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Steps Forward: Review and Recommendations for Research on Walkability, Physical Activity and Cardiovascular Health

Gina S. Lovasi, PhD, MPH,[1]
Stephanie Grady,[1]
Andrew Rundle, DrPH, MPH[1]

ABSTRACT

Built environments that support walking and other physical activities have the potential to reduce cardiovascular disease (CVD). Walkable neighborhoods—characterized by density, land use diversity, and well-connected transportation networks—have been linked to more walking, less obesity, and lower coronary heart disease risk. Yet ongoing research on pedestrian-friendly built environments has the potential to address important gaps. While much of the literature has focused on urban form and planning characteristics, additional aspects of street-scapes, such as natural and architectural amenities, should also be considered. Promising future directions include (1) integration of multiple built environment measures that facilitate an understanding of how individuals perceive and act within their environment; (2) examination of both the daily physical activities that are most feasibly influenced by the local environment and those more deliberate or vigorous patterns of physical activity that are most predictive of CVD; (3) consideration of multiple pathways that could mediate a link between walkability and CVD, including not only physical activity, but also air quality improvements from reduced vehicle mileage and enhanced neighborhood social cohesion from unplanned interactions; (4) testing competing hypotheses that may explain interactions of built environment characteristics with each other and with personal barriers to walking; (5) stronger conceptualization of the multiple neighborhoods or activity spaces that structure opportunities for physical activity throughout the day; (6) collecting and strategically analyzing longitudinal data to support causal inference; and (7) studying neighborhood preferences and selection to move beyond biased assessments of neighborhood health effects. While walkability has been linked to health-related behaviors and CVD risk factors, the implications of the observed correlations are not yet clear. New theoretical insights, measurement technologies,

[1] Department of Epidemiology, Mailman School of Public Health, Columbia University.

Corresponding Author Information: Gina S. Lovasi at glovasi@columbia.edu; Department of Epidemiology, Mailman School of Public Health, Columbia University, 722 W. 168th St, Room 804, New York, NY 10032.

and built environment changes represent opportunities to enhance the evidence base for bringing health promotion and cardiovascular disease prevention into the conversation about how communities are planned and built.

Key words: Residence characteristics, spatial behavior, physical activity, Body Mass Index, cardiovascular diseases

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INTRODUCTION

Although cardiovascular mortality has been decreasing in recent decades, cardiovascular disease (CVD) remains the most common cause of death globally[1] and accounts for the majority of lifestyle attributable deaths in the US.[2] Thus, primary prevention of CVD development and progression is a public health priority, as is the prevention and management of major risk factors such as hypertension and obesity prior to a CVD event.

Yet prevention is a tough sell.[3] Simple prevention activities like walking for physical activity in bouts of at least ten minutes for a total of 30 minutes every day[4] elude many of us, even though there is good evidence to support a range of short- and long-term health benefits relevant not only to CVD[5,6] but to conditions such as diabetes and some cancers as well.[7] Despite commonly stated goals to become more active and lose weight[8] and the effectiveness of intentional weight loss for improving health,[9] large numbers of North Americans and Europeans are sedentary and obese.[10,11] Insufficient time and energy are reported as crucial barriers to physical activity, the preparation of healthy meals, and weight management.[12,13] One promising solution is to use the local built environment to support positive health behaviors, like walking, so that they fit more easily into daily activities.[14]

The built environment includes features such as homes, businesses, street networks, and green spaces that are relatively stable and thus have the potential to offer a lasting effect on behavior and on health.[15,16] Built environment characteristics have been linked to health behaviors and weight.[17,18] This initial research has generated considerable interest and momentum and has contributed to policy discussions highlighting the relevance of regulatory, transportation, urban planning, and real estate development decisions for health.[19,20]

Research on the built environment and health has been stimulated by research funding initiatives including the Active Living Research program from the Robert Wood Johnson Foundation and the Obesity and the Built Environment initiative from the National Institutes of Health,[21,22] among others. Methodological advances in this work have been made possible by the development of Geographic Information Systems (GIS) software and data resources,[23,24] coupled with statistical software to facilitate work with geographically clustered data using generalized estimating equations,[25] multi-level models,[26] or spatial statistics.[27]

