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Science & Technology in childhood Obesity Policy

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Start date of project: 1st June 2018 Duration: 48 months

D3.1: Report on the role of multiple environments and exposures in predisposing to children obesity, based on cohorts (M 22)

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Dissemination Level

PU	Public	☒
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

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1 Introduction

General goals of WP3

Adiposity in childhood is related to a higher risk of morbidity (e.g. including the metabolic syndrome and type 2 diabetes) both during childhood and later in adult life, and subsequent greater risk of premature mortality. Body size in childhood results from the interaction between genetic make-up, lifestyle factors, obesogenic environments and social determinants. However, the extent of the influence of the wider environment on obesity risk factors and obesity itself not well-characterised and it is unclear which molecular processes are involved in the causal network.

Overall, in WP3 we take a hierarchical approach to the analysis of pathways to obesity:

1. Environmental context analysis, based on geospatial analysis ("urban exposome") to assess built, natural and food environment, deprivation, facilities, pollutants etc. (D 3.1)

2. Individual level factors including physical/sedentary activity, dietary patterns, socio-economic factors, prenatal and family exposures (D3.1 and D3.2)

3. Internal factors, including "molecular signatures" (epigenetics, metabolomics) and role of gut hormones (D3.2, D3.3, D3.4)

A strong emphasis is placed on the role of socio-economic status in pathways to obesity, and in a final causal assessment based on mediation analysis (D3.5).

In **Deliverable 3.1** we aim to assess the role of multiple environments and exposures in predisposing to children obesity, based on European population-based cohorts (including pre-birth and pre-conception).

2 Part 1 – Characterising obesogenic neighbourhoods: methods – lead: ICL

Daniela Fecht, Diego Francesco Malacarne

2.1 Aim

The work conducted at ICL, as part of Task 3.1, aimed to quantify obesogenic features of children's residential (and where available school) neighbourhoods in terms of physical activity and food environment. We collected and processed geospatial information for the characterization of neighbourhoods and linked these with cohort participants. Our focus was to create a coherent dataset across all European cohorts included in STOP by complementing existing data and adding new data. Some cohorts included in STOP are part of previous studies (e.g. HELIX and Lifecycle) and already had some geospatial information linked. Other cohorts such as those in Eastern Europe (Croatia, Slovenia and Rumania) did not have any geospatial data.

2.2 Methods

2.2.1 Geocoding cohort participants' residential locations

The linkage between geospatial data and cohort participants was based on the home and school addresses. Cohorts included in HELIX and Lifecycle had already geocodes for residential (and where available school) locations. For Eastern European cohorts, information on addresses was provided by each cohort and the data transfer has been completed (with exceptions, see below). We received geographical information on the place of residence for the entire dataset from the Ljubljana/Slovenia cohort (3,582 subjects + 11 schools) and the Timisoara/Rumania cohort (200 subjects). We are still waiting for some outstanding data from the Zagreb/Croatia cohort (719 + 14 schools received so far) which did not have address information on cohort participants readily available and had to retrospectively collect this information as part of STOP; which caused the delay. For the Slovenian cohort participants, residential addresses were already geocoded (Figure 1). For the Rumanian and Croatian cohorts, addresses of cohort participants were transferred to Imperial for geocoding (assigning x, y location to each address). The completeness of the provided addresses varied. In most cases, the full address, including house number was provided. Others only recorded the street or locality name. Addresses were geocoded using a QGIS (https://www.qgis.org/en/site/) geocoding tool based on the Google Maps API and OpenStreetMap database. The geocoding success rate for Timisoara/Rumania was 96%, correctly positioning 288 out of 300 addresses. Of the 691 addresses received so far from Zagreb, 57 were excluded due to lack of address detail which resulted in poor accuracy. The remaining addresses were geocoded with a success rate of 98.4%.

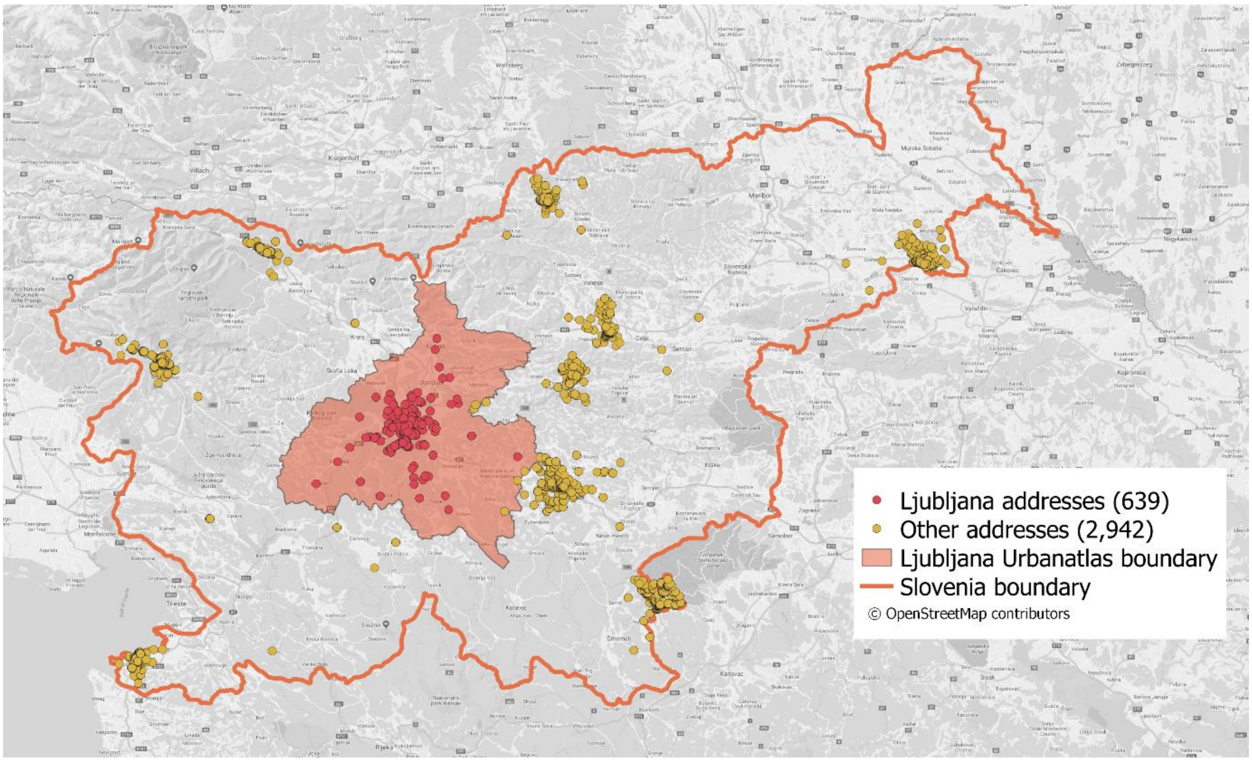

Figure 1. Spatial distribution of Ljubljana/Slovenia cohort participants

2.2.2 Defining residential/school neighbourhoods

Based on the location of residential addresses (and schools, where available) of cohort participants, different neighbourhood boundaries were constructed reflecting different conceptualisations of neighbourhoods. These included:

- Circular buffer: 300 m distance from address – consistent with the neighbourhood definition used in HELIX and Lifecycle
- Circular buffer: 1500 m distance from address - corresponding to a ~15 min walk
- Accessibility buffer: 1500 m distance from address via the road network – corresponding to a ~15 min walk along roads and area between roads
- Network buffer: 1500 m distance from address via the road network and restricted to 25 m either side of the road – corresponding to a ~15 min walk along roads

All buffers were constructed within a geographic information system (GIS) using PostgreSQL software. The network and accessibility buffers were created using the *pgrouting* extension for PostgreSQL. Information on roads was obtained from OpenStreetMap. Motorways were excluded from the network because they are not walkable. For each cohort participant's address, a network of within 1500 lengths was routed. To derive the accessibility buffer, the *alpha-shape* algorithm, which creates a concave shape around a cluster of points, was used to define the area between roads. For the network buffer, a 25m buffer around the routed network was created to represent areas directly adjacent to roads. Examples of buffers for a random point (to preserve the confidentiality of cohort participants) are shown in Figure 2.

