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Residential buffer, perceived neighborhood, and individual activity space: New refinements in the definition of exposure areas – The RECORD Cohort Study

Camille Perchoux [a,b,c,d,*], Basile Chaix [a,b], Ruben Brondeel [a,b,e], Yan Kestens [c,d]

[a] Sorbonne Universités, UPMC Université Paris 06, UMR_S 1136, Institut Pierre Louis d'Epidémiologie et de Santé Publique, 75012 Paris, France
[b] INSERM, UMR_S 1136, Institut Pierre Louis d'Epidémiologie et de Santé Publique, F-75012 Paris, France
[c] Département de médecine sociale et préventive, Université de Montréal, Montreal, QC, Canada
[d] Centre de Recherche du Centre Hospitalier Universitaire de Montréal (CRCHUM), Montreal, QC, Canada
[e] Ecole des Hautes Etudes en Santé Publique (EHESP), 35043 Rennes, France

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ABSTRACT

Neighborhood effects on health have been widely investigated; yet the definition of neighborhoods is usually arbitrary. This study analyses how disparities in environmental exposure according to urbanicity vary when considering a home-centered network-buffer, the perceived residential neighborhood, or the activity space. Exposures to the density of destinations and proportion of green space were compared for three spatial definitions of exposure areas, overall and stratified by urbanicity of the residence. Environmental exposure levels and gradients by urbanicity were found to vary depending on the spatial definition of the exposure area.

1. Introduction

The previous decades have witnessed a renewed focus on the effect of environmental factors on population health. More recently, technological developments in the collection of locational data and advances in spatial analytic methods have opened up new possibilities to observe and analyze space-time exposures and go beyond the commonly used residential neighborhood (Chaix, 2009; Diez Roux, 2001; Kerr, 2013; Pickett and Pearl, 2001; Riva et al., 2007). Yet, such advances call into question which environments or exposure areas are relevant.

Commonly used definitions of the exposure area in place and health studies include administrative neighborhoods (i.e. census tracts, postal codes) and residence-centered circular or street network buffers areas (Leal and Chaix, 2011). More recently, participants' perceived residential neighborhoods have been proposed as an alternative (Chaix et al., 2009; Vallée et al., 2014; Vallée and Shareck, 2014). The perceived residential neighborhood relies on the participants' cognitive construct of their neighborhood (Coulton et al., 2001; Guest and Lee, 1984). Substantial differences in the measures of environmental exposures (park availability, commercial physical activity facilities, restaurants, and food stores) were observed between the residential and the perceived neighborhood (Colabianchi et al., 2014).

These definitions of the exposure area are however exclusively focused on the residential neighborhood, even if individuals are mobile and get exposed within a variety of environments (Chaix et al., 2009; Matthews, 2011; Matthews and Yang, 2013; Perchoux et al., 2013; Shareck et al., 2014a, 2014b). Exposure outside the residential neighborhood might differ from exposure within the residential neighborhood (Basta et al., 2010; Inagami et al., 2007; Kestens et al., 2012, 2010; Lipperman-Kreda et al., 2015; Mason, 2010; Setton et al., 2011; Zenk et al., 2011). Most studies accounting for exposure beyond the residential neighborhood have used the concept of activity space - i. e. the set of daily visited activity locations (Golledge and Stimson, 1997) - to operationalize personal areas of exposure.

Despite the growing use of the concept of activity space, few studies were able to report how much residential and non-residential environmental exposures differ. For instance, a study based on the tracking of participants with GPS receivers in the Seattle area observed that more than 90% of the built environment

* Corresponding author at: INSERM, UMR_S 1136, Institut Pierre Louis d'Epidémiologie et de Santé Publique, 27 rue de Chaligny, 75012 Paris, France.
E-mail address: camille.perchoux@gmail.com (C. Perchoux).

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measures differed between residential and non-residential locations (Hurvitz and Moudon, 2012). Similar differences were found elsewhere (Basta et al., 2010; Crawford et al., 2014; Kestens et al., 2010; Lipperman-Kreda et al., 2015; Shareck et al., 2014b; Zenk et al., 2011). Except one study (Crawford et al., 2014), these published reports have paid no attention to the difference in built environment measures between the perceived residential neighborhood and the broader activity space.

Whereas reducing measurement error in exposure measures has been recommended, accounting for the non-residential places visited does also require caution. Concerns about confounding related to the selective daily mobility bias have been raised (Chaix et al., 2012, 2013; Kerr, 2013; Kestens et al., 2012). This bias arises when "measures of accessibility to given environmental resources are also determined from the locations that were specifically visited to use the corresponding resources" (Chaix et al., 2013, p.48). To overcome this potential source of confounding, Chaix et al. suggested to either exclude the activity places visited related to the behavior of interest when measuring exposure or to only retain major activity locations (Hägerstrand, 1970) corresponding to constrained activities that cannot be rescheduled or carried out in another location (Chaix et al., 2012). Such a selection of activity places could provide measures of exposure that mitigate the selective daily mobility bias.

