



Horizon 2020

Societal Challenge: Improving the air quality and reducing the carbon footprint of European cities



Project: 690105 – ICARUS

Full project title:

Integrated Climate forcing and Air pollution Reduction in Urban Systems

Milestone 6: Agreement on method for accounting for SES

WP4: Population exposure and health impact assessment

Lead beneficiary: UNIBRIS



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1 Introduction

1.1 Rationale

The EU Horizon 2020 project ICARUS WP4 will include the following:

- Monitoring of air pollution and greenhouse gases via satellite, airborne and personal remote sensing in nine varied European cities
- Agent-based modelling (ABM) used to
 - understand generation of and exposure to air pollution for all sociodemographic groups
 - forecast efficacy of potential air pollution and greenhouse gas reduction policies
- Outcomes:
 - a cloud-based solution developed to (1) provide information about citizens' own behavior and exposure (2) inform citizens of environmentally-conscious alternative behaviours that may have a positive impact on air quality and carbon footprint and on their health and (3) motivate them to adopt alternative behaviours
 - a web-based guidebook detailing transition pathways to transform cities towards a close to zero or negative carbon footprint at the same time as maximising wellbeing within the next 50 years.

In its design ICARUS explicitly recognizes that for the creation of successful transition pathways an understanding of *socioeconomic status* (SES) is required and measures to compensate for SES differences must be an integral component.

There is no single definition of SES¹ but it can be said to embody an array of social and economic resources: material capital such as money and goods, human capital such as skills, knowledge, prestige or power, and social capital - beneficial social connections.²⁻⁵ These resources can be deployed in order to protect and promote health. Disease, disability and premature death are higher for lower socioeconomic groups, two or three times higher in the EU.⁶

Here it is important to discuss the relationship between demographic characteristics and SES. Demographic characteristics include *age* (the length of time a person has lived or a particular stage in life⁷), *gender* (including (1) biological gender (or sex) which includes external genitalia, sex chromosomes, gonads, sex hormones, and internal reproductive structures⁸ and (2) the socially constructed characteristics of women and men – such as norms, roles and relationships of and between groups of women and men⁹) *ethnicity* (common ancestry and elements of culture, identity, religion, language and physical appearance¹⁰, *religion* (a particular system of belief and worship of a superhuman power¹¹), *marital status* (whether a person has, or has had, an intimate and or legal relationship with (generally) one other person; for example whether a person has never been married, or is married, widowed and not remarried, divorced and not remarried, married but legally separated or in a de facto union¹²) *disability* (A physical or mental condition that limits a person's movements, senses, or activities¹³,) and number of people in a person's *household* (a household is one person living alone, or a group of people (not necessarily related) living at the same address who share cooking facilities and share a living room, sitting room or dining area¹⁴). These factors we would not include as SES per se but certain permutations of these factors increase vulnerability to low SES.



Examples of how these demographic characteristics may increase vulnerability to low SES follow: income is highest in middle age although satisfaction with income continues to grow into older age.¹⁵ communities although there can be wide SES differences within some ethnic groups¹⁶⁻¹⁸. Women are overrepresented among those in poverty and women in the same occupations and with the same education level as men earn less money.¹⁹ Some ethnic groups tend to have higher socioeconomic status whereas others tend to have lower SES and these differences can be widened by ethnic groups' tendency to live in segregated areas. Muslims, particularly if wearing head scarves, have been discriminated against when applying for jobs in Europe.²⁰ Economic insecurity is related to higher levels of religiosity as it may be a protective factor for the poorest people when welfare is less available.²¹ Living alone (particularly compared to living with a partner) and overcrowding are associated with lower socioeconomic status.^{22 23} Higher levels of disability are found among low socioeconomic status groups globally.²⁴

1.2 How does socioeconomic status impact health?

Previously²⁵ we have described pathways between SES and health identified in the academic literature. The literature would suggest that a study seeking to account for SES differences in health should include the external exposome (environmental) differences detailed in table 1.1 and the genome differences detailed in table 1.2. An important factor that does not really fit in either of these tables is age. Life course models suggest that SES differences in health can start in utero and occur throughout our lives.

