“Contextualizing Context”: Reconciling Environmental Exposures, Social Networks, and Location Preferences in Health Research

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Title:

‘Contextualising context’: Reconciling environmental exposures, social networks, and location preferences in health research

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Abstract Paragraph (150 words)

Significant advances in environmental or neighborhood effects have been made in the last decades. Specifically, conceptual and methodological developments have improved our consideration of spatial processes, shifting from a residential-based view of context to a more dynamic activity space and daily mobility paradigm. With an increasing capacity to collect high-precision data on daily mobility and behavior, new possibilities in understanding how environments relate to behaviour and health inequalities arise. Yet, whereas the consideration of spatial processes can be seen as a significant step forward, two key aspects have been mainly overlooked and need to be addressed: the questions of ‘with or for whom’, and ‘why’. While the former calls for a better consideration of social networks and social interactions, -because social and spatial processes are linked-, the latter calls to refine our understanding of place preference and decision making leading to daily mobility and multiple exposures. This paper reviews recent advances in the health and place field to introduce these points.

Keywords
Environmental exposure; Neighborhood effects; Social networks; Causality; Spatial decision making; Daily mobility

Word count: 4153

Introduction

There has been renewed interest in the role of place as a determinant of health and health inequalities, specifically through a focus on environmental or neighborhood effects. While there have been significant conceptual and methodological advances in our understanding of the role of place, two aspects may have been overlooked and could help understanding causal pathways linking environments to health: the role of social networks and social interactions on one hand, and a better understanding of place preference and decision making leading to daily mobility and multiple exposures on the other hand.

Earlier studies were inclined to downplay the potential place effects on health, arguing, - based on the scheme of risk factor epidemiology-, that individual characteristics were more important predictors of health outcomes [1-3]. At the beginning of the 1990's, the debate was reframed by putting neighborhoods back as an important element potentially structuring health inequalities and health profiles, with several fields contributing to this debate, i.e. public health, epidemiology, sociology, or social geography [4-6]. The role of place in the framework of the determinants of health was re-emphasized, arguing that the process that determines one's health operates differently across places [7-11]. Places are made of different physical characteristics, and contains social relations, both of which might influence health. Also tackling those physical characteristics and social relationships rather than only the proximal determinants of health outcomes might have an additional impact on the health of the population [12-14]. This renewed interest in 'context' was in part linked to the observation that the traditional individual-level factors only explain a fraction of the social gradient in health [15], but perhaps more generally, as A.Diez Roux stated in 2001 [4], because of a convergence of factors including a renewed interest in social determinants of health, possibly operating through exposures to different contextual conditions, a renewed interest in ecological v/ariables in the field of epidemiology, the availability of new methodologies (e.g., multilevel models, geographic information systems) and the re-emergence of the debate about social and spatial residential segregation, especially in the US.

Along these developments, we have witnessed advances in the conceptualisation, measurement, and analysis of neighborhood effects, and, more generally, of environmental exposures.These advances have borrowed theoretical foundations and methodological tools from diverse fields, including sociology and educational sciences, environmental and social psychology, and geography, where thinking around notions of place and space have a long tradition.

Curtis and Jones [16] discussed several frameworks supporting the concept of contextual effects on health, including spatial patterning and diffusion of physical and biological risk factors, the role of place in social relations and the concept of landscapes and sense of place and their effect on health. Moreover, the structure and agency debate has informed health geography on how people-place interactions can affect health and health inequalities [17, 18] [19]. Health geographers have contributed to the field by investigating people-place interactions from the perspective of space-time geography [20], through analytical explorations on the relation between landscape and (mental) health or healing [21, 22, 23 283], or from various work analysing spatial patterns of health inequality [16, 24] or of environmental burden from an environmental justice perspective [25, 26]. Such perspectives echoed earlier calls to increase specificity in the study of local social and physical environmental features which might contribute to health profiles and also represent important opportunities for intervention [27].

Measures and tools to account for place in health research

Advances in the conceptualisation of the role of place on health was accompanied by rapid technological developments, mainly in the domain of Geographic Information Science (GIS), which provided new capacity to link residential location information from individuals to environmental datasets for extraction of contextual exposure measures. Developments in analytical procedures and softwares for multi-level modelling further facilitated the consideration of nested designs, i.e. individuals nested within areas and time nested designs. For example, individuals were analyzed as nested within residential areas, allowing to assess distinct levels of influence, considering both the micro (individual) and macro (context) levels [28-33]. Also, considering different time periods nested within individuals made it possible to analyse exposure to different contexts across time, through residential mobility and longitudinal cohort studies [34-38].