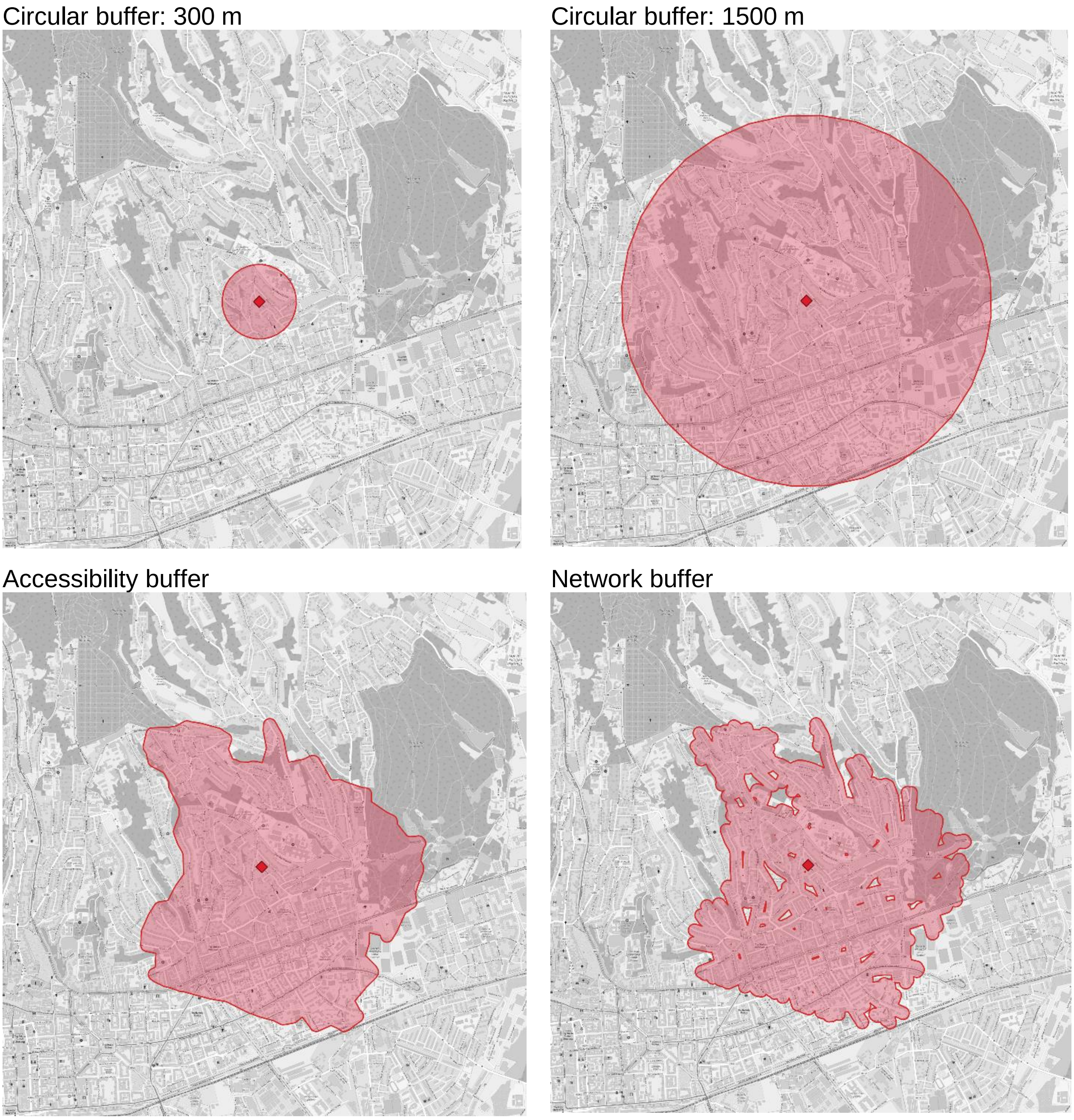

Figure 2. Extension of different neighbourhood definitions used to define obesogenic neighbourhoods

2.2.3 Geospatial information on obesogenic neighbourhood features

Based on our aim to produce a comparable dataset across all STOP cohorts, the choice of geospatial data for linkage with Eastern European cohorts was informed by available information as part of

HELIX and Lifecycle. Additional information related to the availability of sports facilities and playgrounds were linked to Eastern European cohorts who have a strong emphasis on physical activity and very rich data on activity patterns of children. All geospatial information was compiled and spatially integrated within a GIS. Table 1 shows the variables used to characterise obesogenic neighbourhoods.

Table 1. Neighbourhood features and their characteristics

Variables		Source	Accuracy / quality	Year
Walkability	Street connectivity	OpenStreetMap	1.57 m	2019
	Land use	Urban Atlas	Min mapping unit: 0.25 – 1 ha	2012
		Corine Land Cover*	Min mapping unit: 25 ha	2012
	Population density	Urban Atlas	Min mapping unit: 0.25 – 1 ha	2012
		European Environment Agency*	Min mapping unit: 25 ha	2001
Natural environment	NDVI	Landsat	30 m	2019
	Green and blue space boundaries	Urban Atlas	Min mapping unit: 0.25 – 1 ha	2012
		Corine Land Cover*	Min mapping unit: 25 ha	2012
Sport facilities	Playground, sports centres, fitness stations	OpenStreetMap	High in city centres, partial in peripheral areas	2019
Food environment	Fast food locations	OpenStreetMap	High in city centres, partial in peripheral areas	2019

**Urban Atlas is only available for major cities. For areas outside major cities, alternative data sources of the lower resolution were obtained including land cover from Corine Land Cover and population estimates from European Environment Agency*

Walkability of neighbourhoods was defined using the well described walkability index (Frank et al. 2006). This is a composite measure which consists of components relating to different dimensions of walkable areas: i) accessibility – represented by street connectivity (i.e. junction density) and ii) available destinations – represented by high land use mix and population density.

Street connectivity relates to the number of road intersections on major (excluding motorways) and minor roads. Road intersections were defined as intersections of 3 or more roads. Information on the road network was obtained from OpenStreetMap - a popular crowdsourced mapping project (https://www.openstreetmap.org/about). Data quality and coverage of OpenStreetMap has increased rapidly over the years and now represents a valid alternative to commercial and national datasets. Its main advantage is the consistent data structure across different countries and free availability. Data on the road network for each country was downloaded from the Geofabrik server (https://www.geofabrik.de/data/download.html) which aggregates OpenStreetMap data for more extensive regions and the Overpass Turbo tool (https://overpass-turbo.eu/) for specific areas.

Land use mix was described using the land use evenness index (LUEI) (Christian et al. 2011). The land use evenness index provides information on area composition and richness as follows:

Eq. 1 $$LUEI = \sum (Pi^* (ln(Pi))) / ln(n)$$

where *Pi* is the relative abundance of a land use class *i* and *n* is the number of different land cover types. The index varies between 0 and 1. The more classes are present, and the more equally distributed they are, the higher the LUEI value.

Four land cover types have been considered for this index:

- Residential
- Retail
- Mixed (industrial, commercial, public, military and private units)
- Services (sports and leisure facilities and green urban areas)

Information on land use was obtained from the Urban Atlas (https://land.copernicus.eu/local/urban-atlas) for major cities and Corine Land Cover for areas outside major cities, representing the data sources with the highest spatial resolution for each setting.

Population density was defined as the number of residents per area. Information on population was obtained from the Urban Atlas for major cities and the European Environment Agency population dataset for areas outside major cities, representing the data sources with the highest spatial resolution for each setting.

The natural environment was characterized by greenness and the abundance of green (and blue) spaces. Greenness was defined via the Normalized Differential Vegetation Index (NDVI), an index based on the red and near infrared bands detected by satellite cameras, which represent the presence and the vigour of the vegetation. NDVI is based on information from the Landsat mission, because of their high spatial resolution, high sensing frequency, time span and low cost provided free-of-charge). NDVI was downloaded from the Copernicus European geoportal (https://land.copernicus.eu/). Abundance of the natural environment was defined as the percentage area covered by green and blue infrastructures. This information was obtained from the Urban Atlas for major cities and Corine Land Cover for areas outside major cities, representing the data sources with the highest spatial resolution for each setting.

Information on sport facilities including playgrounds, the sports centres and the fitness stations were obtained from OpenStreetMap.

Location of fast food outlets were obtained from OpenStreetMaps. The advantage of OpenStreetMap is that it includes a specific class for fast food outlets, has a consistent data structure across the different countries and is freely accessible. Fast food outlets are defined by OpenStreetMap as places concentrating on very fast, counter-only service and take-away food, in which the sold food

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has a short preparation and serving time, usually because it is industrially prepared food and requires very few additional preparation steps.

2.2.4 Linking geospatial information to neighbourhoods

Geospatial information on neighbourhood features was spatially linked to cohort participants' neighbourhoods using GIS techniques and methods.

Geospatial data and methods were extensively checked, and a series of quality assessment tests conducted to verify the accuracy of the dataset and the tools used. OpenStreeMap data has been extensively compared to external data sources, including Google and national government data to check data completeness and accuracy. Such tests were, for example, performed to assess the quality of information on fast food outlets which were compared to information from the Food Standard Agency (UK) in the cities of London and Bristol. Figure 3 shows as an example the extended data cleaning and checking performed in Urban Atlas data.

