COHORT PROFILE

# Cohort Profile: Residential and non-residential environments, individual activity spaces and cardiovascular risk factors and diseases—The RECORD Cohort Study[†]

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## How did the study come about?

Over the last few decades, due to the geographic concentration of poverty, socio-economic disparities between cities and neighbourhoods have increased in considerable proportions in France,[1] with negative consequences for the daily lives of residents of disadvantaged neighbourhoods. Despite this increase in the geographic component of social inequalities, neighbourhood determinants of health have been largely neglected in French research until recently.[2,3]

In this context, it is critical to monitor territorial disparities in health between affluent and disadvantaged neighbourhoods and understand the processes through which neighbourhood poverty may influence health.[4–7] Such data are important for policymakers to identify priority targets to reduce socio-spatial disparities in health, even if socio-epidemiologists cannot make the a priori assumption that easily modifiable factors exist to substantially decrease health disparities without addressing fundamental inequalities in wealth or income and socio-spatial segregation itself.

The RECORD Cohort Study ('Residential Environment and Coronary heart Disease', www.record-study.org) was established in 2007–08 to investigate environmental determinants of territorial

[†]Additional information on the RECORD Cohort Study is regularly published at www.record-study.org.

disparities in health. In an urban health perspective,[8] the cohort was recruited in peri-urban and urban municipalities of the Paris metropolitan area, a geographically coherent territory with the largest territorial income disparities among French regions.[1]

The RECORD Study is coordinated by Inserm and Université Pierre et Marie Curie, and developed in collaboration with the Centre d'Investigations Préventives et Cliniques (IPC). The University of Montreal has joined the consortium since the second wave of the study.

## What does it cover?

The first aim of the study is to describe and quantify geographic disparities between socially advantaged and disadvantaged neighbourhoods in cardiovascular risk factors, related use of health-care services, cardiovascular disease prevalence and incidence, and other health outcomes. We hypothesize that socially disadvantaged populations from disadvantaged territories may be in double jeopardy, facing both a high incidence of risk factors and a poor health-care management of these conditions.

The second aim is to investigate associations between numerous neighbourhood dimensions and all of these outcomes,[4,7,9] and to assess whether such influences contribute to neighbourhood socio-economic disparities in health. Promoting an

integrative view of the environment, our goal is to account for the physical environment, the service environment, the social–interactional environment (i.e. social interactions in the neighbourhood) and the symbolic environment (i.e. representations and identities, sometimes positive, sometimes stigmatizing, associated with the different neighbourhoods).

The third aim is to examine whether and how individual mobility patterns, in shaping environmental exposures within activity spaces and as a source of physical activity,[10–13] contribute to the health disparities documented between social groups and territories.

The fourth aim is to explore the mediating mechanisms through which neighbourhood characteristics influence health outcomes.[14] The potential mediators of interest include health and health-care utilization behaviour; the cognitive, affective and relational experiences made in one's environment; psychological characteristics of participants; and the psycho-cognitive determinants of behaviour.[7]

Finally, our project has a strong methodological component and is a platform for developing strategies to improve the measurement of neighbourhood exposures and the modelling of their effects on health.[7,13,15,16]

## Who is in the sample?

The French National Health Insurance System for Salaried Workers offers a free medical examination every 5 years to all working and retired employees and their families. In the RECORD Cohort Study, we recruited without a priori sampling people who were getting these 2-h-long preventive medical check-ups, in four of the centres of the Centre IPC, located in the Ile-de-France region (Paris, Argenteuil, Trappes and Mantes-la-Jolie). The following occupational categories are not insured by the National Health Insurance System for salaried workers and could not be recruited: shopkeepers, craftsmen, farmers, salaried farm workers and self-employed occupations (lawyers, architects, etc.). However, in the Ile-de-France region (comprising the Paris metropolitan area), working and retired employees and their families (eligible for recruitment) represent almost 95% of the population.

Eligibility criteria were as follows: age 30–79 years; ability to complete study questionnaires and residence in one of the 10 (out of 20) administrative divisions of Paris or 111 other municipalities of the metropolitan area. These territories were selected a priori so as to include areas from contrasted socio-economic backgrounds and from peri-urban and urban areas.