Yet, whereas traditional views of 'neighborhoods' may give the illusion that contextual dimensions operate within fixed and well-defined local areas, a more comprehensive and dynamic understanding of place and space makes it clear that research questions cannot be handled with the classical nested structures design. Neighbourhoods or local areas are most often operationalised with clear and tight boundaries, for example using administrative or historical delimitations. A reason for this is that scientists often have access to data aggregated at these units. However, nesting individuals in areas with fixed limits does not always make sense [39, 40]). Despite the advances in analytical procedures and softwares for multi-level modelling, Owen et al. [41] discuss three main issues regarding how geography is handled in health research using multilevel models: the difficulty of defining spatial contexts; the fact that research usually concentrates on a single neighbourhood context, where in fact contexts have multiple dimensions and hierarchical scales, and people are exposed to multiple contexts through their life-time; and lastly, the difficulty to account for spatial dependency.

More recent developments through multiple membership models allow assigning individuals simultaneously to several neighbourhood level units, assessing distinct but concomitant or time-varying contextual contributions, using repeated measures and replacing the traditional nested structure [42, 43]. Yet, more subtle considerations of continuous spatial effects may require analytical frameworks in order to account for spatial dependency, such as auto-regressive models [44], or of spatial heterogeneity, such as geographically weighted regressions [45]. The former explicitly accounts for the correlation structure between neighbouring units, while the latter allows estimators to vary spatially, providing maps of parameter estimates instead of global indicators, without pre-defined conceptions of 'neighbourhoods'. This method has the potential to 'reveal' previously unknown existing spatial structures and further guide new hypothesis testing [46].

Given the constraints and limitations of traditional multilevel frameworks in the operationalisation of spatial contexts, spatially-adapted alternatives were compared to classical nested structures

[47]. These approaches proposed more 'individualised' ways of estimating neighborhood effects, i.e. not using common fixed areas in which individuals were nested, but through personalised local areas generally centered on the place of residence. Various procedures were proposed to derive environmental exposures or structures of opportunities at this individual level. Most often, context was operationalised using proximity and spatial accessibility measures to environmental resources - both positive or potentially detrimental- , either based on the Euclidean space or on a reticular space (e.g., circular vs. network buffers) [48] or using density approaches [49], such as kernel density estimators, - here again, for a more continuous consideration of spatial effects.

Integrating mobility in health and place research

As specificity in environmental exposure measures were increasing through such residence-centered approaches and use of Geographic Information System spatial analytic functions, critics pointed to the risk of the 'local' [50] or 'residential' [51] trap, referring to the need to consider more 'dynamic' or 'relational' individual exposures measures, and acknowledging that the smaller areas or more 'local' exposures may not always be the most relevant context at play. The application of the well-known notion of Modifiable Area Unit Problem [52] to this issue of exposure measurement led to the concept of 'Uncertain Geographic Area Context', i.e. the unknown delineation of the 'true causally relevant' geographic context [53]. More individualised definitions, using perceived neighbourhood limits, have also been tested, based on the presumption that they would be more meaningful. It was shown that such units - which size may vary with individual and contextual dimensions - revealed or reinforced certain social gradient patterns that constant size areas ignored or underestimated [54]. Overall, the conclusion is that limiting environmental exposure to 'what is around one's home' 'within a fixed and potentially irrelevant unit type' (e.g. administrative buffers) is problematic. Fundamentally, ignoring exposure to places beyond home areas generates inaccuracy in measures of exposure [55] or spatial misclassification [56]. Worse, because some populations are more home-bound than others, the level of misestimation can vary according to other characteristics, and therefore lead to systematic bias [57]. For example, activity destinations of wealthier households with high car access are both more dispersed, induce longer distances traveled than poorer households [58] even after controlling for the number of trips and local and regional accessibility [59]. Other studies showed that low income families travel outside their neighbourhoods for shopping purposes [60, 61]. A study considering daily mobility showed relative risk in exposure to air pollution in the Vancouver area was underestimated by 16% when computing exposure at place of residence and ignoring out-of-home mobility. The same approach applied to data in the Los Angeles area showed the underestimation grew with distance and time spent out of home [62] . In conclusion, areas defining context based on ego-centered neighbourhoods may have limited validity both because these may not fit the 'causal pathway', i.e. their delineation is ill-defined, and because they ignore significant mobility-related levels/duration of exposure to other relevant places.

