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LONGPOP

Methodologies and Data mining techniques for the analysis of Big Data based on Longitudinal Population and Epidemiological Registers

Tools to locate life courses on maps

Deliverable n. 2.5

The challenges of locating life courses in space

One of the basic principles of life course study is the location of individual trajectories in time and space (Elder et al., 2015; Kok, 2007). While a considerable amount of researches has explored the articulation between history and biographies, with important theoretical and empirical contributions, the spatial dimensions have long been understudied. Along the last years the teams engaged in LONGPOP have been active actors in the development of solutions to fill this gap.

Progresses have been made possible thanks to the availability of longitudinal databases and the reconstruction of individual life courses. This is the central expertise of our network. On the other side, the partners' institutions in LONGPOP have invested in the development of geographic databases. For the past populations, this task has been extremely difficult since depending on the existence and accuracy of more or less precise historical maps. Moreover, scanning, georeferencing and digitizing those historical maps is costly. This financial aspect has a scientific echo: what is the appropriate spatial level to increase our understanding of the life trajectories? In other words, do we remain at the level of parishes or municipalities, or do we go down to the block, or building / parcel boundary levels, and for which added value? (Hedefalk et al., 2018). For contemporary populations, access to the data is more easy thanks to the digitization of the cadastres by public administrations and the contribution of private enterprises like our partner, ESRI. However, the choice of the spatial level of analysis remains a relevant issue. Finally, in the past or in the present, life courses are by definition dynamic and cannot be located on static maps. Typically, farms can be divided to give a plot to each heir, or municipalities can be merged to create a more coherent institutional territory. Object lifelines or longitudinal spatial units, have to be reconstructed.

Once this long and tedious work achieved, a spatial grid is by far not enough. Scientists need to qualify each geographic unit with various attributes that are susceptible to affect demographic behaviours and the directions taken by individual life courses. As Finn Hedefalk and his colleagues (2018, 36) note, geographic context is "a broad term that includes all of the geographic factors that affect the associated individuals". We can distinguish the environmental aspects (topography, hydrography, quality of soils and their coverage, types and density of buildings, presence or absence of green spaces, etc.) from the aggregation of individual socio-economic characteristics. The interactions of those two dimensions are important. Do we observe accumulation of vulnerabilities? A contemporary example is the concentration of mono-parental female headed poor households in the deindustrialized polluted areas offering cheap but poor housing conditions, in South Belgium (See Eggericks et al., 2000). Or inversely do we see an accumulation of advantages? For example in Geneva the wealthy households lived on the hill with private wells; they established beautiful houses along the lake only after the Pasteurian discoveries and the disappearance of the marshy lands where previously lived the poor (Perroux, 2015). Another issue is the deserve by private and public services, the connections between the various spaces and the resulting question of accessibility, that is crucial for well-being, especially in crisis time (during a heat wave for example).

