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INVITED COMMENTARY on the manuscript, “The ‘residential’ effect fallacy in neighborhood and health studies: formal definition, empirical identification, and correction”:

COMMENTARY TITLE: Is a person’s place in the home (neighborhood)?

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The notion that space and place provide texture to the distribution and determinants of population health is baked into the DNA of many epidemiologists. Young epidemiologic scholars are socialized through the telling of our ‘origin myth’ of John Snow’s map illustrating the cluster of cholera cases around the Broad Street Pump. Despite this early example, the perceived value of place as a causally informative dimension in epidemiology has waxed and waned. The contemporary strain of ‘neighborhood effects’ epidemiology borrows from urban sociology in understanding places, such as residential neighborhoods, as facilitators or constraints on health-relevant exposure and opportunity^{1,2}. The adoption of multilevel regression techniques in the 1990’s and 2000’s gave epidemiologists important tools for beginning to operationalize, albeit simplistically, the complex person–place relations suggested by ecosocial theories³. However, the resulting surge of neighborhood effects epidemiology research was met by important concerns about potential for biased estimates resulting from unmeasured confounding, non-random selection of individuals into neighborhoods, and non-positivity^{4,5}. While some read these critiques as the end of the line for a practicable neighborhood effects epidemiology, others continued to push for improved designs, measures, and clarity of causal assumptions^{6–8}. In the current issue of *Epidemiology*, Chaix, Duncan, Vallée, Vernez-Moudon, Benmarhnia, and Kestens continue this tradition, describing a plausibly ubiquitous, but rarely acknowledged, source of bias in conventional neighborhood effects research and, importantly, proposing design and analytic approaches to evaluate and reduce this bias⁹.

The conventional neighborhood effects design conceives of individuals nested within, and contained by, discretely bounded local residential areal units. The putative exposures of interest are therefore attributes of this local neighborhood. The ‘residential’ effect fallacy described by Chaix et al., is a form of confounding arising from a dependency between

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Conflicts of Interest

None.

causally important *non-residential* factors and the *residentially* defined exposure of interest. In their example, Chaix et al. ask whether the density of shops and services in the residential neighborhood is causally associated with an individual's probability of choosing walking as a mode of transport in the course of a day. The confounding is produced from the intersection of two processes: a) individuals routinely move outside the bounds of their 'residential' neighborhood, thus experiencing 'non-residential' as well as 'residential' exposure to service density; and b) territorial 'macro-organization' (e.g. patterns of urban development) produces geographic clustering of service density. As a result, an estimated association between residential service density and propensity to walk that ignores the contribution of non-residential service density will be biased away from the null. In addition to developing the mechanistic and conceptual basis for the 'residential' effect fallacy, Chaix et al. empirically document the magnitude of the potential bias. They do so by leveraging the rich spatiotemporal mobility data of participants in the French RECORD-GPS cohort study to quantify trip-specific detail, including multiple daily trip origins and destinations in residential versus non-residential places. These data make possible the quantification of the *residential* exposure–outcome association adjusting for *non-residential* exposures.

We largely agree with their assessment that the conventional practice of making inference about residential environments without accounting for the non-residential exposures of individuals is causally fraught, and we appreciate their illustration of this problem and proposals for design and analytic approaches to address the bias. We wonder, however, whether improved analysis of conventional designs is sufficient to advance consequentialist neighborhood effects research. As Muntaner suggested, perhaps it is not just better methods but also better theory that is needed¹⁰. Based on other writings by many of these same authors, we suspect Chaix et al would not disagree^{11–13}.

The problem described by Chaix et al. hinges largely on the conventional implementation of neighborhood effects studies which privileges residential space typically operationalized at a single arbitrary spatial scale such as census geographies, ignores routine spatial behavior within and outside of that residential unit, and treats the macro determinants of spatial stratification as an unknowable nuisance rather than a causally important feature of the urban ecosystem. Advances to address the limitations of conventional approaches should indeed address methodologic concerns to minimize bias but do so within the context of greater understanding of the complex conceptual and theoretical mechanisms that underpin the relationships between people and place.

Home sweet home

Most urban sociospatial epidemiology research focuses solely on *residential* environments—the local area around the place we sleep at night. This monocular view of place persists for both conceptual and practical reasons. From a theoretical perspective, the place one lives represents a socially and culturally meaningful contributor to the identity, social networks, and social capital of individuals and families¹, and may deterministically define eligibility for services such as schooling, and responsibilities such as taxation. From a practical point of view it is also undeniable that much neighborhood effects research privileges 'residence' out of convenience: residential address or postal code is the only geographic location

available in many data sources. However, the uncritical adoption of a single arbitrary scale dichotomizing the world into residential versus non-residential space fails to engage with mechanistic and relational thinking about how places and persons interact¹⁴.

Recent findings from one of the most prominent examples in the ‘neighborhood effects’ literature, Moving to Opportunity, illustrate the importance of scale, and the potential problems associated with dichotomizing residential and non-residential spaces¹⁵. While participants who moved to a neighborhood (measured as census tracts) with less concentrated disadvantage did not experience improvements in their mental health, participants who moved to a neighborhood with less concentrated disadvantage that was also *surrounded* by neighborhoods with less concentrated disadvantage did experience improvements, suggesting that the mechanisms or processes through which place affects mental health are not best captured at the scale of a typical census tract.