Such considerations have naturally led to an increasing interest in daily mobility [63, 64]. Conceptual advances targeting a better apprehension of within-day spatio-temporal dynamics and refinements in the operationalisation of the multiplicity of exposures to improve the estimation of place effects have borrowed from various fields [65], including space-time geography [20, 66, 67], transportation [68, 69], environmental psychology [70], and geo-ethnography [71]. The notion of activity space, i.e. the 'subset of all locations within which an individual has direct contact as a result of his or her day-to-day activities' ([72] p. 279), has been largely adopted, providing a framework acknowledging people's multiple belonging to places, leading to more recent notions of 'spatial polygamy' [73] or 'healthscape' [20]. Yet, while daily mobility was increasingly considered as an important aspect regarding how place relates to health, it also revealed the scarcity of detailed spatio-temporal mobility data in existing health datasets. Location information, when even available, has generally been limited to place of residence, sometimes including work location, and at varying spatial resolutions. Different methods have since been proposed to add mobility data to health datasets. Options include using existing mobility data such as travel surveys [74, Setton, 2011 #134, 75, 76], linkage of health data with existing travel surveys [77, 78], or using specifically designed tools to collect activity space data, including electronic map-based questionnaires [79] to facilitate self-report of regular destinations [58, 80], perceived neighbourhood limits [81, 82] , or routes [83]. Finally, technological developments and miniaturisation of sensors have led to using wearable sensors including Global Positioning System (GPS) receivers, either with dedicated trackers or through smartphone-embedded GPS [84]. Activity-space based conceptualisation of place effects have mainly contributed to explorations of peoples' interactions with food environments [85-88] and of daily mobility and built environment's relation to physical activity [89, 90]. They have also contributed to advance our understanding of social inequalities, with application in smoking [91], mental health [92], cervical screening [93], or, more generally in regards to residential segregation [94]. With the increasing use of GPS trackers, often combined with accelerometers for objective assessments of physical activity and sedentary behaviour, specificity in the measure of multiple exposure has increased. However, such high-resolution data also comes with new challenges. In a recent review of the emerging field of 'spatial energetics', conceptual, technological and analytical shortcomings are identified [95]. Among those, one important question is how exactly such high-precision objective data can help us in identifying (environmental) causal pathways. One of the difficulties is that using such detailed daily trajectories requires addressing the selective daily mobility bias [96]. This bias can be seen as the 'daily mobility' extension of the 'residential mobility' bias that wrongly attributes behaviour (e.g. walking) to the effects of environmental characteristics (e.g. high walkable neighbourhood) when in fact people could have chosen their destination because they value its characteristics for ease of practicing the behaviour in question (e.g. high walkable neighborhood). In other words, the observed association between a neighborhood characteristic and a behaviour could be a result of people's self-selection towards contrasting neighbourhoods.

Based on our current understanding of how relations between place and health are being conceptualised and studied, we would like to point towards two important aspects that we believe call for improvement. First, more attention should be paid on the role of social networks and social interactions, because social and spatial processes are strongly intertwined. By looking beyond individual risk factors and re-introducing notions of place, we may have neglected the social, i.e. the 'with whom'. Yet, social interactions may be an underlying reason for being exposed to a place, and social interaction may buffer or modify the effect of environments on health. Second, to address causality, more needs to be known about people's decision making processes. In short, to the 'where' and 'when', we should add the 'why' to fully understand how context influence behaviour. All aspects - 'where', 'when', 'with whom' and 'why' - are of course not independent.

Improving the consideration of social processes in health and place research

Considering social networks and social interactions makes sense theoretically to better understand place and health. There is a rich literature about social structures or social interactions and their links to health [97]. To name just a few examples, social participation [98], social support [99, 100], or social network structures [101-103] have been associated with improved health outcomes in aging [104] and mental health [105]. Interestingly, the interplay between social structures and individual spatial structures - e.g. activity spaces - have rarely been considered in health and place research. However, the much used concept of activity space originated from a larger notion of 'action space' [72]. As pointed out by Golledge and Stimson [72], Jackle et al (1976) mentioned that the action space:

'specifically draws attention to the individual's relationships with his surrounding social and spatial environment and allows us to examine the patterns in which individuals interact in space. We can most effectively use the concept by dividing it into meaningful components - movement and communications' (p.94)