Among people presenting at the health centres and who were eligible based on age and residence, 10.9% were not selected for participation because of linguistic or cognitive difficulties in filling out study questionnaires. Of the persons selected for participation, 83.6% accepted to participate and completed the

data collection protocol. Overall, 7290 participants were recruited between March 2007 and February 2008. The study protocol was approved by the French Data Protection Authority.

In a recent publication,[17] to address the fact that participants were recruited without a priori sampling and investigate possibly resulting participation-related selection biases for the neighbourhood–health associations of interest,[18] we investigated whether individual age, gender and education and multiple neighbourhood characteristics related to the socio-economic, physical, service and social–interactional environments were associated with the rate of participation of populations in the RECORD Study. As shown in Figure 1, a multi-level analysis indicated that there were geographic variations in the rate of study participation, with higher participation rates in the western part of the territory where the recruiting health centres are located. Adjusted regression models showed higher participation rates for males and educated people, for populations from high
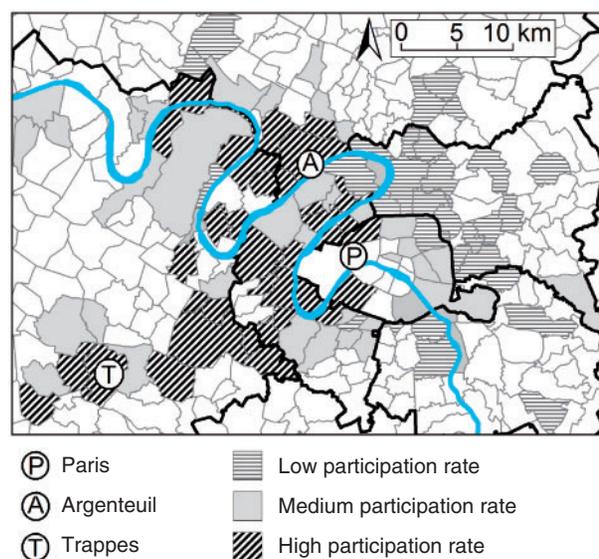


**Figure 1** Geographic variations between municipalities in the rate of participation in the RECORD Cohort Study, estimated from a multi-level model for study participation (only the central part of the RECORD Study territory is shown on the map; the fourth recruiting centre—Mantes-la-Jolie—is located outside the map). Based on the number of residents (from the 2006 population census) and number of participants per age group and sex per municipality, we estimated a multi-level Poisson model only adjusted for age and sex with people nested within municipalities. The map plots the municipality-level random effect of the multi-level model, interpretable as a log rate ratio for participation in each municipality compared with the whole study territory. High- and low-participation municipalities are areas with a rate ratio of participation respectively higher than 1.25 and lower than $1/1.25 = 0.80$ (compared with the whole study territory). Municipalities in white colour are not part of the pre-defined study territory

socio-economic status neighbourhoods (as reflected independently by neighbourhood income and dwelling values) and for residents of low building density areas (as reflected by the proportion of built-up surface and building height). Our recently published article[17] suggests that spatial variations in the participation rate biased the relationship of interest between neighbourhood socio-economic status and type 2 diabetes, but that we were able to correct some of these biases through the joint modelling of the neighbourhood determinants of both study participation and type 2 diabetes.[19]

# How often have they been followed up?

The participants were recruited in 2007–08. For the second wave of the RECORD Study, all of the participants are invited to have another health examination in 2011–12.

In addition to this actual follow-up, we also conduct a virtual follow-up of participants through different national administrative registers (see details below).

# What has been measured?

## Baseline examination

As summarized in Table 1, during the 2-h-long general health check-up, participants underwent biological and clinical examinations. The anthropometric and body composition assessment included among others, a measure of sitting height allowing the determination of leg length[20] and bioelectrical impedance analysis.[21]

As part of the health check-up, participants filled out questionnaires related to their socio-demographic status, health behaviour, family and personal medical history, treatments and psychological characteristics.[22,23] In addition, participants were invited to fill out a questionnaire developed for the RECORD Study. As detailed in Table 1, this questionnaire collected additional information on socio-economic status; physical activity over the previous week, including walking time to different destinations[24] inside and outside the residential neighbourhood; the affective, cognitive and relational experiences made by individuals in their residential environment and the current and previous residential addresses. Moreover, questions on different environmental dimensions allow us to derive environmental variables at the neighbourhood level. In this ecometric modelling approach,[25–27] the aggregation of answers of participants from the same neighbourhood to different survey questions on each environmental dimension is performed with specific three-level multi-level models that provide neighbourhood-level explanatory variables.