In this review, we do not set out to duplicate previously published systematic reviews[17,28-30] or meta-analyses[31,32] relevant to the connections between context, physical activity, obesity, and cardiovascular risk. Rather, we focus on opportunities for further advancement in the study of contexts and CVD, with particular attention to the emerging challenges for studying built environment characteristics thought to support walking and physical activity. The recommendations highlighted may also have relevance to CVD risk factors, such as blood pressure and diabetes, but the geographic patterns for these risk factors have not received as much attention as patterns for physical activity or obesity.[30] We begin by commenting briefly on the range of research linking context to CVD. We then discuss more specifically the emerging pattern of evidence linking built environment characteristics to walking and cardiovascular risk factors. Recommendations for harnessing recent developments to improve the basis for causal inference are discussed, and a few summary comments conclude the report.

Community and Geographic Patterns in Cardiovascular Risk

Key aspects of context that have been studied in relation to CVD include socioeconomic context and supportive social networks, as well as characteristics of the local built environment.[33] While built environment characteristics relevant to physical activity are the primary focus of this review, other types of neighborhood context warrant brief attention here because they will intersect with our discussion of neighborhoods.

The most commonly studied geographic determinants of cardiovascular disease are socioeconomic context measures.[30] Socioeconomic context measures contribute independently to CVD prevalence after statistical control for individual level socioeconomic status (SES).[34] The association of area-level socioeconomic indicators with CVD appears to be only partially mediated by individual risk factors and health behaviors.[26,35] Stress and related processes may contribute to the socioeconomic gradient in CVD.[36,37] Efforts to promote health through neighborhood change must consider the special case of minority and low SES individuals if we are to address and reduce current health disparities.[29]

Supportive social networks, like higher SES, have been linked to cardiovascular health.[38,39] Social networks can be viewed as conduits, allowing for the transmission of social support and health knowledge and behaviors.[40] Social networks may also have a "buffering effect", meaning that well-connected individuals would be more resilient in the face of acute stressors or health complications.[41] The effect of social networks on CVD may be mediated by behaviors such as smoking, diet, physical activity and weight control.[42,43] An area of developing interest has been the intersection between social and physical space within neighborhoods.[44,45] Low neighborhood social cohesion in particular has been linked with obesity and hypertension,[30] as well as myocardial infarction risk.[35]

Both SES and supportive social networks influence where people live and their access to the opportunities for healthy living within those environments. We now turn to those opportunities that are embedded in the local built environment.

PEDESTRIAN-SUPPORTIVE BUILT ENVIRONMENTS

Built environment characteristics have been hypothesized to influence physical activity and other behaviors with relevance to cardiovascular health. Aspects of the built environment associated with walking for transportation or intentional physical activity are potentially attractive targets for intervention, as their influence on local populations could have wide reach and endure for decades after initial investment.

Characteristics of the built environment that have attracted particular attention include physical activity venues such as pedestrian-friendly neighborhoods or bicycle paths that may provide a safe alternative to travel in a private vehicle[46,47] and private gyms and public parks.[13,48] Other work on the built environment and behavior with potential relevance to CVD includes analyses of landscape or urban design components that affect the balance between pro-social[49] and anti-social interactions[50]; sources of food for later preparation or immediate consumption[51]; and density or presence of stores selling or promoting alcohol and tobacco products.[52,53] We focus our discussion on built environment characteristics that support walking, the most commonly reported physical activity.[54] Walking most often takes place along neighborhood streets,[54] making the design of those streets a plausible target for interventions to encourage walking.

