackle the growing burden of disease and health inequalities in cities. This study, *Urban Environment and Health: a cross-sectional multiregional project based on Population Health Surveys in Spain* (DAS-EP project), aims to investigate the complex association between the urban environmental exposures (UrbEEs) and health.

**Methods and analysis:** DAS-EP is a Spanish multiregional cross-sectional project that combines Population Health Surveys (PHS) and Geographical Information System (GIS) allowing to collect rich individual level data from 17,000 adult citizens participating in the PHS conducted in the autonomous regions of the Basque Country, Andalusia, and the Valencian Community, and the city of Barcelona in years 2021 to 2023. This study focuses on the population living in cities or metropolitan areas with more than 100,000 inhabitants. UrbEEs are described by objective estimates at participants' home addresses by GIS, and subjective indicators present in PHS. The health outcomes included in the PHS and selected for this study are self-perceived health (general and mental), prevalence of chronic mental disorders, health-related quality of life, consumption of medication for common mental disorders, and sleep quality. We aim to further understand the direct and indirect effect between UrbEEs and health, as well as to estimate the impact at the population level taking respondents' socio-demographic and socio-economic characteristics, and lifestyle into consideration.

### **Ethics and dissemination:**

The study was approved by the regional Research Ethics Committee of the Basque Country (CEIm-E; PI2022138), Andalusia (CEIM GRANADA; 2078-N-22), Barcelona (CEIC-PSMar; 2022/10667), and Valencian Community (CEIC DGSP/CSISP; 20221125/04). The results will be

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3 communicated to the general population, health professionals and institutions through  
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5 conferences, reports, and scientific articles.  
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#### 8 **Strengths and limitations of this study**

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- 10 • The linkage of four independent population health surveys (PHS) will provide the study  
11 with a large volume of information and sample size.  
12
- 13 • The method is novel for the inclusion of objective & subjective UrbEEs as well as the  
14 combination of PHS from different study areas and GIS estimates.  
15
- 16 • Despite the cross-sectional nature of the study, the results will ultimately help identify  
17 urban indicators, increasing the capacity to detect and intervene in community health  
18 outcomes, improving the routine surveillance and monitoring of the cities' health  
19 information systems.  
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## 1. Introduction

According to the World Health Organization, modifiable environmental factors are responsible for 23% and 22% of the global mortality and morbidity respectively [1]. As reported by the European Environment Agency, in 2021 75% of the European population lived in urban areas including cities but also smaller urban settlements and suburban areas, developed for residential, industrial or recreational purposes [2]. The local urban environment influences people's health by determining their level of urban environmental exposures (UrbEEs) [3,4]. The UrbEEs include the totality of the surrounding natural (e.g., green and blue spaces), built (e.g., walkability, urbanisation level, traffic,) and social (e.g., security, public services) environments within which people live, move, and interact, as well as environmental stressors like air pollution and noise. Increasing evidence shows that UrbEEs such as lack of greenness, air pollution and noise can impact population's mental and physical health and quality of life [5–9]. The health implications of environmental exposures become even more relevant in the contemporary demographic setting, given that they are perhaps starker in urban areas [10–14]. Moreover, in many regions, environmental exposures are not evenly distributed across socioeconomic status and thus, socio-economically vulnerable populations are also affected by poorer environmental quality [10,11]. In fact, this double jeopardy may result in individuals from poorer socioeconomic backgrounds more significantly affected by environmental exposures [4,15]. A comprehensive approach is crucial for understanding the interplay of various environmental determinants with health and well-being within urban settings. A holistic multi-exposure framework should be adopted, as outlined by Hammersen et al. [16], that extends beyond traditional considerations and incorporates critical urban contextual issues such as substandard housing, crowding, economic inequality, and the evolving challenges posed by climate change, as well as individual psychosocial factors [17,18].

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3 26 UrbEEs, including environmental stressors, traffic-infrastructure, natural spaces, and  
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5 27 built environment, have all been studied in relation to health. Widespread evidence in the  
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7 28 literature shows that air pollution, noise, and lack of green space are related to a range of  
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9 29 chronic physical diseases [19–24]. Recently, it has been suggested that air pollution is  
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11 30 associated with a range of mental disorders and poorer sleep quality [21,25–28]. Other recent  
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13 31 studies observed that environmental noise has negative effects on mental health, well-being,  
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15 32 and sleep quality [27,29–31], while evidence on its impact on prescriptions and consumption  
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17 33 of medication for common mental disorders has yet to be scientifically confirmed [32].  
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19 34 Otherwise, current scientific evidence indicates that residential greenness is positively  
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21 35 associated with mental health and quality of life [31,33,34], and lower consumption of  
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23 36 anxiolytics, antidepressants, and sleeping pills [27,35]. Blue spaces (aquatic environments such  
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25 37 as rivers, lakes, and the coast) are expected to have similar health effects to those described  
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27 38 here, however, evidence on this subject is limited [35,36]. As for the built environment,  
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29 39 walkability or accessibility have also been related to reduced obesity and better cardiovascular  
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31 40 health [37], improved mental health [38,39] and well-being [40]. To date, the main  
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33 41 mechanisms proposed to explain these associations are the mitigation of exposure to  
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35 42 environmental pollutants, the promotion of physical activity, and the strengthening of social  
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37 43 cohesion [33,34,37,41–43]. Moreover, these mechanisms are probably synergistic [44]. The  
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39 44 correlations between several UrbEEs and their relationship with behavioural exposures, such  
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41 45 as physical activity and social cohesion, makes the assessment of these associations and  
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43 46 pathways highly challenging [45–49]. Hence, noise and air pollution could act both as  
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45 47 exposures, mediators, or potential confounders. Overall, results of previous studies are quite  
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47 48 mixed and the associations as well as the underlying mechanisms between UrbEEs and mental  
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49 49 health outcomes need more robust scientific evidence [5,47,50–52].

50 This knowledge gap can be partly explained by the heterogeneity and limitations of  
51 exposure and outcome metrics used in the studies [19,52,53]. Moreover, there is a lack of

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3 52 studies addressing the impact of UrbEEs on health integrating objective and perceived  
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5 53 accounts of such exposures [54]. Therefore, it is evident that more research is needed to  
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7 54 determine which UrbEEs are associated with health, the potential mechanisms involved, and  
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9 55 the role of social aspects in those associations. Beyond this, researchers are increasingly called  
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11 56 to provide information that can guide the selection of the best and most feasible interventions  
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13 57 to improve public health in cities. In this respect, experts in the field have claimed the vital role  
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15 58 that health impact assessment tools play when integrating the evidence in the decision-making  
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17 59 process [55,56].  
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22 *Urban Environment and Health: a cross-sectional multiregional project based on*  
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24 61 *Population Health Surveys in Spain* (DAS-EP project) is a 3-year project (2023-2025) aimed at  
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26 62 further investigating the associations and underlying mechanisms, including direct and indirect  
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28 63 effects, between UrbEEs and health with a health equity perspective. Five main objectives  
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30 64 have been established for this project:  
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- 34 65 1. To estimate, describe, and compare the objective and subjective levels of UrbEEs in  
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36 66 the study areas.  
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38 67 2. To describe urban environmental inequalities according to socio-demographic and  
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40 68 socio-economic variables, as well as the study area.  
41  
42 69 3. To estimate the association of UrbEEs with self-perceived general and mental health,  
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44 70 health-related quality of life, chronic mental disorders, consumption of medication for  
45  
46 71 common mental disorders, and sleep quality (Figure 1)<sup>1</sup>.  
47  
48  
49 72 4. To estimate the impact of UrbEEs on the health outcomes under evaluation, at the  
50  
51 73 population level, and to conduct a health impact assessment.  
52  
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58 <sup>1</sup> For a summary of current prevalence of common mental disorders in Spain, please see section 3.A in  
59 the Supplementary file.  
60



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2  
3 74 5. To assess the mediating role of physical activity, social cohesion, and environmental  
4  
5 75 stressors on the association between UrbEEs and the health outcomes under  
6  
7 76 evaluation (Figure 1).  
8  
9

10 77 The general hypothesis of this research project is that the urban environment directly or  
11  
12 78 indirectly affects mental health and quality of life. In line with the first objective of the project,  
13  
14 79 we expect significant differences in levels of exposure to urban environmental variables among  
15  
16 80 the cities under study. Regarding the second objective, we expect participants with lower  
17  
18 81 socio-economic status, lower educational levels, and less remunerated occupations to live in  
19  
20 82 residential environments of poorer environmental quality. We expect them to live in areas  
21  
22 83 with less availability of green and blue spaces, lower walkability scores, and higher levels of  
23  
24 84 noise and air pollution. Finally, we expect the various environmental exposures reported in this  
25  
26 85 study to be significantly associated with the various health and mental health variables studied  
27  
28 86 in the project. Notably, we anticipate that air pollution and noise may have negative effects on  
29  
30 87 mental health, while exposure to natural (green and blue), and more walkable spaces will  
31  
32 88 show protective effects against bad mental health. Furthermore, in line with recent literature,  
33  
34 89 we expect that part of these potential effects on mental health might be produced through  
35  
36 90 increased physical activity and social cohesion.  
37  
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## 42 91 **2. Methods and analysis**

### 43 44 45 46 92 **2.1. Study design**

47  
48 93 This is a cross-sectional study based on information from Population Health Surveys  
49  
50 94 (PHS) carried out in adult population living in urban areas, with more than 100,000 inhabitants,  
51  
52 95 in the autonomous regions of the Basque Country, Andalusia, the Valencian Community, and  
53  
54 96 the city of Barcelona in Spain. The study integrates observational data collected within the four  
55  
56 97 independent PHS in 2021-2023 with Geographic Information System (GIS) estimations of  
57  
58 98 individual UrbEEs. It entails the following research activities: 1) preparing, integrating, and  
59  
60

1  
2  
3 99 calibrating PHS data from each study area, 2) harmonising the variables that have been  
4  
5 100 collected differently in the four study areas, 3) georeferencing survey respondents' home  
6  
7 101 addresses, 4) characterizing each home address in terms of UrbEEs by GIS, 5) linking UrbEEs  
8  
9 102 estimates with PHS data, and 6) pooling of datasets from the four study areas (Figure 2). Using  
10  
11 103 the final pooled database, we will analyse the association between UrbEEs and health in a  
12  
13 104 cross-sectional manner, considering sociodemographic, socioeconomic and lifestyle factors.  
14  
15 105 Figure 1 shows the conceptual framework designed within the scope of this project. DAS-EP  
16  
17 106 received Ethics Approval from the relevant regional ethics committees (see more  
18  
19 107 Supplementary file section 5). This project has received funding from the Instituto de Salud  
20  
21 108 Carlos III (ISCIII) under the Strategic Action in Health with the Health Research Fund (FIS) in the  
22  
23 109 call 2022 (file No. PI22/01051 and No. PI22/00512). The project runs from 2023 to 2025.  
24  
25  
26  
27  
28

## 29 110 **2.2. Study population**

30  
31  
32 111 The target population are inhabitants of the autonomous communities of the Basque Country,  
33  
34 112 Andalusia, the Valencian Community, and the city of Barcelona. The sampling frames are  
35  
36 113 made up of people over 15 or 16 years of age of the respective study areas. The study  
37  
38 114 population includes the PHS' participants living in urban areas with more than 100,000  
39  
40 115 inhabitants in the regions mentioned before (Figure S1, S2). The cities and metropolitan areas  
41  
42 116 participating in this study are: the city of Vitoria-Gasteiz, and the metropolitan areas of Bilbao  
43  
44 117 and Donostia-San Sebastián in the Basque Country; the cities of Almeria, Cadiz, Cordoba,  
45  
46 118 Huelva, Jaen, and the metropolitan areas of Granada, Malaga, and Seville in Andalusia; the  
47  
48 119 cities of Castellon, Valencia, Elche and Alicante in the Valencian Community; and the city of  
49  
50 120 Barcelona (Table S1).  
51  
52  
53

54  
55 121 The PHS included in this project are official statistical operations that are incorporated in  
56  
57 122 the Statistical Plans of each study area. These activities are conducted by every regional or  
58  
59 123 local public administration with jurisdiction in health and are a fundamental tool to monitor  
60

1  
2  
3 124 the status and evolution of relevant health conditions in the population, their main  
4  
5 125 determinants, and the use of health services [57–60]. Accordingly, these regional and local  
6  
7 126 cross-sectional epidemiological surveys are carried out by the Basque Department of Health in  
8  
9 127 the Basque Country [57], Andalusian School of Public Health (EASP) in Andalusia [58],  
10  
11 128 Barcelona Public Health Agency (ASPB) in Barcelona [59], and Foundation for the Promotion of  
12  
13 129 Health and Biomedical Research in the Valencian Region (DGSP) in Valencian Community [60].  
14  
15 130 They have been organised every 4-5 years since 1986 (Basque Country), 1999 (Andalusia),  
16  
17 131 1983 (Barcelona) and 1991 (Valencian Community). The sample design and the selection of the  
18  
19 132 sample is carried out independently in each region by the statistical institute (The Basque  
20  
21 133 Institute for Statistics in the Basque Country, Institute of Statistics and Cartography of  
22  
23 134 Andalusia in Andalusia, and municipal statistical office of the Barcelona city council in  
24  
25 135 Barcelona) or health population information system (Valencian Community). Data from the  
26  
27 136 latest version of these surveys is included in this project. After the surveys are completed, we  
28  
29 137 expect a total estimated sample of 16,953 individuals, of which 7,846 participants will be from  
30  
31 138 the Basque Country, 3,085 from Andalusia, 3,134 from the Valencian Community, and 4,000  
32  
33 139 from the city of Barcelona. More detailed information is provided in Table S1.  
34  
35  
36  
37  
38  
39

### 40 **2.3. Data collection**

#### 41 2.3.1. GIS estimates of urban environmental exposures (UrbEEs)

42  
43  
44  
45 142 Objective measures of UrbEEs are estimated by a company specialised in GIS based on the  
46  
47 143 geographic coordinates of the participants' home addresses. A significant number of these  
48  
49 144 variables will be expressed in buffers around each participant's residence or at the building  
50  
51 145 level. All environmental exposures will be assessed preceding to, and as close as possible to  
52  
53 146 the time the PHS are being conducted (2021-2023) to avoid temporal mismatch [61]. The  
54  
55 147 objective UrbEEs of interest in this project include exposures originated from surrounding  
56  
57 148 natural spaces, built environment, traffic-infrastructure, and environmental stressors. Detailed  
58  
59  
60

1  
2  
3 149 information on the UrbEEs estimated within the scope of this project can be found in the  
4  
5 150 Supplementary file (Table S2).

6  
7  
8 151 *Surrounding natural spaces*

9  
10  
11 152 - Green spaces. Five green space exposure metrics will be calculated in buffers of 100, 300  
12  
13 153 and 500 m around each geocode: 1) percentage of green space; 2) mean Normalised  
14  
15 154 Difference Vegetation Index (NDVI) [62,63]; 3) percentage of tree cover; 4) Euclidean  
16  
17 155 distance to the nearest green space larger than 5,000 m<sup>2</sup> [64], and 5) presence of a major  
18  
19 156 green area (greater than 5,000 m<sup>2</sup>).

20  
21  
22 157 - Blue spaces. Any blue environments, including lakes, rivers, or coastline will be considered  
23  
24 158 as blue space. Three blue space exposure variables will be estimated: 1) presence of water  
25  
26 159 surface; 2) percentage of water surface; and 3) Euclidean distance to nearest water surface  
27  
28 160 greater than 5,000m<sup>2</sup>. The first two refer 100, 300 and 500 m buffers around each geocode  
29  
30 161 [65].

31  
32  
33  
34 162 *Built environment*

35  
36  
37 163 - Building density. The building density around each home address in 100, 300 and 500 m  
38  
39 164 buffers will be estimated, considering not only the perimeter of the buildings but also  
40  
41 165 their height [66].

42  
43  
44 166 - Walkability. An overall walkability index in 100, 300 and 500 m buffers around the  
45  
46 167 participants' home addresses will be calculated. This index will include of the following  
47  
48 168 subindices: 1) population density (at the census tract level), 2) street density, 3) street  
49  
50 169 connectivity, 4) land use Shannon Evenness Index, 5) facility richness, 6) facility density, 7)  
51  
52 170 average slope, and 8) transport density [67,68].

53  
54  
55  
56 171 *Traffic infrastructure*

- 1  
2  
3 172 - Major road (Yes vs. No). Presence of a major road (with >3 million vehicle passages per  
4  
5 173 year) in 100, 300 and 500 m buffers around the participants' home addresses [66].  
6  
7 174 - Distance to major road. Distance to the nearest major road (with >3 million vehicle  
8  
9 175 passages per year) from the participants home addresses [66].  
10  
11  
12

13 176 *Environmental stressors*

- 14  
15 177 - Air pollution. Spatiotemporal daily models at household-level for particulate matter (PM<sub>10</sub>  
16  
17 and PM<sub>2.5</sub>) and nitrogen dioxide (NO<sub>2</sub>) will be constructed for all study areas using  
18 178 multistage mixed models. These models are known as spatiotemporal land-use random-  
19  
20 179 forest model [69] and combine ground-level and satellite measurements, land use and  
21  
22 180 meteorology. A precise daily estimate of the exposures will be obtained for all study  
23  
24 181 subjects (period 2006 to 2023). Using the daily estimates, annual average for the last five  
25  
26 182 years and the five-year average of NO<sub>2</sub>, PM<sub>10</sub> and PM<sub>2.5</sub> exposure levels will be calculated  
27  
28 183 at PHS respondents' home address as indicators for long-term air quality.  
29  
30 184  
31  
32 185 - Environmental noise. The Strategic Noise Maps derived under the EU Directive  
33  
34 186 2002/49/EC from the Ministry for the Ecological Transition and the Demographic Challenge  
35  
36 187 will be used. All potential sources of environmental noise at street level will be examined,  
37  
38 188 including road traffic, rail, industrial, airports and total noise [70,71]. Major roads, major  
39  
40 189 railways, and major airports will be included in cities where this information is available  
41  
42 190 and not included in the agglomeration layer. Agglomerations corresponding to the closest  
43  
44 191 street to the dwelling, and major roads and airports corresponding to the closest isoline  
45  
46 192 will be used. In all cases, the Euclidean distance to each source will also be calculated. The  
47  
48 193 daytime (L<sub>d</sub>), evening (L<sub>e</sub>), night-time (L<sub>n</sub>), and total (L<sub>den</sub>) noise indices will be assigned.  
49  
50  
51  
52  
53 194 2.3.2. Contextual socioeconomic variables  
54  
55  
56 195 Neighbourhood-level socioeconomic status (SES) will be considered via three variables,  
57  
58 196 namely, mean income, income distribution P80/P20, and the MEDEA deprivation index  
59  
60

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2  
3 197 (composed by percentage of the population with manual labour, percentage of the population  
4  
5 198 with casual labour, percentage of the population unemployed, percentage of the population  
6  
7 199 with insufficient education, percentage of the population of young people with insufficient  
8  
9  
10 200 education) [72]. All these metrics will be obtained from the publicly available data developed  
11  
12 201 by the Spanish National Institute for Statistics (INE) and expressed at the census tract level  
13  
14 202 (Table S3).