The baseline and previous residential addresses were accurately geocoded. Research assistants rectified all incorrect or incomplete addresses with the participants over telephone. Extensive investigations with local Departments of Urbanism were conducted to complete the geocoding. We determined a large number of variables related to the physical environment, service environment and social–interactional and symbolic environment, most often in local neighbourhoods centred on participants' residences.

Moreover, we accurately geocoded the supermarket where participants did most of their food shopping[28] based on supermarket brands and addresses, and retrieved supermarkets' business identification codes.

## Administrative data linkage

With support of the National Health Insurance Office for Salaried Workers, exhaustive health-care reimbursement data from the SNIIR-AM register (Système National d'Informations Inter-Régimes de l'Assurance Maladie, National Information System of the Health Insurance Offices) are merged at the individual level to the RECORD Cohort Study on an yearly basis (so far from 2006 to 2010). The data include detailed information on all the health professionals visited, treatments reimbursed, examinations and biological tests and hospitalizations. We are able to geolocate at the street address level each health-care provider visited by the participants over the years, allowing us to delineate their health-care-seeking behaviour activity space.

With support from the National Old-age Insurance Office, for each participant, we obtained for the entire professional career the yearly income and business identification codes of the three main employers per year. Business codes allow us to geolocate places of work of participants.

Information on vital status and causes of death will be linked to the database.

## Second wave of the study

Since February 2011, all study participants are invited to another 2-h-long health check-up at the Centre IPC. The examination includes all medical assessments performed during the baseline examination. Moreover, the tricipital skinfold and arm circumference[29] are measured to obtain information on body muscle mass.[30,31]

Virtually all studies on neighbourhood and health have focused exclusively on the residential environment.[7,11,12,32] A particularly innovative aspect of the second wave of the study is the assessment of each participant's network of usual destinations (as illustrated in Figure 2 for three different study participants). Such information on the usual activity space will be used to examine whether effects of residential neighbourhood characteristics are stronger for people with an activity space primarily restricted to their residential neighbourhood. Most importantly, we will

**Table 1** Types of data available in the RECORD Cohort Study

| Domains | Variables or dimensions |
|---|---|
| Health data | Medical questionnaire (personal and family history of health conditions, self-rated health, angina pectoris and intermittent claudication, women's health, etc.) (W1 and W2) |
| | Fasting blood and urine samples (W1 and W2) |
| | ECG and blood pressure (W1 and W2) |
| | Body mass index and waist and hip circumferences (W1 and W2) |
| | Body composition through bioelectrical impedance (W1 and W2) |
| | Tricipital skinfold and arm circumference (W2) |
| | Sitting height (W1) |
| | Spirometry (W1) |
| | Dental examination (W1 and W2) |
| | Hearing and visual tests (W1 and W2) |
| | Hospitalization data over 4 years (SNIIR-AM) |
| Demographic and socio-economic variables | Age, sex and cohabitation status (W1 and W2) |
| | Country of citizenship (W1 and W2) |
| | Countries of birth of the participant, her/his parents and her/his grandparents (W2) |
| | Personal education level and parents' education level (W1 and W2) |
| | Occupation, employment status, work conditions (W1 and W2) |
| | Household income, health insurance, housing tenure (W1 and W2) |
| | Lifetime and current financial difficulties (W1 and W2) |
| | Yearly individual income for the whole occupational career (CNAV) |
| | Old-age pension of retired participants (CNAV) |
| | Standard of living, ownership of material goods and wealth (W1 and W2) |
| | Family properties during childhood (W2) |
| Health behaviour and related psychological, cognitive and attitudinal factors | Smoking, alcohol, tea and coffee consumption; usual physical activity (W1 and W2) |
| | Occupational physical activity over 7 days (W1) |
| | Recreational physical activity over 7 days (W1 and W2) |
| | Recreational and utilitarian walking over 7 days (W1 and W2) |
| | Sedentary behaviour over 7 days (W2) |
| | Consumption of fruits and vegetables and fast foods (W1) |
| | Mediterranean diet score[36] (W2) |
| | Circumstances of food intake (W2) |
| | Exhaustive data on health-care utilization over 4 years (consultations, treatments, biological tests) (SNIIR-AM) |
| | Psycho-cognitive and attitudinal variables related to hypertension (W2) |
| |   Knowledge of hypertension |
| |   Self-reported systolic blood pressure |
| |   Blood pressure control strategies |
| |   Attitudes towards anti-hypertensive medications |
| | Psycho-cognitive and attitudinal variables related to weight status (W2): |
| |   Knowledge related to diet, nutritional recommendations and obesity |
| |   Perceived body weight, ideal body weight and range of acceptable weight |
| |   Perceived change in weight since baseline |
| |   Own weight levels perceived as detrimental to health or fitness |
| |   Perceived waist circumference |
| |   Weight-related locus of control |
| |   Weight-related self-efficacy |
| |   Attitudes towards obesity in the neighbourhood (stigmatization) |
| |   Intentions, motivations and efforts related to weight control |
| |   Strategies for weight control, propensity to set weight targets |
| | Psycho-cognitive and attitudinal variables related to health (W1): |
| |   Priority given to health |
| |   Internal and external locus of control |
| |   Attitude towards prevention |
| | Sleeping time, sleep quality, daytime sleepiness (W2) |
| Psychological health | QD2A depression questionnaire[22] (W1 and W2) |
| | Perceived stress scale[23] (W1 and W2) |