Table 1.1 Exposome pathways between SES and health²⁶

| Pathway | Subcategories/description |
|-------------------------------|--|
| <i>Health behaviour</i> | |
| Health service use | Vaccinations, dental, screening |
| Obesity/diet | BMI related/nutrition, diet related contaminants |
| Physical activities | Leisure, occupational, for transport |
| Smoking | |
| Other | Sunbed use, alcohol, sleep |
| <i>Supportive environment</i> | |
| Parenting | Skill acquisition, children at risk |
| Relationships | Social network/support |
| Government provision | Access to health services, education for disadvantage groups |
| Stigma | Due to age, gender, ethnicity, disability etc |
| <i>Physical environment</i> | |



| | |
|--|--|
| Exposure to socially stress producing situations | Violence, residential mobility, family turmoil and conflict, lack of routine |
| Housing conditions | Damp, temperature, building materials, ventilation, infestations, hygiene, food preparation facilities |
| Neighbourhood conditions | Abandoned lots, graffiti, noise, advertisements, design, traffic |
| Access | Municipal services, places for physical exercise, purchasing points for healthy food and unhealthy substances e.g. tobacco alcohol |
| Exposure to chemicals | Toxins and hazardous wastes, ambient pollutants, lead, tobacco smoke |
| Exposure to nature | Recreation and food growing opportunities |

Table 1.2 Differences created by the genome that may explain associations between SES and health²⁵

| Pathway | Subcategories/description |
|--------------------------|-----------------------------------|
| <i>Tangible</i> | |
| Demographic [#] | sex |
| Physical differences* | height, potential for poor health |
| <i>Worldview</i> | |
| Psychological* | personality |
| Cognitive* | IQ |

[#]Race is not included here because current research suggests that genetic susceptibility is a minor predictor of poor health and is not strongly patterned by race ²⁷

*In addition to their genetic component these are also impacted by the exposome

1.3 How does socioeconomic status impact exposure to air pollution?

Tables 1.1 and 1.2 indicated the complexity of the relationship between SES and health. ICARUS is focussing on differences stemming from exposure to air pollution. Systematic reviews undertaken for ICARUS Deliverable 1.4 (A critical review on the influence of socioeconomic status in relation to exposure to air contaminants and disease causation)²⁸ concluded that citizens with low socioeconomic status are generally more likely to be exposed to higher levels of air pollution despite lower levels of travel and in particular polluting car use in these groups. Low SES groups are also more highly exposed to tobacco smoke (from active and passive smoking) and mould spores from damp housing.



Conversely such citizens are less likely to take up new technologies which may be invented in order to reduce exposure to air pollution. ICARUS is developing new wearable technologies in order to understand citizens' exposure to air pollution and enhance health and wellbeing. The conclusions of Deliverable 1.4 suggests that low SES citizens will need special encouragement if they are to participate in the project and use the wearables developed by ICARUS.²⁸

1.4 How should SES be measured?

Previously²⁵ we have identified common measures of SES and their strengths and weaknesses. Just as there is no single definition of SES there is no single measure.¹ When considering a measure it is important to think about the level of the measure: person, household or area. A respondent might rely on resources from other household members but might not know details about those resources when asked. Relying on area level measurements reduces individual respondent burden but an inhabitant might not be typical of local people.

The traditional measures of SES are education, income and occupation (social class).²⁶ Other commonly used and available measures include employment status, neighbourhood deprivation, lone parents, housing tenure and car access.^{29,30} Each of these measures has advantages and disadvantages (see table 1.3). When choosing a measure it is important to take confounding factors into account. For example lone parents are more likely to be women and older people are less likely to be lone parents, more likely to have paid off a mortgage and are more likely to be retired than having a current occupation. There have been different measures of SES proposed for children and young people as many usual measures may not apply.³¹ Numbers are also an issue. Small numbers of unemployed people or single parents for example may reduce the chances of finding a significant result whereas most people can be categorised by housing tenure or neighbourhood deprivation.³² However it is necessary to consider to which it is useful to explore extreme levels of poverty within a sample – for example being unemployed may reflect more severe disadvantage compared to living in rented accommodation. Sometimes composite measures of disadvantage may be useful to consider the poverty gradient³³ in which more and less extreme disadvantage can be monitored.²⁹ Another advantage of a composite measure over the inclusion of many single SES measures is that it reduced the risk of multi-collinearity given that all these indicators are intended to measure the same underlying construct. Methods of combining measures include factor analysis or weighting different indicators or using a count of the number of indicators of high or low SES.²⁹