Urbanatlas Category (legend)	
Master Map Category	**%**
Agricultural + Semi-natural areas + Wetlands	
0000 Natural surface	92.082
Discontinuous Dense Urban Fabric (S.L. : 50% - 80%)	
0000 Multiple surface (garden)	54.095
0321 Building	22.323
0000 Manmade surface or step	9.696
Discontinuous Medium Density Urban Fabric (S.L. : 30% - 50%)	
0000 Multiple surface (garden)	31.165
0000 Natural surface	15.462
0321 Building	14.51
Forests	
0384 Non coniferous trees	51.445
0000 Natural surface	34.224
Green urban areas	
0000 Natural surface	92.176
Industrial, commercial, public, military and private units	
0000 Manmade surface or step	35.808
0321 Building	27.043
0000 Natural surface	17.704
Isolated Structures	
0000 Natural surface	51.278
0000 Multiple surface (garden)	42.937
0321 Building	5.716
Sports and leisure facilities	
0000 Natural surface	90.774
Water bodies	
0400 Inland water	82.575

Figure 3. Urban Atlas – quality assessment of land use information

For each cohort participant, obesogenic neighbourhoods were characterised around their residential address and (where available) school using the four different conceptualisations of neighbourhood in Table 1.

To construct the **walkability** score, the following domain variables were created:

i) *street connectivity*: number intersections of 3 or more roads for each buffer

ii) *land use mix*: LUEI for each buffer - LUEI was set to 0 when only 1 land cover class present in buffer

iii) *population density*: number of residents within each buffer divided by the buffer area

Street connectivity, LUEI and population density were standardised across each cohort using z-scores.

The walkability index was consequently created as the combination of the three standardised variables as follows:

Eq. 2 $W_i = (SCz_i + LUEIz_i + PDz_i) / 3$

where Wi is the walkability score in buffer i, SCz_i the street connectivity z-score in buffer i, $LUEIz_i$ the Land Use Evenness Index z-score in buffer i and PDz_i the population density z-score in buffer i.

To characterise the **natural environment**, satellite images were acquired through a QGIS plugin (semi-automatic classification plugin) connected to the USGS database. Images were carefully selected considering cloud cover, vegetative period and, when possible, the same sensing dates across the study area. The NDVI was then calculated by applying *Equation 3* to the Landsat image bands as follows:

Eq.3 $$\text{NDVI} = \frac{(\text{NIR - Red})}{(\text{NIR + Red})}$$

where *NDVI* is the Normalized Difference Vegetation Index, and *NIR* the spectral reflectance measurements acquired in the red (visible) and near-infrared regions, respectively

This calculation was applied to each 30m x 30m grid cell using the QGIS raster calculator. For each buffer the mean NDVI value was then calculated.

Green and blue spaces were defined as the surface area covered by land cover classes mainly composed by vegetation or water bodies. Green and blue spaces were expressed as both square kilometres of covered area and percentage of the covered area as compared to the total buffer surface area.

To identify the availability of sport amenities, the number facilities were counted in each buffer. The considered classes of facilities are “playground”, described by OpenStreetMap as areas specifically designed for children to play, “fitness station”, described as an outdoor facility with a single or a collection of exercise equipment and “sports centre”, defined as a facility where sport takes place within an enclosed area.

To describe the **food environment** for each cohort participant, the number of fast food outlets, the fast food outlet density (number of fast food outlet divided by buffer area) and fast food outlets per person (number of fast food outlets divided by number of residents in each buffer) have been calculated.

The main processing was conducted using PostGIS, a geospatial extension for the PostgreSQL database management system. This solution allows to manage adequately large datasets with high performance and to produce and store a series of SQL scripts for the automation of complex processing. The resulting scripts can be applied to different datasets which share a common (or similar) data structure. This allows for rolling out geospatial data assignment to all STOP cohorts, as required, needing very few adjustments to account for cohort-specific data infrastructure.

2.3 Ethical approval

Ethical approval for this study is the responsibility of each cohort. Data Transfer Agreements between the cohorts and Imperial College are in place which outlines the use and transfer of data. The Croatian Physical Activity in Adolescence Longitudinal Study (CRO-PALS) was performed according to the Declaration of Helsinki, and all the procedures were approved by the Ethics Committee of the Faculty of Kinesiology, University of Zagreb, Croatia (No. 1009-2014). The Analysis of Children's Development in Slovenia 2013 (ACDSi) has approval from the National Medical Ethics Committee, June 2013 (ID 138/05/13). In each case, both cohort participants and their parent/guardians signed an informed written consent after receiving detailed information on study aims and procedures. Participation of children was voluntary, and they could withdraw from the whole study or any part of it at any time. No risks were associated with any of the tests. The compiled database does not include any personal identification, and the identity codes of the participants are kept separately and securely. All reporting of data is anonymous. Schools, parents and children are kept informed of the progress of the study through our web pages and the personal presentations of findings on their schools. The Rumanian cohort 'Use of nutrigenomic models for the personalised treatment with medical foods in obese people' respects the Declaration of Helsinki and was approved by the Ethics Committee of the Faculty of Medicine, University of Medicine and Pharmacy Victor Babes Timisoara, Rumania (No. 06/20.06.2016)

2.4 Results

We quantified obesogenic features of children's residential (and where available school) neighbourhoods in terms of physical activity and food environment. We used four different conceptualisations of neighbourhood to reflect different activity patterns and comparability with previous studies. The following information was compiled for each cohort participant and buffer type:

- Population density (people / km^2)
- Street connectivity (z-score)
- Land Use Evenness Index (z-score)
- Population density (z-score)
- Walkability (score)
- NDVI (index related to the vegetation vigour)
- Green and blue space (m^2)
- Percentage green and blue space (%)
- Playgrounds (count)
- Fitness stations (count)

- Sports centres (count)
- Fast food outlet (count)
- Fast food density (fast food outlet / km^2)
- Fast food per person (fast food outlets / people)

This geospatial information was transferred back to cohorts for linkage and integration with cohort database. Zagreb/Croatia is currently still pending but expected completion by end March 2020.

2.5 Exposure assessment case study – Analysis of Children's Development in Slovenia

We quantified obesogenic environments via the residential neighbourhood for 2,725 children' which are part of the Analysis of Children's Development in Slovenia (ACDSi) study. The majority of children (83%) lived outside major cities and, consequently, neighbourhood characteristics had been defined using lower resolution geospatial information. Tables 2-5 highlight differences in neighbourhood characteristics across cohort participants and different buffer types.

Table 2 Descriptive statistics of obesogenic neighbourhood features – circular buffer, 300m

Characteristics	Mean	Standard deviation	5th percentile	10th percentile	90th percentile	95th percentile
Population density (*pop/km2)*	2,337	2,469	53	63	5,739	7,134
Walkability score	0.0	0.8	-0.8	-0.8	1.3	1.7
NDVI	0.5	0.1	0.3	0.4	0.7	0.7
Green/blue space (*km^2*)	0.12	0.11	0.00	0.00	0.28	0.28
Green/blue space (*%*)	43	39	0	0	100	100
Playgrounds (*n*)	0	1	0	0	1	2
Fitness stations (*n*)	0	0	0	0	0	0
Sport centres (*n*)	0	0	0	0	0	0
Fast food outlets (*n*)	0	1	0	0	0	1
Fast food density (*n/km^2*)	1	4	0	0	0	4
Fast food per person (*n/pop*)	0	0	0	0	0	0

Table 3 Descriptive statistics of obesogenic neighbourhood features – circular buffer, 1500m

Characteristics	Mean	Standard deviation	5th percentile	10th percentile	90th percentile	95th percentile
Population density (*pop/km2)*	1,051	1,408	39	48	2,687	4,902
Walkability score	0.0	0.9	-0.9	-0.8	1.0	2.3
NDVI	0.6	0.1	0.4	0.4	0.7	0.7

Green/blue space (*km*^{2})	5.10	1.55	1.37	2.69	7.02	7.02
Green/blue space (*%*)	73	22	20	38	100	100
Playgrounds (*n*)	2	4	0	0	8	9
Fitness stations (*n*)	0	0	0	0	0	1
Sport centres (*n*)	1	1	0	0	2	2
Fast food outlets (*n*)	2	7	0	0	3	21
Fast food density (*n/km*^{2})	0	1	0	0	0	3
Fast food per person (*n/pop*)	0	0	0	0	0	0

Table 4 Descriptive statistics of obesogenic neighbourhood features – accessibility buffer