(continued)

**Table 1** Continued

| Domains | Variables or dimensions |
|---|---|
| Affective experience in the residential neighbourhood | Attachment to the neighbourhood (W1) <br> Feeling of residential captivity (W1) <br> Feeling of social relegation (W1) <br> Feeling of insecurity (W1) <br> Neighbourhood as a source of stress or depressive feelings (W1) |
| Cognitive experience in the residential neighbourhood | Self-reported presence of parks, sport facilities, other services, etc. (W1) <br> Perceived evolution of the neighbourhood standard of living (W1) |
| Relational experience in the residential neighbourhood | Family, friends or acquaintances in the neighbourhood (W1) <br> Social support from the neighbours (W1) <br> Conflict with neighbours (W1) <br> Hostility or mistrust towards the neighbours (W1) <br> Participation in associations in the neighbourhood (W1) <br> Victimization in the neighbourhood (W1) |
| Mobility and non-residential environments | Primary supermarket for food shopping (spatial coordinates and characteristics) (W1) <br> Health-care providers over 4 years (date and type of service and spatial coordinates) (SNIIR-AM) <br> Place of work (yearly information, spatial coordinates) (CNAV) <br> Geocoding of the network of usual destinations (places of residence, places of work, supermarkets, outdoor markets, bakeries, butcher shops, fruit and vegetable shops, fish stores, cheese merchants, specialized food stores, tobacco shops, bank, post offices, hairdresser, transportation stations, sport facilities, entertainment facilities, places for regular cultural, community or spiritual activities, places to which relatives are taken and places where people are visited) (W2) <br> Perceived delimitations of the residential neighbourhood (W2) <br> Attitudes towards mobility and distance (W2) <br> Transportation habits (W2) <br> Perceived barriers to mobility (W2) <br> Residential preferences at the previous move (selective migration) (W2) |
| Neighbourhood-level variables | Residential address at baseline (2007–08), previous residential address, residential history after 2007–08 (spatial coordinates) <br> Numerous socio-demographic or socio-economic variables aggregated in various ego-centred or administrative areas <br> Numerous variables on the physical and service environment defined with a geographic information system <br> Different ecometric variables aggregating participants' perceptions <br>   Physical decay of the neighbourhood (W1; improved in W2) <br>   Greenness of the environment (W1; improved in W2) <br>   Aesthetics and pleasantness of the neighbourhood (W2) <br>   Pedestrian-friendly environment/walkability (W2) <br>   Healthiness of the food environment (W2) <br>   Delinquency/criminality/violence (W1; improved in W2) <br>   Social anomy (W2) <br>   Social cohesion (W1; improved in W2) <br>   Stigmatization of the neighbourhood (W1; improved in W2) |