. Table 1.3 Some common SES measures³¹

| Measure | Advantages | Disadvantages |
|-----------|--|--|
| Education | All children have the potential to be educated | <ul style="list-style-type: none"> • Education systems change over time • It may be difficult to match foreign and local qualifications • It may be difficult to conduct cross country comparisons • Younger people may not have finished their education |
| Income | Intuitively what we think of when thinking about economic position | <ul style="list-style-type: none"> • People may be unwilling to state their income • Utility of income depends on the number of people it needs to support • People may not be aware of other people's income in their household • People's income may vary and be difficult to estimate |



| | | |
|---------------------------|--|---|
| Occupation | Traditional measure of SES particularly in the UK | <ul style="list-style-type: none"> • An accurate measure of social class requires time consuming coding of an array of information (e.g. job title, size of organisation, number of employees, skill) using an official coding scheme • Many people may not have an occupation e.g. students, retired • Some suggestion that traditional class boundaries are breaking down with the demise of heavy industry leading to weaker relationships with health³⁴ |
| Economic status | All adults can be coded (overcomes disadvantage of occupational codes) | <ul style="list-style-type: none"> • Working or not working is not particularly helpful as high SES groups are more likely to become students and retirees may have a high income, housewives/husbands may have a high income partner • Distinguishing unemployed people may lead to small numbers • People not working for health reasons may lead to confounding |
| Neighbourhood deprivation | Allows people to be classified without gaining personal information | <ul style="list-style-type: none"> • Only provides information about the average for an area- a person could be rich in a poor area and vice versa • Information about areas necessary • Data at small area resolution is preferable but may not be available |
| Lone parents | Often in extreme disadvantage | <ul style="list-style-type: none"> • May have small numbers • Age and often gender dependent • Extent of disadvantage may depend on local culture |
| Housing tenure | Numbers without a home usually negligible | <ul style="list-style-type: none"> • May miss young people living with their parents who may class themselves as 'other' rather than parental tenure • age dependent • Utility depends on the national housing tenure profile and legal framework |
| Car access | Easy to ask about and measure | <ul style="list-style-type: none"> • Congestion and public transport availability mean this is increasingly a poor measure of SES in cities • Some people may forego a car for environmental reasons |

Within ICARUS, we understand that SES is intimately connected to demographic characteristics which increase vulnerability to low SES. Thus we will measure differential exposures in vulnerable populations as a result of age, gender, (dis)ability, ethnicity, and religion, in addition to the traditional measures of SES.

1.5 Summary

ICARUS' ultimate objective is for environment-friendly cities where all citizens are healthy. Citizens of lower SES usually encounter higher exposure levels to air pollution. ICARUS needs to understand more about these differences in order to address them. Towards this aim, several data has to be collected regarding population groups of different SES.



2 Summary of research on ensuring low SES representation

Chiefly we present here the findings of a systematic review³⁵ conducted on the recruitment of socioeconomically disadvantaged groups given that they tend to be underrepresented in research studies and even when recruited have higher drop out rates³⁶. The systematic review³⁵ included 116 papers from 115 studies and 31 reviews and examined barriers to representation and how recruitment can be improved.

The following sampling strategies to improve recruitment and retention were identified:

- Oversampling:³⁵ more respondents are sampled from low income areas than other areas.
- Snowball sampling:³⁵ each respondent is asked to identify further potential respondents
- Community group sampling:³⁵ respondents who attend a particular venue (e.g. welfare centre, nursery in a low SES area or supermarket) or who are members of an organization are sampled. This may require first recruiting gatekeepers – officials or leaders of the organization. This may involve bureaucratic procedures so time must be allowed for this.³⁷
- Peer or known recruiters³⁵ to get round fear of authority and lack of trust. Recruiters from outside the research team must be kept motivated to recruit to the research study for example with reminder phone calls, incentives, prizes for high recruitment etc.³⁷
- Media campaigns³⁵ using simple language, that include media used by disadvantaged groups e.g. text messages, are translated to languages used by disadvantaged groups and are culturally appropriate
- Multiple contact attempts (>6)³⁵ at different times of day³⁷.
- Incentives e.g. vouchers or money³⁵
- Free phone lines, assistance with transport and childcare³⁵
- Keep questionnaires short and use simple everyday language.³⁵ Pilot questionnaires with low SES respondents.
- Being clear what the advantages of being in the study are for the participant and their community and making such advantages tangible.³⁵

Anything other than a simple random sample will have implications for statistical analysis but this may still be preferable to missing out low SES participants altogether.

ICARUS has a big advantage with the final point, benefits for the participant, given that the development of wearables to reduce participants' air pollution exposure are integral to the project.

3 Accounting for SES in ABM modelling

It is important to understand how the dynamic processes between sub-groups and their environment influence behaviours and thus potentially exposure. Differences in exposure profiles between people can be explained by time-activity patterns of individuals, as well as the environments they spend their time.³⁸ In fact, even people living in the same neighbourhood can experience different exposure profiles because of different activities undertaken and different locations visited.³⁹

Using an Agent Based Model (ABM) we are able to overcome some fundamental issues in traditional approaches, such as people remaining in one location, and investigate the dynamic processes that shape people's movements and exposure profiles. ABMs have been used to investigate topics such as the transmission of infectious disease,⁴⁰ transportation,^{41 42} and diet,⁴³ however ABMs are a novel approach within air pollution exposure estimation.