### 17 203 2.3.3 Individual socio-demographic and socio-economic variables

20 204 To describe respondents' individual-level SES, eight variables will be selected: country of birth,  
21  
22 205 marital status, household size, level of education, employment and occupational status,  
23  
24 206 reported household income, and economic difficulty of the household (Table S4)

### 27 207 2.3.4 Information collected through Population Health Surveys

30  
31 208 Information from four independent PHS that represent four study areas is included in the  
32  
33 209 study. The surveys are carried out between 2021-2023, being Barcelona city the earliest in  
34  
35 210 completing the collection (2021 February – 2022 March), followed by the Valencian  
36  
37 211 Community (2022 April – 2022 December), Andalusia (2022 April – 2023 April), and the Basque  
38  
39 212 Country (2022 October – 2023 June) (Table S1). During each survey, detailed information is  
40  
41 213 collected though face-to-face interviews and self-administered questionnaires. The PHS collect  
42  
43 214 information on different health aspects, morbidity, and use of health services. It also gathers  
44  
45 215 information on social determinants of health such as socio-economic status, working  
46  
47 216 conditions, social cohesion, health-related behaviours and perception on residential  
48  
49 217 environment. Most of these variables are measured with validated screening tools. The  
50  
51 218 selection of relevant variables to be included in this project was based on a literature review  
52  
53 219 and the most appropriate variables to meet the objectives of the study were selected from  
54  
55 220 among the variables collected by the PHS. All the study areas collected the main variables of  
56  
57 221 the study (i.e., mental health, health-related quality of life, physical activity, social cohesion,  
58  
59  
60

1  
2  
3 222 and sleep), however, in some cases, the measuring instruments differ across the study areas.  
4  
5 223 Detailed information about the variables and the measuring instruments used in each study  
6  
7 224 area can be found in Table S4.  
8  
9

10 225 *Health outcomes*  
11  
12

13 226 Several health outcome variables are included in this study.  
14

15 227 - Perceived general health. Self-assessment of health was measured as an ordinal response,  
16  
17 228 with five categories (1, Excellent; 2, Very good; 3, Good; 4, Fair; 5, Poor).  
18

19  
20 229 - Perceived mental health. This variable was collected with the Mental Health Inventory  
21  
22 230 [73], the SF-12 (Short-Form Health Survey 12) scale [74] or the General Health  
23  
24 231 Questionnaire (GHQ-12) [75].  
25

26 232 - Health-related quality of life. This variable was measured with the Euroqol-5D-5L-EAV scale  
27  
28 233 [76] or the SF-12 (Short-Form Health Survey 12) scale [74].  
29

30  
31 234 - Sleep duration and quality. The duration of sleep, indicated as the total number of hours  
32  
33 235 per day spent on sleep including napping was calculated. The quality of sleep was collected  
34  
35 236 using the SATED scale (Satisfaction Alertness Timing Efficiency and Duration Scale) [77] or  
36  
37 237 discrete items.  
38

39  
40 238 - Prevalence of chronic mental health problems. Participants had to indicate whether they  
41  
42 239 had been diagnosed with depression, anxiety, and sleeping disorders at any time  
43  
44 240 throughout the life. We then built a dichotomized (yes/no) variable for each condition.  
45

46  
47 241 - Consumption of medication for common mental disorders. Information on consumption of  
48  
49 242 medication for common mental disorders, such as, anxiolytics, antidepressants and  
50  
51 243 hypnotics was reported on bi-daily or bi-weekly basis depending on the study area.  
52

53  
54 244 *Covariates*  
55

56  
57 245 A set of individual level variables will be used as control variables in the statistical analyses.  
58  
59  
60

1  
2  
3 246 - Anthropometric variables. The surveys collect information on sex, age, weight, and height  
4  
5 247 of individuals. A Body Mass Index (BMI) (kg/m<sup>2</sup>) will be calculated using information given  
6  
7 248 by the participants about their height and weight at the moment of filling the  
8  
9  
10 249 questionnaire.

11  
12 250 - Individual socio-demographic and socio-economic variables. To describe respondents'  
13  
14 251 individual-level SES, eight variables will be selected: country of birth, marital status,  
15  
16 252 household size, level of education, employment and occupational status, reported  
17  
18 253 household income, and economic difficulty of the household.

19  
20  
21 254 - Lifestyle factors. These will include consumption habits such as alcohol consumption,  
22  
23 255 passive smoking at home, and tobacco use.

24  
25 256 - Physical health. A chronicity index will be calculated based on presence of one or more  
26  
27 257 non-psychological chronic conditions (e.g., diabetes, heart disease, cancer, etc.).

28  
29  
30 258 The following social and behavioural variables will be treated as potential mediators.

31  
32  
33 259 Social cohesion and loneliness. Social cohesion is measured with the Duke-UNC-11 scale [78]  
34  
35 260 or the OSLO-3 tool [79]. Perceived loneliness is collected with a single item for participants to  
36  
37 261 report about the frequency in which they feel loneliness. The variable is displayed in a 1 to 4  
38  
39 262 (1= always; 2= often; 3= sometimes; 4= never) response scale.

40  
41  
42  
43 263 - Physical activity. The International Physical Activity Questionnaire (IPAQ) [80] to measure  
44  
45 264 the physical activity performed by the participants. Days per week and time spent in  
46  
47 265 vigorous physical activity, in moderate physical activity, and walking more than 10  
48  
49 266 minutes, and time spent sitting on a normal day will be available.

50  
51  
52  
53 267 *Perception of the neighbourhood*

54  
55  
56 268 Perceived accounts of UrbEEs are collected through PHS employing 3-point or 5-point  
57  
58 269 Likert format questions depending on the study area. These include: 1) perception of noise  
59  
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2  
3 270 outside the dwelling, 2) perception of shortage of green areas in the residential environment,  
4  
5 271 3) perception of air pollution in the residential environment, and 4) perception of insecurity in  
6  
7 272 the neighbourhood.  
8  
9

#### 10 273 **2.4. Data analysis**

11  
12  
13  
14 274 Initially, all databases will be cleaned. The variables will be harmonised, when needed,  
15  
16 275 following the Maelstrom Research Guidelines for rigorous harmonisation of retrospective data  
17  
18 276 [81]. Nonetheless, because most variables have already been collected consistently in the  
19  
20 277 respective Population Health Surveys, few variables will require harmonisation (see  
21  
22 278 Supplementary file Section 3). Among the few variables requiring harmonisation, most will be  
23  
24 279 re-categorised. For more information, see Supplementary file Section 4. Subsequently, both  
25  
26 280 exploratory and descriptive analysis will be applied using numerical and graphical techniques  
27  
28 281 [82]. Before proceeding to inference, sample weights for each survey will be adjusted through  
29  
30 282 calibration [83], so that we may compensate for non-response and coverage biases and  
31  
32 283 improve accuracy. This calibration will be carried out separately for each study area, so that  
33  
34 284 region-level estimates are obtained first, and then harmonized to obtain estimates at  
35  
36 285 population level.  
37  
38  
39  
40

41  
42 286 The relationships between the various UrbEEs and health outcomes will be analysed  
43  
44 287 according to the multilevel, or hierarchical structure [84] that the data possesses, as census  
45  
46 288 tracts are nested within cities, and cities are nested within autonomous regions. Generalised  
47  
48 289 linear mixed models (GLMMs) will be applied to investigate the relationship between urban  
49  
50 290 environment and health. The sets of adjustment covariates used in these models will be  
51  
52 291 chosen by applying robust causal inference techniques based on directed acyclic graphs (DAGs)  
53  
54 292 [85], both for the estimation of direct effects and hypothetical indirect effects mediated by air  
55  
56 293 pollution, environmental noise, physical activity, and social cohesion. This will imply the prior  
57  
58 294 design of a DAG describing the relationships among UrbEEs, health outcomes and other  
59  
60

1  
2  
3 295 potentially implicated variables [86,87]. The testable implications derived from this DAG will be  
4  
5 296 checked following the procedure described by Ankan and colleagues [88], thereby updating  
6  
7 297 the DAG if needed [89,90]. These graphical models will guide the inclusion of relevant socio-  
8  
9  
10 298 demographic and socioeconomic variables, allowing us to account for potential confounding  
11  
12 299 factors and illuminate causal relationships. The length of time living in the same home/place  
13  
14 300 will be considered by excluding individuals living at the same place of residence for less than  
15  
16 301 one and less than five years in separate models. Equity will be addressed performing subgroup  
17  
18 302 analysis to investigate potential vulnerable groups such as lower-income populations, the  
19  
20  
21 303 elderly, women, and marginalized communities.  
22  
23

24 304 In case of demonstrating a significant relationship between a given exposure and a certain  
25  
26 305 outcome, we also intend to identify the specific exposures that cause most disease in the  
27  
28 306 populations of interest via the population attributable fraction (PAF) [91]. To estimate the PAF  
29  
30  
31 307 we will require previous estimations of relative risk (RR) and either the prevalence of exposure  
32  
33 308 in the population or the prevalence of exposure among the cases of disease. All these previous  
34  
35 309 estimates will be available. The possible existence of spatial clusters in the UrbEEs distribution  
36  
37 310 will also be studied using the standard spatial scan statistic method [92] and calculating the  
38  
39 311 posteriori probabilities for the smoothed standardised ratios to be greater than unity, in the  
40  
41  
42 312 general framework of Bayesian hierarchical standardised ratio smoothing models.  
43  
44

45 313 The analyses will be implemented using the latest version of the R software packages  
46  
47 314 *dagitty* [85], *DClusterm* [93,94], *R INLA* [95], *Sampling* [96] and others.  
48  
49

## 50 315 **2.5. Data Management Plan**

51  
52  
53 316 The data management plan can be found in the Supplementary file Section 4. The source and  
54  
55 317 type of data that will be collected within the scope of this project is described in this plan,  
56  
57 318 together with the accessibility and ownership of data. Data storage and processing, as well as  
58  
59  
60 319 the procedure to guarantee the specific ethical and legal requirements, are likewise explained.

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3 320 **2.6. Patient and Public Involvement**  
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5 321 Patients and the public will not be involved in the design, or conduct, or reporting, or  
6  
7 322 dissemination plans of our research.  
8

9  
10 323 **3. Discussion**  
11

12 324 The present study is a clear commitment to the generation of urban environmental  
13  
14 325 indicators potentially explanatory of self-perceived health (physical and mental), chronic  
15  
16 326 mental disorders, health-related quality of life, consumption of medication for common  
17  
18 327 mental disorders and sleep quality with a health equity perspective. This project responds to  
19  
20 328 the national Spanish Strategic Plan for Health and the Environment (PESMA) 2022-2026 [97],  
21  
22 329 to the local implementation of the Strategy for Health Promotion and Prevention in the  
23  
24 330 National Health System [98] as well as to the main objective of the Spanish Urban Agenda  
25  
26 331 2019 [99] that cities should have a global vision that takes into consideration the physical,  
27  
28 332 mental, and social well-being of their inhabitants. Likewise, it is aligned with three of the  
29  
30 333 Sustainable Development Goals (SDG) of the World Health Organization (SDG.3 - Good Health  
31  
32 334 and Well-being, SDG.10 – Reduced Inequalities, and SDG.11 – Sustainable Cities and  
33  
34 335 Communities) (97,98).  
35  
36  
37  
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39

40 336 When it comes to health-promoting urban and transport design, there is a lack of  
41  
42 337 standardized, quantitative indicators to guide the integration of health components right from  
43  
44 338 the outset [57,100]. In this context, the DAS-EP project not only aims to obtain individual  
45  
46 339 UrbEEs estimates but also to assess their association with, and impact on various health  
47  
48 340 outcomes. By means of PHS, the health effects to be studied in this project are derived from an  
49  
50 341 unbiased population, which allows to obtain an approximate estimate of the impact at  
51  
52 342 population level. Moreover, it is important to identify the precise routes that connect urban  
53  
54 343 environment to health because they can guide the most efficient interventions, allowing us to  
55  
56 344 design healthy(er) cities [55,101]. In this sense, the DAS-EP project investigates various  
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3 345 components of the urban environment and health at individual level. Besides using  
4  
5 346 complementary indicators that describe both the physical and the social urban environment  
6  
7 347 (e.g., neighbourhood insecurity), combines objective and perceived indicators to deepen the  
8  
9 348 characterization of the urban environment. By combining these data, it is possible to develop a  
10  
11 349 more precise understanding of the effects of urban environment on health, while describing  
12  
13 350 the complexity of the relationship influenced by neighbourhood environmental and individual  
14  
15 351 characteristics [102–104].

16  
17  
18 352 The main limitation of this study is its cross-sectional nature. Due to the chronic character of  
19  
20 353 the health conditions included in the study (e.g., depression, insomnia) and the possible long-  
21  
22 354 term effects of UrbEEs, a longitudinal design would be more informative and appropriate.  
23  
24 355 Although PHS have a cross-sectional approach, the question "since when have you been living  
25  
26 356 at your current address" enables to account for the extent of exposures. Drawing on this  
27  
28 357 mobility data, sensitivity analysis of the models will be fitted reducing the risk of exposure  
29  
30 358 misclassification. Another limitation is that the samples from the study areas of the Basque  
31  
32 359 Country, Andalusia, and Valencian community, although representative of the study  
33  
34 360 population (considering the inclusion criteria) may not be representative of the autonomous  
35  
36 361 communities from which they come as we are not considering the non-urban municipalities  
37  
38 362 (<100,000 inhabitants). Despite the weight calibration to be conducted to reduce coverage and  
39  
40 363 representativeness biases, the reweighing procedure will not guarantee the elimination of  
41  
42 364 other response biases that may affect data collection from PHS (as acquiescence, social  
43  
44 365 desirability, etc.) which could affect the validity of the results [105,106]. Furthermore, the  
45  
46 366 project is subject to residual confounding, which in turn implies confounders that could not be  
47  
48 367 controlled and, importantly, measurement errors in the confounders that have been included.  
49  
50 368 In this regard, the estimation UrbEEs by GIS is affected by the problem of uncertainty of the  
51  
52 369 temporal and geographical context [107].  
53  
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3 370 The use of buffer zones may not be appropriate to evaluate contextual effects on health  
4  
5 371 because they fail to analyze the spatial-temporal distribution of residents' activities and their  
6  
7 372 relationship with built environment factors. Using activity space measures would be preferable  
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9  
10 373 to comprehensively assess of environmental exposures by capturing the complexity of  
11  
12 374 individual movements [108–110]. The reliance on publicly available data applicable to all study  
13  
14 375 areas together with scalability challenges were major barriers to estimate street-level (or  
15  
16 376 microscale) variables like bicycle and pedestrian infrastructure [111–113]. Moreover, future  
17  
18 377 studies should not only include more variables reflecting the social capital (e.g., perceived  
19  
20 378 sense of community) but also analyse the health implications of other relevant urban  
21  
22 379 exposures like substandard housing, crowding, and indoor air pollution. Finally, the  
23  
24 380 heterogeneity across study areas in terms of geographic scale (autonomous communities vs.  
25  
26 381 city) may be a source of information bias. In this vein, the majority -but not all- of the scales  
27  
28 382 and variables included in the different PHS are identical. These minor differences in data  
29  
30 383 collection across PHS may lead to additional information biases hindering the comparability of  
31  
32 384 the data. To minimize this problem, special attention will be paid to the selection and  
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34 385 harmonization of the variables to be included to ensure the consistency of data before making  
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36 386 the comparisons across study areas.

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42 387 As for the strengths of this project, pooling linked surveys across study areas will make  
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44 388 it possible to compare the results in different populations, providing a comprehensive dataset  
45  
46 389 that is larger than most existing cohort studies, and that have an unique national and  
47  
48 390 population perspective. The results will be novel in terms of their thematic (objective &  
49  
50 391 subjective UrbEEs) and methodological approach (combination of PHS from different study  
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52 392 areas and GIS estimates), as well as in terms of the large volume of information that will be  
53  
54 393 handled and the large sample size of the study. Beyond that, the standardization of the  
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56 394 procedure described herein will generate useful information to assist in the planning of  
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3 395 national health surveillance programs, research studies and, more importantly, interventions  
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5 396 to strengthen population's health.  
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8 397 In short, the results and products (i.e., databases, computer codes) of this project will  
9  
10 398 greatly contribute to estimate the proportion of the population exposed to different UrbEEs,  
11  
12 399 identify health disparities while considering UrbEEs, estimate how these exposures relate to  
13  
14 400 and affect various health variables, and conduct a health impact assessment of UrbEEs. We will  
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16 401 have taken a further step towards understanding and improving the urban environment and  
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18 402 being able to establish corrective measures in the urban development plans of the cities.  
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peer review only

## Declarations

### Ethics and dissemination

The study was approved by the regional Research Ethics Committee of the **Basque Country**, ETHICS COMMITTEE FOR RESEARCH INVOLVING MEDICINAL PRODUCTS IN THE BASQUE COUNTRY (*CEIm-E*) (protocol code PI2022138, dated 9<sup>th</sup> November 2022); **Andalusia**, BIOMEDICAL RESEARCH ETHICS COMMITTEE OF THE PROVINCE OF GRANADA (CEI/CEIM GRANADA) (protocol code 2078-N-22, dated 27<sup>th</sup> December 2022); **Barcelona**, PARC DE SALUT MAR CLINICAL RESEARCH ETHICS COMMITTEE (CEIm) (protocol code 2022/10667, dated 2<sup>nd</sup> December 2022); **Valencian Community**, ETHICS COMMITTEE FOR CLINICAL RESEARCH OF THE DIRECTORATE GENERAL OF PUBLIC HEALTH AND CENTER FOR ADVANCED RESEARCH IN PUBLIC HEALTH (CEIC DGSP / CSISP) (protocol code 20221125/04, dated 25<sup>th</sup> November 2022). The results will be communicated to the general population, health professionals and institutions through conferences, reports, and scientific articles.

### Competing interests

The authors declare that they have no competing interests.

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### Authors' contributions

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3 Conceptualisation, A.L., A.C.-L., M.S-P

4  
5 Methodology, A.L., A.C.-L., M.S-P

6  
7 Writing, original draft preparation, A.B., A.L., M.S-P., A.C-L

8  
9 Writing, review and editing, A.B., A.L., M.S-P., A.C-L., S.C.G., G.G-B., S.D.G., F.B., M.E., A.M.,  
10  
11 A.E., M.A.I., C.B., R.M., L.F-R., X.B., K.P., L.O., A-C.B., A.D., L.G., H.G.C., M.L.N., R.C., M.M.R.,  
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18 Funding acquisition, A.L., A.C-L., M.S-P

19  
20 All authors have read and agreed to the published version of the manuscript.

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32  
33 *Valencian Region* (DGSP) in Valencian Community] developing the Population Health Surveys  
34  
35 that are used in this project.