Studies of pedestrian supportive built environments have often measured density, land use diversity, and transportation network design elements that are thought to promote non-vehicular travel.[16] Residential density, measured either as population density or housing density, may play a key role not only by placing more neighbors within walking distance, but also by supporting demand for commercial destinations and transit connectivity. The mixture of residential and commercial land uses within a neighborhood (referred to as land use mix or diversity) and a gridded street pattern (connectivity) make walking a more efficient form of transportation and allow individuals to complete the tasks of daily living without needing a car. These urban form characteristics have been the focus of recent research, but were already articulated as key supports of safe and thriving urban neighborhoods 50 years ago.[55] These urban form characteristics are associated not only with more walking[56] and less obesity,[17] but also with lower blood pressure,[57] less insulin resistance,[58] and lower risk of coronary heart disease.[59]

The density of homes, diversity of land uses, and design of street and transit systems are correlated with each other, and may be meaningfully assembled into "walkability" or "sprawl" indices.[60,61] Walkability and sprawl indices include similar components, but are typically measured on different spatial scales; walkability indices measure the multiple aspects of the neighborhood that may encourage pedestrian activity within a highly localized area, whereas sprawl indices measure the extent to which counties or metropolitan areas are spread out, with lower densities of commercial and residential land uses that foster vehicle dependence. [60,61] A z-score based walkability index such as that created by Frank and colleagues[60] can be modified for particular environments as was done for New York City.[62] Another option is to create and calibrate such an index using observed pedestrian counts; such a pedestrian count proxy index was created using population density, commercial density, and transit ridership, and was correlated with pedestrian counts from field observation across 588 blocks in New York City (Spearman's rank order correlation = 0.62).[63] The component variables were selected based on the assumption that people walking on the street were mainly local residents, patrons of commercial attractions, or users of local transit.

Beyond these commonly measured aspects of walkable urban form, aesthetic characteristics may support pedestrian activity and a healthy weight.[28] Previous research has linked natural or green spaces to less obesity,[64,65] lower blood pressure,[66] and even reduced health inequalities.[67] Signs of physical and social disorder, such as litter and crime, have also been associated with lower physical activity,[68] higher BMI,[69] and higher mortality.[70] Ewing and colleagues have developed measures of design qualities that make streets comfortable, memorable, interesting, and appealing and other aesthetic street-scape considerations, such as trees, greenery, public art and street cafes, may have positive impacts on pedestrian activity.[63,71]

RECOMMENDATIONS

In addition to a host of challenges common to most observational epidemiology, studies of context and health must address an array of measurement, modeling, and causal inference challenges. The published literature on pedestrian-friendly built environments, physical activity, and CVD leaves unanswered questions with implications for future health promotion initiatives. In order to address these gaps in the literature, we recommend attention to the selection of measures, to mediation and moderation, to the definition of neighborhoods or other activity spaces, to longitudinal patterns, and to self-selection processes (Table 1).

Assessing the built environment

A common method to assess context is through self-report, and this approach has the advantage of incorporating a nuanced view of the environment from the residents' own perspective. Yet study participants asked to report on their physical or social context may have incomplete information on some resources or problems in their neighborhoods. There is often a large discrepancy between self-report data and contextual data from independent sources.[72] One response to this discrepancy has been to reduce reliance on self-report data. Yet self-reported perceptions of social context can be a vital counterpart to externally-derived measures,[73] such as those based on GIS data, field audits, or survey responses from others living in the same geographic area. Perceptions of context are strongly related to individual behavior and health.[18] Moreover, residents' perceptions of aesthetic characteristics may be symbolically important,[74] independent of any correlation with "objective" characteristics calculable from spatial data sets and GIS tools. Multiple measures or ecometric assessments[75] may provide an important strategy, since the lack of concordance between self-reports and objective measures is both a potential source of bias and potentially of direct interest.[72] Interventions to change perceptions of the environment may be an efficient way to modify the behavior of individuals within their local context, particularly if local resources are underused. New approaches are needed to enhance our understanding of the ways that people selectively experience and perceive their environments.[72]

Table 1

Summary of recommendations to address research challenges relevant to walkability and CVD