Characteristics	Mean	Standard deviation	5th percentile	10th percentile	90th percentile	95th percentile
Population density (*pop/km2)*	1,616	1,644	56	62	3,816	5,493
Walkability score	0.0	0.9	-0.9	-0.9	0.8	2.1
NDVI	0.6	0.1	0.4	0.4	0.7	0.7
Green/blue space (*km*^{2})	1.38	0.80	0.14	0.28	2.43	2.69
Green/blue space (*%*)	55	31	8	13	100	100
Playgrounds (*n*)	2	3	0	0	5	8
Fitness stations (*n*)	0	0	0	0	0	0
Sport centres (*n*)	0	1	0	0	1	2
Fast food outlets (*n*)	2	6	0	0	2	18
Fast food density (*n/km*^{2})	1	1	0	0	1	4
Fast food per person (*n/pop*)	0	0	0	0	0	0

Table 5 Descriptive statistics of obesogenic neighbourhood features – network buffer

Characteristics	Mean	Standard deviation	5th percentile	10th percentile	90th percentile	95th percentile
Population density (*pop/km2)*	1,816	1,715	59	67	4,189	5,589
Walkability score	0.0	0.9	-0.9	-0.9	0.8	2.1
NDVI	0.5	0.1	0.4	0.4	0.7	0.7
Green/blue space (*km*^{2})	0.76	0.43	0.11	.019	1.36	1.58
Green/blue space (*%*)	49	33	7	11	100	100
Playgrounds (*n*)	2	3	0	0	5	8
Fitness stations (*n*)	0	0	0	0	0	0
Sport centres (*n*)	0	1	0	0	1	1
Fast food outlets (*n*)	2	6	0	0	2	18

Fast food density (*n/km²*)	1	1	0	0	1	4
Fast food per person (*n/pop*)	0	0	0	0	0	0

Population density varies between cohort members (reflecting urban/rural differences) and buffer types used to construct neighbourhoods. While the mean density is similar between neighbourhood types, differences are pronounced for children living in more densely populated areas, with the 300m circular buffer showing the highest population densities. The walkability of neighbourhoods is similar across all buffer types, as is the provision of green/blue space. The exception is the circular 1500 m buffer which encompasses more areas away from roads and consequently has a higher abundance of green/blue space. Presence of green/blue space, however, does not equal accessibility; which cannot be established with a circular (area-based) buffer. The number of fitness stations and sports centres is negligible across all buffer types. Number of playgrounds reflect the size of the neighbourhood. Generally, the number of fast-food outlets within children's residential neighbourhood is very low (mean number of fast food outlets: 2) although some children have a larger number of outlets within their residential neighbourhood (max: 34 restaurants). The number changes marginally depending on neighbourhood buffer type reflecting the fact that most fast food outlets will be along roads which are captured in all buffer types (circular, network and accessibility).

Table 6 shows the intercorrelation between some of the neighbourhood features, highlighted here for the network buffer. Neighbourhood features are mostly weak or moderately correlated, as shown using the Spearman's rho correlation to allow for the skewed distribution of data. Exceptions are features of the natural environment, including NDVI and green and blue space abundance. These are strongly negatively correlated with population density and walkability, and to a lesser degree to the number of fast food outlets. Walkability and population density are highly correlated, as expected given that population density is one of the domains included in the walkability index.

Table 6. Spearman's rho correlation between neighbourhood features within 1500m network buffer for residential addresses of ACDSi cohort participants

	Pop dens	**Walkability**	**NDVI**	**Green/blue (%)**	**Play-grounds**	**Fitness stations**	**Sport centres**	**Fast food**
Pop dens	-	0.915	-0.812	-0.889	0.555	0.224	0.451	0.610
Walkability	**	-	-0.851	-0.875	0.583	0.269	0.544	0.588
NDVI	**	**	-	0.895	-0.398	-0.335	-0.538	-0.682
Green/blue (%)	**	**	**	-	-0.360	-0.217	-0.488	-0.613
Play-grounds	**	**	**	**	-	0.403	0.216	0.473
Fitness stations	**	**	**	**	**	-	0.445	0.273

Sport centres	**	**	**	**	**	**	-	0.164
Fast food	**	**	**	**	**	**	**	-

*** indicates statistical significance at the 0.01 level*

2.6 Discussion

The exposure assessment focusing on obesogenic features of residential neighbourhoods of 2,725 children, part of the Analysis of Children's Development in Slovenia (ACDSi) study, has shown the importance of neighbourhood definition. Neighbourhoods are not a pre-defined concept but reflect the physical, social and cultural characteristics of societies. The definition of geographical boundaries might, therefore, change between countries and regions.

For the purpose of STOP, neighbourhoods need to be defined consistently to allow comparison between cohort studies. Some of the cohorts are already linked to geospatial information as part of previous studies (HELIX and Lifecycle). Using the same definition of neighbourhoods as applied in these studies (i.e. circular buffer of 300m from residential address), allows for direct comparison between cohort studies. This is also aided by the use of comparable geospatial input data and spatial methods to model and link data to cohort participants.

As part of STOP, however, we also explored additional definitions of neighbourhoods which are more relevant and aligned to the outcome and pathway under study. The availability of high-resolution, freely available spatial data in a consistent manner across large geographical areas (e.g. via OpenStreetMap), in addition to advances in spatial processing, has allowed us to create different types of buffers which incorporate the accessibility of areas via the road/path network. As we have seen here, the type of buffer (either network or accessibility buffer) does not impact on results. This is due to the geographical pull of the road network. As people conduct their daily lives, they only seldom move away from the usual road/path network. We, therefore, conclude that the use of the network buffer will best capture the specific features of obesogenic environments that are the focus of STOP (i.e. the physical and food environment).

2.7 References

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3 Part 2 – Associations between physical neighbourhood characteristics and obesity – lead: ICL

Daniela Fecht, Diego Francesco Malacarne, Gregor Stark

3.1 Aim

The aim of our analysis was to explore associations of characteristics of the physical neighbourhood, including walkability, playgrounds and green spaces with physical activity and obesity outcomes. In doing so, we established the role of physical activity in the physical environment – obesity framework. Harmonisation of variables on physical neighbourhood characteristics is currently still ongoing across STOP cohorts and will be written up in a publication later this year. Here we present preliminary results to demonstrate our concept using the Analysis of Children's Development in Slovenia (ACDSi) study as a case study.

3.2 Methods

3.2.1 Cohort information

The Analysis of Children's Development in Slovenia 2013 (ACDSi 2013) is the most recent follow-up of a 40-year old cohort study on children's development (Jurak et al. 2013). The focus of ACDSi 2013 is, amongst other areas, on kinesiology and public health. Establishing the somatic and motor development of primary-school children in Slovenia (e.g. physical fitness, body composition) and their relationship to lifestyle factors was one of its main aims.

ACDSi 2013 is a cross-sectional, sentinel site study which recruited children from 11 primary schools in Slovenia. The sampling frame took both school size and class size into account to provide a nationally representative sample of primary school children in Slovenia. Of 4,236 children between 6 and 14 yearsinitially invited to participate in the study, 3,476 children were consequently included in baseline assessment in 2013 (see Table 7); 2% of children in this age bracket in Slovenia.

Table 7. The ACDSi 2013 study sample by sex and age (Jurak et al. 2013)

Age	Boys	Girls	All
5 years	54	62	116
6 years	234	248	482
7 years	217	221	438
8 years	210	206	416
9 years	169	192	361
10 years	177	170	347
11 years	197	193	390

12 years	163	136	299
13 years	182	162	344
14 years	162	115	277
15 years	4	2	6
All	**1,769**	**1,707**	**3,476**

3.2.2 Exposure: Physical neighbourhood characteristic

Exposure assessment focuses on physical features of the residential neighbourhood of cohort participants that have previously been shown to increase physical activity levels. These include features which support walking and cycling such as walkable neighbourhoods. Of particular importance for childhood physical activity are playable spaces which we assessed here via the provision of green spaces and playgrounds. Physical features of children's residential neighbourhoods were assessed within a 1500 m network buffer from residential address as follows:

- Walkability score – constructed for each 1500 m network buffer and standardised across cohort participants
- Normalized Differential Vegetation Index (NDVI) – mean across 1500 m network buffer
- Percentage of green and blue space surface as proportion of network buffer area
- Number of playgrounds within 1500 m network buffer

For a detailed description of physical neighbourhood characteristics, including geospatial input data and spatial methodology, see Part 1. In total, we were able to assign exposures to 2,712 children (78% of the original cohort) which was due to addresses outside the modelling domain or problems with geocoding.

3.2.3 Outcome data

Outcome data included in the statistical analysis focused on physical activity levels and body composition of children. This information was obtained from baseline assessment of ACDSi 2013 participants via physical fitness tests, anthropometric measurements and questionnaires in September/October 2013. A web-based questionnaire was used for 12-14 years olds only, information on younger children (6-11 years old) was obtained via a parent's questionnaire.