W1, first study wave; W2, second study wave; SNIIR-AM, Système National d'Informations Inter-Régimes de l'Assurance Maladie (National Information System of the Health Insurance Offices); CNAV, Caisse Nationale d'Assurance Vieillesse (National Old-age Insurance Office).

develop novel measures of exposure to geographic life environments that take into account the various places participants experience during their regular activities.[12] As illustrated in Figure 2, participants' regular destinations are assessed through the VERITAS application ('Visualization and Evaluation of Regular Individual Travel destinations and Activity Spaces'), a web-based computer tool integrating interactive mapping capacities based on Google Maps that allow survey technicians to search for and geolocate participants' activity locations (see details of destinations in Table 1). In addition, participants are invited to draw the perceived boundaries of their residential neighbourhood,[33] as illustrated in Figure 2. This evaluation is completed by survey questions on the attitudes towards distance and mobility.

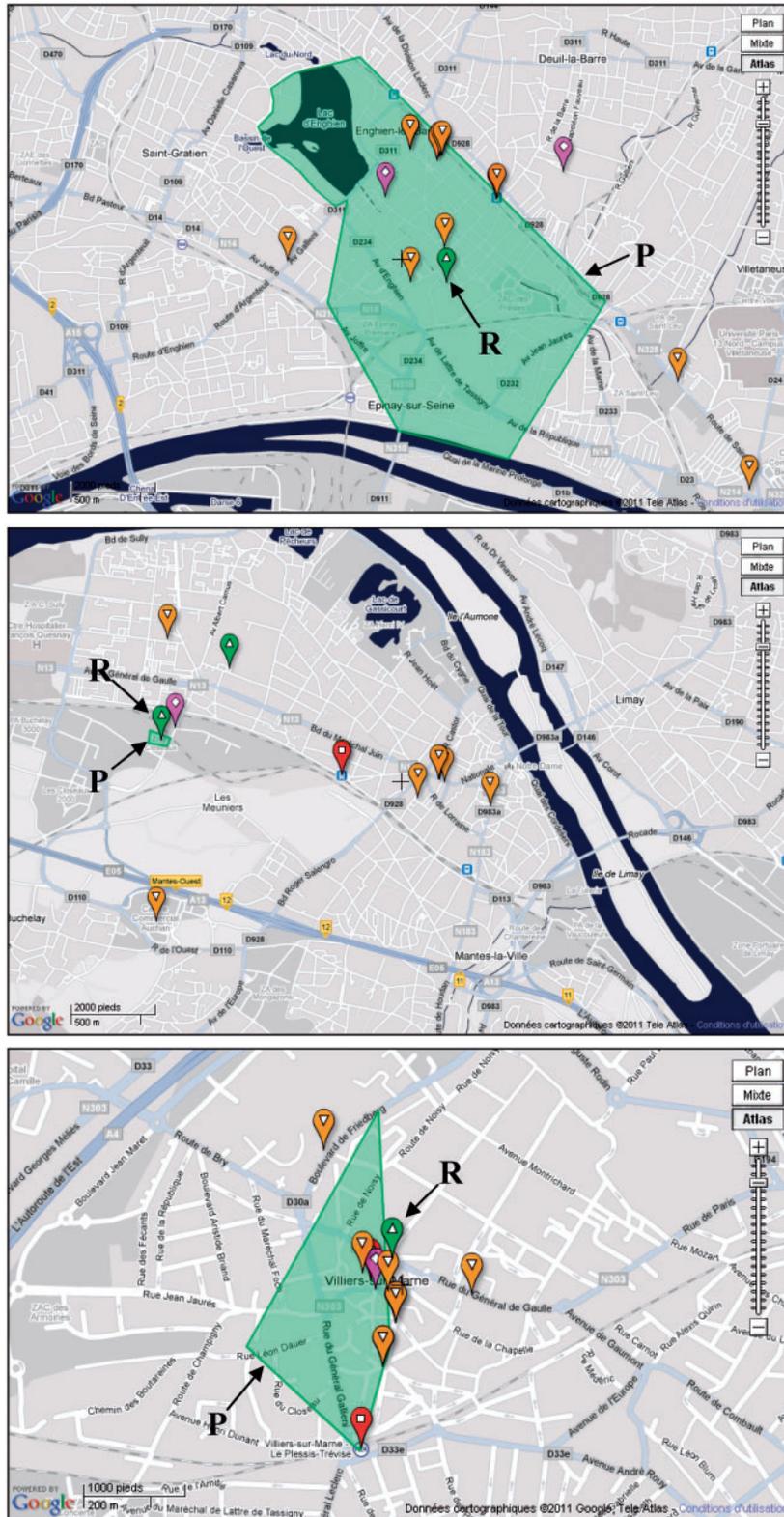Both self- and interviewer-administered questionnaires are proposed on PC tablets that allow filtering