Measurement Selection	To better understand how individuals select their environment and to combat the inconsistencies between self-report and contextual data, multiple built environment measurement modes should be considered, and predictors of discordance examined. In addition, the selection of physical activity measures should balance the advantages of those responsive to the local environment and those that are powerfully predictive of CVD.
Multiple Mediating Pathways	There are multiple potential pathways beyond physical activity that link walkability to CVD, including air quality and social context. Examining a wide range of mediators may provide information on association specificity or co-benefits across behavioral and biological systems. Unlikely mediators can be included as negative controls.
Investigation of Effect Modification	Competing hypotheses may explain interactions of built environment characteristics with each other and with personal barriers to walking. For example, various models suggest that built environment characteristics may be more influential on health outcomes in the absence of other personal, social and physical barriers.
Individualize Neighborhood Definitions	Multiple "neighborhoods" or activity spaces may influence health, and an array of accepted or innovative neighborhood definitions are available (Figure 1). Residential location can be considered alongside school or work location. Individualized neighborhood definitions can also be created through participant reported neighborhood boundaries, or through GPS tracking.
Leverage of Longitudinal Data	Longitudinal data can help to establish temporal ordering of built environment exposure, behavior, and health outcomes. Changing neighborhoods and residential relocations may provide transitions useful for causally informative designs such as marginal structural models, instrumental variable analyses, or case-crossover analyses. However, longitudinal designs do not address all of the biases that threaten cross-sectional research.
Study of Self-Selection Processes	Investigations of neighborhood preferences and selection processes could quantify and overcome self-selection bias assessments of neighborhood health effects. Qualitative research on neighborhood preferences and self-selection may be needed to further develop survey material to place walkability within the hierarchy of priorities for selecting livable neighborhoods.

Selecting responsive and relevant walking measures

While some attention has been paid to the relative merits of physical activity measurement with questionnaires, travel diaries, and motion sensors for capturing overall physical activity,[76,77] this attention to the mode of measurement has left out an important issue related to the content of those measures. The physical activity measures most sensitive to the built environment are not necessarily those most closely tied to CVD outcomes.[78] Built environment characteristics are most clearly linked to walking for transportation[60] and walking in the neighborhood.[79] Yet these types of walking may have more limited explanatory power for CVD outcomes,[17] particularly if the typical walking duration is shorter[18] or the pace is slower; physical activity intensity and walking pace have been robustly linked to cardiovascular health.[80] The tension between selecting a walking measure that will be responsive to the local environment and selecting a walking measure that will powerfully predict CVD may be resolved through simultaneous measurement of multiple types of physical activity in large populations. Yet this tension also suggests that the magnitude of an association between walkability and CVD may be quite small, unless walking itself represents only one of several mediating pathways.

Considering multiple mediation pathways

The CVD relevance of a walkable built environment may extend beyond the walking-mediated pathway discussed above. Air pollution, for example, has been modeled to be lower in pedestrian-supportive areas due to a reduction in vehicle miles traveled,[60] and local air pollution levels are linked to CVD.[81] The built environment has likewise been linked with the social structure of local communities,[49,82] although the directionality of such associations is not well established. Aesthetic characteristics have also been linked to mental health and affect,[83] which might represent other pathways between the built environment and CVD. Even among behaviorally mediated pathways, built environment characteristics can be associated not only with physical activity, but also with dietary patterns and obesity.[17,18] The presence of multiple mediating pathways may indicate co-benefits across multiple systems. However, an association that lacks specificity also raises the possibility of biases such as confounding by prior health status or total wealth. There may be a benefit to considering implausible mediators such as height as a negative control for causal testing.[84]

Modeling and investigating effect modification

Prior reviews have called for more direct assessments of effect modification to improve our understanding of the variations in the strength associations observed for built environments and obesity.[17,56] Historical experience suggests that environmental "improvement" does not always lead to health improvements for all members of the resident population.[85] The social context may partially determine the effectiveness of built environment improvements or other health promotion efforts. For example, some have suggested that the health effects of walkability would be particularly strong for vulnerable or socioeconomically disadvantaged groups,[17,86] perhaps because resource limitations would constrain their access to distant neighborhoods, private gyms, or home exercise equipment. However, the available data suggest that the opposite may be true: the association of walkable urban form with obesity may be strongest among socioeconomically advantaged groups.[87] Other neighborhood characteristics, such as aesthetic amenities or safety hazards may be more salient than walkable urban form for disadvantaged racial, ethnic, and specific socioeconomic groups.[29,88] Interactions with such demographic categories may be hypothesized to result from different patterns of neighborhood self-selection, or perhaps with interactions among multiple environment characteristics[16] or with personal barriers to an active lifestyle.[89]