Whereas the last decade has provided important advances in the consideration of 'place' in health research, the 'communication' and 'individual's relationships' part has been either neglected, or studied mostly distinctively from its spatial counterpart. We echo earlier calls from the transportation domain to incorporate the 'social dimension' in travel behavior [106] 'transport modeling has ignored the social dimension of travel in the past'; Carrasco et al. 2008 [107]: 'little is known about the linkages between social and spatial interactions'). Yet, 'social structures facilitate and constrain opportunities, behaviors, and cognitions' ([107] p. 963). For health research interested in the effect of place, the spatial dimension of a social networks is certainly of importance. Each network member has his/her own activity space, with core anchor points such as home place or work location, but also with social activity places that overlap with peers and may influence ego's own spatial behavior [108]. In turn, one's own activity space and choice of destinations is often motivated by social contact needs. The structure of our social network, and the social contacts that result - which can be more or less constrained, depending on the status of the alter and the related nature of the social tie-, can influence our choice of destinations [107], and consequently impacts our exposure to environments. How these environments, in turn, influence our social network structure, is also of interest [109]. Overall, people's constraints and choices towards specific environments and people constraints and choices towards specific social contacts mutually influence each other.

From a travel behaviour perspective, embracing the network structure shifts the vision of the "perfectly informed and unilaterally utility-maximising traveller" to a 'network actor, who draws on the resources of his or her network but is constrained by its expectations while negotiating productive solutions for his or her daily life.' [110] p. 982 ' Improving the measure and analysis of the dynamics of social and spatial interactions can help health and place research identify relevant pathways explaining health profiles and health inequalities, while guiding the development of new interventions. For example, understanding adolescents' social dynamics in a given area can help understand if building secure bicycle paths will lead to more active mobility and improved health among this group or not. Similarly, if bike paths are implemented and are not being used, are there norms and habits in social relations that prevent their use, upon which one can act? Although the built environment itself appears more amenable to change than social networks do, accounting for social network dynamics that interact with places is core to successfully reach people for whom interventions are meant.

Currently, detailed data on people's social network structures and spatial dynamics are often lacking from health datasets. But recent developments offer interesting opportunities to collect such data. Questionnaires on activity space can be combined with social network questionnaires. As an example, VERITAS, an interactive map-based online application initially targeting the collection of regular activity locations [79], was recently adapted to further allow the collection of ego-centered social network information attached to destinations [111]. As participants report 'where' they conduct their daily activities, they can provide information regarding 'with whom' these activities are done. As they do so, the spatialised ego-centered network is progressively revealed. Once all activity locations have been identified, and network members met at those location described, further social network questions identify alters who are generally not met in person (i.e. without 'spatial' connection) to complete one's ego network . Complementary information on the strength and nature of ties with ego, and on the ties between alters, are then reported. By providing detailed information on both social interactions and daily mobility, this questionnaire allows to cover the 'movement and communication' aspects of people's action spaces, which should help understanding how environments and social contexts interact and influence behaviour and health. Social survey components can also be added to GPS-based prompted recall surveys, i.e. mobility surveys performed on the basis of a GPS data collection.

Passive data collection methods may also provide potentially rich information on both social and spatial processes relevant for health. For example, location information, i.e. 'geotags', is often contained in social media, such as Twitter messages. This means the social networks of social media can be spatialised, and the nature of ties or themes of interest (i.e. message content) can be analysed. As an example, a public health surveillance analysis of US-based twitter messages using the Ailment Topic Aspect Model (ATAM) [112] showed correlations between localised twitter message contents and behavioral risk factors at the state level [113]. More refined location-based social media analyses in relation to health are warranted. Social contacts can also be collected using wearable sensors that can detect proximity, using various radio-frequency protocols such as bluetooth, ANT+, or openbeacon [114]. Such person-to-person contact information can not only be used to model spread of infectious disease, they can also be combined with complementary sensors such as accelerometers to understand social dynamics associated with active living or other outcomes of interest where context plays a hypothesised role. Similarly, smartphone data can be mined to establish measures of social interactions [115, 116]. Combinations of embedded GPS and accelerometry readings, call and text logs location information can reveal socio-spatial patterns of interest, although calls and SMS frequency has been shown to not always be a good indicator of tie strength [117]. More research using either dedicated wearables or using smartphone logs and applications are needed to improve the validity of such data. Studies comparing the validity of dedicated wearables and smartphone logs are also needed, and may provide useful information on signal degradation and sample size requirements for large-scale smartphone-based surveys.