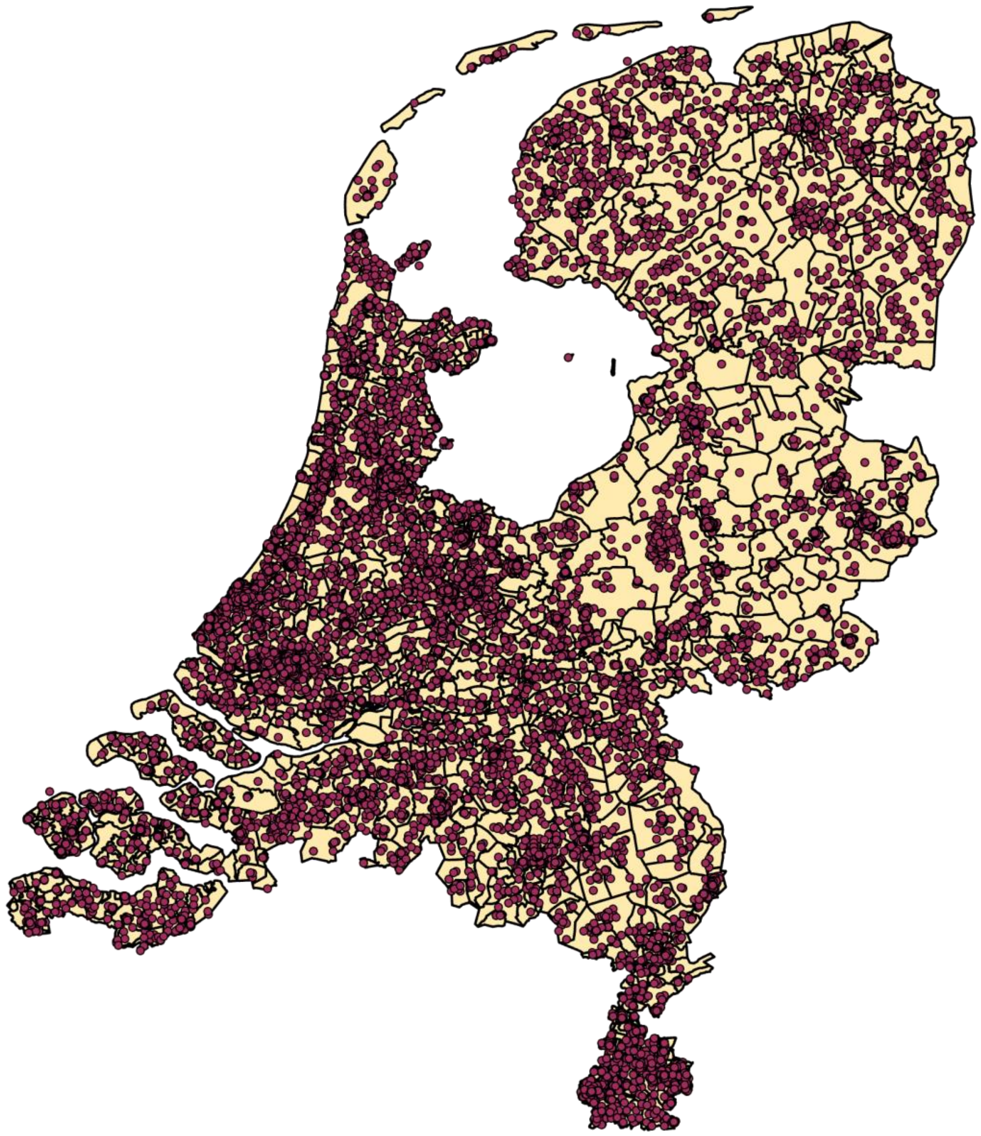
Finally, to test the impact of those attributes of geographic units on individual life trajectories, we need to match properly object lifelines and residential histories. In other words we have to link the spatial and demographic databases. Once again this is an uneasy task for historical populations, more easer for the contemporary ones, although never completely obvious.

In the following, we report the work done by our teams, work which has been done directly as part of LONGPOP activities or which is valorised under LONGPOP head.

Geocoding the Historical Sample of the Netherlands

The Historical Sample of the Netherlands is world-known resource for population studies. It is one of the most important databases in historical demography, based on a sample of 85’500 persons born between 1812 and 1922. Since the address is in string format the researchers have identified and separated the street, the house number, the locality, the municipality and the province. Those indications are associated with a time stamp to reconstruct the residential histories. This work, mainly realized by Diogo Paiva, LONGPOP ESR, has been complicated because the address is at the household and not the individual level, and because the administrative schemes were different in the large urban centres and in the rural settings. Moreover, since data entry is faithful to the original sources, all spelling variants have been transcribed, without a complete uniformity in the address structure. A normalisation was consequently the first step, indispensable for mitigating those issues. Names have been standardised. For the streets, the International Institute of Social History team reduced 85’158 forms to 37’195 standardised names. In the next step, the places indicated by those names have been located and three sets of coordinates, hierarchized, have been attributed: for the centroid of the municipality, of the locality within a municipality, and of a street within a locality. Till now already 37’000 life courses have been reconstructed, with data until 1940, and including more than 333’000 addresses. Since the greatest difficulty remains the identification of historical streets, Amsterdam, Rotterdam and Den Haag will be more specifically studied during the coming months, with the idea that those case studies could later be used for further development. Map 1 represents the found addresses (this paragraph is based on the presentation Diogo Paiva and Kees Mandenaekers made during the 3rd European Conference of Historical Demography held in Pécs, Hungary, 26-29 June 2019).