Going forward, tests of interactions have the potential to support or discredit specific explanations of how built environments influence behaviors, and to raise new possibilities for future investigation. The built and social environmental influences on walking have been proposed to exist in a hierarchy,[90] rather than simply representing independent influences. This hierarchy hypothesis suggests that personal and neighborhood barriers to an active lifestyle can be ordered, and that the presence of barriers at the most basic level would eliminate other associations. Thus, sprawling residential areas with poor street connectivity and a lack of nearby destinations may restrict the feasibility of walking for transportation regardless of the other neighborhood characteristics that make walking routes attractive. Likewise safety concerns may be more fundamental than positive aesthetic amenities to the decision of whether to walk in places where walking is feasible and socially normative; this suggests that natural scenery and other aesthetic amenities may be more closely tied to activity and obesity in the safest areas. Alternatively, a simple threshold may be operative in the ways that multiple barriers act together to influence health behavior, requiring that multiple barriers be removed before an effect on lifestyle or health can be observed. Socially disadvantaged populations may experience so many barriers to maintaining an active lifestyle and a healthy weight that removing any one barrier has little effect; that is, if walkability alone is improved, local safety problems and other factors may still be acting to encourage sedentary lifestyles and weight gain. Both the hierarchy and the threshold model suggest that a given built environment characteristic will be more influential in the absence of other barriers, and suggest hypotheses for future interaction analyses.

Individualizing neighborhood assessment

The level of analysis for neighborhood units should match the conclusions reached. The scale of built environment measurement for studies of physical activity or CVD is potentially important because of the modifiable areal unit problem (MAUP): observed associations may differ depending on the scale and zoning of geographic units.[91] Validity of future studies will depend on the correct specification of the multiple neighborhoods within which built environment infrastructure potentially influences pedestrian activity and health.[92] Rainham and colleagues have developed the idea of the "Healthscape", which is the sum of the properties of the multiple geographic areas experienced by individuals and the time spent in each.[92] Yet investigators commonly take a "one spatial definition fits all" approach to defining study subject's neighborhoods, in which a single neighborhood definition is applied to all study respondents. Studies generally focus solely on the area around the residence, assessing the built environment within administrative spatial units, or within a pre-specified radius of the home (Figure 1a-d). One kilometer circular or network buffers are a common choice when studying determinants of walking,[93,94] perhaps because of the high permeability of urban environments to pedestrians,[95] the relatively small territory typically covered on foot,[18,96] and the lack of correlation between perceived and objective measures of the built environment beyond one kilometer.[94]

The exposure measure of neighborhood walkability derived from a standard uniform neighborhood definition applied to all study subjects may incorporate data from areas not regularly experienced by the subject.[97] Furthermore, it is likely that the walking range and the types of areas individuals are willing to walk in vary by sociodemographic characteristics such as age, gender, race, ethnicity and SES, which themselves are risk factors for CVD.[92,98] Additionally, activity spaces in which individuals walk are likely to depend on larger macro-scale variables such as regionalism, urbanicity, crime and local social norms regarding walking.[97,99] To our knowledge, population-based studies of neighborhood walkability and health have not yet used individualized neighborhood definitions that reflect the spatial areas that each study subject conceptualizes as their neighborhood.