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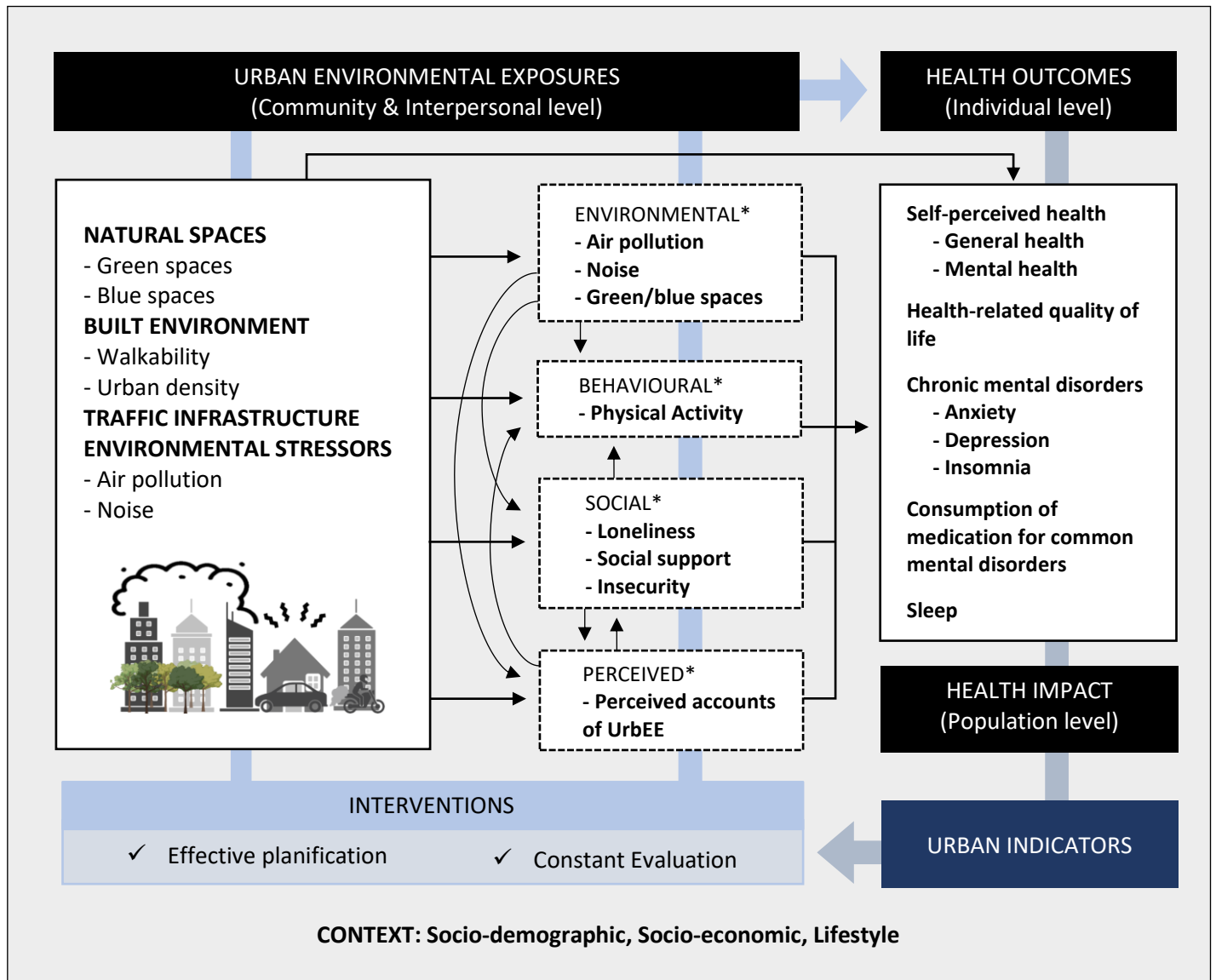
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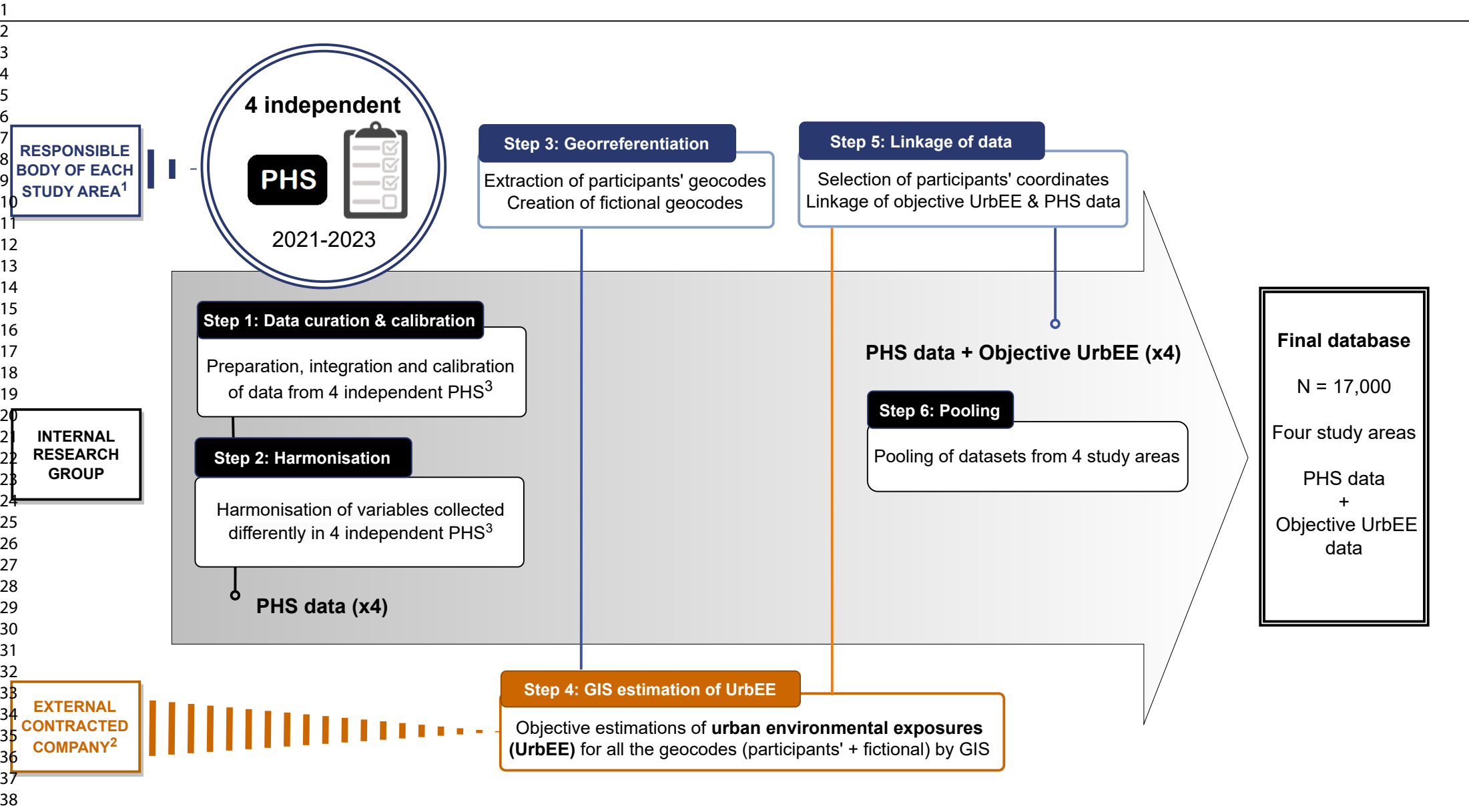
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**Figure 1.** Conceptual framework designed within the scope of this project, including potential direct and indirect effects of urban environmental exposures (UrbEEs) on the health outcomes under study. \* Potential mediators on the association between UrbEEs and the health outcomes under evaluation.

**Figure 2.** Summary of data management plan and the institutions involved during the development of the final database (DB) to be used by the research group in the analyses.





Responsible body of the Population health survey (PHS) from each study area: the Basque Department of Health (Basque Country), Escuela Andaluza de Salud Pública (EASP) (Andalusia), Agència de Salut Pública de Barcelona (ASPB) (Barcelona), and Conselleria de Salut Universal i Salut Pública (DGSP) (Valencian Community).  
 External contracted company specialised in GIS estimations.  
 For each PHS carried out in the study areas of the autonomous communities of the Basque Country and Andalusia, Valencian Community, and the city of Barcelona.  
 For peer review only - <http://bmjopen.bmj.com/site/about/guidelines.xhtml>

## Supplementary file

**File name:** Supplementary file\_DAS-EP

**File format:** Word document (.docx)

**Title of data:** Supplementary data of Urban Environment and Health: a cross-sectional multiregional project based on Population Health Surveys in Spain (DAS-EP project), study protocol.

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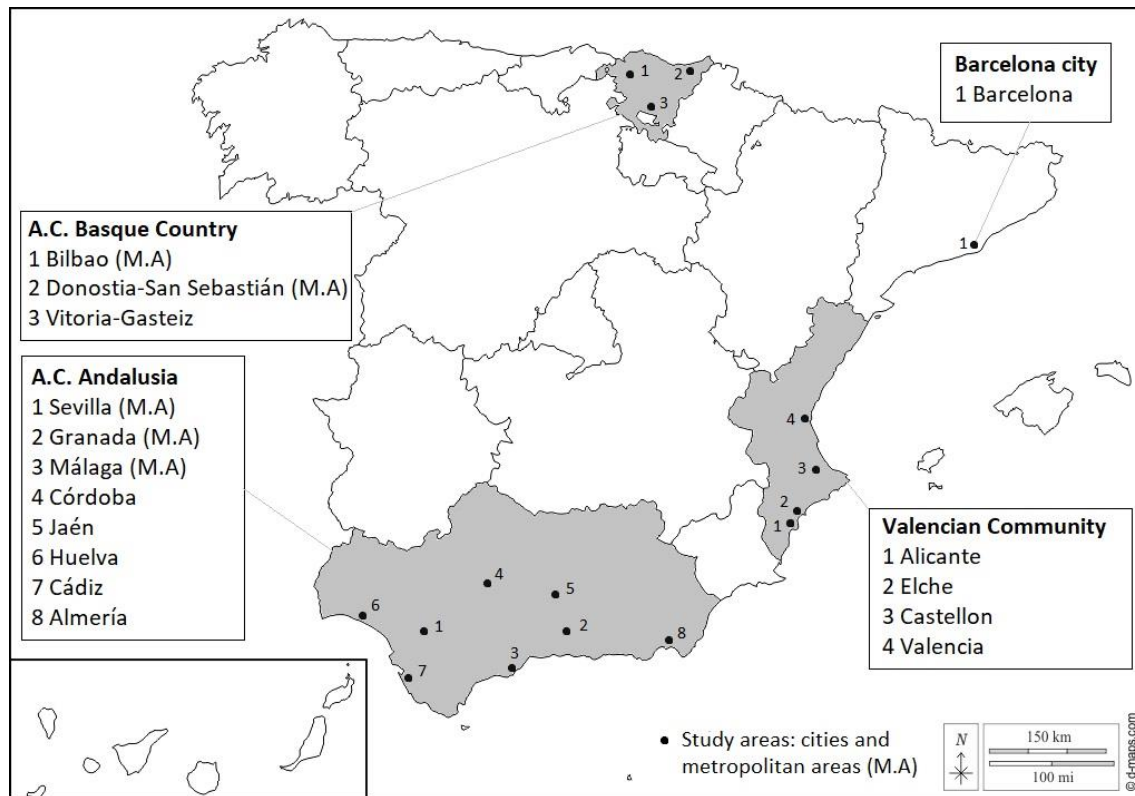
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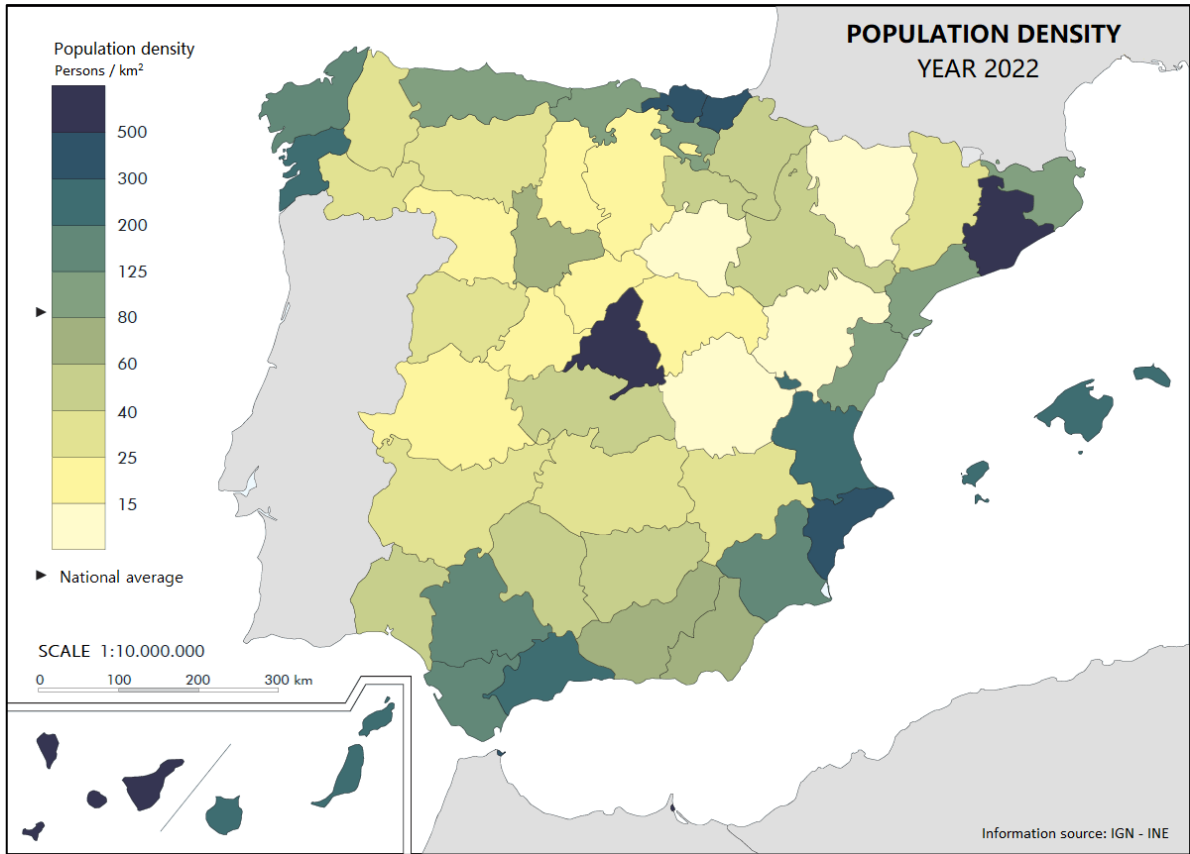
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## Section 1. GENERAL CHARACTERISTICS OF THE STUDY AREAS



**Figure S1.** Study areas of the project, being the cities and metropolitan areas (M.A) with more than 100,000 inhabitants from the autonomous communities of the Basque Country and Andalusia, Valencian Community, and the city of Barcelona. Figure edited from Daniel Dalet / d-maps.com.



**Figure S2.** Population density of Spanish provinces in 2022. Figure edited from Instituto Geográfico Nacional, *La población en España 2022*. Accessed through: <https://www.ign.es/pobesp/pe1.htm>

## Section 2. GENERAL CHARACTERISTICS OF THE POPULATION HEALTH SURVEYS

**Table S1.** Characteristics of the study areas and the population health surveys comprised in the project.

Study area	Cities and areas of influence	Population health survey	Responsible body	Sample size	Data collection period
A.C. Basque Country	Vitoria-Gasteiz Donostia-San Sebastián (M.A) Bilbao (M.A)	Encuesta de Salud de la Comunidad Autónoma País Vasco (ESCAV)	✓ Basque Department of Health	7,846	2022 October – 2023 June
A.C. Andalusia	Almería Cádiz Córdoba Huelva Jaén Granada (M.A) Malaga (M.A) Sevilla (M.A)	Encuesta Andaluza de Salud (EAS)	✓ Andalusian School of Public Health (EASP)	3,085	2022 April – 2023 April
Barcelona city	Barcelona	Encuesta de Salud de Barcelona (ESB)	✓ Barcelona Public Health Agency (ASPB)	4,000	2021 February – 2022 March
Valencian Community	Castellon Valencia Elche Alicante	Encuesta Salud Comunidad Valenciana (ESCV)	✓ Foundation for the Promotion of Health and Biomedical Research in the Valencian Region (DGSP)	3,134	2022 April – 2022 December

Abbreviations: A.C., Autonomos community; M.A, Metropolitan Area.

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**Section 3. OVERVIEW OF THE VARIABLES OF THE STUDY PER STUDY AREA**

**Table S2.** Objective urban environmental exposures obtained through GIS estimations.

GIS Variables			Study areas: A.C. s of the Basque Country and Andalusia, Valencian Community & the city of Barcelona
OBJECTIVE URBAN ENVIRONMENTAL EXPOSURES	Scale	Variable	
<b>a) Surrounding natural spaces</b>			
<b>Green Spaces</b>			
Green space percentage	100, 300, 500m buffers	Percentage of green space.	
NDVI	100, 300, 500m buffers	Annual mean Normalised Difference Vegetation Index (NDVI) of the year when the surveys were conducted and the mean NDVI of the last 5 years previous to the surveys.	
Tree percentage	100, 300, 500m buffers	Percentage of tree cover based on Growing stock volume (GSV) data.	
Distance to green space		Euclidean distance to the nearest major green space (green surface over 5,000m <sup>2</sup> ).	
Green spaces Yes (vs. No)	100, 300, 500m buffers	Dichotomous variable of presence of major green spaces (green surface over 5,000m <sup>2</sup> ) from local topographical or Europe-wide maps (Urban atlas).	
<b>Blue spaces</b>			
Blue spaces Yes (vs. No)	100, 300, 500m buffers	Dichotomous variable of presence of water surfaces. Based on Urban Atlas.	
Blue space percentage	100, 300, 500m buffers	Percentage of water surface. Based on Urban Atlas.	
Distance to blue space		Euclidean distance to the nearest water surface over 5,000m <sup>2</sup> . Based on Urban Atlas.	
<b>b) Built environment</b>			
Building density	100, 300, 500m buffers	The building density around each household will be calculated accounting for the perimeter and height of the buildings from local cadastre data or Europe-wide maps (Urban Atlas).	
Population density	100, 300, 500m buffers	The number of inhabitants (per km <sup>2</sup> ) surrounding the home addresses.	
Street connectivity	100, 300, 500m buffers	Using data from OpenStreetMap®.	
Accessibility (bus lines)	100, 300, 500m buffers	Access to public transport bus lines from local topographical maps or OpenStreetMap®.	
Accessibility (bus stops)	100, 300, 500m buffers	Access to public transport bus stops from local topographical maps or OpenStreetMap®.	
Facility richness	100, 300, 500m buffers	Using local topographical maps or OpenStreetMap®.	
Facility density	100, 300, 500m buffers	Using local topographical maps or OpenStreetMap®.	
Land use	100, 300, 500m buffers	Mixed land use will be estimated by Shannon's Evenness Index based on Urban Atlas data.	
Walkability index	100, 300, 500m buffers	Index constructed from seven indicators: population density, street connectivity, street density, facility richness, facility density, land use, transport density, and average slope.	
<b>c) Traffic infrastructure</b>			
Major road Yes (vs. No)	100, 300, 500m buffers	Dichotomous variable of presence of a major road (OpenStreetMap®).	
Inverse distance		Inverse distance to the nearest major road (OpenStreetMap®).	

GIS Variables	Study areas: A.C. s of the Basque Country and Andalusia, Valencian Community & the city of Barcelona	
OBJECTIVE URBAN ENVIRONMENTAL EXPOSURES	Scale	Variable
<b>d) Environmental stressors</b>		
<b>Air pollution</b>		
PM <sub>2.5</sub>	Street level (at residential address)	PM <sub>2.5</sub> exposure indicators include: a) the annual average for the last five years, and b) the five-year average for the last five years based on spatiotemporal land-use random-forest models.
PM <sub>10</sub>	Street level (at residential address)	PM <sub>10</sub> exposure indicators include: a) the annual average for the last five years, and b) the five-year average for the last five years based on spatiotemporal land-use random-forest models.
NO <sub>2</sub>	Street level (at residential address)	NO <sub>2</sub> exposure indicators include: a) the annual average for the last five years, and b) the five-year average for the last five years based on spatiotemporal land-use random-forest models.
<b>Noise</b>		
Day (L <sub>d</sub> )	Street level (at residential address)	Exposition to environmental noise at street level during the day indicated as: a) the annual average for the last five years, and b) the five-year average for the last five years based on Strategic Noise Maps derived under the EU Directive 2002/49/EC from the Ministry for the Ecological Transition and the Demographic Challenge.
Evening (L <sub>e</sub> )	Street level (at residential address)	Exposition to environmental noise at street level during the evening indicated as: a) the annual average for the last five years, and b) the five-year average for the last five years based on Strategic Noise Maps derived under the EU Directive 2002/49/EC from the Ministry for the Ecological Transition and the Demographic Challenge.
Night (L <sub>n</sub> )	Street level (at residential address)	Exposition to environmental noise at street level during the night indicated as: a) the annual average for the last five years, and b) the five-year average for the last five years based on Strategic Noise Maps derived under the EU Directive 2002/49/EC from the Ministry for the Ecological Transition and the Demographic Challenge.
Total (L <sub>den</sub> )	Street level (at residential address)	Total exposition to environmental noise at street level indicated as: a) the annual average for the last five years, and b) the five-year average for the last five years based on Strategic Noise Maps derived under the EU Directive 2002/49/EC from the Ministry for the Ecological Transition and the Demographic Challenge.