Map 1. Historical Sample of the Netherlands. Found addresses



Source: Paiva and Mandenaekers, 2019

Enriched with this work, HSN has gained a considerable added value. The Radboud University team has created a Mobility Tool (*D 2.1*) to facilitate the research on historical migration with historical longitudinal datasets stored in the IDS like HSN. Thjjs Hermsen has written the R scripts that form this “Migration Extraction Tool”. It is expected to be published in *Historical Life Course Studies* in the coming months. Moreover, a LONGPOP ESR also from the Radboud University team, Dolores Sesma Carlos, analyses the interrelations between internal migrations and old-age mortality. Isolating in HSN a sub-sample of some eight thousand persons still alive at the age of 50, she has been able to reconstruct all the changes of municipality from their birth till 50. Recently she has started to study return-migration in old age, disentangling between returns to the places where ego is born and has grown and returns to places where ego lived during adulthood. It appears that in old age closeness-to-death is a strong predictor of returning home (Sesma Carolos, 2019a, 2019b). Thanks to collaboration with Diogo Paiva, Sesma Carlos will also map for her sample members their places of birth, the places where they lived at 50, and their places of death.

The Scanian experience: zooming at the maximum

The Lund University team has realized a geographic database that is original from several points of view. First, it is restricted to five parishes but covers a very long period of time, from the 17th century till now. Second, the spatial level of precision is very high, at the property unit / parcel boundary / building level (Hedefalk et al., 2017b). Third, while the agrarian regime changed a lot under the influence of the physiocratic reforms, from little dispersed plots to large farms, they arrived to construct the object life-lines. Fourth, through an impressive research in a variety of archival sources they associated to their very precise spatial units several attribute, like the soil quality, the distance to wetlands (where lived the mosquitos at the origin of malaria) and population density.

For the second of those indicators they show that the distance to the border of the wetlands is more relevant that the centroid. For the third indicator, they insist on the importance, in epidemiological research, to not consider each spatial unit as an isolated island but also as a component of a larger environment. The researchers from Lund seem to have been the first to demonstrate that geographically weighted population density including the surrounding units are giving more robust results when studying important demographic outcomes, especially death in their studies. Their methodological contributions to the use of spatio-temporal micro level data are important and receive a great echo in the international scientific community (see Hedefalk et al, 2018, 2017a, 2017b).

Recently, Lund team has applied its expertise to a new setting, the Swedish industrial town of Landskrona. For the period 1948-1967, they have geocoded 54’000 persons address and building level, and reconstructed their residential trajectories. Using ego-centric neighbourhoods (an approach on which we will come back below), Hedefalk and Dribe (2018) show that social class and income of the people living around when an individual was young are significant predictors of attending college later in the life course.

Madrid, Amsterdam, Antwerpen: looking within the big cities

Looking within the big cities is important to avoid ecological fallacy in the establishment of relations between the context and individual life courses. Indeed, an aggregation of socioeconomic individual characteristics at the level of a little village or at the level of hundreds of thousands, or even millions of inhabitants, has absolutely not the same accuracy, the same relevance for someone living in those territories, nor the same impact on his or her life trajectory. Bigger are the cities, more important it is to look within. This is indeed what our teams in Madrid, in Amsterdam and in Antwerp are doing.