Chaix et al. acknowledge that their intervention was not designed to replicate an entirely ‘plausible real-world intervention’, yet the messy question of scale remains. In their analysis, Chaix et al. use 1-kilometer street-network buffers around each individual’s home to define their residential environment. The implied intervention they seek to proxy is therefore a change in the service density within that 1-km buffer of home. But is this the optimal spatial scale at which service density would affect decisions to walk at any point during the day? And would a real-world policy intervention implement change at that scale? Efforts to modify service density might use zoning, urban renewal tax districts, and other planning tools to enhance walkability and service density in sub-regions of the entire city, thus affecting not just the 1,000 meters around one’s home, but a much broader swathe of urban space. There is no single correct spatial scale for all questions of interest, making thoughtful consideration of theoretical and mechanistic processes relevant to the question at hand all the more important¹⁶. Ideally investigators will follow the lead of Chaix et al. in measuring residential location as a discrete point, thus permitting alternative assignments or definitions of ‘what is local’. However, even in the absence of street-level geocodes, many neighborhood effects studies could employ multi-scale sensitivity analyses to compare effect estimates for alternate definitions of home, and in so doing gain understanding of how relationships vary with scale¹⁷.

Living with spatial polygamy

The problem with dichotomizing space into residential versus non-residential is not only an issue of scale, but also one of heterogeneity in individual spatial behavior. People tend towards what Matthews termed ‘spatial polygamy’¹⁸, or the simultaneous membership in and exposure to multiple places; in other words residential locations are not the sole, and perhaps not even the most important, places where individuals experience health-relevant exposures or opportunities. Chaix et al. provide clear evidence in their illustration of service density and walking that individual’s exposure to non-residential service density matters. Cumulatively, in fact, non-residential exposure matters more than residential exposure. From this, Chaix et al. draw their “somewhat paradoxical conclusion” that, to understand residential effects, we must know about non-residential exposures. If the pure residential effect is of primary interest this is true; but less attention is given to the flipside—rather than

controlling for the effect of non-residential exposures, should their clear importance prompt us to look *beyond* the residential neighborhood?

Further integrating the concept of ‘spatial polygamy’ into the study of neighborhood effects may allow for a much richer story of the interaction between people and place to emerge. Such an approach necessitates a move away from the residential vs. non-residential dichotomy, toward consideration of the many places people experience in their daily lives. The spatial mobility data collected by Chaix, et al permitted the illustration of bias that arises from the conventional approach, but more significantly offers evidence for the importance of individual spatial behavior in understanding exposure intensity and duration, and exploring heterogeneity in the association between exposures and outcomes. Elsewhere, these same authors have drawn attention to the importance of non-residential space in health studies^{19,20}. Future investigators may extend Chaix et al.’s approach allowing place effects on health to be decomposed into the various environments a person encounters—home, work, and school for example—providing insight into where and when interventions may be most effective. Further, such an approach allows for the possibility that different environments, including the residential neighborhood, hold different weight for different people, depending on a variety of factors including age, socio-economic status, gender, and race, as well as the health behavior or outcome under study.

The engines of spatial stratification

Tobler’s First Law of Geography states that, while “everything is related to everything else, ...near things are more related than distant things.”²¹ Fundamental to the biased estimate of residential exposures and health behavior described by Chaix et al., is the presence of spatial autocorrelation or clustering of place-based attributes in space, consistent with Tobler’s law. This macro-organization of geographic space may be shaped by differences in population density and land use between urban, suburban, and rural areas. Alternatively, the spatial dependency among places may be a result of racial or economic residential segregation, which itself is a non-random process reflecting the exercise of political, social, and economic power to spatially stratify places and populations²². Whether this dependency between places is a biasing nuisance to be adjusted away or a causal process of interest in its own right depends on the theory of place and health underlying the question at hand. It is not apparent how results might have differed if the spatial autocorrelation in service density in Paris Ile-de-France, where the RECORD-GPS cohort was assembled, was substantially larger or smaller. However, an extension of neighborhood effects research that seeks to understand how the macro-organizing processes of regions affect neighborhood experiences is conceivable. A recent study in the U.S. demonstrated that the association between neighborhood poverty and self-rated health varied not only by individual race, but also by the degree of metropolitan residential racial segregation²³. By employing a novel design in which individuals are nested within neighborhoods, which are further nested within an adequate number of distinct metropolitan regions, it was possible to observe and account for the degree to which regional segregation ‘sorted’ Blacks into high-poverty neighborhoods, while also demonstrating that the degree of regional segregation modified the association between local neighborhood poverty and self-rated health.

‘The reports of my death are greatly exaggerated’

Chaix et al. make the latest of several important critiques of conventional approaches to neighborhood effects epidemiology. Their intent is not to declare the death of neighborhood effects, but instead to drive the field to more rigorous and thoughtful design and analysis. Their illustration is instructive and clear, but we think they would agree that the approach can only take us so far in understanding how place, residential or otherwise, affects health. As Sharkey and Faber offer, we no longer need to ask *if* neighborhoods matter, but instead must grapple with ‘where, when, why, and for whom’ neighborhoods matter.¹⁶ Bias is of critical importance, but understanding the structure of bias—what is or is not a confounder or a selective force—is completely dependent on the causal question of interest. To define these questions, epidemiologists must integrate relevant theory with the design, measures, and analysis of place-based research.

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Biography

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