Physical fitness was assessed via a range of well-established field-based motor performance tests including SLOFit and EUROFIT protocols. A total of 17 physical fitness test were performed including sprints and runs of various lengths, resting heart rate, strengths and balancing tests as well as sit-up and jumping tests. Test results were combined into a physical fitness index (PFI).

To establish outdoor physical activity (which we used as a proxy for outdoor play) children aged 12 to 14 years were assessed using the School Health Action, Planning and Evaluation System (SHAPES) physical activity questionnaire (1970). Information on moderate and vigorous physical activity (MVPA) was collected using a seven-day recall. Vigorous physical activity (VPA) was defined as any physical activities that increase heart and breathing rate and make the participant sweat.

Moderate physical activity (MPA) was defined as 'lower intensity physical activities such as walking, biking to school, and recreational swimming.' Participants recorded the number of hours and 15-minute increments they engaged in MVPA in the previous week. For children aged 6 to 11, the Children's Leisure Activity Study Survey (CLASS) was used. This consists of a checklist of 30 physical activities that parents can indicate their child engages in during a typical week during term time. A subcategory was created to indicate physical activity in outdoor locations. MVPA was expressed as minutes per day.

Body height and body mass were measured using a GPM 101 anthropometer and portable Tanita BWB-800P electronic scale, respectively. Skinfolds, as an indicator of body fat, was measured using a Harpenden fat calliper applied to 7 locations on the right side of the body. The sum of skinfold measurements was used for analysis.

3.2.4 Statistical analysis

We used descriptive statistics, Spearman's rho correlation and box plots to describe the distribution of exposure and outcome variables. We compared mean outcome variables across exposure tertiles as we did not assume a linear relationship between urban environment and outcome. The use of tertiles also makes interpretation more meaningful for policy purposes. Outcome measures were continuous variables.

3.3 Results

Descriptive statistics of exposure and outcome variables are shown in Table 8. The distribution of the physical neighbourhood characteristics has already been described in detail in Part 1. Physical activity levels vary greatly between study participants. The interquartile range for MVPA, for example, is 120 min per day; 84 min per day for outdoor MVPA. The majority of children have a lower than normal or normal body mass index under 24.9 (93.4%).

We did not detect any correlation (Spearman's rho) between physical neighbourhood features within 1500m network buffer and physical activity and body composition with r < I0.09I in all cases (see Table 9).

Table 8. Descriptive statistics of physical neighbourhood features within 1500m network buffer and physical activity and body composition variables in ACDSi cohort participants

	Mean	Standard deviation	5th percentile	10th percentile	90th percentile	95th percentile
Physical neighbourhood characteristics						
Walkability score	0.0	0.9	-0.9	-0.9	0.8	2.1
Playgrounds (*n*)	2	3	0	0	5	8
NDVI	0.5	0.1	0.4	0.4	0.7	0.7
Green/blue space (%)	49	33	7	11	100	100

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Physical activity						
Physical fitness index	50.8	28.9	5.6	10.6	90.7	95.6
Physical activity (min/day)	148	106	39	58	300	370
Outdoor activity (min/day)	86	70	14	26	189	225
Body composition						
Body mass index	17.7	3.5	14.2	14.7	23.5	25.7
Skinfold (sum)	46.9	27.2	26.3	29.	95.4	110.4

Table 9. Spearman's rho correlation between physical neighbourhood features within 1500m network buffer and physical activity and body composition variables in ACDSi cohort participants

	Physical fitness index	**Physical activity**	**Outdoor activity**	**Body Mass Index**	**Skinfolds**
Walkability	-0.014	-0.013	-0.068	-0.089**	-0.051**
Play-grounds	0.051*	-0.032	-0.067	-0.099**	-0.053**
NDVI	0.054**	0.014	0.067	0.073**	0.037
Green/blue (%)	0.046*	0.000	0.044	0.079**	0.038

*** indicates statistical significance at the 0.01 level; * indicates statistical significance at the 0.05 level*

Physical activity levels are mostly similar across different categories of physical neighbourhood characteristics (see Table 10). The physical fitness index tends to be higher in the greener neighbourhoods compared to the least green neighbourhoods. ~~lowest category.~~ Children's physical fitness index is lower in neighbourhoods without playgrounds (PFI = 49.9) compared to those with four or more playgrounds (PFI = 54.0). The pattern for minutes of moderate and vigorous physical activity per day overall and outdoors is less clear. Children living in the greenest neighbourhoods, however, engage in 8 minutes more outdoor play than those living in the least green neighbourhoods.

Mean body mass index (BMI) is slightly reduced in the most walkable neighbourhoods (BMI = 18.2) compared with the least walkable third of neighbourhoods (BMI = 18.9). We observed a similar pattern for neighbourhoods with more than 4 playgrounds (BMI = 17.8) compared to neighbourhoods with no playground (BMI = 18.7). Supporting this trend, children had less skinfolds (SF) in more walkable neighbourhoods (SF = 53.1), and neighbourhoods with more than 4 playgrounds (SF = 51.3) compared to the least walkable neighbourhoods (SF = 57.7) and neighbourhoods without playgrounds (SF = 57.0). The opposite trend was observed with green spaces for both NDVI and percentage blue and green space. Here the most green neighbourhoods had higher BMI and SF (NDVI: BMI = 18.9; SF = 57.7; %green/blue: BMI = 19.0; SF = 58.6) compared with the least green neighbourhoods (NDVI: BMI = 18.2; SF = 54.3; %green/blue: BMI = 18.2; SF = 53.9).

Table 10. Mean physical activity levels and body composition by categories of physical neighbourhood characteristics in ACDSi cohort participants

	Physical fitness index	Physical activity	Outdoor activity	Body Mass Index	Skinfolds
Walkability					
T1: least walkable	51.8	168	102	18.9	57.7
T2	51.3	174	107	18.4	55.6
T3: most walkable	49.5	166	95	18.2	53.1
Playgrounds					
T1: no playgrounds	49.9	171	103	18.7	57.0
T2	51.6	162	94	18.2	54.6
T3: ≥ 4 playgrounds	54.0	165	94	17.8	51.3
NDVI					
T1: least green	47.7	168	97	18.2	54.3
T2	52.9	168	100	18.4	54.4
T3: most green	52.0	170	105	18.9	57.7
Green/blue space					
T1: least green	48.7	168	97	18.2	53.9
T2	53.2	171	102	18.3	54.1
T3: most green	51.1	168	101	19.0	58.6

3.4 Discussion

Our analysis aimed at exploring associations of characteristics of the physical neighbourhood with physical activity and body composition in 2,712 children participating in ACDSi 2013. Although physical activity variables varied across the children, body composition was very similar across the cohort with only ~7% of children overweight. This is reflected in our results which showed a weak relationship of physical neighbourhood features with physical activity levels and body composition.

Initial results suggest that physical fitness and physical activity in ACDSi cohort participants is not dependent on the presence of green/blue spaces. Instead, physical activity is probably predominantly promoted within the school and sport club settings. Further statistical analysis, including the incorporation of the Timisoara/Rumania and the Zagreb/Croatia cohorts, is ongoing.

3.5 References

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4 Part 3 - Urban environment and lifestyle in childhood – Lead ISGlobal

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Unhealthy lifestyle behaviours are one of the main causes of noncommunicable diseases, including cardiovascular diseases and obesity, especially low physical activity [1]. There is an increasing interest in studying if the urban design is related to unhealthy lifestyle behaviours [2].

Some observational studies have examined the relation of the urban environment with physical activity and walking in children, but results are inconsistent. These discrepancies could be explained by the indicators used; some of them have used perceived indicators and others objectively measured indicators, and also many studies have assessed a single indicator in relation to single lifestyle behaviour, while others took into account multiple urban indicators [34].

Evidence suggests that the availability of parks and playgrounds may promote leisure physical activity and especially presence of green spaces could increase physical activity and active commuting in adults [56]. The presence of a park within 800m close to the house was also associated with higher physical activity in children [7]. A recent study conducted in the population based study IDEFICS, showed that availability of public open spaces has a positive association with physical activity in childhood and street intersections a negative association in adolescence [8]. However, compared to adults, the evidence is more limited in children and adolescents.

4.1 Objectives of current study

To evaluate the association between several urban environment indicators from different domains, namely built environment, traffic and natural spaces, and several lifestyle behaviours in childhood from six European cohorts.