ABM is a new computer modelling paradigm that allows autonomous and interacting agents situated in space and time to be simulated.^{44 45} 'Agents' (or people), can be assigned behaviours and certain characteristics (such as SES, ethnicity, gender and age). Agents can interact with each other; interact with the environment; make decisions; learn from past events; and lead to change in behaviour and lifestyles. We can thus model how different groups in society navigate their daily lives in urban areas, and use this to inform our exposure profiles. The significant advantage of using ABM over standard surveys methods are time and cost savings – costly and sometimes intrusive tracking of individuals is not needed. A limitation of the ABM approach is the outputs are only as good as the rules we use to describe human behaviour.

In order to create city case studies for ICARUS and establish the best rules for the ABM each of the cities were asked to collate the a range of data including population census data including SES variables, geospatial data, and time activity patterns (Table 3.1).

Table 3.1 Data collated for ABM modelling

| Data type | Specific variables | Possible sources |
|-------------------------------|---|--|
| Population and SES | Age | Census |
| | Gender | |
| | Occupation | |
| | Employment type (FT, PT...) | |
| | Educational level | |
| | Car ownership | |
| | Ethnicity | |
| | Religion | |
| Existing studies | Existing personal monitoring studies | |
| Geospatial | Road network incl. information such as road capacity and number of lanes | OpenStreetMap |
| | Buildings inc. 'type' | |
| | Land-use/cover | |
| | Boundaries of administrative regions (or postal code regions) for which SES data is available | Mapzen |
| Time activity patterns | Information on population movements/behaviours | Country specific through the statistics office |



| | | |
|--|--|---|
| | | MTUS (www.timeuse.org/mtus) HETUS |
|--|--|---|

Individual agents (people) are assigned a number of sociodemographic attributes from the population data. This information will be used to form a number of sub-groups who behave in different ways depending on their SES attributes. Based on the sociodemographic attributes, and of course based on the distance between point of departure and their targeted destination, human agents will choose different means of transportation. In the same way, different human agents will follow a different sequence and types of activities. For example, children and adults are programmed to move from a household to an assigned school or office whereas human agents that belong to the elderly will follow a different sequence of activities. To create these behavioural rules for each sub-group, time activity pattern data derived from MTUS or HETUS will be used to establish the amount of time sub-groups spend in specific micro-environments and the activities they do within them. In some instances, cities will have access to existing studies that can be used for this information or to supplement the population and time activity pattern data.



4 Accounting for SES in Primary data collection

4.1 Fixed monitors

Most cities are going to collect air pollution data from fixed monitors. In the case of data gaps regarding air pollution data from fixed monitors, spatial distribution data will be generated with the data fusion methods described in Task 3.1.

Population census data and municipal data will be used to ensure that the SES of the location of each monitor is known and where possible they are located in areas with contrasting SES profiles.

For cities where there are SES differences between areas, cities will consider whether these can be explained by sources of pollution such as busy roads and industries or by topographical features. Note that this will not be the case for Ljubljana as areas are not differentiated by SES. This may lead city planners to plan future housing developments to be more equitable in future or for some polluting industries to be closed down to prevent environmental injustices.^{46 47}

4.2 Personal wearables

4.2.1 Sample size

To decide the sample size needed for recruitment of people to wear personal monitors and have fixed monitors in their homes, the following steps will be undertaken. Suggestions for answers have been provided in italics.

1) What is the most important research question of the primary data collection?

e.g. do high SES residents in my city have lower exposure to air pollution than low SES residents

2) What is your main predictor and main outcome?

e.g. SES and air pollution

3) What is your main measure of your predictor and your main measure of your outcome?

e.g. SES operationalised primarily as area level education measured by quintiles of level of education of area residents (% population has no educational qualifications in each district) (lowest vs higher quintiles) and air pollution with our central measure of NO2 measured by annual exposure to NO2

3) Find studies that have previously that has previously looked at your SES measure. Use our previous systematic reviews of SES and air pollution ²⁵ (appendix tables A2.1.4 to A2.1.7) ²⁸ (table 2.2) If there are no relevant studies perhaps go back and change the main measures.

e.g. citizens in manual occupation vs citizens in non manual occupations and daily exposure to PM10

4) Identify the relevant effect size for the main measures of variables in the research question



e.g. OR=1.28

5) If necessary convert effect size into one suitable for power calculation ⁴⁸ (e.g. using the following web pages <https://www.campbellcollaboration.org/escalc/html/EffectSizeCalculator-Home.php>)

e.g. d= 1.09

6) Undertake power calculations to find the sample size required ^{49 50}. Again there are online calculators (e.g. <https://www.stat.ubc.ca/~rollin/stats/ssize/>)