The CSIC played a pioneering role in this field with the Historical Spatial Data Infrastructure of Madrid (HISDI-MAD). They realized the digitalisation of the map of Madrid done in 1902 by Facundo Cañada, a very precise and rich document. Blocks, singular buildings and empty spaces, parks and gardens, streets and their axis, land use, streams and water channels, facilities of interest, railways and tram lines, barrios (neighbourhoods) borders; and a map grid which can be visualised from the resulting database, that documents the urban development of the capital of Spain, urban planning and buildings history. In addition, a demographic database has been constituted with the census of 1905 as well as the deaths and births in 1905 and 1906. Linkages used the postal address that for 1905 has been coded in 96% of the cases. The many abandoned children are also considered in a specific database covering the Foundling Hospital of Madrid. The project has the long-term ambition to cover the period 1880-1930 which was decisive for the city expansion (Ramiro Fariñas et al., 2014).

The rich already existing database has been exploited by LONGPOP researchers to study demographic behaviours located in specific moments of the life courses. Diego Ramiro Fariñas and the ESR Dariya Ordanovitch, with Yolanda Casaso Ruiz from CSIC, have analysed the impact of urban sanitation on child mortality. A careful reconstruction of the water distribution and the sewage system was decisive to understand the impressive spatial variations in the level of child mortality across the capital (Ramiro Fariñas et al., 2018). Another research explored the fertility differentials between natives and immigrants in a city that pioneered the fertility decline in Spain. Apparently, migrants have the same legitimate fertility that the women born in Madrid. However, looking more precisely at the origins of the migrants and their life trajectories to Madrid, it appears that they came from areas with a much higher fertility than the one observed in the capital, and consequently migrants' fertility was low compared to the one of their fellows who stayed. Those results call for two possible interpretations which are not necessarily incompatible. First, a selection effect with the most open to change that left their villages for Madrid while the most conservative stayed. And/or an adaptation effect. This is however not, as it is usually expected in the literature, an adaptation to the urban culture (since indeed we do not see differences in fertility between the women who arrived in Madrid before 15 and those who arrived after), but probably an adaptation to the lodging conditions in town, especially in the poor barrios far from the city centre where migrants made up to 70 percent of the population (Mazzoni et al., 2019). Obviously, more research is needed.

In Amsterdam, we already evoked above the last developments in the host institution of the HSN, the International Institute for Social History in Amsterdam, where a specific exploration of the most important Dutch cities is ongoing to reach the street level. It is already possible to represent the natives of Amsterdam and the immigrants at this level of precision and to confront their spatial pattern. Results show more cohabitation than segregation (Paiva and Mandenaekers, 2019).

Important progresses have also been achieved in the big port city of Antwerpen and in Flanders, in Belgium, with a methodology highly similar to the one applied to the Historical Sample of the Netherlands. Indeed the two LONGPOP ESR from Amsterdam, Diogo Paiva and Francisco Anguita, strongly supported the Katholieke Universiteit Leuven team who has developed the COR-database. This data source has reconstructed life courses of an alphabetical sample of individuals for the city and the municipalities around (the 'arrondissement'). To reconstruct the residential histories and locate the life courses on maps, going beyond the geocoding of municipalities and reaching the level of the streets was essential. A normalization procedure was applied to 14'536 different addresses. Links have been done or with the existing streets or with the 1898 streets of Antwerp database. The remaining are "historical streets" that have disappeared. Researches here used not only the search engines of Google Maps but also of ArcGIS Pro, which has been elaborated and maintained by our partner enterprise in LONGPOP, ESRI. At the municipal level, the so-called 'Lambert coordinates' indicate the centroid. At the street level the GIStorical Antwerp project database was completed thanks to old maps. A medium point was obtained for each street. It is also fair to recognize the failures. This is in the most densely populated area, the city of

Antwerp, that the rate of identification of the addresses was the highest, while lower in the industrial and rural municipalities of the 'arrondissement'. This is the long delayed echo of institutional history, with a much better administration in the old historical town that around (see Paiva, 2019; Jenkinson et al., 2019; Matsuo and Matthijs, 2018, 2019).