4.2 Methods

4.2.1 Population

We used data from the Human Early-Life Exposome (HELIX) study [9], a collaborative project across six established and ongoing longitudinal population-based birth cohort studies in Europe: the Born in Bradford (BiB) study in the UK [10], the Étude des Déterminants pré et postnatals du développement et de la santé de l'Enfant (EDEN) study in France [11], the INfancia y Medio Ambiente (INMA) cohort in Spain [12], the Kaunus cohort (KANC) in Lithuania [13], the Norwegian Mother, Father and Child Cohort Study (MoBa) [14] and the RHEA Mother Child Cohort study in Crete, Greece [15].

For the current analyses, we used data from the HELIX subcohort that included mother-child pairs with complete questionnaires and characterized for their internal and external environmental exposures. Children were born between 1999 and 2010. We organized an additional follow-up visit for these mother-child pairs between 2013 and 2016, when children were 6-11 years of age, as fully described elsewhere[9], and at this visit, children were clinically examined and their biological samples were collected. Standardized questionnaires were developed for the HELIX study, and then translated to each of the study languages. The cohorts included in this study are shown in Figure 1.

Figure 1 Study population

Table 1 shows the characteristics of the study population.

Table 1 Population characteristics (n=1613)

	Moba	KANC	BiB	Eden	INMA	Rhea
N	287	207	230	198	491	200
Sex (male) (%)	154 (53.7)	114 (55.1)	126 (54.8)	114 (57.6)	256 (52.1)	111 (55.5)
Sex (female) (%)	133 (46.3)	93 (44.9)	104 (45.2)	84 (42.4)	235 (47.9)	89 (44.5)
Child age, years ± SD	8.44±0.51	6.50±0.48	6.63±0.24	10.79±0.58	9.04±0.65	6.53±0.28
Child zbmi, score ± SD	0.08±0.90	0.50±1.21	0.23±1.18	0.21±1.10	0.74±1.22	0.68±1.37
Family Affluence Score, score ± SD	5.81±0.88	4.8±1.31	4.47±1.62	6.17±0.93	5.45±1.28	4.84±1.39
Maternal education level (primary) (%)	0 (0)	13 (6.5)	98 (48.3)	12 (6.1)	104 (23.9)	9 (4.5)
Maternal education level (secondary) (%)	55 (19.9)	70 (35.0)	36 (17.7)	73 (37.2)	186 (42.9)	111 (56.1)
Maternal education level (tertiary) (%)	222 (80.1)	117 (58.5)	69 (34.0)	111 (56.6)	144 (33.2)	78 (39.4)

4.2.2 Urban environment indicators

We obtained the residential and school address of each child during the follow up and were geocoded to derive urban environment indicators by using the following software: the PostgreSQL (copyright © 1996-2017 The PostgreSQL Global Development Group), PostGIS (Creative Commons Attribution-Share Alike 3.0 License http://postgis.net) and QGIS (QGIS Development Team, 2016. QGIS Geographic Information System).

The detailed exposure assessment is described elsewhere [16]. We measured surrounding vegetation following with the PHENOTYPE protocol and applied the Normalized Difference Vegetation Index (NDVI), which is an indicator of greenness (with higher numbers indicating more greenness) [17,18]. We calculated the distance from home and school to the nearest blue or green space from topographical maps [19], as a proxy of access to natural spaces. We calculated traffic density indicators from road networks maps (ie. traffic density on nearest street, traffic load on major roads and all roads, and inverse distance to nearest major road). Building density was calculated by dividing the area of building cover (km^2) by the area of buffer (km^2). We calculated population density as the number of inhabitants (per km^2) surrounding the home and the school area, and the street connectivity as the number of intersections by the area (km^2) of the selected buffer [20]. Access to public transport was calculated as the number of bus stops and bus lines inside 300m buffer. We calculated a facility richness index based on the number of different facility types (e.g. community services, schools, financial institutions) divided by the maximum potential number of facility types specified in a buffer of 300 meters. Mixed land use was calculated by the Shannon's Evenness Index as the proportional abundance of each land used. We created an indicator of walkability, based on previous ones, calculated as the mean of the deciles of population density, street connectivity, facility richness and land use (with a range from 0 to 1) [21,22].

A summary of the urban environment indicators used in this study and their sources is shown in Table 2.

Table 2. Urban environment indicators

DOMAIN	EXPOSURE	SOURCE
Built environment	• **Population density** (number of inhabitants/km2), • **Building density** (m2 built/km2) within a buffer of 300m, • **Connectivity density** (number of intersections / km2) within a buffer of 300m;	• Population density: Global Human Settlement Layer (GHSL) except for MOBA (local sources), building density: European Settlement Map 2017 (ESM2p5m) except for MOBA (Open Street Maps) • Street network (from NAVTEQ) • Bus transport (local sources),

	• **Access to public transport** in terms of lines (meters of bus public transport mode lines inside 300m buffer), • **Access to public transport** in terms of stops (number of bus public transport mode stops inside 300m buffer); • **Facility density** (number of facilities present divided by the area of the 300m buffer); • **Facility richness** (number of different facility types present divided by the maximum potential number of facility types (at a 300m buffer), • **Mixed land use** (Land use Shannon's Evenness Index) • **Walkability index** (as mean of deciles of facility richness index, landuse shannon's Evenness Index, population density, connectivity density)	• Points of interest (from NAVTEQ) • Land use (Urban atlas) except MOBA (Local source)
Traffic	• **Total traffic load of major roads in 100 m buffer;** • **Total traffic load of all roads in 100 m buffer;** • **Traffic density on nearest road;** • **Inverse distance to nearest road**	Traffic intensities from local sources (except RHEA: we used data collected in a traffic monitoring campaign conducted by ISGlobal as part EXPOsOMICS project to characterize the traffic of the streets of Heraklion) / Distance to nearest road (NAVTEQ)
Natural spaces	• **Straight line distance to nearest green and blue space > 5,000m2;** • **Area of closest green and blue space > 5,000m2;** • **Average of Normalized Difference Vegetation Index (NDVI) values within a buffer of 100m;** • **Green and blues space within 300 m**	• NDVI imagery derived from Landsat 4–5 Thematic Mapper (TM), Landsat 7 Enhanced Thematic Mapper Plus (ETM+), and Landsat 8 Operational Land Imager (OLI)/Thermal Infrared Sensor (TIRS) with 30m x 30m resolution. • Urban Atlas except MOBA (Local source)

4.2.3 Lifestyle in childhood

Lifestyle behaviours in childhood were obtained through standardized questionnaires at age 6-11 years. The behaviours were self-reported from parents, and moderate and vigorous physical activity was validated by using accelerometers. We considered several lifestyle behaviours in these analyses (in minutes per day, except for sleeping in hours per day): sleeping time, sedentary behaviours (including television time, computer and video games, and other sedentary activities), moderate to vigorous physical activity and extracurricular physical activity. We also calculated daily time performing active commuting from home to school based on the data obtained through the QGIS, which is a free and open source Geographic Information System (Version 1.8.0 – http://www.qgis.org/en/site/).

Figure 2 shows the description of lifestyle behaviours across cohorts.