Abbreviations: A.C., Autonomous community; NDVI, Normalised Difference Vegetation Index; GSV, Growing stock volume; PM<sub>2.5</sub>, Fine particulate matter with a diameter of 2.5µm or less; PM<sub>10</sub>, Fine particulate matter with a diameter of 10µm or less; NO<sub>2</sub>, Nitrogen dioxide

**Table S3.** Area-level socioeconomic (SES) variables obtained through GIS estimations.

GIS Variables		Study areas: A.C. s of the Basque Country and Andalusia, Valencian Community & the city of Barcelona	
AREA-LEVEL SES VARIABLES	Scale	Variable	
<b>a) Mean income</b>			
Average household net income	Census tract	Average household net income. Income data collection is based on standardised annual requests to the different collaborating tax organisations. Data from 2021. Data source INE <sup>1</sup> .	
Average household gross income	Census tract	Average household gross income. As components of gross income, five exhaustive categories are considered: wages, pensions, unemployment benefits, other benefits, other income. Data from 2021. Data source INE <sup>1</sup> .	
Average net income per person	Census tract	Net income per person is obtained, for each household, by dividing the net household income by the number of members of said household. Data from 2021. Data source INE <sup>1</sup> .	
Average gross income person	Census tract	Gross income per person is obtained, for each household, by dividing the gross household income by the number of members of said household. Data from 2021. Data source INE <sup>1</sup> .	
Average income per consumption unit	Census tract	Equivalised income is a measure of household income that takes account of the differences in a household's size and composition, and thus is equivalised or made equivalent for all household sizes and compositions. The equivalised income is calculated by dividing the household's total net income by its equivalent size, which is calculated using the modified OECD equivalence scale. This scale attributes a weight to all members of the household: 1.0 to the first adult; 0.5 to the second and each subsequent person aged 14 and over; 0.3 to each child aged under 14. Data from 2021. Data source INE <sup>1</sup> .	
<b>b) Income distribution P80/P20</b>	Census tract	Ratio between the 80th percentile and the 20th percentile of the income distribution per unit of consumption. Data from 2021. Data source INE <sup>1</sup> .	
<b>c) Gini index</b>	Census tract	The Gini index measures the degree of inequality in the distribution of income/wealth, used to estimate how far a country's wealth or income distribution deviates from an equal distribution <sup>2</sup> . A Gini coefficient of 0 reflects perfect equality, where all income or wealth values are the same, while a Gini coefficient of 1 (or 100%) reflects maximal inequality among values, a situation where a single individual has all the income while all others have none. Data from 2021. Data source INE <sup>1</sup> .	
<b>d) MEDEA deprivation index</b>	Census tract	A deprivation index developed to study the social inequalities in health in Spain. The index is composed by percentage of the population with manual labour, percentage of the population with casual labour, percentage of the population unemployed, percentage of the population with insufficient education, percentage of the population of young people with insufficient education <sup>3</sup> . Data from 2021.	

Abbreviations: A.C., Autonomous community; SES., Socioeconomic status

<sup>1</sup> INEbase. Atlas de Distribución de Renta de los Hogares (ADRH). INE. Retrieved 19 December 2023, from [https://www.ine.es/metodologia/metodologia\\_adrh.pdf](https://www.ine.es/metodologia/metodologia_adrh.pdf)

<sup>2</sup> Gini, Corrado (1936). "On the Measure of Concentration with Special Reference to Income and Statistics", Colorado College Publication, General Series No. 208, 73–79.

<sup>3</sup> Domínguez-Berjón, M. F., Borrell, C., Cano-Serral, G., Esnaola, S., Nolasco, A., Pasarín, M. I., Ramis, R., Saurina, C., & Escolar-Pujolar, A. (2008). Construcción de un índice de privación a partir de datos censales en grandes ciudades españolas: (Proyecto MEDEA). *Gaceta Sanitaria*, 22(3), 179–187.

**Table S4.** Variables collected through Population Health Surveys.

Population Health Survey Variables	Study areas			
	A.C. Basque Country	A.C. Andalusia	Barcelona city	Valencian Community
<b>OUTCOMES</b>				
<b>a) Perceived health</b>				
General Health	Ordinal 1-5	Ordinal 1-5	Ordinal 1-5	Ordinal 1-5
Mental Health	Ordinal 1-5 [MHI/5 items]	Ordinal 1-6 [SF-12/3 items]	Ordinal 1-4 [GHQ-12/12 items]	Ordinal 1-4 [GHQ-12 /12 items]
<b>b) Quality of life</b>				
Health-related quality of life	Ordinal 1-5 [EuroQoL / 5 items]	Ordinal 1-6/1-5 [SF-12 / 5 items]	Ordinal 1-5 [EuroQoL / 5 items]	Ordinal 1-5 [EuroQoL / 5 items]
<b>c) Sleep</b>				
Sleep duration	Continuous - Total hours/day	Continuous - Total hours/day	Continuous - Total hours/day	Continuous - Total hours/day
Quality of sleep	Ordinal 1-5 [SATSD / 5 items]	Ordinal 1-4 [4 items]	Ordinal 1-10	Ordinal 1-5 [SATSD / 5 items]
<b>d) Consumption of medication for common mental disorders<sup>1</sup></b>				
Antidepressants	yes/no – reference 2 days	yes/no – reference 2 weeks	yes/no - reference 2 days	yes/no - reference 2 weeks
Hypnotics	yes/no - reference 2 days	yes/no - reference 2 weeks	yes/no - reference 2 days	yes/no – reference 2 weeks
Anxiolytics	yes/no - reference 2 days	yes/no - reference 2 weeks	yes/no - reference 2 days	yes/no - reference 2 weeks
<b>e) Chronic mental health problems<sup>2</sup></b>				
Anxiety	yes/no - reference ever	yes/no – reference present	yes/no - reference ever	yes/no – reference ever
Depression	yes/no - reference ever	yes/no - reference present	yes/no - reference ever	yes/no - reference ever
Insomnia	yes/no - reference ever	-	-	yes/no - reference ever
Other	yes/no - reference ever	-	yes/no - reference ever	yes/no - reference ever
<b>COVARIATES</b>				
<b>a) Anthropometric variables</b>				
Age	Discrete	Discrete	Discrete	Discrete
Weight	Continuous	Continuous	Continuous	Continuous
Height	Continuous	Continuous	Continuous	Continuous
BMI	Continuous	Continuous	Continuous	Continuous
Biologic sex	Categorical - 3 conditions	Categorical - 2 conditions	Categorical - 2 conditions	Categorical - 2 conditions
Gender identity	Categorical - 3 conditions	-	Categorical - 3 conditions	-
<b>b) Individual socioeconomic variables</b>				
Education level	Categorical - 9 conditions	Categorical - 13 conditions	Categorical - 11 conditions	Categorical - 9 conditions
Occupational status	Categorical [CNO11]	Categorical [CNO11]	Categorical [CNO11]	Categorical [CNO11]
Household size	Discrete	Discrete	Discrete	Discrete

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Population Health Survey Variables	Study areas			
	A.C. Basque Country	A.C. Andalusia	Barcelona city	Valencian Community
Household income	Categorical - 11 conditions	-	-	Categorical - 8 conditions
Economic difficulty	Categorical - 6 conditions	Categorical - 6 conditions	Categorical - 6 conditions	Categorical - 6 conditions
Employment status	yes/no	yes/no	yes/no	yes/no
Country of birth	Categorical & Open	Categorical & Open	Categorical & Open	Categorical & Open
Marital status	Categorical - 6 conditions	Categorical - 5 conditions	Categorical - 5 conditions	Categorical - 5 conditions
<b>c) Lifestyle factors</b>				
Alcohol consumption	Categorical - 8 conditions	Categorical - 10 conditions	Categorical - 4 conditions	Categorical - 8 conditions
Passive smoking at home	Likert 1-5	yes/no	Discrete (Nº smokers)	yes/no
Daily tobacco consumption	yes/no	Categorical - 4 conditions	Categorical - 3 conditions	Categorical - 4 conditions
<b>e) Physical Health</b>				
Chronic health problems	Categorical - 38 conditions	Categorical - 25 conditions	Categorical - 25 conditions	Categorical - 21 conditions
<b>d) Mobility</b>				
Years at household	Discrete	-	Discrete	Discrete
<b>MEDIATORS</b>				
<b>a) Physical activity</b>				
Physical activity	Discrete - IPAQ	Discrete - IPAQ	Discrete - IPAQ	Discrete - IPAQ
- Vigorous	MET-min/week	MET-min/week	MET-min/week	MET-min/week
- Moderate	MET-min/week	MET-min/week	MET-min/week	MET-min/week
- Walking	MET-min/week	MET-min/week	MET-min/week	MET-min/week
- Sitting	Time spent (hours + minutes)	Time spent (hours + minutes)	Time spent (hours + minutes)	Time spent (hours + minutes)
<b>b) Social cohesion</b>				
Social support	Ordinal 1-5 [Duke / 11 items]	Ordinal 1-5 [Duke / 11 items]	Ordinal 1-5/1-4 [OSLO/ 3 items]	Ordinal 1-5 [Duke / 11 items]
Loneliness	Ordinal 1-4	Ordinal 1-4	Ordinal 1-4	Ordinal 1-4
<b>SUBJECTIVE URBAN ENVIRONMENTAL EXPOSURES</b>				
<b>a) Perception of the neighbourhood</b>				
Noise outside dwelling	Likert 1-3	Likert 1-3	Likert 1-5	Likert 1-3
Neighbourhood air pollution	Likert 1-3	Likert 1-3	-	Likert 1-3
Shortage of green spaces	Likert 1-3	Likert 1-3	-	Likert 1-3
Insecurity	Likert 1-3	Likert 1-3	Likert 1-5	Likert 1-3

<sup>1</sup> The subjects are provided with a list of medications and are asked if they have consumed any of them in the last 2 days or 2 weeks depending on the study area.

<sup>2</sup> Subjects are provided with a list of chronic health problems and are asked if they currently suffer or have ever suffered (depending on the study area) from any of them.



### A) Prevalence of common mental disorders in Spain.

A recent report published by the Spanish National Health System (2020), based on a representative sample of users of said system, found that the overall prevalence of mental health problems in Spain is 27.4%. The most common general mental health issues were anxiety, depression, and sleep disorders, with a prevalence of 6.7%, 4.1%, and 5.4%, respectively. Higher prevalence of these disorders was observed in the female population, those born in Spain and with increasing age. The same report notes that in the case of anxiety and depression, a clear social gradient is observed, with both disorders being 3.4 and 2.5 times more prevalent in the population with lower income levels. In the case medication prescriptions, anxiolytics, antidepressants, and hypnotics were prescribed at rates of 34% for women and 17% for males over 40. The 2020 European Health Survey revealed no discernible territorial differences in the prevalence of chronic mental health conditions among individuals aged 15 and older in Spain. However perceived health status showed slight regional disparities, with Valencia reporting the highest percentage of "bad or very bad" health at 9.4%, followed by Andalucía (7.4%), the Basque Country (7%), and Catalonia (4.9%). However, given that the results presented in this report pertain to a timeframe predating the onset of the COVID-19 pandemic, it is anticipated that the prevalence of these conditions has risen universally among all age groups and regions (Henares Montiel et al., 2020). This increase can be attributed to escalated stress and health-related concerns stemming from the pandemic, exacerbated by associated constraints like lockdown measures and the resultant impact on mental health care services during the pandemic (Balluerka et al., 2020).

Balluerka, N., Gómez, J., Hidalgo, M., Gorostiaga, A., Espada, P., Padilla, J., & Santed, M. (2020). LAS CONSECUENCIAS PSICOLÓGICAS DE LA COVID-19 Y EL CONFINAMIENTO INFORME DE INVESTIGACIÓN

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INEbase / Society /Health /European Survey of Health in Spain. INE. Retrieved December 2023. [https://www.ine.es/dyngs/INEbase/en/operacion.htm?c=Estadistica\\_C&cid=1254736176784&idp=1254735573175](https://www.ine.es/dyngs/INEbase/en/operacion.htm?c=Estadistica_C&cid=1254736176784&idp=1254735573175)

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## Section 4. DATA MANAGEMENT PLAN

### A) RESEARCH ACTIVITIES

#### Step 1. Population Health Surveys' (PHS) data curation and calibration

The selected individuals were contacted by a phone call, SMS, or letter to arrange an appointment for a face-to face interview for the purpose of the survey. The database produced with the interviews will be pseudonymised from that with the personal data for the contact by assigning a unique code for each participant and remains under the custody of the responsible body in each study area; the Basque Department of Health in the Basque Country, Escuela Andaluza de Salud Pública (EASP) in Andalusia, Agència de Salut Pública de Barcelona (ASPB) in Barcelona, and Conselleria de Salut Universal i Salut Pública (DGSP) in Valencian Community.

#### Step 2. Harmonisation

Initially, the databases of each study area will be cleaned, and the variables that require it will be harmonised. The vast majority of the variables to be used in the project have been collected identically in the Population Health Surveys of the study areas included. The variables to be harmonized are listed below and the measures used in each study area can be found in Table S2.

The variables that need harmonisation can be distinguished between simple or complex variables, depending on the level of difficulty and the manipulation of data that require the harmonisation of the respective variable:

- Simple variables: Chronic mental health problems, Educational level, Occupation status, Household income, Loneliness, Noise outside dwelling, and Insecurity.

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3 - Complex variables: mental health, health-related quality of life, sleep quality,  
4 consumption of medication for common mental disorders, alcohol consumption,  
5 passive smoking at home, tobacco consumption, physical health, and social support.  
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10 The Maelstrom Research Guidelines for the rigorous harmonisation of retrospective data  
11 (77) will be applied. Among the variables that need harmonisation, the majority can be easily re-  
12 categorised (simple variables). For instance, in the case of scales with different score ranges  
13 (e.g., Likert scale levels), standardised scores will be calculated, or other procedures will be  
14 followed to ensure comparability. The procedure to follow with variables measured with  
15 different scales will be more complex (complex variables). For these, the content of each  
16 variable will be studied to detect the common content (e.g., items) in each of the study areas.  
17 Once detected, aggregate scores will be calculated for the common items, and these scores will  
18 be used for statistical analyses. The remaining non-harmonizable variables will be assessed for  
19 their potential for performing separate statistical analysis for each study area.  
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### 33 Step 3. Georeferentiation

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37 The responsible bodies, in collaboration with regional Statistical Institutes or Population  
38 Registers, will link the health survey data to the geographical coordinates of each respondent's  
39 home address. The geographical coordinates will also be pseudonymised and sent this way to  
40 the research group specialised in Geographic Information System (GIS) estimations that will  
41 calculate UrbEE. In order to further ensure the protection of the personal data of the survey  
42 participants and enhance their anonymity, fictional coordinates will be created in a number five  
43 times the number of participants selected for the study in each study area and sent to the  
44 research group specialised in GIS estimations together with the real coordinates.  
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### 55 Step 4. GIS estimation of Urban Environmental Exposures (UrbEE)

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3 A company specialised in GIS estimations will calculate the objective urban  
4 environmental exposures (UrbEE) of all the geocodes, including the participants' coordinates  
5 and the fictional coordinates by GIS.  
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#### 10 Step 5. Selection and linkage of data

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13  
14 After the estimations are finalised, the responsible bodies of the surveys in each study  
15 area will re-select the geocodes of the participants and add the new urban environmental  
16 variables to the database with the PHS data. The researchers will be provided with the resultant  
17 database of each study area composed by the PHS data and the UrbEE (without geocodes and  
18 personal data of the participants). This guarantees that the data supplied are protected by  
19 statistical secrecy, not misused and treated anonymously and globally at all times.  
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#### 28 Step 6. Pooling

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31 Finally, the final databases of all the study areas will be pooled, creating the final pooled  
32 database to be used in the planned analyses.  
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### 36 B) DATA STORAGE AND PROCESSING

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40 Data will be kept at all times on servers located in the responsible centre of this project. This  
41 way, data will be stored on the University of the Basque Country UPV/EHU's own servers,  
42 complying with the greater security and privacy requirements of the LOPD as the data is not sent  
43 to external servers. The entire process of recording, dumping and storage of the data will be  
44 anonymised, with the data collected being exclusively linked to a sample unit code. Access to  
45 the anonymised microdata will be limited to technicians from the responsible centres of each  
46 study area through profiles with regulated permissions that allow for supervising and controlling  
47 access to the information. Supervision of the data management will be assigned to the principal  
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3 investigators with expert advice, and to the data protection officer of the centre responsible for  
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5 the project.  
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#### 8 C) ETHICAL CONSIDERATIONS AND ACCOUNTABILITY 9

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11 The study was approved by the regional Research Ethics Committee of the **Basque Country**,  
12 ETHICS COMMITTEE FOR RESEARCH INVOLVING MEDICINAL PRODUCTS IN THE BASQUE  
13 COUNTRY (CEIm-E) (protocol code PI2022138, dated 9th November 2022); **Andalusia**,  
14 BIOMEDICAL RESEARCH ETHICS COMMITTEE OF THE PROVINCE OF GRANADA (CEI/CEIM  
15 GRANADA) (protocol code 2078-N-22, dated 27th December 2022); **Barcelona**, PARC DE SALUT  
16 MAR CLINICAL RESEARCH ETHICS COMMITTEE (CEIm) (protocol code 2022/10667, dated 2nd  
17 December 2022); **Valencian Community**, ETHICS COMMITTEE FOR CLINICAL RESEARCH OF THE  
18 DIRECTORATE GENERAL OF PUBLIC HEALTH AND CENTER FOR ADVANCED RESEARCH IN PUBLIC  
19 HEALTH (CEIC DGSP / CSISP) (protocol code 20221125/04, dated 25th November 2022).  
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33 This study is based on secondary data obtained from four independent Population  
34 Health Surveys (PHS) from Spain. Since the present study does not involve the activity of data  
35 collection, to obtain the informed consent from the subjects is not applicable for this study.  
36  
37 However, the PHS included this project are official statistical operations included in the  
38  
39 respective Statistical Plans of each study area. This ensures that the data provided is protected  
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41 by statistical confidentiality, it is not misused, its treatment is anonymous and global at all times,  
42  
43 and that indirect identification is impossible. Data are collected and processed in accordance  
44  
45 with the provisions of the General Data Protection Regulation (GDPR) and in accordance with  
46  
47 the provisions of Article 5 of the Organic Law 3/2018 of 5 December on the Protection of  
48  
49 Personal Data and the guarantee of digital rights (Regulation (EU) 2016/679), they will be treated  
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51 confidentially, with access to them being granted to personnel who strictly need to process them  
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53 in the framework of the study.  
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3 Furthermore, the transfer of data occurs between organisations within the Public Health  
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5 System of each region and the regional or local government itself. This is done in the context of  
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7 a research project conducted exclusively in the public sphere and with the legitimacy of the use  
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9 of administrative records as research infrastructures in accordance with the General Health Act,  
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11 the Biomedical Research Act and the General Law on Public Health. The results of the study will  
12  
13 provide information at a sufficiently aggregated territorial level to prevent indirect  
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15 identification. Furthermore, the project's results will be beneficial to the general population in  
16  
17 a holistic way, thanks to its socioeconomic and environmental context, and its evolution over  
18  
19 several years from the onset of the COVID-19 pandemic. Therefore, the risk to the privacy of the  
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21 study population is minimal compared to the potential benefits the results will bring.  
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# BMJ Open

## Urban Environment and Health: a cross-sectional multiregional project based on Population Health Surveys in Spain (DAS-EP project), study protocol.