Integrating space in the epidemiological research on individual level data

The integration of demographic and geographic databases as tools to locate life courses on maps offers rich perspectives to answer both old and new questions. However, as we have seen in the Scanian, Dutch and Madrilenian cases, the contributions are the most immediate in researches on mortality of various subpopulations defined by gender and by location in the life course. This observation is also valid for the studies based on contemporary databases. LONGPOP teams contribute to the life-course epidemiology of health, ageing and well-being.

In that perspective, the team of Sassari University has realized several ecological studies of mortality at the level of the municipalities, in Sardinia, Italy, but also in Andalusia, thanks to a partnership with our LONGPOP associate, the Institute of Statistics and Cartography of Andalusia. All the municipalities identified as at high-risk of mortality in Italy are located in areas where heavy industries are present (Santos Sanchez et al., 2018 & 2019). This result appears more specific in a study on Andalusia, more precisely the industrialized province of Cadiz. The proximity to industrial facilities increases significantly the risks of dying from digestive cancers for both men and women, what confirm an environmental impact of industrial pollution (Santos Sanchez et al., submitted).

The Longitudinal Database of the Andalusian Population includes around 8.3 million persons who are continuously followed, with all the events of life recorded. Those demographic data are linked to various administrative data about, for example, unemployment, as well as with the many information collected during the population censuses, for example on lodging conditions. In a recent paper, the LONGPOP ESRs Mathias Voigt, Dariya Ordanovitch, Laura Cilek and colleagues (2019) have used those data for a study of all-causes mortality among individuals between ages 35 and 80. At a very detailed level (the census tracts), they calculated an index of urbanicity, by integrating population density, artificial surface, road density and accessibility to services. However, they fairly accept the surprising result that those physical urban measures have no real impact while individual-level risk factors weight, and even more the socioeconomic context (levels of unemployment, single households, etc. measured at the census tract level).

The wealth of the Andalusian data is also utilized by ESR Dariya Ordanovitch, based at ESRI Madrid, to study the elderly mortality answers to heat waves. The year 2019 contained the most and worst heat waves in Europe since we have modern observations of the temperatures. Such episode clearly highlights the importance of looking at individual and population adaptations to climate changes. A technical but also substantial challenge is how to transform the data from points of observation distributed across space (meteorological and air quality stations in this case) to a continuous coverage of the studied territory. This is obtained via a spectrum of advanced Bayesian geostatistical methods. Dariya Ordanovitch enhances local kriging modelling with regression predictions based on a series of explanatory contextual (geographic) variables. To ensure the accuracy of those efforts in prediction she accounts for the reference data produced by the global climatic reanalysis models. Altogether those methodological advances are tools for all the scientists working in this area of researches.

This is the case of the LONGPOP team in the University of Geneva who also studied the heat waves, especially the 2003 episode, which was the most intense ever recorded until 2019, and which remains the most murderous one. Relying on meteorological information linked to exhaustive person-days of exposure to mortality, this study showed that the effect of heat during the summer periods 2001-2007 was small and relatively undifferentiated across socioeconomic groups, living contexts and environments – particularly during intense and prolonged heat episodes. The main mortality effect of heat was actually accounted for by the spatial clustering of populations which are more at risk of death in general, especially among men. Heat specifically exacerbated the risk of mortality only for institutionalized and unmarried women. The analysis thus confirms the determinant role played by frailty in old age and by the accumulation and spatial concentration of risk factors, rather than their specific effects during heat waves (Lerch and Oris, 2018). This is coherent with the results obtained by Ordanovitch and colleagues (2018) for the completely different climatic and environmental region of Andalusia.