4.2.2 Sampling frame

Cities are going to sample from a variety of sampling frames. Some cities (for example Athens and Thessaloniki) are going to recruit from children's nurseries and information days. Brno is going to recruit from existing (ELSPAC) and a new cohort studies which they run in conjunction with local hospitals. Participation will be higher from high SES groups as expected for cohort studies but there will be participation from low SES groups. Ljubljana are going to recruit by random sampling of several city areas. They expect 50% participants to be of average income from previous studies.

4.2.3 Encouraging low SES citizens to participate

The cities are going to consider taking the following methods to achieve required numbers of low SES participants:

- Incentives e.g. vouchers or money. Ljubljana and Brno are going to offer incentives to participants
- Media campaigns using simple language, that include media used by disadvantaged groups e.g. text messages, are translated to languages used by disadvantaged groups and are culturally appropriate: Athens and Thessaloniki are going to advertise for participants on online sites, social networks, local magazines and via word-of-mouth
- Recruiting from venues attended by low SES groups (e.g. welfare centre, nursery in a low SES area or supermarket, employers of low SES staff)
- Recruit local people to help recruit low SES people

4.2.4 Prevention of drop out of low SES participants

The cities are going to consider the following to keep low SES participants in the study:

- Multiple contact attempts (>6) at different times of day
 - Keep questionnaires short and use simple everyday language.
 - Translate questionnaire if low SES respondents speak different languages
 - Pilot questionnaires with low SES respondents.
-



- Free phone lines, assistance with transport and childcare (if helpful)

4.2.5 Collection of SES data from participants.

The cities are going to collect data via interviews, questionnaires, official data and data about the participants already collected for other studies (e.g. Brno's cohort participants).

The following SES variables will be collected:

SES variables:

- education
- occupation
- housing tenure
- housing type (house/apartment)
- car access

Household income and personal income are also going to be collected by some cities

Vulnerable populations variables:

- gender
- age
- ethnicity

If SES data is collected via an interview standard question formats from the European Social Survey will be used

http://www.europeansocialsurvey.org/docs/round8/questionnaire/ESS8_source_questionnaire.pdf

If SES data is collected via a self-complete questionnaire, questions from a typical questionnaire for assessing SES related information can be used (see appendix).

4.2.6 Collection of data which may explain SES differences from participants

Our previous literature reviews have suggested many reasons why there are SES differences in health. To explain social and cultural differences in SES, ICARUS cities will consider collecting data on the following topics. Note "(ap)" suggests a topic should be included because previous literature suggests it may explain higher exposure to air pollution among low SES groups whereas "(hw)" suggests a topic should be included because it may explain the health and wellbeing deficit among low SES groups

- 1) Observational data
-



- a. Graffiti and vandalism near dwelling (hw)
- b. Type of dwelling (house, flat) (ap, hw)
- c. Damp/mould patches in house (ap, hw)
- d. General state of repair (hw)
- e. Access to outside space (private/shared) (hw)
- f. Cleaning materials in the home (write down ingredients) (ap)
- g. Facilities for preparing healthy food (hw)
- h. Interactions between children and adults

2) Interview/questionnaire data

- a. Cigarette, shisha or e-cigarette use by household members and visitors (ap,hw)
- b. Technology in the home (PC, tablet, smartphones etc) and how often uses apps
- c. Number of close friends (how met friends and occupations of friends) (hw)
- d. Number of neighbours with whom exchange favours (hw)
- e. Health services use: (hw)
 - i. Vaccinations up to date
 - ii. Attended screening
 - iii. Dental check ups
- f. Type of heating (hw)
- g. Type of ventilation (ap)
- h. Long term illnesses and disabilities (hw)
- i. Ever experienced any stigma for reasons of income, ethnicity, disability (hw)
- j. Exposure to stress (daily and lifetime adverse events)
- k. Residential mobility
- l. Whether they have trouble making ends meet
- m. Cognitive ability: Short term vs long term thinking
- n. Whether any problems with local neighbourhood

3) Time activity diary

- a. Time spent indoors and outdoors (ap)
 - b. Transport in the past week (ap)
-