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## Abstract

**Introduction:** The European Environment Agency estimates that 75% of the European population lives in cities. Despite the many advantages of city life, the risks and challenges to health arising from urbanization need to be addressed in order to tackle the growing burden of disease and health inequalities in cities. This study, *Urban Environment and Health: a cross-sectional multiregional project based on Population Health Surveys in Spain* (DAS-EP project), aims to investigate the complex association between the urban environmental exposures (UrbEEs) and health.

**Methods and analysis:** DAS-EP is a Spanish multiregional cross-sectional project that combines Population Health Surveys (PHS) and Geographical Information System (GIS) allowing to collect rich individual level data from 17,000 adult citizens participating in the PHS conducted in the autonomous regions of the Basque Country, Andalusia, and the Valencian Community, and the city of Barcelona in years 2021 to 2023. This study focuses on the population living in cities or metropolitan areas with more than 100,000 inhabitants. UrbEEs are described by objective estimates at participants' home addresses by GIS, and subjective indicators present in PHS. The health outcomes included in the PHS and selected for this study are self-perceived health (general and mental), prevalence of chronic mental disorders, health-related quality of life, consumption of medication for common mental disorders, and sleep quality. We aim to further understand the direct and indirect effect between UrbEEs and health, as well as to estimate the impact at the population level taking respondents' socio-demographic and socio-economic characteristics, and lifestyle into consideration.

### **Ethics and dissemination:**

The study was approved by the regional Research Ethics Committee of the Basque Country (CEIm-E; PI2022138), Andalusia (CEIM GRANADA; 2078-N-22), Barcelona (CEIC-PSMar; 2022/10667), and Valencian Community (CEIC DGSP/CSISP; 20221125/04). The results will be

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2  
3 communicated to the general population, health professionals and institutions through  
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5 conferences, reports, and scientific articles.  
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#### 8 **Strengths and limitations of this study**

- 10 • Multicentric project in Spain with a cross-sectional approach
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- 12 • Large volume of data from a large sample of participants
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- 14 • Linkage of four independent population health surveys and environmental exposures
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- 16 • Inclusion of objective & subjective urban environmental exposures
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- 18 • Health equity perspective
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## 1. Introduction

According to the World Health Organization, modifiable environmental factors are responsible for 23% and 22% of the global mortality and morbidity respectively [1]. As reported by the European Environment Agency, in 2021 75% of the European population lived in urban areas including cities but also smaller urban settlements and suburban areas, developed for residential, industrial or recreational purposes [2]. The local urban environment influences people's health by determining their level of urban environmental exposures (UrbEEs) [3,4]. The UrbEEs include the totality of the surrounding natural (e.g., green and blue spaces), built (e.g., walkability, urbanisation level, traffic,) and social (e.g., security, public services) environments within which people live, move, and interact, as well as environmental stressors like air pollution and noise. Increasing evidence shows that UrbEEs such as lack of greenness, air pollution and noise can impact population's mental and physical health and quality of life [5–9]. The health implications of environmental exposures become even more relevant in the contemporary demographic setting, given that they are perhaps starker in urban areas [10–14]. Moreover, in many regions, environmental exposures are not evenly distributed across socioeconomic status and thus, socio-economically vulnerable populations are also affected by poorer environmental quality [10,11]. In fact, this double jeopardy may result in individuals from poorer socioeconomic backgrounds more significantly affected by environmental exposures [4,15]. A comprehensive approach is crucial for understanding the interplay of various environmental determinants with health and well-being within urban settings. A holistic multi-exposure framework should be adopted, as outlined by Hammersen et al. [16], that extends beyond traditional considerations and incorporates critical urban contextual issues such as substandard housing, crowding, economic inequality, and the evolving challenges posed by climate change, as well as individual psychosocial factors [17,18].



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3 25 UrbEEs, including environmental stressors, traffic-infrastructure, natural spaces, and  
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5 26 built environment, have all been studied in relation to health. Widespread evidence in the  
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7 27 literature shows that air pollution, noise, and lack of green space are related to a range of chronic  
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9 28 physical diseases [19–24]. Recently, it has been suggested that air pollution is associated with a  
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11 29 range of mental disorders and poorer sleep quality [21,25–28]. Other recent studies observed  
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13 30 that environmental noise has negative effects on mental health, well-being, and sleep quality  
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15 31 [27,29–31], while evidence on its impact on prescriptions and consumption of medication for  
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17 32 common mental disorders has yet to be scientifically confirmed [32]. Otherwise, current  
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19 33 scientific evidence indicates that residential greenness is positively associated with mental  
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21 34 health and quality of life [31,33,34], and lower consumption of anxiolytics, antidepressants, and  
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23 35 sleeping pills [27,35]. Blue spaces (aquatic environments such as rivers, lakes, and the coast) are  
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25 36 expected to have similar health effects to those described here, however, evidence on this  
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27 37 subject is limited [35,36]. As for the built environment, walkability or accessibility have also been  
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29 38 related to reduced obesity and better cardiovascular health [37], improved mental health  
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31 39 [38,39] and well-being [40]. To date, the main mechanisms proposed to explain these  
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33 40 associations are the mitigation of exposure to environmental pollutants, the promotion of  
34  
35 41 physical activity, and the strengthening of social cohesion [33,34,37,41–43]. Moreover, these  
36  
37 42 mechanisms are probably synergistic [44]. The correlations between several UrbEEs and their  
38  
39 43 relationship with behavioural exposures, such as physical activity and social cohesion, makes the  
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41 44 assessment of these associations and pathways highly challenging [45–49]. Hence, noise and air  
42  
43 45 pollution could act both as exposures, mediators, or potential confounders. Overall, results of  
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45 46 previous studies are quite mixed and the associations as well as the underlying mechanisms  
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47 47 between UrbEEs and mental health outcomes need more robust scientific evidence [5,47,50–  
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57 49 This knowledge gap can be partly explained by the heterogeneity and limitations of  
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59 50 exposure and outcome metrics used in the studies [19,52,53]. Moreover, there is a lack of

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3 51 studies addressing the impact of UrbEEs on health integrating objective and perceived accounts  
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5 52 of such exposures [54]. Therefore, it is evident that more research is needed to determine which  
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7 53 UrbEEs are associated with health, the potential mechanisms involved, and the role of social  
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9 54 aspects in those associations. Beyond this, researchers are increasingly called to provide  
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11 55 information that can guide the selection of the best and most feasible interventions to improve  
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13 56 public health in cities. In this respect, experts in the field have claimed the vital role that health  
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15 57 impact assessment tools play when integrating the evidence in the decision-making process  
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17 58 [55,56].  
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22 59 *Urban Environment and Health: a cross-sectional multiregional project based on*  
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24 60 *Population Health Surveys in Spain* (DAS-EP project) is a 3-year project (2023-2025) aimed at  
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26 61 further investigating the associations and underlying mechanisms, including direct and indirect  
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28 62 effects, between UrbEEs and health with a health equity perspective. Five main objectives have  
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30 63 been established for this project:  
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- 34 64 1. To estimate, describe, and compare the objective and subjective levels of UrbEEs in the  
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36 65 study areas.  
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38 66 2. To describe urban environmental inequalities according to socio-demographic and  
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40 67 socio-economic variables, as well as the study area.  
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42 68 3. To estimate the association of UrbEEs with self-perceived general and mental health,  
43  
44 69 health-related quality of life, chronic mental disorders, consumption of medication for  
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46 70 common mental disorders, and sleep quality (Figure 1)<sup>1</sup>.  
47  
48 71 4. To estimate the impact of UrbEEs on the health outcomes under evaluation, at the  
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50 72 population level, and to conduct a health impact assessment.  
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58 <sup>1</sup> For a summary of current prevalence of common mental disorders in Spain, please see section 0 in the  
59 Supplementary file.  
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3 73 5. To assess the mediating role of physical activity, social cohesion, and environmental  
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5 74 stressors on the association between UrbEEs and the health outcomes under evaluation  
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7 75 (Figure 1).  
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10 76 The general hypothesis of this research project is that the urban environment directly or  
11  
12 77 indirectly affects mental health and quality of life. In line with the first objective of the project,  
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14 78 we expect significant differences in levels of exposure to urban environmental variables among  
15  
16 79 the cities under study. Regarding the second objective, we expect participants with lower socio-  
17  
18 80 economic status, lower educational levels, and less remunerated occupations to live in  
19  
20 81 residential environments of poorer environmental quality. We expect them to live in areas with  
21  
22 82 less availability of green and blue spaces, lower walkability scores, and higher levels of noise and  
23  
24 83 air pollution. Finally, we expect the various environmental exposures reported in this study to  
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26 84 be significantly associated with the various health and mental health variables studied in the  
27  
28 85 project. Notably, we anticipate that air pollution and noise may have negative effects on mental  
29  
30 86 health, while exposure to natural (green and blue), and more walkable spaces will show  
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32 87 protective effects against bad mental health. Furthermore, in line with recent literature, we  
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34 88 expect that part of these potential effects on mental health might be produced through  
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36 89 increased physical activity and social cohesion.  
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## 42 90 **2. Methods and analysis**

### 43 91 **2.1. Study design**

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46 92 This is a cross-sectional study based on information from Population Health Surveys  
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48 93 (PHS) carried out in adult population living in urban areas, with more than 100,000 inhabitants,  
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50 94 in the autonomous regions of the Basque Country, Andalusia, the Valencian Community, and  
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52 95 the city of Barcelona in Spain. The study integrates observational data collected within the four  
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54 96 independent PHS in 2021-2023 with Geographic Information System (GIS) estimations of  
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56 97 individual UrbEEs. It entails the following research activities: 1) preparing, integrating, and  
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3 98 calibrating PHS data from each study area, 2) harmonising the variables that have been collected  
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5 99 differently in the four study areas, 3) georeferencing survey respondents' home addresses, 4)  
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7 100 characterizing each home address in terms of UrbEEs by GIS, 5) linking UrbEEs estimates with  
8  
9 101 PHS data, and 6) pooling of datasets from the four study areas (Figure 2). Using the final pooled  
10  
11 102 database, we will analyse the association between UrbEEs and health in a cross-sectional  
12  
13 103 manner, considering sociodemographic, socioeconomic and lifestyle factors. Figure 1 shows the  
14  
15 104 conceptual framework designed within the scope of this project. DAS-EP received Ethics  
16  
17 105 Approval from the relevant regional ethics committees (see more Supplementary file section 1).  
18  
19 106 This project has received funding from the Instituto de Salud Carlos III (ISCIII) under the Strategic  
20  
21 107 Action in Health with the Health Research Fund (FIS) in the call 2022 (file No. PI22/01051 and  
22  
23 108 No. PI22/00512). The project runs from December 2023 to December 2025.  
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## 29 109 **2.2. Study population**

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32 110 The target population are inhabitants of the autonomous communities of the Basque Country,  
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34 111 Andalusia, the Valencian Community, and the city of Barcelona. The sampling frames are made  
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36 112 up of people over 15 or 16 years of age of the respective study areas. The study population  
37  
38 113 includes the PHS' participants living in urban areas with more than 100,000 inhabitants in the  
39  
40 114 regions mentioned before (Figure S1, S2). The cities and metropolitan areas participating in this  
41  
42 115 study are: the city of Vitoria-Gasteiz, and the metropolitan areas of Bilbao and Donostia-San  
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44 116 Sebastián in the Basque Country; the cities of Almeria, Cadiz, Cordoba, Huelva, Jaen, and the  
45  
46 117 metropolitan areas of Granada, Malaga, and Seville in Andalusia; the cities of Castellon, Valencia,  
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48 118 Elche and Alicante in the Valencian Community; and the city of Barcelona (Table S1).  
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51  
52 119 The PHS included in this project are official statistical operations that are incorporated in  
53  
54 120 the Statistical Plans of each study area. These activities are conducted by every regional or local  
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56 121 public administration with jurisdiction in health and are a fundamental tool to monitor the status  
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58 122 and evolution of relevant health conditions in the population, their main determinants, and the  
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3 123 use of health services [57–60]. Accordingly, these regional and local cross-sectional  
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5 124 epidemiological surveys are carried out by the Basque Department of Health in the Basque  
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7 125 Country [57], Andalusian School of Public Health (EASP) in Andalusia [58], Barcelona Public  
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9 126 Health Agency (ASPB) in Barcelona [59], and Foundation for the Promotion of Health and  
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11 127 Biomedical Research in the Valencian Region (DGSP) in Valencian Community [60]. They have  
12  
13 128 been organised every 4-5 years since 1986 (Basque Country), 1999 (Andalusia), 1983 (Barcelona)  
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15 129 and 1991 (Valencian Community). The sample design and the selection of the sample is carried  
16  
17 130 out independently in each region by the statistical institute (The Basque Institute for Statistics  
18  
19 131 in the Basque Country, Institute of Statistics and Cartography of Andalusia in Andalusia, and  
20  
21 132 municipal statistical office of the Barcelona city council in Barcelona) or health population  
22  
23 133 information system (Valencian Community). Data from the latest version of these surveys is  
24  
25 134 included in this project. After the surveys are completed, we expect a total estimated sample of  
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27 135 16,953 individuals, of which 7,846 participants will be from the Basque Country, 3,085 from  
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29 136 Andalusia, 3,134 from the Valencian Community, and 4,000 from the city of Barcelona. More  
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31 137 detailed information is provided in Table S1.  
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### 38 **2.3. Data collection**

#### 39 2.3.1. GIS estimates of urban environmental exposures (UrbEEs)

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41  
42 140 Objective measures of UrbEEs are estimated by a company specialised in GIS based on the  
43  
44 141 geographic coordinates of the participants' home addresses. A significant number of these  
45  
46 142 variables will be expressed in buffers around each participant's residence or at the building level.  
47  
48 143 All environmental exposures will be assessed preceding to, and as close as possible to the time  
49  
50 144 the PHS are being conducted (2021-2023) to avoid temporal mismatch [61]. The objective  
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52 145 UrbEEs of interest in this project include exposures originated from surrounding natural spaces,  
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54 146 built environment, traffic-infrastructure, and environmental stressors. Detailed information on  
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3 147 the UrbEEs estimated within the scope of this project can be found in the Supplementary file  
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5 148 (Table S2).

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8 149 *Surrounding natural spaces*

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11 150 - Green spaces. Five green space exposure metrics will be calculated in buffers of 100, 300  
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13 151 and 500 m around each geocode: 1) percentage of green space; 2) mean Normalised  
14  
15 152 Difference Vegetation Index (NDVI) [62,63]; 3) percentage of tree cover; 4) Euclidean  
16  
17 153 distance to the nearest green space larger than 5,000 m<sup>2</sup> [64], and 5) presence of a major  
18  
19 154 green area (greater than 5,000 m<sup>2</sup>).

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21  
22 155 - Blue spaces. Any blue environments, including lakes, rivers, or coastline will be considered  
23  
24 156 as blue space. Three blue space exposure variables will be estimated: 1) presence of water  
25  
26 157 surface; 2) percentage of water surface; and 3) Euclidean distance to nearest water surface  
27  
28 158 greater than 5,000m<sup>2</sup>. The first two refer 100, 300 and 500 m buffers around each geocode  
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30 159 [65].

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32  
33  
34 160 *Built environment*

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37 161 - Building density. The building density around each home address in 100, 300 and 500 m  
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39 162 buffers will be estimated, considering not only the perimeter of the buildings but also their  
40  
41 163 height [66].

42  
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44 164 - Walkability. An overall walkability index in 100, 300 and 500 m buffers around the  
45  
46 165 participants' home addresses will be calculated. This index will include of the following  
47  
48 166 subindices: 1) population density (at the census tract level), 2) street density, 3) street  
49  
50 167 connectivity, 4) land use Shannon Evenness Index, 5) facility richness, 6) facility density, 7)  
51  
52 168 average slope, and 8) transport density [67,68].

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56 169 *Traffic infrastructure*

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3 170 - Major road (Yes vs. No). Presence of a major road (with >3 million vehicle passages per year)  
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5 171 in 100, 300 and 500 m buffers around the participants' home addresses [66].  
6

7 172 - Distance to major road. Distance to the nearest major road (with >3 million vehicle passages  
8  
9 173 per year) from the participants home addresses [66].  
10  
11

#### 12 13 174 *Environmental stressors*

14  
15 175 - Air pollution. Spatiotemporal daily models at household-level for particulate matter (PM<sub>10</sub>  
16  
17 and PM<sub>2.5</sub>) and nitrogen dioxide (NO<sub>2</sub>) will be constructed for all study areas using multistage  
18 176 mixed models. These models are known as spatiotemporal land-use random-forest model  
19  
20 177 [69] and combine ground-level and satellite measurements, land use and meteorology. A  
21  
22 178 precise daily estimate of the exposures will be obtained for all study subjects (period 2006  
23  
24 179 to 2023). Using the daily estimates, annual average for the last five years and the five-year  
25  
26 180 average of NO<sub>2</sub>, PM<sub>10</sub> and PM<sub>2.5</sub> exposure levels will be calculated at PHS respondents' home  
27  
28 181 address as indicators for long-term air quality.  
29  
30 182

31  
32  
33 183 - Environmental noise. The Strategic Noise Maps derived under the EU Directive 2002/49/EC  
34  
35 184 from the Ministry for the Ecological Transition and the Demographic Challenge will be used.  
36  
37 185 All potential sources of environmental noise at street level will be examined, including road  
38  
39 186 traffic, rail, industrial, airports and total noise [70,71]. Major roads, major railways, and  
40  
41 187 major airports will be included in cities where this information is available and not included  
42  
43 188 in the agglomeration layer. Agglomerations corresponding to the closest street to the  
44  
45 189 dwelling, and major roads and airports corresponding to the closest isoline will be used. In  
46  
47 190 all cases, the Euclidean distance to each source will also be calculated. The daytime (L<sub>d</sub>),  
48  
49 191 evening (L<sub>e</sub>), night-time (L<sub>n</sub>), and total (L<sub>den</sub>) noise indices will be assigned.  
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#### 52 53 192 2.3.2. Contextual socioeconomic variables

54  
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57 193 Neighbourhood-level socioeconomic status (SES) will be considered via three variables, namely,  
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59 194 mean income, income distribution P80/P20, and the MEDEA deprivation index (composed by  
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3 195 percentage of the population with manual labour, percentage of the population with casual  
4  
5 196 labour, percentage of the population unemployed, percentage of the population with  
6  
7 197 insufficient education, percentage of the population of young people with insufficient  
8  
9 198 education) [72]. All these metrics will be obtained from the publicly available data developed by  
10  
11 199 the Spanish National Institute for Statistics (INE) and expressed at the census tract level (Table  
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13  
14 200 S3).