Geneva researchers use a tool that has been developed relatively recently, which is the “ego-centric neighbourhoods”, i.e. the k persons or households who are the closest neighbours of the individual we study (Panczak et al., 2012). Closeness is measured through Euclidian distance but also taking into account the road network. Working on the American town of Newark, New Jersey, Xu, Logan and Short (2014) have obtained better results with the ego-centric neighbourhoods that with the administrative units. This is also the conclusion of the LONGPOP Lund team (Hedefalk et al., 2018).

Another issue that is shared by all the teams is the difficulty to manage small areas (what implies small numbers) and empty spaces (or almost empty like mountains in Switzerland, dry areas in Andalusia, etc.). We have seen above that one option is to use weighted averages of the studied area and the surrounding ones (Hedelfalk et al., 2018). Bayesian smoothing techniques are also quite efficient (Zufferey and Oris, 2018).

The Scottish model of "life course of place" and its contribution to the epidemiology of mental health

Integrating properly individual life course data in their spatial context, while taking into account the variety of spaces, the proper level of analysis and the changes across time, requires an long-term investment, and for contemporary data a collaboration with public administrations that must be based on mutual interest and also on confidence, especially as far as the protection of private data is concerned. The Scottish members of the LONGPOP team in Edinburgh University have studied this issue for several decades. Indeed they have inherited panel data that are collected already from 1936, the Lothian Birth Cohort. With that kind of sources, they are not limited to the ultimate outcome, death, but can also consider physical or mental health issues in old age, as the results of long life-courses.

In that perspective, many studies have tested important life-course theories like the accumulation of (dis)advantages and the impact of critical life periods, but very few have integrated in their analytical framework places as "spatial-temporal products" (Pearce et al., 2018, 1). Scottish colleagues used both historical and contemporary data to qualify the areas where lived the members of the Lothian Birth Cohort 1936, from the cradle until they reached the age of 70. They show that growing as a child in a socially disadvantaged neighbourhood increases the risks of anxiety and depression. Early life conditions heavily impact health much later in life, confirming the importance of childhood as a critical age of life. Since results about the exposure to green spaces were ambiguous, the team looked more in-depth at this issue. They considered not only the presence of this kind of spaces in the residential place during childhood, but also around the school and on the route between home and school, so globally the "activity space". It appears that park availability during adolescence predicts a good cognitive ageing in old age, but only when the road to school was safe (few traffic accidents) (Cherrie et al., 2019).

LONGPOP ESR Gergö Baranyi inscribed his research in this tradition and brought a contribution of his own, working on a database elaborated in the University of Geneva, to which he received access. The basis is SHARE, the Survey on Health, Aging and Retirement, which is the larger data collection on the health and living conditions of the older adults in Europe. Data from 10'328 individuals from 13 countries were used in this research where SHARE wave 2004/05 is the baseline. Risks of depression between this wave and 2015 are assessed through multilevel logistic models that include as explanatory variables environmental indicators (access to service and nuisances in the neighbourhood where ego is living) and life-course measures of childhood stressors, adverse experiences and health problems. Results suggests first an accumulation of advantages since good childhood conditions are very protective against depression for those living in 2004/05 well-deserved areas. Secondly, the risks of presenting depressive symptoms increase with more neighbourhood nuisances, what is indicative of a frailty, of a high sensibility of older adults to physical and social problems in their immediate living environments, which are clearly a threat to their well-being (Baranyi et al., 2019).

More collaborative works between Edinburgh and Geneva teams are ongoing, on research topics requiring the location of life courses in places and spaces.

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In summary, to locate life courses on maps, LONGPOP teams have invested in the construction of geographic databases that have been linked to the demographic ones, leading to the reconstruction of hundreds of thousands of residential life histories. Those teams share data, but even more their expertise to face the many technical, analytical and substantial challenges that implies the study of the dynamic of life in dynamic environmental conditions. Results are already more than promising.

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