- i. Modes of transport
 - ii. Routes
 - iii. Length of journey
 - iv. Reliability of transport
 - v. Trip chaining (multiple places visited: e.g. school, shop, work)
 - c. Holidays in the past year (aphw)
 - i. Transport mode
 - ii. Location
 - iii. Length of stay
 - d. Occupation (ap)
 - i. Use of chemicals
 - ii. Physical activity
 - iii. Any travel for work (typical week and year – locations)
 - iv. Shift patterns
 - v. How did they end up in their current/most recent job (hw)
 - e. Activities attended in past year
 - i. Cultural: theatre, cinema, concerts (pop, classical), restaurants, cafes, libraries, discos and night clubs(hw)
 - ii. Sports: participated, spectator (indoor and outdoor) (aphw)
 - iii. Outside activities: gardening, sunbathing, time spent in nature (foraging, hiking, biking, skiing etc.) (aphw)
 - iv. Children's activities: mother and baby groups, soft play, dance and music, sport, theme park, cost of activities (hw)
 - v. Religious activities: church services, meetings (hw)
 - vi. Voluntary work: political parties , trade unions, caring, etc (hw)
 - f. Activities undertaken in the past week:
 - i. Indoor leisure: social media (favourite apps and sites), TV (favourite channels & programs), radio (favourite channels), reading books (favourite genres), newspapers (usual paper – online or offline) (hw)
 - ii. Other crafts and hobbies (ask about use of air pollutants) (aphw)
 - iii. Time spent with friends and family members living in other households (hw)
-



- g. Domestic duties over the past week (ap)
 - i. Cooking
 - ii. Cleaning
 - iii. Playing with children
- h. Food consumption over the past week (hw)
 - i. Portion size
 - ii. Food groups
 - iii. Nutrients
 - iv. Contaminants
 - v. Alcohol
- i. Sleep (aphw)

4) GIS data

- a. Ease of getting to (walking, public transport, car) (hw)
 - i. Green or blue space (any and good quality)
 - ii. Social and cultural activities
 - iii. Tobacco, alcohol, sunbeds and fast food stores

If GIS data is unavailable on these topics cities can consider collecting it themselves via existing or developing apps.⁵¹

- b. Prevalence (hw)
 - i. Crime levels
 - ii. Unemployment levels
 - iii. Ethnic profile

5) Official data

- a. Government (national and local)spending e.g. (hw)
 - i. Schools and education
 - ii. Welfare safety net
 - iii. Cultural activities
 - iv. Community cohesion
 - v. Social services & domestic violence
 - vi. Gini coefficient locally and nationally and other measures of equality
-



- b. Any information available about study participants that researchers are allowed access to e.g. medical records

Thus in order to explain SES differences in air pollution and in health and wellbeing, cities will consider collecting extra data from observations of participants' dwelling conditions, interviews and questionnaires, time activity diaries, GIS data and other official records.





5 Summary

To meet this milestone we have described how ICARUS will include SES in ABM modelling, measure the SES of areas in which fixed air pollution monitors are located, measure SES of participants in the wearable study and other data that can be collected from these participants which may explain any SES differences found. Changing factors which cause SES differences will be important in building cities of the future with optimum health and wellbeing for all citizens.



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7 Appendix: Example of questions to collect SES data via a typical self-complete questionnaire

Notes:

Suggested variable names are bracketed in red font

A. HOUSEHOLD QUESTIONS

A1. Please tell us about everybody in your household? [If age not known, please give best estimate] The main earner is the household member who usually earns the most money (Hh1ppl)

| Relationship to you e.g. daughter/husband/partner/lodger/parent | Female | Male | Age | Main earner | Study child |
|--|-----------------------------|-----------------------------|---|--------------------------|--------------------------|
|  Myself | <input type="checkbox"/> _2 | <input type="checkbox"/> _1 |  | <input type="checkbox"/> | <input type="checkbox"/> |
| | <input type="checkbox"/> _2 | <input type="checkbox"/> _1 | | <input type="checkbox"/> | <input type="checkbox"/> |
| | <input type="checkbox"/> _2 | <input type="checkbox"/> _1 | | <input type="checkbox"/> | <input type="checkbox"/> |
| | <input type="checkbox"/> _2 | <input type="checkbox"/> _1 | | <input type="checkbox"/> | <input type="checkbox"/> |
| | <input type="checkbox"/> _2 | <input type="checkbox"/> _1 | | <input type="checkbox"/> | <input type="checkbox"/> |
| | <input type="checkbox"/> _2 | <input type="checkbox"/> _1 | | <input type="checkbox"/> | <input type="checkbox"/> |
| | <input type="checkbox"/> _2 | <input type="checkbox"/> _1 | | <input type="checkbox"/> | <input type="checkbox"/> |
| | <input type="checkbox"/> _2 | <input type="checkbox"/> _1 | | <input type="checkbox"/> | <input type="checkbox"/> |
| | <input type="checkbox"/> _2 | <input type="checkbox"/> _1 | | <input type="checkbox"/> | <input type="checkbox"/> |
| | <input type="checkbox"/> _2 | <input type="checkbox"/> _1 | | <input type="checkbox"/> | <input type="checkbox"/> |
| | <input type="checkbox"/> _2 | <input type="checkbox"/> _1 | | <input type="checkbox"/> | <input type="checkbox"/> |