### 17 201 2.3.3 Individual socio-demographic and socio-economic variables

20 202 To describe respondents' individual-level SES, eight variables will be selected: country of birth,  
21  
22 203 marital status, household size, level of education, employment and occupational status,  
23  
24 204 reported household income, and economic difficulty of the household (Table S4)

### 27 205 2.3.4 Information collected through Population Health Surveys

30 206 Information from four independent PHS that represent four study areas is included in the study.  
31  
32 207 The surveys are carried out between 2021-2023, being Barcelona city the earliest in completing  
33  
34 208 the collection (2021 February – 2022 March), followed by the Valencian Community (2022 April  
35  
36 209 – 2022 December), Andalusia (2022 April – 2023 April), and the Basque Country (2022 October  
37  
38 210 – 2023 June) (Table S1). During each survey, detailed information is collected though face-to-  
39  
40 211 face interviews and self-administered questionnaires. The PHS collect information on different  
41  
42 212 health aspects, morbidity, and use of health services. It also gathers information on social  
43  
44 213 determinants of health such as socio-economic status, working conditions, social cohesion,  
45  
46 214 health-related behaviours and perception on residential environment. Most of these variables  
47  
48 215 are measured with validated screening tools. The selection of relevant variables to be included  
49  
50 216 in this project was based on a literature review and the most appropriate variables to meet the  
51  
52 217 objectives of the study were selected from among the variables collected by the PHS. All the  
53  
54 218 study areas collected the main variables of the study (i.e., mental health, health-related quality  
55  
56 219 of life, physical activity, social cohesion, and sleep), however, in some cases, the measuring



1  
2  
3 220 instruments differ across the study areas. Detailed information about the variables and the  
4  
5 221 measuring instruments used in each study area can be found in Table S4.  
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7

8 222 *Health outcomes*  
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10 223 Several health outcome variables are included in this study.  
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13 224 - Perceived general health. Self-assessment of health was measured as an ordinal response,  
14  
15 225 with five categories (1, Excellent; 2, Very good; 3, Good; 4, Fair; 5, Poor).  
16  
17

18 226 - Perceived mental health. This variable was collected with the Mental Health Inventory [73],  
19  
20 227 the SF-12 (Short-Form Health Survey 12) scale [74] or the General Health Questionnaire  
21  
22 228 (GHQ-12) [75].  
23

24 229 - Health-related quality of life. This variable was measured with the Euroqol-5D-5L-EAV scale  
25  
26 230 [76] or the SF-12 (Short-Form Health Survey 12) scale [74].  
27  
28

29 231 - Sleep duration and quality. The duration of sleep, indicated as the total number of hours per  
30  
31 232 day spent on sleep including napping was calculated. The quality of sleep was collected using  
32  
33 233 the SATED scale (Satisfaction Alertness Timing Efficiency and Duration Scale) [77] or discrete  
34  
35 234 items.  
36  
37

38 235 - Prevalence of chronic mental health problems. Participants had to indicate whether they  
39  
40 236 had been diagnosed with depression, anxiety, and sleeping disorders at any time throughout  
41  
42 237 the life. We then built a dichotomized (yes/no) variable for each condition.  
43

44 238 - Consumption of medication for common mental disorders. Information on consumption of  
45  
46 239 medication for common mental disorders, such as, anxiolytics, antidepressants and  
47  
48 240 hypnotics was reported on bi-daily or bi-weekly basis depending on the study area.  
49  
50

51 241 *Covariates*  
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54 242 A set of individual level variables will be used as control variables in the statistical analyses.  
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3 243 - Anthropometric variables. The surveys collect information on sex, age, weight, and height  
4  
5 244 of individuals. A Body Mass Index (BMI) (kg/m<sup>2</sup>) will be calculated using information given  
6  
7 245 by the participants about their height and weight at the moment of filling the questionnaire.  
8  
9  
10 246 - Individual socio-demographic and socio-economic variables. To describe respondents'  
11  
12 247 individual-level SES, eight variables will be selected: country of birth, marital status,  
13  
14 248 household size, level of education, employment and occupational status, reported  
15  
16 249 household income, and economic difficulty of the household.  
17  
18 250 - Lifestyle factors. These will include consumption habits such as alcohol consumption,  
19  
20 251 passive smoking at home, and tobacco use.  
21  
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23 252 - Physical health. A chronicity index will be calculated based on presence of one or more non-  
24  
25 253 psychological chronic conditions (e.g., diabetes, heart disease, cancer, etc.).  
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28 254 The following social and behavioural variables will be treated as potential mediators.  
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31 255 Social cohesion and loneliness. Social cohesion is measured with the Duke-UNC-11 scale [78] or  
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33 256 the OSLO-3 tool [79]. Perceived loneliness is collected with a single item for participants to  
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35 257 report about the frequency in which they feel loneliness. The variable is displayed in a 1 to 4 (1=  
36  
37 258 always; 2= often; 3= sometimes; 4= never) response scale.  
38  
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40  
41 259 - Physical activity. The International Physical Activity Questionnaire (IPAQ) [80] to measure  
42  
43 260 the physical activity performed by the participants. Days per week and time spent in  
44  
45 261 vigorous physical activity, in moderate physical activity, and walking more than 10 minutes,  
46  
47 262 and time spent sitting on a normal day will be available.

### 263 *Perception of the neighbourhood*

- 264 Perceived accounts of UrbEEs are collected through PHS employing 3-point or 5-point Likert  
265 format questions depending on the study area. These include: 1) perception of noise outside the  
266 dwelling, 2) perception of shortage of green areas in the residential environment, 3) perception

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3 267 of air pollution in the residential environment, and 4) perception of insecurity in the  
4  
5 268 neighbourhood.  
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#### 8 269 **2.4. Data analysis**

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11 270 Initially, all databases will be cleaned. The variables will be harmonised, when needed,  
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13 271 following the Maelstrom Research Guidelines for rigorous harmonisation of retrospective data  
14  
15 272 [81]. Nonetheless, because most variables have already been collected consistently in the  
16  
17 273 respective Population Health Surveys, few variables will require harmonisation (Table S4).  
18  
19 274 Among the few variables requiring harmonisation, most will be re-categorised. For more  
20  
21 275 information, see Supplementary file section 5. Subsequently, both exploratory and descriptive  
22  
23 276 analysis will be applied using numerical and graphical techniques [82]. Before proceeding to  
24  
25 277 inference, sample weights for each survey will be adjusted through calibration [83], so that we  
26  
27 278 may compensate for non-response and coverage biases and improve accuracy. This calibration  
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29 279 will be carried out separately for each study area, so that region-level estimates are obtained  
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31 280 first, and then harmonized to obtain estimates at population level.  
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37 281 The relationships between the various UrbEEs and health outcomes will be analysed  
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39 282 according to the multilevel, or hierarchical structure [84] that the data possesses, as census  
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41 283 tracts are nested within cities, and cities are nested within autonomous regions. Generalised  
42  
43 284 linear mixed models (GLMMs) will be applied to investigate the relationship between urban  
44  
45 285 environment and health. The sets of adjustment covariates used in these models will be chosen  
46  
47 286 by applying robust causal inference techniques based on directed acyclic graphs (DAGs) [85],  
48  
49 287 both for the estimation of direct effects and hypothetical indirect effects mediated by air  
50  
51 288 pollution, environmental noise, physical activity, and social cohesion. This will imply the prior  
52  
53 289 design of a DAG describing the relationships among UrbEEs, health outcomes and other  
54  
55 290 potentially implicated variables [86,87]. The testable implications derived from this DAG will be  
56  
57 291 checked following the procedure described by Ankan and colleagues [88], thereby updating the  
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3 292 DAG if needed [89,90]. These graphical models will guide the inclusion of relevant socio-  
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5 293 demographic and socioeconomic variables, allowing us to account for potential confounding  
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7 294 factors and illuminate causal relationships. The length of time living in the same home/place will  
8  
9 295 be considered by excluding individuals living at the same place of residence for less than one  
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11 296 and less than five years in separate models. Equity will be addressed performing subgroup  
12  
13 297 analysis to investigate potential vulnerable groups such as lower-income populations, the  
14  
15 298 elderly, women, and marginalized communities.  
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19  
20 299 In case of demonstrating a significant relationship between a given exposure and a certain  
21  
22 300 outcome, we also intend to identify the specific exposures that cause most disease in the  
23  
24 301 populations of interest via the population attributable fraction (PAF) [91]. To estimate the PAF  
25  
26 302 we will require previous estimations of relative risk (RR) and either the prevalence of exposure  
27  
28 303 in the population or the prevalence of exposure among the cases of disease. All these previous  
29  
30 304 estimates will be available. The possible existence of spatial clusters in the UrbEEs distribution  
31  
32 305 will also be studied using the standard spatial scan statistic method [92] and calculating the  
33  
34 306 posteriori probabilities for the smoothed standardised ratios to be greater than unity, in the  
35  
36 307 general framework of Bayesian hierarchical standardised ratio smoothing models.  
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40  
41 308 The analyses will be implemented using the latest version of the R software packages  
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43 309 *dagitty* [85], *DClusterM* [93,94], *R INLA* [95], *Sampling* [96] and others.  
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## 46 310 **2.5. Data Management Plan**

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49 311 The data management plan can be found in the Supplementary file section 5. The source and  
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51 312 type of data that will be collected within the scope of this project is described in this plan,  
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53 313 together with the accessibility and ownership of data. Data storage and processing, as well as  
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55 314 the procedure to guarantee the specific ethical and legal requirements, are likewise explained.  
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## 59 315 **2.6. Patient and Public Involvement**

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3 316 Patients and the public will not be involved in the design, or conduct, or reporting, or  
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5 317 dissemination plans of our research.  
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### 7 318 **3. Discussion**

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10 319 The present study is a clear commitment to the generation of urban environmental  
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12 320 indicators potentially explanatory of self-perceived health (physical and mental), chronic mental  
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14 321 disorders, health-related quality of life, consumption of medication for common mental  
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16 322 disorders and sleep quality with a health equity perspective. This project responds to the  
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18 323 national Spanish Strategic Plan for Health and the Environment (PESMA) 2022-2026 [97], to the  
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20 324 local implementation of the Strategy for Health Promotion and Prevention in the National Health  
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22 325 System [98] as well as to the main objective of the Spanish Urban Agenda 2019 [99] that cities  
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24 326 should have a global vision that takes into consideration the physical, mental, and social well-  
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26 327 being of their inhabitants. Likewise, it is aligned with three of the Sustainable Development  
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28 328 Goals (SDG) of the World Health Organization (SDG.3 - Good Health and Well-being, SDG.10 –  
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30 329 Reduced Inequalities, and SDG.11 – Sustainable Cities and Communities) (97,98).  
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36 330 When it comes to health-promoting urban and transport design, there is a lack of  
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38 331 standardized, quantitative indicators to guide the integration of health components right from  
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40 332 the outset [57,100]. In this context, the DAS-EP project not only aims to obtain individual UrbEEs  
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42 333 estimates but also to assess their association with, and impact on various health outcomes. By  
43  
44 334 means of PHS, the health effects to be studied in this project are derived from an unbiased  
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46 335 population, which allows to obtain an approximate estimate of the impact at population level.  
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48 336 Moreover, it is important to identify the precise routes that connect urban environment to  
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50 337 health because they can guide the most efficient interventions, allowing us to design healthy(er)  
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52 338 cities [55,101]. In this sense, the DAS-EP project investigates various components of the urban  
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54 339 environment and health at individual level. Besides using complementary indicators that  
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56 340 describe both the physical and the social urban environment (e.g., neighbourhood insecurity),  
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341 combines objective and perceived indicators to deepen the characterization of the urban  
342 environment. By combining these data, it is possible to develop a more precise understanding  
343 of the effects of urban environment on health, while describing the complexity of the  
344 relationship influenced by neighbourhood environmental and individual characteristics [102–  
345 104].

346 The main limitation of this study is its cross-sectional nature. Due to the chronic character of the  
347 health conditions included in the study (e.g., depression, insomnia) and the possible long-term  
348 effects of UrbEEs, a longitudinal design would be more informative and appropriate. Although  
349 PHS have a cross-sectional approach, the question "since when have you been living at your  
350 current address" enables to account for the extent of exposures. Drawing on this mobility data,  
351 sensitivity analysis of the models will be fitted reducing the risk of exposure misclassification.  
352 Another limitation is that the samples from the study areas of the Basque Country, Andalusia,  
353 and Valencian community, although representative of the study population (considering the  
354 inclusion criteria) may not be representative of the autonomous communities from which they  
355 come as we are not considering the non-urban municipalities (<100,000 inhabitants). Despite  
356 the weight calibration to be conducted to reduce coverage and representativeness biases, the  
357 reweighting procedure will not guarantee the elimination of other response biases that may  
358 affect data collection from PHS (as acquiescence, social desirability, etc.) which could affect the  
359 validity of the results [105,106]. Furthermore, the project is subject to residual confounding,  
360 which in turn implies confounders that could not be controlled and, importantly, measurement  
361 errors in the confounders that have been included. In this regard, the estimation UrbEEs by GIS  
362 is affected by the problem of uncertainty of the temporal and geographical context [107].

363 The use of buffer zones may not be appropriate to evaluate contextual effects on health because  
364 they fail to analyze the spatial-temporal distribution of residents' activities and their relationship  
365 with built environment factors. Using activity space measures would be preferable to  
366 comprehensively assess of environmental exposures by capturing the complexity of individual

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3 367 movements [108–110]. The reliance on publicly available data applicable to all study areas  
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5 368 together with scalability challenges were major barriers to estimate street-level (or microscale)  
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7 369 variables like bicycle and pedestrian infrastructure [111–113]. Moreover, future studies should  
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9 370 not only include more variables reflecting the social capital (e.g., perceived sense of community)  
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11 371 but also analyse the health implications of other relevant urban exposures like substandard  
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13 372 housing, crowding, and indoor air pollution. Finally, the heterogeneity across study areas in  
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15 373 terms of geographic scale (autonomous communities vs. city) may be a source of information  
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17 374 bias. In this vein, the majority -but not all- of the scales and variables included in the different  
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19 375 PHS are identical. These minor differences in data collection across PHS may lead to additional  
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21 376 information biases hindering the comparability of the data. To minimize this problem, special  
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23 377 attention will be paid to the selection and harmonization of the variables to be included to  
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25 378 ensure the consistency of data before making the comparisons across study areas.  
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31 379 As for the strengths of this project, pooling linked surveys across study areas will make  
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33 380 it possible to compare the results in different populations, providing a comprehensive dataset  
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35 381 that is larger than most existing cohort studies, and that have an unique national and population  
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37 382 perspective. The results will be novel in terms of their thematic (objective & subjective UrbEEs)  
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39 383 and methodological approach (combination of PHS from different study areas and GIS  
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41 384 estimates), as well as in terms of the large volume of information that will be handled and the  
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43 385 large sample size of the study. Beyond that, the standardization of the procedure described  
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45 386 herein will generate useful information to assist in the planning of national health surveillance  
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47 387 programs, research studies and, more importantly, interventions to strengthen population's  
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49 388 health.  
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54 389 In short, the results and products (i.e., databases, computer codes) of this project will  
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56 390 greatly contribute to estimate the proportion of the population exposed to different UrbEEs,  
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58 391 identify health disparities while considering UrbEEs, estimate how these exposures relate to and  
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392 affect various health variables, and conduct a health impact assessment of UrbEEs. We will have  
393 taken a further step towards understanding and improving the urban environment and being  
394 able to establish corrective measures in the urban development plans of the cities.

For peer review only



## Declarations

### Ethics and dissemination

The study was approved by the regional Research Ethics Committee of the **Basque Country**, ETHICS COMMITTEE FOR RESEARCH INVOLVING MEDICINAL PRODUCTS IN THE BASQUE COUNTRY (*CEIm-E*) (protocol code PI2022138, dated 9<sup>th</sup> November 2022); **Andalusia**, BIOMEDICAL RESEARCH ETHICS COMMITTEE OF THE PROVINCE OF GRANADA (CEI/CEIM GRANADA) (protocol code 2078-N-22, dated 27<sup>th</sup> December 2022); **Barcelona**, PARC DE SALUT MAR CLINICAL RESEARCH ETHICS COMMITTEE (CEIm) (protocol code 2022/10667, dated 2<sup>nd</sup> December 2022); **Valencian Community**, ETHICS COMMITTEE FOR CLINICAL RESEARCH OF THE DIRECTORATE GENERAL OF PUBLIC HEALTH AND CENTER FOR ADVANCED RESEARCH IN PUBLIC HEALTH (CEIC DGSP / CSISP) (protocol code 20221125/04, dated 25<sup>th</sup> November 2022). The results will be communicated to the general population, health professionals and institutions through conferences, reports, and scientific articles.

### Competing interests

The authors declare that they have no competing interests.

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## Authors' contributions

Conceptualisation, A.L., A.C.-L., M.S-P

Methodology, A.L., A.C.-L., M.S-P

Writing, original draft preparation, A.B., A.L., M.S-P., A.C-L

Writing, review and editing, A.B., A.L., M.S-P., A.C-L., S.C.G., G.G-B., S.D.G., F.B., M.E., A.M.,

A.E., M.A.I., C.B., R.M., L.F-R., X.B., K.P., L.O., A-C.B., A.D., L.G., H.G.C., M.L.N., R.C., M.M.R.,

M.S

Project administration, A.L., A.C-L., A.B., M.S-P

Funding acquisition, A.L., A.C-L., M.S-P

All authors have read and agreed to the published version of the manuscript.