2. Objectives

This study aimed to investigate how environmental exposures vary according to the spatial definition of the exposure area, using two built environment characteristics conducive to walking, i. e. the density of destinations and the proportion of green spaces (Chaix et al., 2014; Sugiyama et al., 2012). A first objective was to evaluate how exposure measurements varied depending on whether exposure areas were defined as i) street-network residential buffers, ii) self-reported perceived residential neighborhoods, or iii) activity space areas. Variations in exposure measures according to the urbanicity of the residence were compared according to these three spatial definitions. A second objective was to evaluate the selective daily mobility bias. To do so, we assessed whether activity space exposure measures and gradients differed when using either i) all reported destinations (full activity space) or ii) only destinations unrelated to the exposure of interest (truncated activity space, theoretically reducing the selective mobility bias).

3. Methods

3.1. Population

The study relies on the second wave of the RECORD Cohort Study (Chaix et al., 2011). Overall, 5542 participants were surveyed without *a priori* sampling (convenience sample) between February 2011 and October 2013 during preventive health checkups conducted by the Center d'Investigations Préventives et Cliniques (IPC) in Paris. Participants were living in one of 10 (out of 20) administrative divisions of Paris or 111 *a priori* selected municipalities of the Ile-de-France region in 2011–2013 or had been living in these municipalities in 2007–2008 during the recruitment of the cohort (some of them had moved to other places since then). In addition to the RECORD Study inclusion criteria (residence and age 30–79 in 2007–2008), the present analyses retained only participants residing in the Ile-de-France region who reported at least one non-residential destination. The entire data collection protocol was approved by the French Data Protection Authority. All participants had to sign a consent form to enter the study.

3.2. Activity space data

Self-reported activity places were geocoded using the VERITAS application ('Visualization and Evaluation of Regular Individual Travel destinations and Activity Spaces') (Chaix et al., 2012). The VERITAS application is a web-based computer tool that integrates Google Maps interactive mapping functionalities, and allows users to self-report activity locations and perceived spaces (Chaix et al., 2012, p. 441). With help of a survey technician, participants geocoded their regular activity locations, and provided the frequency of visit to these locations (coded as at least once per month, once per week, or more often). Participants were successively asked to locate their places of residence, workplaces, services (supermarket, outdoor market, bakeries, butchers, fruit and vegetables shops, specific food stores, tobacco/press shops, bank, post offices, etc.), transportation stations used from home, recreational activities (sports facilities, place of cultural activity, place of labor organization, political, or religious activity), and social activities (place of social activities, place where participants take relatives, place where participants visit relatives). The participants were further asked to draw the boundaries of their perceived neighborhood. More details on the VERITAS data collection in the RECORD Study can be found in Chaix et al. (2012).

3.3. Spatial definitions of exposure areas

'Classical' residential exposure area: A 1000 m street network buffer was defined around each participant's home. This distance, previously used in place and health research studies, corresponds to a 15 min walk (Brondeel et al., 2014; Chaix et al., 2014; Frank et al., 2005; Karusisi et al., 2013; Troped et al., 2010; Villanueva et al., 2014).

Perceived residential exposure area: The perceived residential neighborhood was obtained from participants' self-report drawing the perceived boundaries of their neighborhood using VERITAS.

Activity space exposure areas: Activity space exposure areas were defined using buffers around activity destinations. A full activity space included all regular activity places reported in VERITAS. In order to control for the selective daily mobility bias, a truncated activity space was further defined, by removing the activity places specifically referring to the activities related to the exposure of interest. For example, the spatial accessibility to services was measured from all activity locations reported except from services themselves. It means that only relatively constrained and fixed destinations were retained, including the residence, the workplace, the regular bank, and the places where participants take relatives. The spatial accessibility to green spaces was measured from all activity locations except from sport activity destinations, as such destinations include the green and open spaces that were specifically visited to exercise.

For both definitions of the activity space, street network buffers were constructed around each reported activity location. Because the degree of exposure plausibly depends on the time spent at the location or on the frequency of visit, varying buffer radiuses were used depending on the types of activity locations. As we had no data on the time spent around each location, it was decided to use larger buffers for major activity locations such as the residence and the workplace (1000 m), intermediary buffers for recreational/social activity locations (500 m), and smaller buffers for service activity locations (200 m) (Chaix et al., 2012). This hierarchy of buffer sizes has been used previously in a study examining built and social environment influences on recreational walking (Perchoux et al., 2015). Fig. 1 illustrates the residential buffer, perceived neighborhood, and full activity space as areas of exposure.