**Figure 2** Assessment of the perception of the boundaries of the residential neighbourhood and geocoding of the network of regular destinations of participants through the VERITAS application: examples for three different participants (R for the residence and P for the perceived neighbourhood on the maps). As an example, the destinations geocoded on the first map include, from the left to right, a hairdresser, a gym, a post office, another hairdresser, a cheese merchant, a fish store, a fruit and vegetable shop, a butcher, an outdoor market, a bakery, the place of residence, a train station, another bakery, a jogging site, a language school, a supermarket and another fruit and vegetable shop. The place of residence of the participant's parents was also geocoded but is outside the map

of questions, immediate data validation and tests of coherence, and additional tests after each day of data collection that are difficult or impossible to perform through automatic procedures (e.g. comparison of the survey administration behaviour of the two technicians, verification of the quality of street addresses, verification of the use of the 'unable to answer' category in survey questions). A report edited after each day of data collection is discussed on a daily basis between the operations coordinator and the survey technicians in order to improve the quality of the data collection process.

Many questions are devoted to the psycho-cognitive correlates of body weight and shape (Table 1) to test the hypothesis that disparities in weight status between affluent and deprived neighbourhoods may be partly explained, beyond environmental factors, by differences in perceptions, values and attitudes related to body weight.[34,35] Comparable, but less detailed data are also collected for hypertension.

Numerous survey questions (approximately 50) are related to the residential neighbourhood, with different items for each environmental dimension in order to create psychometrically and ecometrically sound environmental variables at the neighbourhood level (see details in Table 1).[25,27] As ecometric modelling requires a certain number of participants per neighbourhood to provide reliable neighbourhood-level variables, in the second wave of the study, we recruit new participants to compensate for those moving out of the study territory and to increase the rate of participation in areas where we did not initially recruit enough participants (independent of this additional recruitment, we follow all of the initial participants, even if they moved out of the study area).

The other domains covered by the survey include: dietary habits;[36] walking and physical activity with survey questions comparable with those of the first wave of the study; sedentary behaviour; transportation habits; sleep; additional socio-economic data; demographic data including country of birth of individuals, their parents and grandparents; and residential preferences at the time of the previous move (in order to adjust for selective migration).[37,38]

## What is attrition like?

The indications we have so far about the commitment of the cohort is encouraging. Every 6 months, we send a newsletter to all study participants (downloadable from www.record-study.org), which allows us to identify through non-delivered mails participants who have recently moved. As of January 2011 (6 months after sending the preceding letter), we were still looking for the new residential address of 181 participants. Overall, since recruitment, 3993 participants were contacted over telephone to complete aspects of the questionnaire or for the follow-up of residential addresses. Eleven participants so far have expressed their desire to definitely withdraw from the study.

As of 16 June 2011, 419 of the initial participants (5.7% of the cohort) and 403 new participants (see rationale above), i.e. 822 participants overall, have been surveyed in the second wave of the study (that started in February 2011).

## What has it found?

Apart from the aforementioned work on neighbourhood determinants of study participation,[17] we investigated or are investigating the relationships between neighbourhood environments and cardio-metabolic risk factors.

One study[39] documented relatively strong associations between neighbourhood socio-economic status (especially neighbourhood education) and body mass index or waist circumference. Propensity score-matching techniques revealed that these adjusted neighbourhood–health associations could be estimated without excessive model extrapolations (a controversial aspect in the literature[40]).