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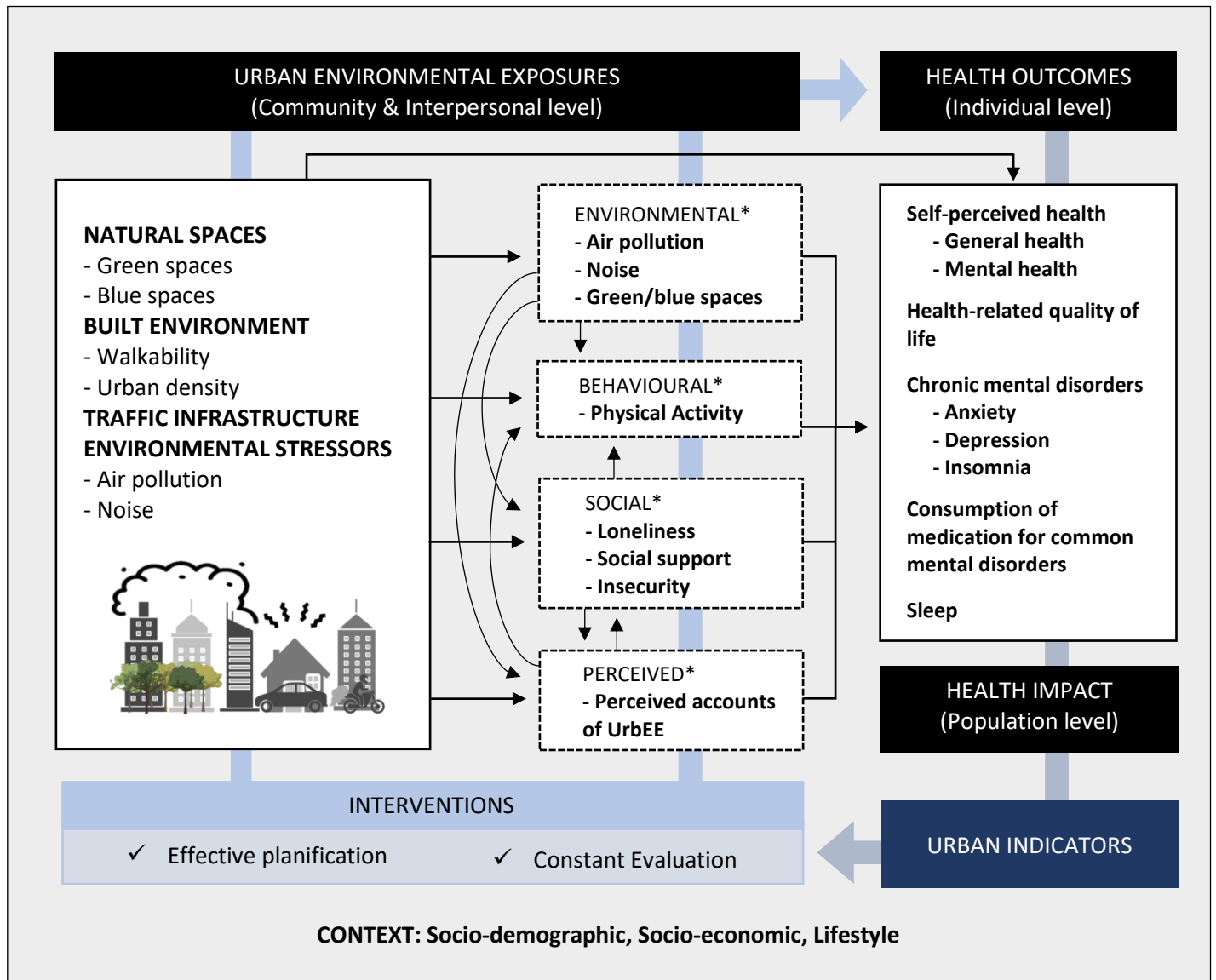
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## 44 Legends

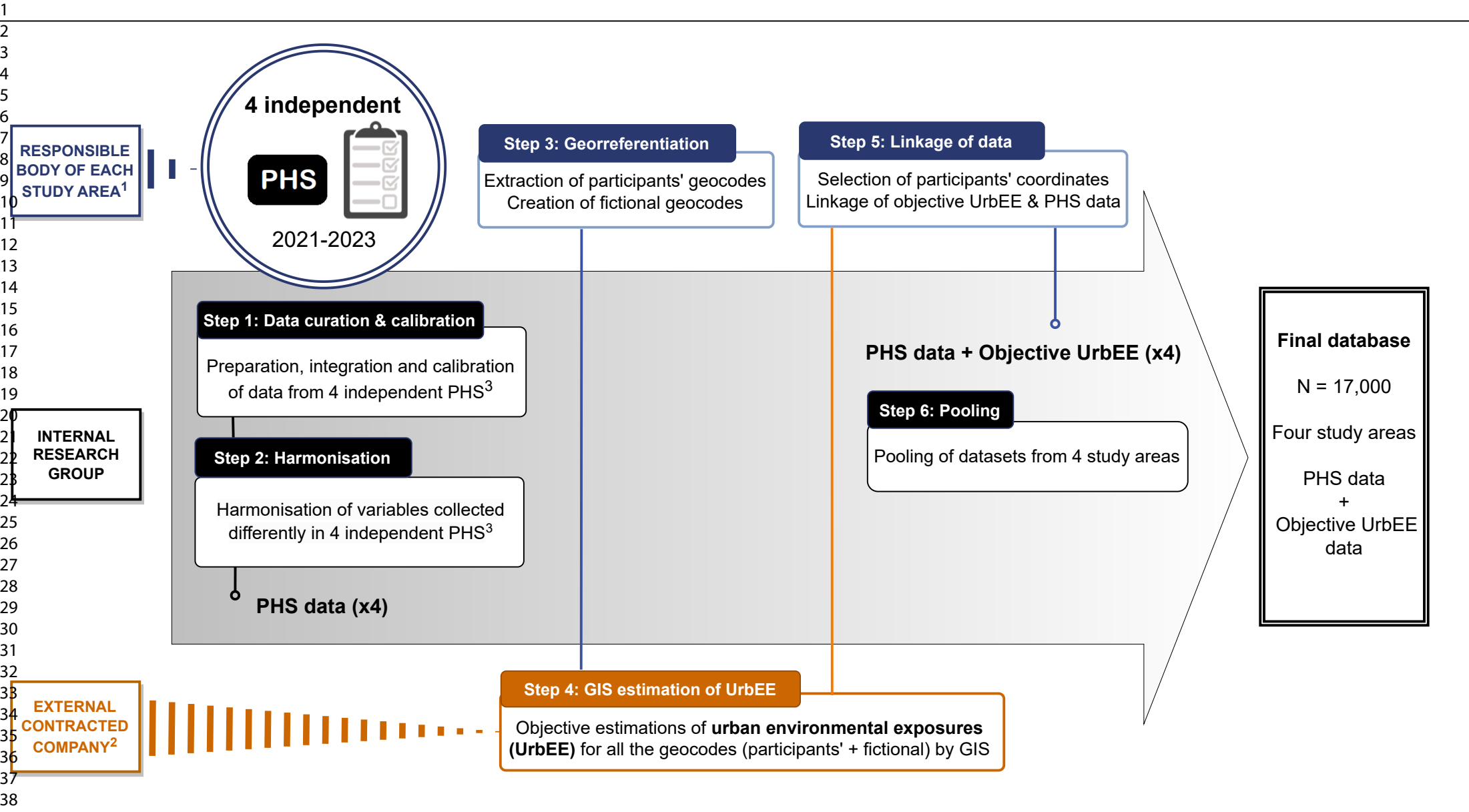
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47 **Figure 1.** Conceptual framework designed within the scope of this project, including potential  
48 direct and indirect effects of urban environmental exposures (UrbEEs) on the health outcomes  
49 under study. \* Potential mediators on the association between UrbEEs and the health outcomes  
50 under evaluation.

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52 **Figure 2.** Summary of data management plan and the institutions involved during the  
53 development of the final database (DB) to be used by the research group in the analyses.

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Responsible body of the Population health survey (PHS) from each study area: the Basque Department of Health (Basque Country), Escuela Andaluza de Salud Pública (EASP) (Andalusia), Agència de Salut Pública de Barcelona (ASPB) (Barcelona), and Conselleria de Salut Universal i Salut Pública (DGSP) (Valencian Community).  
 External contracted company specialised in GIS estimations.  
 For each PHS carried out in the study areas of the autonomous communities of the Basque Country and Andalusia, Valencian Community, and the city of Barcelona.  
 For peer review only - <http://bmjopen.bmj.com/site/about/guidelines.xhtml>

## Supplementary file

**File name:** Supplementary file\_DAS-EP

**File format:** Word document (.docx)

**Title of data:** Supplementary data of Urban Environment and Health: a cross-sectional multiregional project based on Population Health Surveys in Spain (DAS-EP project), study protocol.

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A) Prevalence of common mental disorders in Spain.

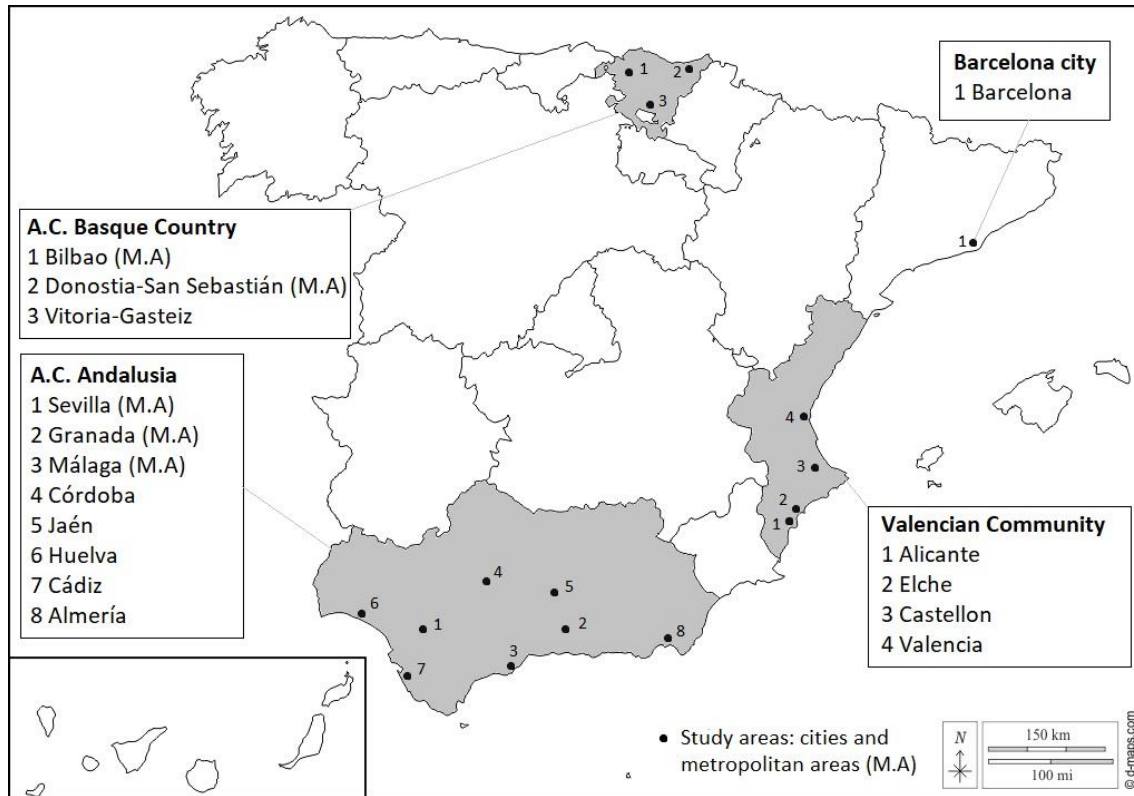
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A) Research activities

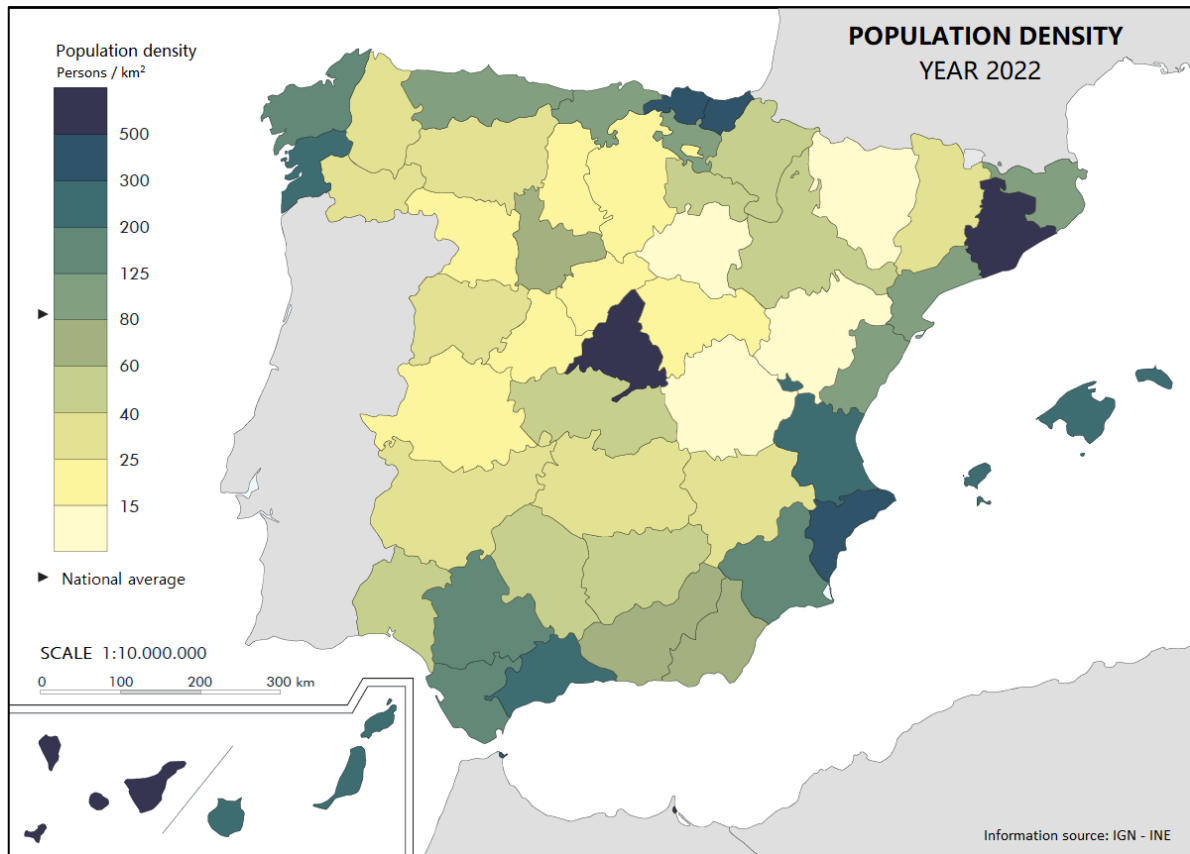
B) Data storage and processing

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## Section 1. GENERAL CHARACTERISTICS OF THE STUDY AREAS



**Figure S1.** Study areas of the project, being the cities and metropolitan areas (M.A) with more than 100,000 inhabitants from the autonomous communities of the Basque Country and Andalusia, Valencian Community, and the city of Barcelona. Figure edited from Daniel Dalet / d-maps.com.



33 **Figure S2.** Population density of Spanish provinces in 2022. Figure edited from Instituto  
34 Geográfico Nacional, *La población en España 2022*. Accessed through:  
35 <https://www.ign.es/pobesp/pe1.htm>

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## Section 2. GENERAL CHARACTERISTICS OF THE POPULATION HEALTH SURVEYS

**Table S1.** Characteristics of the study areas and the population health surveys comprised in the project.

Study area	Cities and areas of influence	Population health survey	Responsible body	Sample size	Data collection period
A.C. Basque Country	Vitoria-Gasteiz Donostia-San Sebastián (M.A) Bilbao (M.A)	Encuesta de Salud de la Comunidad Autónoma País Vasco (ESCAV)	✓ Basque Department of Health	7,846	2022 October – 2023 June
A.C. Andalusia	Almería Cádiz Córdoba Huelva Jaén Granada (M.A) Malaga (M.A) Sevilla (M.A)	Encuesta Andaluza de Salud (EAS)	✓ Andalusian School of Public Health (EASP)	3,085	2022 April – 2023 April
Barcelona city	Barcelona	Encuesta de Salud de Barcelona (ESB)	✓ Barcelona Public Health Agency (ASPB)	4,000	2021 February – 2022 March
Valencian Community	Castellon Valencia Elche Alicante	Encuesta Salud Comunidad Valenciana (ESCV)	✓ Foundation for the Promotion of Health and Biomedical Research in the Valencian Region (DGSP)	3,134	2022 April – 2022 December

Abbreviations: A.C., Autonomos community; M.A, Metropolitan Area.

### Section 3. OVERVIEW OF THE VARIABLES OF THE STUDY PER STUDY AREA

**Table S2.** Objective urban environmental exposures obtained through GIS estimations.

GIS Variables	Study areas: A.C. s of the Basque Country and Andalusia, Valencian Community & the city of Barcelona	
OBJECTIVE URBAN ENVIRONMENTAL EXPOSURES	Scale	Variable
<b>a) Surrounding natural spaces</b>		
<b>Green Spaces</b>		
Green space percentage	100, 300, 500m buffers	Percentage of green space.
NDVI	100, 300, 500m buffers	Annual mean Normalised Difference Vegetation Index (NDVI) of the year when the surveys were conducted and the mean NDVI of the last 5 years previous to the surveys.
Tree percentage	100, 300, 500m buffers	Percentage of tree cover based on Growing stock volume (GSV) data.
Distance to green space		Euclidean distance to the nearest major green space (green surface over 5,000m <sup>2</sup> ).
Green spaces Yes (vs. No)	100, 300, 500m buffers	Dichotomous variable of presence of major green spaces (green surface over 5,000m <sup>2</sup> ) from local topographical or Europe-wide maps (Urban atlas).
<b>Blue spaces</b>		
Blue spaces Yes (vs. No)	100, 300, 500m buffers	Dichotomous variable of presence of water surfaces. Based on Urban Atlas.
Blue space percentage	100, 300, 500m buffers	Percentage of water surface. Based on Urban Atlas.
Distance to blue space		Euclidean distance to the nearest water surface over 5,000m <sup>2</sup> . Based on Urban Atlas.
<b>b) Built environment</b>		
Building density	100, 300, 500m buffers	The building density around each household will be calculated accounting for the perimeter and height of the buildings from local cadastre data or Europe-wide maps (Urban Atlas).
Population density	100, 300, 500m buffers	The number of inhabitants (per km <sup>2</sup> ) surrounding the home addresses.
Street connectivity	100, 300, 500m buffers	Using data from OpenStreetMap®.
Accessibility (bus lines)	100, 300, 500m buffers	Access to public transport bus lines from local topographical maps or OpenStreetMap®.
Accessibility (bus stops)	100, 300, 500m buffers	Access to public transport bus stops from local topographical maps or OpenStreetMap®.
Facility richness	100, 300, 500m buffers	Using local topographical maps or OpenStreetMap®.
Facility density	100, 300, 500m buffers	Using local topographical maps or OpenStreetMap®.
Land use	100, 300, 500m buffers	Mixed land use will be estimated by Shannon's Evenness Index based on Urban Atlas data.
Walkability index	100, 300, 500m buffers	Index constructed from seven indicators: population density, street connectivity, street density, facility richness, facility density, land use, transport density, and average slope.
<b>c) Traffic infrastructure</b>		
Major road Yes (vs. No)	100, 300, 500m buffers	Dichotomous variable of presence of a major road (OpenStreetMap®).
Inverse distance		Inverse distance to the nearest major road (OpenStreetMap®).

GIS Variables	Study areas: A.C. s of the Basque Country and Andalusia, Valencian Community & the city of Barcelona	
OBJECTIVE URBAN ENVIRONMENTAL EXPOSURES	Scale	Variable
<b>d) Environmental stressors</b>		
<b>Air pollution</b>		
PM <sub>2.5</sub>	Street level (at residential address)	PM <sub>2.5</sub> exposure indicators include: a) the annual average for the last five years, and b) the five-year average for the last five years based on spatiotemporal land-use random-forest models.
PM <sub>10</sub>	Street level (at residential address)	PM <sub>10</sub> exposure indicators include: a) the annual average for the last five years, and b) the five-year average for the last five years based on spatiotemporal land-use random-forest models.
NO <sub>2</sub>	Street level (at residential address)	NO <sub>2</sub> exposure indicators include: a) the annual average for the last five years, and b) the five-year average for the last five years based on spatiotemporal land-use random-forest models.
<b>Noise</b>		
Day (L <sub>d</sub> )	Street level (at residential address)	Exposition to environmental noise at street level during the day indicated as: a) the annual average for the last five years, and b) the five-year average for the last five years based on Strategic Noise Maps derived under the EU Directive 2002/49/EC from the Ministry for the Ecological Transition and the Demographic Challenge.
Evening (L <sub>e</sub> )	Street level (at residential address)	Exposition to environmental noise at street level during the evening indicated as: a) the annual average for the last five years, and b) the five-year average for the last five years based on Strategic Noise Maps derived under the EU Directive 2002/49/EC from the Ministry for the Ecological Transition and the Demographic Challenge.
Night (L <sub>n</sub> )	Street level (at residential address)	Exposition to environmental noise at street level during the night indicated as: a) the annual average for the last five years, and b) the five-year average for the last five years based on Strategic Noise Maps derived under the EU Directive 2002/49/EC from the Ministry for the Ecological Transition and the Demographic Challenge.
Total (L <sub>den</sub> )	Street level (at residential address)	Total exposition to environmental noise at street level indicated as: a) the annual average for the last five years, and b) the five-year average for the last five years based on Strategic Noise Maps derived under the EU Directive 2002/49/EC from the Ministry for the Ecological Transition and the Demographic Challenge.