A2. Do you have any children who do not currently live in your household? (Hh2nliv)

No _2

Yes _1

Please give ages :

 

A3a. Please indicate your legal marital status: (Hh3stas)

Married _1

Civil partnership _2

Single _3

Separated _4

Divorced _5

Widowed _6

A3b. If you ARE living with a spouse or partner in what year did you start living together? (Hh4livt)

 

A4a. Does your household include: (Hh5inc)

both your child's parents _1

one of your child's parents (yourself) _2



A4b. IF you are NOT living with the child's other parent on average how often does your child usually spend time with him/her? (Hh6time)

- | | | | |
|---|----------------------------|----------------------------|----------------------------|
| 5 to 7 nights a week | <input type="checkbox"/> 5 | less than once a fortnight | <input type="checkbox"/> 2 |
| 3 to 4 nights a week | <input type="checkbox"/> 4 | does not see other parent | <input type="checkbox"/> 1 |
| 1 to 2 nights a week or 1 night per fortnight | <input type="checkbox"/> 3 | | |

A5. Does your child's other parent support your child financially nowadays? (Hh7fin)

- Regularly 1 Sometimes 2 Never 3

B. FAMILY BACKGROUND

B1. Please tell us about the ethnicity of yourself and your child's other parent (even if not living with you) (Fb1eth)

| a) Ethnic group | b) Religion | | c) Place of birth | | | | |
|---|-----------------------------|-----------------------------|-------------------|---|-------------------------------|-----------------------------|-----------------------------|
| | You | Other parent | You | Other parent | | | |
| White (Scottish/British) | <input type="checkbox"/> 1a | <input type="checkbox"/> 1b | No religion | <input type="checkbox"/> 1a <input type="checkbox"/> 1b | Scotland | <input type="checkbox"/> 1a | <input type="checkbox"/> 1b |
| White (other) (<i>write in below</i>) | <input type="checkbox"/> 2a | <input type="checkbox"/> 2b | Buddhism | <input type="checkbox"/> 2a <input type="checkbox"/> 2b | Rest of UK | <input type="checkbox"/> 2a | <input type="checkbox"/> 2b |
| Mixed (<i>write in below</i>) | <input type="checkbox"/> 3a | <input type="checkbox"/> 3b | Christian | <input type="checkbox"/> 3a <input type="checkbox"/> 3b | Republic of Ireland | <input type="checkbox"/> 3a | <input type="checkbox"/> 3b |
| Arab | <input type="checkbox"/> 4a | <input type="checkbox"/> 4b | Hinduism | <input type="checkbox"/> 4a <input type="checkbox"/> 4b | Poland | <input type="checkbox"/> 4a | <input type="checkbox"/> 4b |
| Asian (Pakistani, Indian, Bangladeshi) | <input type="checkbox"/> 5a | <input type="checkbox"/> 5b | Jewish | <input type="checkbox"/> 5a <input type="checkbox"/> 5b | India | <input type="checkbox"/> 5a | <input type="checkbox"/> 5b |
| Asian (Chinese, Japanese, Korean) | <input type="checkbox"/> 6a | <input type="checkbox"/> 6b | Muslim | <input type="checkbox"/> 6a <input type="checkbox"/> 6b | Pakistan | <input type="checkbox"/> 6a | <input type="checkbox"/> 6b |
| Asian (other) (<i>write in below</i>) | <input type="checkbox"/> 7a | <input type="checkbox"/> 7b | Sikh | <input type="checkbox"/> 7a <input type="checkbox"/> 7b | Germany | <input type="checkbox"/> 7a | <input type="checkbox"/> 7b |
| Black (African, Caribbean etc) | <input type="checkbox"/> 8a | <input type="checkbox"/> 8b | Other | <input type="checkbox"/> 8a <input type="checkbox"/> 8a | <i>Other (write in below)</i> | <input type="checkbox"/> 8b | <input type="checkbox"/> 8b |
| Other (<i>write in below</i>) | <input type="checkbox"/> 9a | <input type="checkbox"/> 9b | | | | | |

| | | |
|---|---|---|
|  |  |  |
|---|---|---|



B2. Does your household have a car/van for private use? (Fb2car)