A subsequent study showed that, after adjustment for individual/neighbourhood socio-economic characteristics, body mass index and waist circumference increased with decreasing densities of factors related to the physical and service environment (e.g. densities of buildings, restaurants, fruit and vegetable shops, local destinations, etc.). Since these neighbourhood characteristics are strongly correlated with each other, we are developing innovative matching strategies to assess whether the different associations can be separated from each other.

Another study documented increased blood pressure levels in neighbourhoods with a low average education, after individual-level adjustment.[14] Mediation analyses indicated that body mass index and waist circumference statistically explained about half of the relationship between neighbourhood education and blood pressure.

In another analysis on resting heart rate, sensitivity analyses were conducted to investigate the spatial scale on which neighbourhood socio-economic variables were associated with resting heart rate, using census data geocoded at the building level to define neighbourhood variables within circular areas of different radiuses.

Environmental determinants of utilitarian and recreational walking were also examined. Analyses suggest that, after adjustment, different characteristics of the physical, service and social–interactional environments were associated with walking, for example the density of services with utilitarian walking and the presence of green spaces with recreational walking.

Most previous studies on the food environment and obesity have characterized the food environment in the residential neighbourhood of participants, even if many people do not shop in their

own neighbourhood. Taking a different perspective, looking at the supermarket where participants did most of their food shopping, we found that participants who shopped in the same supermarket had a more comparable body mass index and waist circumference than participants who shopped in different supermarkets. Moreover, participants who shopped in certain supermarket chains, and particularly in hard discount supermarkets, had a higher body mass index and larger waist circumference, especially if they had a low personal education level.

Finally, our ongoing studies also consider, among other aspects, health-care utilization related to cardiovascular risk factors, tooth decay, spirometry, disparities in exposure to road-traffic noise[41] and resulting associations with hypertension, etc.

All publications related to the RECORD Study can be downloaded at www.record-study.org.

## What are the main strengths and weaknesses?

A key strength of the RECORD Study, which is specifically devoted to neighbourhood effects on health, is its ability to accurately characterize the residential environment and related individual experiences and to geolocate different non-residential environments related to the workplace, health-care utilization services, primary supermarket for food shopping and (in the second wave of the study) to the complex network of usual destinations of participants.

Clearly, the primary study limitation is that participants were recruited without a priori sampling. As discussed in detail above and investigated elsewhere,[17] resulting selective participation in the study may bias the neighbourhood–health associations of interest, if not corrected during the analyses. Moreover, we could not recruit people who do not speak French sufficiently well to fill the self-administered questionnaires and interact with the survey technicians to perform the other study evaluations. Such exclusions may lead us to underestimate neighbourhood socio-economic disparities estimated for most (but not necessarily all) health outcomes.

The large territory investigated (over 1900 neighbourhoods each comprising approximately 2000 residents) is both a strength and a weakness of the study: a strength because it offers varied combinations of environmental characteristics allowing us to disentangle their associations with health, a limitation because it makes it difficult to obtain objective assessments of residential neighbourhoods through direct observation based on audit tools.[42]

Moreover, the study does not yet include precise information on the daily spatial trajectories or travel patterns assessed with GPS technologies,[43–45] a shortcoming that we are currently trying to address

through the development of the RECORD GPS Study for a subsample of the participants. Finally, another limitation relates to the lack of precise data on dietary behaviour, even if the second wave of the study does include short questionnaires on this topic.

## How can I collaborate? Where can I find out more?

Based on our agreement with the study participants, we are able to release the data to external researchers only in the context of collaborations with the study group. Inquiries related to the use of RECORD Study data are welcome and will be reviewed with interest. More information on the RECORD Cohort Study is provided at www.record-study.org.

and allowed us to access to relevant geographical data (with special thanks to Pascale Breuil and Jean-Luc Lipatz). We thank Geoconcept for allowing us to access to the Universal Geocoder software. We are grateful to Alain Weill from CNAM-TS and to Vincent Poubelle and Isabelle Bridenne from CNAV for their support in merging the health-care consumption data from the SNIIR-AM and the data on professional careers to the RECORD database. We also thank CNAM-TS and the Caisse Primaire d'Assurance Maladie de Paris (CPAM-P, France) for helping make this study possible.

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