Abbreviations: A.C., Autonomous community; NDVI, Normalised Difference Vegetation Index; GSV, Growing stock volume; PM<sub>2.5</sub>, Fine particulate matter with a diameter of 2.5µm or less; PM<sub>10</sub>, Fine particulate matter with a diameter of 10µm or less; NO<sub>2</sub>, Nitrogen dioxide

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**Table S3.** Area-level socioeconomic (SES) variables obtained through GIS estimations.

GIS Variables		Study areas: A.C. s of the Basque Country and Andalusia, Valencian Community & the city of Barcelona	
AREA-LEVEL SES VARIABLES	Scale	Variable	
<b>a) Mean income</b>			
Average household net income	Census tract	Average household net income. Income data collection is based on standardised annual requests to the different collaborating tax organisations. Data from 2021. Data source INE <sup>1</sup> .	
Average household gross income	Census tract	Average household gross income. As components of gross income, five exhaustive categories are considered: wages, pensions, unemployment benefits, other benefits, other income. Data from 2021. Data source INE <sup>1</sup> .	
Average net income per person	Census tract	Net income per person is obtained, for each household, by dividing the net household income by the number of members of said household. Data from 2021. Data source INE <sup>1</sup> .	
Average gross income person	Census tract	Gross income per person is obtained, for each household, by dividing the gross household income by the number of members of said household. Data from 2021. Data source INE <sup>1</sup> .	
Average income per consumption unit	Census tract	Equivalised income is a measure of household income that takes account of the differences in a household's size and composition, and thus is equivalised or made equivalent for all household sizes and compositions. The equivalised income is calculated by dividing the household's total net income by its equivalent size, which is calculated using the modified OECD equivalence scale. This scale attributes a weight to all members of the household: 1.0 to the first adult; 0.5 to the second and each subsequent person aged 14 and over; 0.3 to each child aged under 14. Data from 2021. Data source INE <sup>1</sup> .	
<b>b) Income distribution P80/P20</b>	Census tract	Ratio between the 80th percentile and the 20th percentile of the income distribution per unit of consumption. Data from 2021. Data source INE <sup>1</sup> .	
<b>c) Gini index</b>	Census tract	The Gini index measures the degree of inequality in the distribution of income/wealth, used to estimate how far a country's wealth or income distribution deviates from an equal distribution <sup>2</sup> . A Gini coefficient of 0 reflects perfect equality, where all income or wealth values are the same, while a Gini coefficient of 1 (or 100%) reflects maximal inequality among values, a situation where a single individual has all the income while all others have none. Data from 2021. Data source INE <sup>1</sup> .	
<b>d) MEDEA deprivation index</b>	Census tract	A deprivation index developed to study the social inequalities in health in Spain. The index is composed by percentage of the population with manual labour, percentage of the population with casual labour, percentage of the population unemployed, percentage of the population with insufficient education, percentage of the population of young people with insufficient education <sup>3</sup> . Data from 2021.	

Abbreviations: A.C., Autonomous community; SES., Socioeconomic status

<sup>1</sup> INEbase. Atlas de Distribución de Renta de los Hogares (ADRH). INE. Retrieved 19 December 2023, from [https://www.ine.es/metodologia/metodologia\\_adrh.pdf](https://www.ine.es/metodologia/metodologia_adrh.pdf)

<sup>2</sup> Gini, Corrado (1936). "On the Measure of Concentration with Special Reference to Income and Statistics", Colorado College Publication, General Series No. 208, 73–79.

<sup>3</sup> Domínguez-Berjón, M. F., Borrell, C., Cano-Serral, G., Esnaola, S., Nolasco, A., Pasarín, M. I., Ramis, R., Saurina, C., & Escolar-Pujolar, A. (2008). Construcción de un índice de privación a partir de datos censales en grandes ciudades españolas: (Proyecto MEDEA). *Gaceta Sanitaria*, 22(3), 179–187.



**Table S4.** Variables collected through Population Health Surveys.

Population Health Survey Variables	Study areas			
	A.C. Basque Country	A.C. Andalusia	Barcelona city	Valencian Community
<b>OUTCOMES</b>				
<b>a) Perceived health</b>				
General Health	Ordinal 1-5	Ordinal 1-5	Ordinal 1-5	Ordinal 1-5
Mental Health	Ordinal 1-5 [MHI/5 items]	Ordinal 1-6 [SF-12/3 items]	Ordinal 1-4 [GHQ-12/12 items]	Ordinal 1-4 [GHQ-12 /12 items]
<b>b) Quality of life</b>				
Health-related quality of life	Ordinal 1-5 [EuroQoL / 5 items]	Ordinal 1-6/1-5 [SF-12 / 5 items]	Ordinal 1-5 [EuroQoL / 5 items]	Ordinal 1-5 [EuroQoL / 5 items]
<b>c) Sleep</b>				
Sleep duration	Continuous - Total hours/day	Continuous - Total hours/day	Continuous - Total hours/day	Continuous - Total hours/day
Quality of sleep	Ordinal 1-5 [SATD / 5 items]	Ordinal 1-4 [4 items]	Ordinal 1-10	Ordinal 1-5 [SATD / 5 items]
<b>d) Consumption of medication for common mental disorders<sup>1</sup></b>				
Antidepressants	yes/no – reference 2 days	yes/no – reference 2 weeks	yes/no - reference 2 days	yes/no - reference 2 weeks
Hypnotics	yes/no - reference 2 days	yes/no - reference 2 weeks	yes/no - reference 2 days	yes/no – reference 2 weeks
Anxiolytics	yes/no - reference 2 days	yes/no - reference 2 weeks	yes/no - reference 2 days	yes/no - reference 2 weeks
<b>e) Chronic mental health problems<sup>2</sup></b>				
Anxiety	yes/no - reference ever	yes/no – reference present	yes/no - reference ever	yes/no – reference ever
Depression	yes/no - reference ever	yes/no - reference present	yes/no - reference ever	yes/no - reference ever
Insomnia	yes/no - reference ever	-	-	yes/no - reference ever
Other	yes/no - reference ever	-	yes/no - reference ever	yes/no - reference ever
<b>COVARIATES</b>				
<b>a) Anthropometric variables</b>				
Age	Discrete	Discrete	Discrete	Discrete
Weight	Continuous	Continuous	Continuous	Continuous
Height	Continuous	Continuous	Continuous	Continuous
BMI	Continuous	Continuous	Continuous	Continuous
Biologic sex	Categorical - 3 conditions	Categorical - 2 conditions	Categorical - 2 conditions	Categorical - 2 conditions
Gender identity	Categorical - 3 conditions	-	Categorical - 3 conditions	-
<b>b) Individual socioeconomic variables</b>				
Education level	Categorical - 9 conditions	Categorical - 13 conditions	Categorical - 11 conditions	Categorical - 9 conditions
Occupational status	Categorical [CNO11]	Categorical [CNO11]	Categorical [CNO11]	Categorical [CNO11]
Household size	Discrete	Discrete	Discrete	Discrete

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Population Health Survey Variables	Study areas			
	A.C. Basque Country	A.C. Andalusia	Barcelona city	Valencian Community
Household income	Categorical - 11 conditions	-	-	Categorical - 8 conditions
Economic difficulty	Categorical - 6 conditions	Categorical - 6 conditions	Categorical - 6 conditions	Categorical - 6 conditions
Employment status	yes/no	yes/no	yes/no	yes/no
Country of birth	Categorical & Open	Categorical & Open	Categorical & Open	Categorical & Open
Marital status	Categorical - 6 conditions	Categorical - 5 conditions	Categorical - 5 conditions	Categorical - 5 conditions
<b>c) Lifestyle factors</b>				
Alcohol consumption	Categorical - 8 conditions	Categorical - 10 conditions	Categorical - 4 conditions	Categorical - 8 conditions
Passive smoking at home	Likert 1-5	yes/no	Discrete (Nº smokers)	yes/no
Daily tobacco consumption	yes/no	Categorical - 4 conditions	Categorical - 3 conditions	Categorical - 4 conditions
<b>e) Physical Health</b>				
Chronic health problems	Categorical - 38 conditions	Categorical - 25 conditions	Categorical - 25 conditions	Categorical - 21 conditions
<b>d) Mobility</b>				
Years at household	Discrete	-	Discrete	Discrete
<b>MEDIATORS</b>				
<b>a) Physical activity</b>				
Physical activity	Discrete - IPAQ	Discrete - IPAQ	Discrete - IPAQ	Discrete - IPAQ
- Vigorous	MET-min/week	MET-min/week	MET-min/week	MET-min/week
- Moderate	MET-min/week	MET-min/week	MET-min/week	MET-min/week
- Walking	MET-min/week	MET-min/week	MET-min/week	MET-min/week
- Sitting	Time spent (hours + minutes)	Time spent (hours + minutes)	Time spent (hours + minutes)	Time spent (hours + minutes)
<b>b) Social cohesion</b>				
Social support	Ordinal 1-5 [Duke / 11 items]	Ordinal 1-5 [Duke / 11 items]	Ordinal 1-5/1-4 [OSLO/ 3 items]	Ordinal 1-5 [Duke / 11 items]
Loneliness	Ordinal 1-4	Ordinal 1-4	Ordinal 1-4	Ordinal 1-4
<b>SUBJECTIVE URBAN ENVIRONMENTAL EXPOSURES</b>				
<b>a) Perception of the neighbourhood</b>				
Noise outside dwelling	Likert 1-3	Likert 1-3	Likert 1-5	Likert 1-3
Neighbourhood air pollution	Likert 1-3	Likert 1-3	-	Likert 1-3
Shortage of green spaces	Likert 1-3	Likert 1-3	-	Likert 1-3
Insecurity	Likert 1-3	Likert 1-3	Likert 1-5	Likert 1-3

<sup>1</sup> The subjects are provided with a list of medications and are asked if they have consumed any of them in the last 2 days or 2 weeks depending on the study area.

<sup>2</sup> Subjects are provided with a list of chronic health problems and are asked if they currently suffer or have ever suffered (depending on the study area) from any of them.

### A) Prevalence of common mental disorders in Spain.

A recent report published by the Spanish National Health System (2020), based on a representative sample of users of said system, found that the overall prevalence of mental health problems in Spain is 27.4%. The most common general mental health issues were anxiety, depression, and sleep disorders, with a prevalence of 6.7%, 4.1%, and 5.4%, respectively. Higher prevalence of these disorders was observed in the female population, those born in Spain and with increasing age. The same report notes that in the case of anxiety and depression, a clear social gradient is observed, with both disorders being 3.4 and 2.5 times more prevalent in the population with lower income levels. In the case medication prescriptions, anxiolytics, antidepressants, and hypnotics were prescribed at rates of 34% for women and 17% for males over 40. The 2020 European Health Survey revealed no discernible territorial differences in the prevalence of chronic mental health conditions among individuals aged 15 and older in Spain. However perceived health status showed slight regional disparities, with Valencia reporting the highest percentage of "bad or very bad" health at 9.4%, followed by Andalucía (7.4%), the Basque Country (7%), and Catalonia (4.9%). However, given that the results presented in this report pertain to a timeframe predating the onset of the COVID-19 pandemic, it is anticipated that the prevalence of these conditions has risen universally among all age groups and regions (Henares Montiel et al., 2020). This increase can be attributed to escalated stress and health-related concerns stemming from the pandemic, exacerbated by associated constraints like lockdown measures and the resultant impact on mental health care services during the pandemic (Balluerka et al., 2020).

Balluerka, N., Gómez, J., Hidalgo, M., Gorostiaga, A., Espada, P., Padilla, J., & Santed, M. (2020). LAS CONSECUENCIAS PSICOLÓGICAS DE LA COVID-19 Y EL CONFINAMIENTO INFORME DE INVESTIGACIÓN

Henares Montiel J, Ruiz-Pérez I, Sordo L. Salud mental en España y diferencias por sexo y por comunidades autónomas. *Gaceta Sanitaria*. 2020;34:114–9.

INEbase / Society /Health /European Survey of Health in Spain. INE. Retrieved December 2023. [https://www.ine.es/dyngs/INEbase/en/operacion.htm?c=Estadistica\\_C&cid=1254736176784&idp=1254735573175](https://www.ine.es/dyngs/INEbase/en/operacion.htm?c=Estadistica_C&cid=1254736176784&idp=1254735573175)

Sistema Nacional de Salud. (2020). Base de Datos Clínicos de Atención Primaria-BDCAP. <https://cpage.mpr.gob.es/>

## Section 4. DATA MANAGEMENT PLAN

### A) RESEARCH ACTIVITIES

#### Step 1. Population Health Surveys' (PHS) data curation and calibration

The selected individuals were contacted by a phone call, SMS, or letter to arrange an appointment for a face-to face interview for the purpose of the survey. The database produced with the interviews will be pseudonymised from that with the personal data for the contact by assigning a unique code for each participant and remains under the custody of the responsible body in each study area; the Basque Department of Health in the Basque Country, Escuela Andaluza de Salud Pública (EASP) in Andalusia, Agència de Salut Pública de Barcelona (ASPB) in Barcelona, and Conselleria de Salut Universal i Salut Pública (DGSP) in Valencian Community.

#### Step 2. Harmonisation

Initially, the databases of each study area will be cleaned, and the variables that require it will be harmonised. The vast majority of the variables to be used in the project have been collected identically in the Population Health Surveys of the study areas included. The variables to be harmonized are listed below and the measures used in each study area can be found in Table S2.

The variables that need harmonisation can be distinguished between simple or complex variables, depending on the level of difficulty and the manipulation of data that require the harmonisation of the respective variable:

- Simple variables: Chronic mental health problems, Educational level, Occupation status, Household income, Loneliness, Noise outside dwelling, and Insecurity.

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3 - Complex variables: mental health, health-related quality of life, sleep quality,  
4 consumption of medication for common mental disorders, alcohol consumption,  
5 passive smoking at home, tobacco consumption, physical health, and social support.  
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10 The Maelstrom Research Guidelines for the rigorous harmonisation of retrospective data  
11 (77) will be applied. Among the variables that need harmonisation, the majority can be easily re-  
12 categorised (simple variables). For instance, in the case of scales with different score ranges  
13 (e.g., Likert scale levels), standardised scores will be calculated, or other procedures will be  
14 followed to ensure comparability. The procedure to follow with variables measured with  
15 different scales will be more complex (complex variables). For these, the content of each  
16 variable will be studied to detect the common content (e.g., items) in each of the study areas.  
17 Once detected, aggregate scores will be calculated for the common items, and these scores will  
18 be used for statistical analyses. The remaining non-harmonizable variables will be assessed for  
19 their potential for performing separate statistical analysis for each study area.  
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### 33 Step 3. Georeferentiation

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37 The responsible bodies, in collaboration with regional Statistical Institutes or Population  
38 Registers, will link the health survey data to the geographical coordinates of each respondent's  
39 home address. The geographical coordinates will also be pseudonymised and sent this way to  
40 the research group specialised in Geographic Information System (GIS) estimations that will  
41 calculate UrbEE. In order to further ensure the protection of the personal data of the survey  
42 participants and enhance their anonymity, fictional coordinates will be created in a number five  
43 times the number of participants selected for the study in each study area and sent to the  
44 research group specialised in GIS estimations together with the real coordinates.  
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### 55 Step 4. GIS estimation of Urban Environmental Exposures (UrbEE)

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3 A company specialised in GIS estimations will calculate the objective urban  
4 environmental exposures (UrbEE) of all the geocodes, including the participants' coordinates  
5 and the fictional coordinates by GIS.  
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#### 10 Step 5. Selection and linkage of data

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14 After the estimations are finalised, the responsible bodies of the surveys in each study  
15 area will re-select the geocodes of the participants and add the new urban environmental  
16 variables to the database with the PHS data. The researchers will be provided with the resultant  
17 database of each study area composed by the PHS data and the UrbEE (without geocodes and  
18 personal data of the participants). This guarantees that the data supplied are protected by  
19 statistical secrecy, not misused and treated anonymously and globally at all times.  
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#### 28 Step 6. Pooling

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31 Finally, the final databases of all the study areas will be pooled, creating the final pooled  
32 database to be used in the planned analyses.  
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### 36 37 B) DATA STORAGE AND PROCESSING

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40 Data will be kept at all times on servers located in the responsible centre of this project. This  
41 way, data will be stored on the University of the Basque Country UPV/EHU's own servers,  
42 complying with the greater security and privacy requirements of the LOPD as the data is not sent  
43 to external servers. The entire process of recording, dumping and storage of the data will be  
44 anonymised, with the data collected being exclusively linked to a sample unit code. Access to  
45 the anonymised microdata will be limited to technicians from the responsible centres of each  
46 study area through profiles with regulated permissions that allow for supervising and controlling  
47 access to the information. Supervision of the data management will be assigned to the principal  
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3 investigators with expert advice, and to the data protection officer of the centre responsible for  
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5 the project.  
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#### 8 C) ETHICAL CONSIDERATIONS AND ACCOUNTABILITY 9

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11 The study was approved by the regional Research Ethics Committee of the **Basque Country**,  
12 ETHICS COMMITTEE FOR RESEARCH INVOLVING MEDICINAL PRODUCTS IN THE BASQUE  
13 COUNTRY (CEIm-E) (protocol code PI2022138, dated 9th November 2022); **Andalusia**,  
14 BIOMEDICAL RESEARCH ETHICS COMMITTEE OF THE PROVINCE OF GRANADA (CEI/CEIM  
15 GRANADA) (protocol code 2078-N-22, dated 27th December 2022); **Barcelona**, PARC DE SALUT  
16 MAR CLINICAL RESEARCH ETHICS COMMITTEE (CEIm) (protocol code 2022/10667, dated 2nd  
17 December 2022); **Valencian Community**, ETHICS COMMITTEE FOR CLINICAL RESEARCH OF THE  
18 DIRECTORATE GENERAL OF PUBLIC HEALTH AND CENTER FOR ADVANCED RESEARCH IN PUBLIC  
19 HEALTH (CEIC DGSP / CSISP) (protocol code 20221125/04, dated 25th November 2022).  
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33 This study is based on secondary data obtained from four independent Population  
34 Health Surveys (PHS) from Spain. Since the present study does not involve the activity of data  
35 collection, to obtain the informed consent from the subjects is not applicable for this study.  
36  
37 However, the PHS included this project are official statistical operations included in the  
38  
39 respective Statistical Plans of each study area. This ensures that the data provided is protected  
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41 by statistical confidentiality, it is not misused, its treatment is anonymous and global at all times,  
42  
43 and that indirect identification is impossible. Data are collected and processed in accordance  
44  
45 with the provisions of the General Data Protection Regulation (GDPR) and in accordance with  
46  
47 the provisions of Article 5 of the Organic Law 3/2018 of 5 December on the Protection of  
48  
49 Personal Data and the guarantee of digital rights (Regulation (EU) 2016/679), they will be treated  
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51 confidentially, with access to them being granted to personnel who strictly need to process them  
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53 in the framework of the study.  
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3 Furthermore, the transfer of data occurs between organisations within the Public Health  
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5 System of each region and the regional or local government itself. This is done in the context of  
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7 a research project conducted exclusively in the public sphere and with the legitimacy of the use  
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9 of administrative records as research infrastructures in accordance with the General Health Act,  
10  
11 the Biomedical Research Act and the General Law on Public Health. The results of the study will  
12  
13 provide information at a sufficiently aggregated territorial level to prevent indirect  
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15 identification. Furthermore, the project's results will be beneficial to the general population in  
16  
17 a holistic way, thanks to its socioeconomic and environmental context, and its evolution over  
18  
19 several years from the onset of the COVID-19 pandemic. Therefore, the risk to the privacy of the  
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21 study population is minimal compared to the potential benefits the results will bring.  
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Peer review only