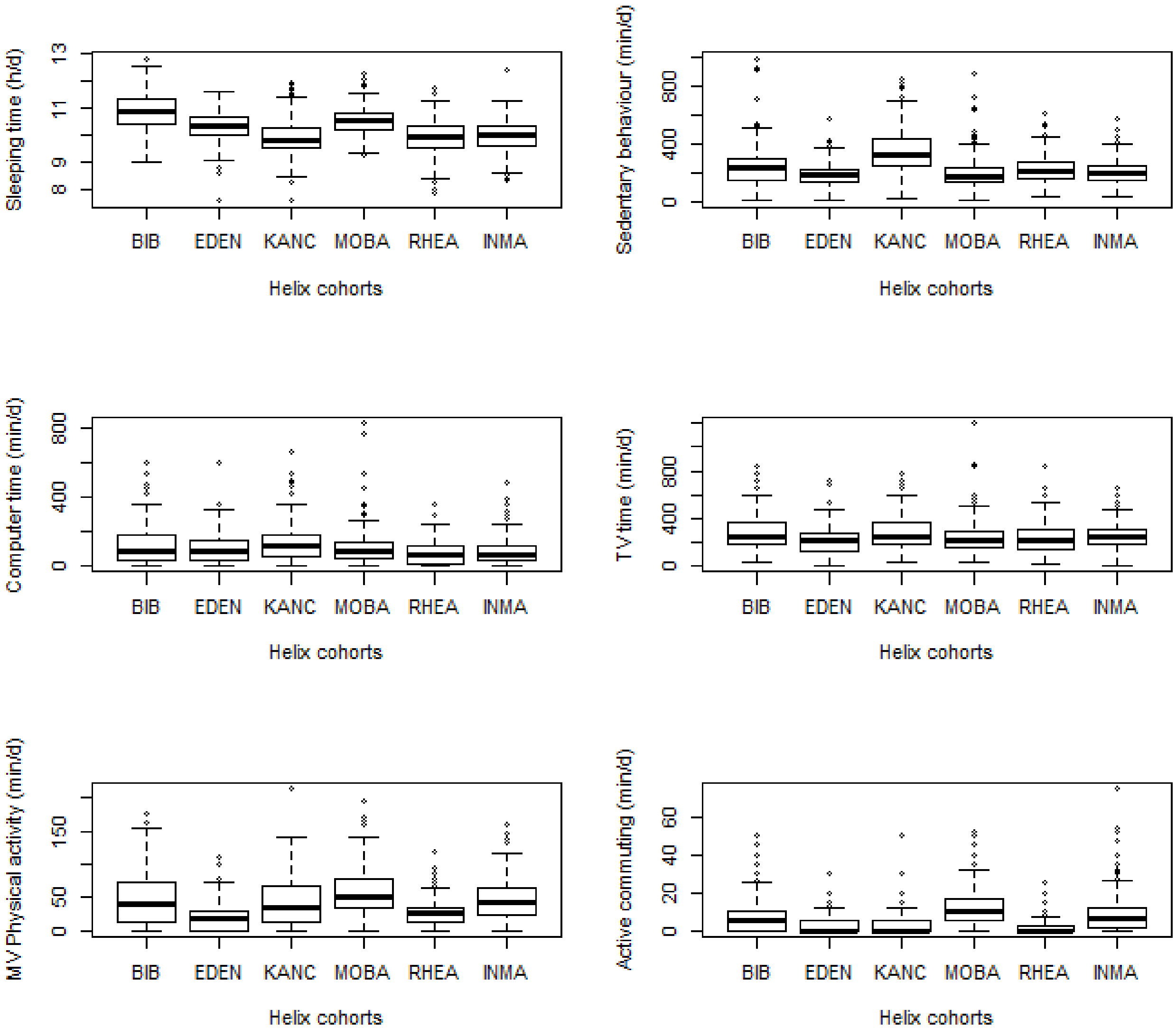

Figure 2 Box plots of the distribution of lifestyle behaviours per cohort. MV: Moderate to vigorous physical activity.

4.2.4 Statistical analysis

We used multiple imputation to deal with missing values in the dataset by using the chained equations method. In total, 20 imputed datasets were generated using the mice package in R. We explored the distribution of the variables before imputation, and we transformed the variables that showed skewed distributions

We standardised all the exposures by the interquartile range (IQR) and we used an exposome-wide association study (ExWAS) approach to study all the exposures independently. This approach consisted of a covariate-by-covariate estimation of the exposure-outcome association by independent linear regression models. These models were adjusted by cohort, child age, child sex, maternal education, family affluence score and area level SES (deprivation index), based on the literature. To correct for multiple hypothesis testing, each p value was compared with a threshold, defined as 0.05 divided by the effective number of tests [23]; the corrected p value was 0.003.

4.3 Results

Some urban indicators were related to lifestyle behaviours in childhood, as shown in Figure 4. Indicators of exposures to green spaces near home (i.e. NDVI, a measure of vegetation, and presence of green spaces) were inversely associated with sedentary behaviours (overall and specific activities) ($p < 0.05$). On the other hand, overall sedentary behaviours increased with higher population density at home and specifically television viewing ($p < 0.05$). None of these associations was significant after correcting the p-value by the effective number of tests.

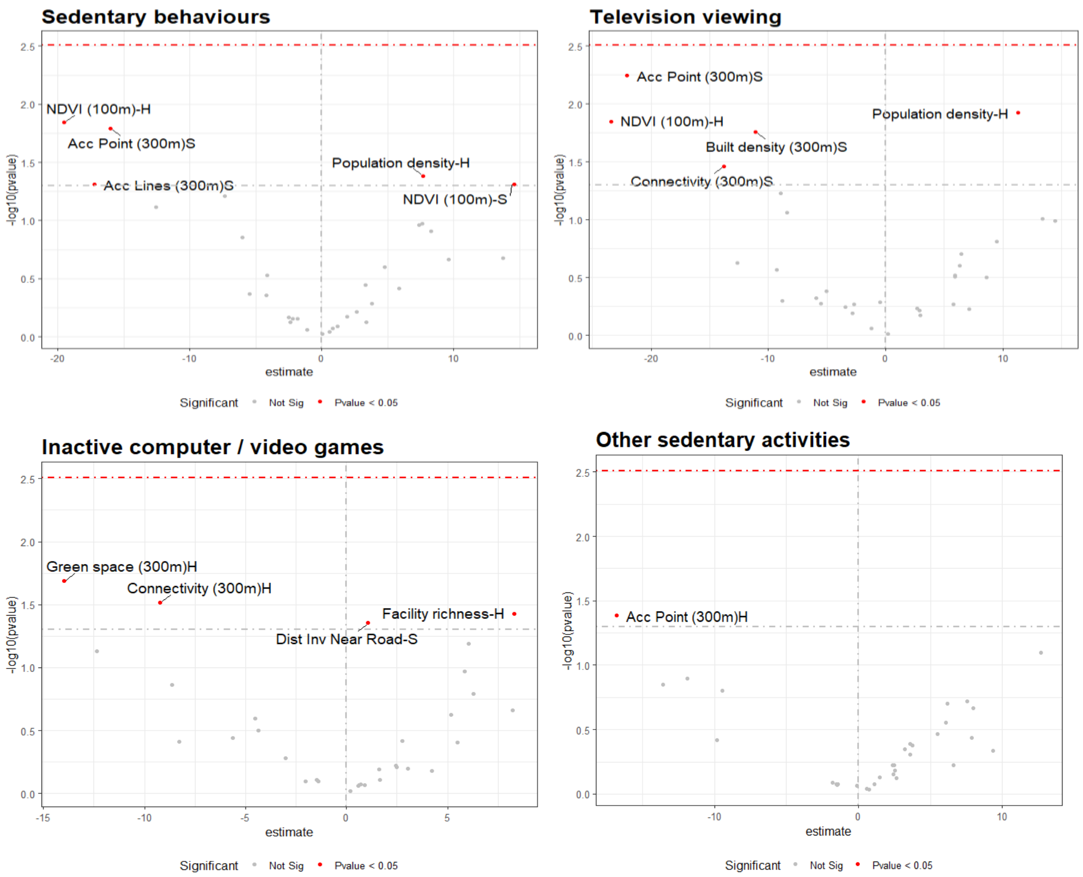

Figure 4 Volcano plots of the association of all exposures of the urban environment with overall sedentary behaviors, television viewing and inactive computer and video games. Exposures with a p-value lower than 0.05 have their names on the graph and a red dotted. The red line represents the corrected p-value threshold using the method of the effective number of test. H: home area; S: school area.

Higher vegetation both in home and school areas was associated with higher moderate to vigorous physical activity in children, and living further from a green area was inversely associated with physical activity outside the school hours ($p < 0.05$). None of these associations was significant after correcting the p value by the effective number of tests.

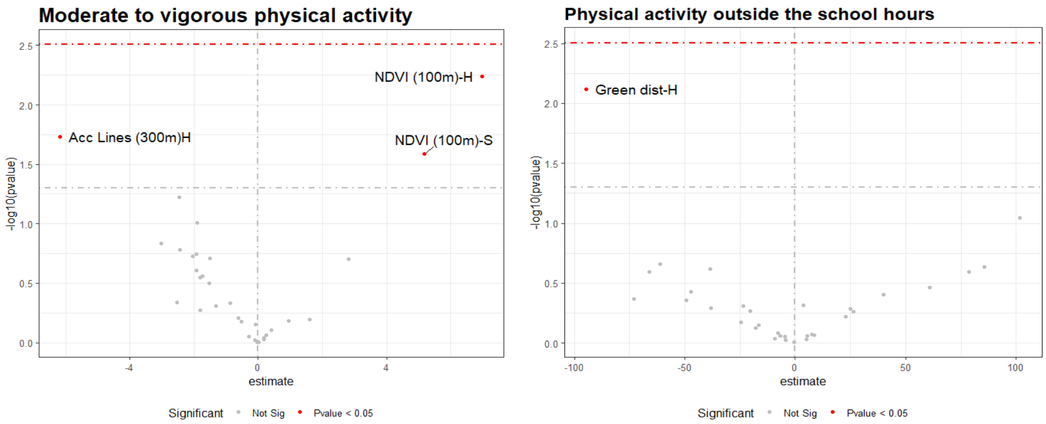

Figure 5 Volcano plots of the association of all exposures of the urban environment with overall moderate to vigorous physical activity and physical activity outside the school hours. Exposures with a p-value lower than 0.05 have their names on the graph and a red dotted. The red line represents the corrected p value threshold using the method of effective number of test. H: home area; S: school area.