- Yes (bought new within the last 6 months) 1 Yes (but not bought new within the last 6 months) 2
 No - cannot afford a car 3 No - other reason 4

B2a. If your household has one or more cars how often do the following people travel in it/them, in hours per day: (Fb3crhr)

| | Weekday | Weekend day |
|------------------------------|---|-------------|
| Yourself |  | |
| Study child | | |
| Your partner (if applicable) | | |
| Main earner (if different) | | |

B3. What is the highest level of successfully completed education for: (Fb4ed)

| | You | Other parent | Main earner (if different) |
|---------------------------|-----------------------------|-----------------------------|-----------------------------|
| None | <input type="checkbox"/> 1a | <input type="checkbox"/> 1b | <input type="checkbox"/> 1c |
| School | <input type="checkbox"/> 2a | <input type="checkbox"/> 2b | <input type="checkbox"/> 2c |
| Vocational/apprenticeship | <input type="checkbox"/> 3a | <input type="checkbox"/> 3b | <input type="checkbox"/> 3c |
| University/degree -level | <input type="checkbox"/> 4a | <input type="checkbox"/> 4b | <input type="checkbox"/> 4c |
| Other (write in) | <input type="checkbox"/> 5a | <input type="checkbox"/> 5b | <input type="checkbox"/> 5c |



B4. What is the current economic activity of: (Fb5ecac)

| | You | Other parent | Main earner (if different) |
|---|-----------------------------|-----------------------------|-----------------------------|
| Working for pay or profit (including unpaid work for a family business or holding; an apprenticeship or paid traineeship; currently on maternity, parental, sick leave or holidays) | <input type="checkbox"/> 1a | <input type="checkbox"/> 1b | <input type="checkbox"/> 1c |
| Pupil, student, further training, unpaid work experience | <input type="checkbox"/> 2a | <input type="checkbox"/> 2b | <input type="checkbox"/> 2c |
| In retirement (including early retirement) | <input type="checkbox"/> 3a | <input type="checkbox"/> 3b | <input type="checkbox"/> 3c |
| Permanently sick or disabled | <input type="checkbox"/> 4a | <input type="checkbox"/> 4b | <input type="checkbox"/> 4c |
| Caring for home and/or family (unpaid) | <input type="checkbox"/> 5a | <input type="checkbox"/> 5b | <input type="checkbox"/> 5c |
| Unemployed | <input type="checkbox"/> 6a | <input type="checkbox"/> 6b | <input type="checkbox"/> 6c |
| Other (write in) | <input type="checkbox"/> 7a | <input type="checkbox"/> 7b | <input type="checkbox"/> 7c |





C. OCCUPATION QUESTIONS

C1. Please tell us about the current (or most recent) job of yourself, your child's other parent and main earner (if different) (Oc1job)

| | Yourself <input type="checkbox"/> 1a | Child's other parent <input type="checkbox"/> 1b | Main earner (if different) <input type="checkbox"/> 1c |
|---|---|--|--|
| Does not work (if no one applicable works go to section D) | | | |
| Job title |  | | |
| Full time ₁ or part time ₂ ? | | | |
| Main job tasks | | | |
| Main activity of the employer/business | | | |
| Tick box if self employed | <input type="checkbox"/> 2a | <input type="checkbox"/> 2b | <input type="checkbox"/> 2c |
| Number of supervisees/ employees | | | |
| Number of people in company | | | |
| Number of hours usually worked per week? | | | |
| Usual transport to work (please tick the one for each person) | | | |
| Work mainly at or from home | <input type="checkbox"/> 3a | <input type="checkbox"/> 3b | <input type="checkbox"/> 3c |
| A car or van | <input type="checkbox"/> 4a | <input type="checkbox"/> 4b | <input type="checkbox"/> 4c |
| Bus | <input type="checkbox"/> 5a | <input type="checkbox"/> 5b | <input type="checkbox"/> 5c |
| Train | <input type="checkbox"/> 6a | <input type="checkbox"/> 6b | <input type="checkbox"/> 6c |
| Motorcycle, scooter or moped | <input type="checkbox"/> 7a | <input type="checkbox"/> 7b | <input type="checkbox"/> 7c |
| Bicycle | <input type="checkbox"/> 8a | <input type="checkbox"/> 8b | <input type="checkbox"/> 8c |
| On foot | <input type="checkbox"/> 9a | <input type="checkbox"/> 9b | <input type="checkbox"/> 9c |
| Other means of transport | <input type="checkbox"/> 10a | <input type="checkbox"/> 10b | <input type="checkbox"/> 10c |
| Don't know | <input type="checkbox"/> 11a | <input type="checkbox"/> 11b | <input type="checkbox"/> 11c |