Improving our understanding of causal pathways leading to location and behaviour choice

While social network structures and social interaction information has an important potential to further our understanding of how place translates into health and health inequalities, it raises the more general question of 'why' people make certain choices in destinations and behavior. Social interactions are one of the core underlying mechanisms explaining such choices. But although this may be true, the underlying mechanisms in terms of spatial and temporal decision making remain generally hidden. If one aims to understand how places shape behaviour, i.e. address the causal mechanism while being able to control for self-selection, motivations need to be documented. Residential self-selection is often controlled for using self-reported indications on how much contextual variables of interest (e.g. walkability) have played a role in choosing the residential neighbourhood in the first place [90, 118, 119]. For daily mobility, equivalent questions at the activity destination level are generally not asked. Daily activities can be analysed from a variety of angles. They are conducted to fulfill a need or obligation, they may or not involve other people, and they can be described spatially (where) and temporally (when). In the transportation field, activity-based travel demand models focus on people's behaviours and decision-making process to predict mobility and traffic [120]. Ramadier et al. [121], referring to Bourdin's (1996) constraints for locating an activity among a choice set of 'anchors', including the fact that there is a need to carry out a given activity in a place - conditioned by norms and power - ; that a place has a ‘native appeal’ - its unicity in resources, local knowledge; that a location has its interest because of its relative position - e.g. closeby or on the way from A to B; and that choices can be made ‘by default’, i.e. to avoid other candidate locations who present some unpleasant characteristics. Through this lens, the choice set of destinations is seen as a set of intentions, articulated from a project and goals perspective, and accounts for dimensions of choices and constraints on one hand and of utility and satisficing (i.e. reaching a level of acceptable threshold without maximizing) on the other hand [122]. This leads to relevant dimensions involved in location choice as partly cognitive - individual’s knowledge and interpretation of the urban environment-, spatio-temporal - i.e. temporal and spatial constraints; social - status, availability of network members, and their related spatial structure-, and material - including the availability of transportation and communication means or other resources. Negotiations between these four dimensions lead to travel and activity behaviour. Finally, interactions with the physical and social environments feed the negotiation process with revised intentions and proposals for new behaviours. One important aspect of this framework is that it leads to the consideration of the level of spontaneity or routine along both the spatial and temporal dimensions to understand choice [121]. Activities can be considered more or less spontaneous/fixed *both* in space and in time. Accordingly, activities can be classified as routine (fixed in time and space); pre-arranged (with known time and space); opportunistic, anchored *either* in space *or* in time, or without anchorage, i.e. flexible *either* in space *or* in time. Such a classification considering spatial and temporal spontaneity offers interesting insights on decision making and underlying motivations. Specifically, it can help identify how much proximal environmental conditions influenced both activity choice and activity location choice. For example, activities that are fixed in space and time (e.g. working at the office from 8:00 a.m. to 4:00 pm) are not subject to the same ‘negotiation’ process than activities that may be less space-dependent (e.g. going out for pizza on wednesday night - somewhere). Knowing how much constraint/flexibility in time and space is associated with a given activity can help identify the potential influence of local environmental contexts. In other words, understanding the thought process leading to an activity (and its related temporal and spatial destination choice) is key to unravel causality.

As wearables do now provide detailed spatio-temporal information on behaviour, additional ‘contextualisation’ of behaviour in terms of decision-making process can be helpful too . Ecological momentary assessment provides interesting ways to collect ‘just-in-time’ information on intents and motivations. By automatically detecting the arrival at a new destination, prompted questions about such spatial and temporal constraints can help us move towards better understanding of causality.

Conclusion

Research on place effects has gained important traction in the past decades, and novel technologies for data collection are improving specificity in measures, allowing documentation of detailed spatio-temporal mobility patterns, behaviour, and related exposures to environmental conditions. Yet, further considerations of social dynamics and decision making processes are needed to disentangle the underlying causal mechanisms linking the environments we live in to health behaviour and health inequality. By putting place back into health research, we have made an important step forward to contextualise health and health inequalities, and generated important evidence useful for designing healthier places. Yet, to further understand the causal pathways, there is a need to re-introduce aspects relating to decision-making processes. Better accounting for social interactions, intentions and motivations can help resolve the interplay between people and places, and may be a step toward better addressing causality in health and place research.

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Conflict of Interest

Yan Kestens, Rania Wasfi, Alexandre Naud and Basile Chaix declare that they have no conflict of interest.

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