These associations are consistent with findings from previous studies, which showed an inverse association with sedentary behaviors and also obesity, and a positive association with physical activity in children and adolescents [244].

In summary, green spaces are relevant for all the lifestyle behaviors studied, and may potentially be protective for diseases related to these lifestyle behaviors. However, these results are preliminary, and further analyses are needed.

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5 Urban environment and child obesity

5.1 Background

Forty-two million infants and young children were overweight or obese in 2013, and 70 million will be overweight or obese by 2025 if current trends continue [25]. Children with higher BMI are at greater risk of developing several diseases during adulthood, including cardiovascular disease[26]. Beside established risk factors for childhood obesity, i.e. diet and physical activity, other modifiable environmental exposures might play a pathogenic role. For example, gestational tobacco smoke has shown consistent evidence for obesogenic effects in childhood.

Air pollution and noise have been found to increase the risk of obesity and other metabolic outcomes in adults [27]. Maternal exposure to ambient air pollution has been convincingly linked to lower birth weight and ultrasound markers of reduced foetal growth, suggesting that this exposure may be etiologically relevant to child growth and subsequent risk of obesity. The potentially obesogenic effects of air pollutants are also supported by studies suggesting an association between residential traffic density, roadway proximity, or air pollutant concentration, and rapid infant weight gain and childhood obesity [28].

Evidence of an association between chronic occupational noise exposure (≥80 – 85 dB) during pregnancy and adverse birth outcomes, i.e. small for gestational age and low birth weight, has been found in three out of four available reviews on the topic [29–31]. Another review did not find any evidence for an association [32]. Some suggestions of a positive association between prenatal and postnatal exposure to noise and overweight have been recently reported [33].

Built environment characteristics and green spaces play a potential role in child physical activity and consequently may be important in understanding and preventing childhood obesity [34]. The vast majority of previous research has been conducted in adults, and the relationship between the urban environment and obesity among children remains relatively unexplored. A systematic review on green spaces and obesity-related outcomes found inconsistent results across studies, with some reporting positive associations and others reporting null or negative associations [35].

Up to now, possible environmental risk factors have been investigated separately, lacking a holistic view of how the totality of human environmental (i.e., nongenetic) exposures, commonly referred to the “exposome”[36], jointly impact on childhood obesity.

5.1.1 Objectives of current study

To determine which prenatal and postnatal outdoor exposures are associated with childhood body mass index (BMI), and overweight/obesity risk at age 3-4 years.

5.2 Methods

5.2.1 Study population

11.673 children age 3-4 years from the six European cohorts participating to the HELIX project.

5.2.2 Urban indicators

The urban environment was assessed using GIS-based modelling according to the residential history of the mothers from pregnancy to 3-4 years of the child. Several components of the urban environment were assessed including air pollution, built environment, natural spaces, traffic, noise and socioeconomic deprivation index. Time-varying exposures including air pollution and meteorology were averaged within different intervals: the whole pregnancy, the 1st, 2nd, and 3rd trimesters of pregnancy, the first year of life, and the year before the measurement of height and weight. The built environment and natural spaces were measured within different buffers: 100m, 300m, or 500m.

5.2.3 Childhood BMI and obesity

Information about child height and weight was collected by each cohort when the child was approximately 3 years in BiB, EDEN and MoBa, and 4 years in INMA, KANC and RHEA. The source of the information differed between cohorts. Height and weight were measured during a follow up visit in BiB, EDEN, RHEA, and INMA. In KANC and MoBa information about height and weight was retrieved by a questionnaire answered by the parents. In BiB, EDEN, INMA and RHEA medical records were also available and were used when data from the follow up visit were missing. Body Mass Index (BMI) was calculated as weight in kilograms divided by the square of height in metres (kg/m^2). Age- and sex-specific BMI z-score were calculated using WHO Child Growth Standards.

5.2.4 Covariates

The covariate selection was based on a DAGs. The confounders retained in the final model were center (Gipuzkoa, Heraklion, Kaunas, Nancy, Oslo, Poitiers, Sabadell, Valencia), maternal education (low, medium, high), maternal age at birth (continuous), parental country of origin (both native, at least one non-native), maternal BMI (continuous), Since we used WHO z-scores rather than population specific z-scores, age and sex can still partially explain variability in our outcomes. We therefore adjusted our models for child sex and age (months). Postnatal models were further adjusted for birthweight for taking into account potential backdoor pathways.

5.2.5 Statistical Analysis

We performed an exposome-wide association analysis (ExWAS), where the effect of each of the available exposures was assessed separately with independent models accounting for multiple comparisons via corrections based on the number of effective tests.

5.3 Results

In both prenatal and postnatal models, the living closer to blue spaces was associated with BMI z-score (higher BMI z-scores for exposure in the first and third tertiles compared to the second tertile) and a higher risk of being overweight/obese compared to normal weight/underweight at $p<0.05$.

Prenatal $PM_{2.5}$ was associated with a reduction in the risk of being overweight/obese ($p<0.05$). We found no other statistically significant association. Only postnatal exposure to blue spaces passed the multiple testing corrected p-value threshold of 0.003. These results are preliminary.

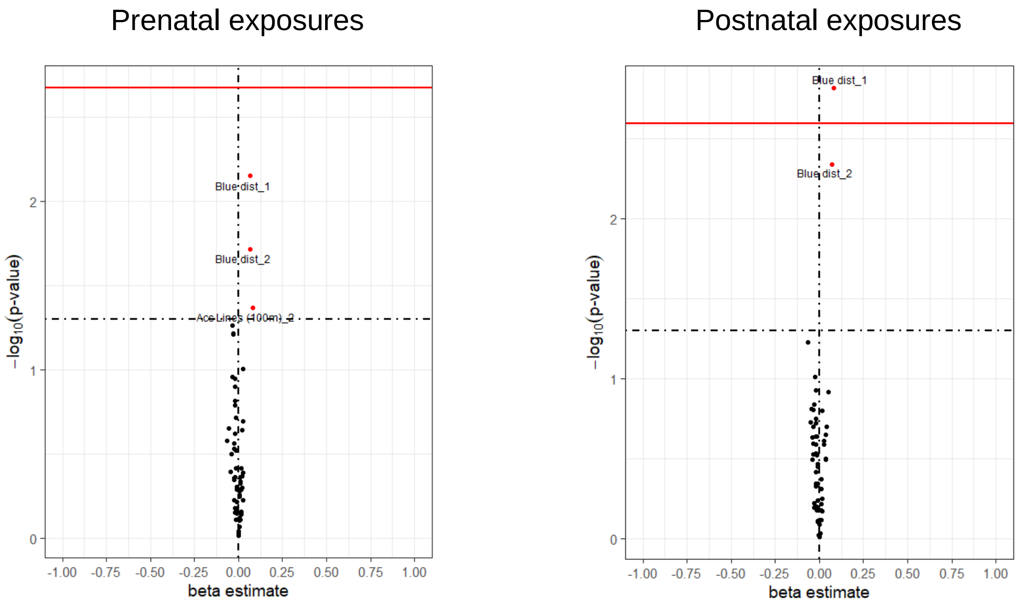

Figure 6 Volcano plots of the association of prenatal and postnatal exposures of the urban environment with child bmi z-score. Exposures with a p-value lower than 0.05 have their names on the graph and a red dotted. The red line represents the corrected p-value threshold using the method of the effective number of test.

6 Overall conclusions

In this deliverable we have fine-tuned methods for geo-referencing children and investigating the relationships between their living environment, obesogenic behaviours and the risk of obesity. We have used a standardized definition of neighbourhood across studies and included many cohorts in different parts of Europe. In a Slovenian cohort (N=3,500) we have performed initial statistical analyses and found some evidence that green spaces and playground facilities are beneficial to the physical fitness of children, while higher walkability scores and number of playgrounds may have a small beneficial effect on BMI. Slovenian schools intensively promote physical activity among children, and we will extend this analysis to other contexts in Eastern Europe, including Croatia and Romania. Similar analyses were performed in the HELIX consortium for analysis with sedentary and physical activity for around 1,200 children aged 6-11 years and BMI in almost 12,000 children aged 3-4 years. In the HELIX children there was suggestive evidence for an association between green space and beneficial behaviours; however, there was no evidence for an effect of the urban environment directly on child BMI. This latter analysis was at a very young age though (3-4 years) and requires further longitudinal follow-up at later ages during childhood. Final analyses and further harmonization are ongoing. One limitation of the current work is the use of a walkability score developed in the American context. Therefore the development of urban environment indicators more appropriate for European children is an important next step in this work.

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