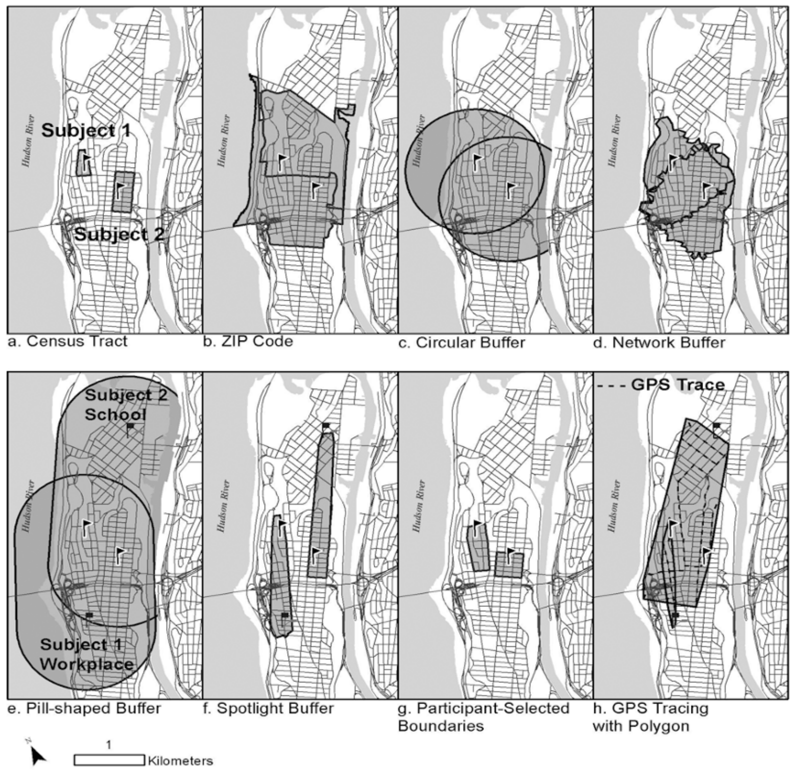

Fig. 1. Multiple Potential Neighborhood Definitions. Each panel includes the home location of two hypothetical study participants (marked by a flag) surrounded by their respective neighborhoods, shaded gray. Standard neighborhood definitions shown include administrative units (a, b) and 1-km buffers (c, d). In addition, options for incorporating a second, non-residential location include either a "pill-shaped" buffer around the line from home to work or school (e) or a "spotlight" buffer extending from the participant's census tract to a buffer surrounding the non-residential location. Finally, individualized neighborhood definitions shown include either participant-designated neighborhood boundaries (g) or a convex hull surrounding a GPS trace.

Source: Basemap: NYC Department of City Planning, US Census 2000.

Two approaches can be taken to improve the specification of neighborhood definitions for walkability studies. First, one can move beyond the exclusive focus on the residential neighborhood (Figure 1e-f). Individuals employed or attending school outside their residential neighborhood are likely to be influenced by built environments outside of their residential neighborhood.[92] As with residential neighborhoods, investigators need to consider how to define the relevant boundaries of neighborhoods around work, school and other frequently visited locations.[100] A second approach is to use information from respondents to create individualized definitions of residential neighborhoods (Figure 1g-h). Subjects could be asked simply to report the maximum distance from their home that they consider to be part of their neighborhood, although a weakness of this approach is the assumption that individuals perceive or access space around their home uniformly in all directions.[98] Another option is to ask respondents to draw their own neighborhood boundaries.[97] Google Earth™ can be used to increase the efficiency of this method by allowing study subjects to click on street intersections to indicate the spatial area they consider to be their neighborhood. The Google Earth™ interface can capture these points and geocode them so that minimum convex polygons defining each subject's self-reported neighborhood can be created and characterized.[92] An even more intensive approach uses multi-day, GPS monitoring of each study subject to define their unique travel pattern.[92] The advantage of GPS is that the technology captures both spatial and temporal information on all travel throughout the period, allowing a full analysis of the individual's health-scape. However the conduct of large scale GPS studies is hindered by the level of participant burden and by technology barriers, including battery life, memory constraints, the reliability of GPS devices maintaining signals in urban areas, and the extensive data processing required.[92,101] When personalized neighborhood assessment is not feasible for the full study sample, data from pilot studies using one of these approaches to collect data on average neighborhood ranges for defined sub-groups (e.g., defined by age, gender, or car ownership), could be used to inform the neighborhood definitions used for each sub-group group in the full study.

Leveraging longitudinal data

A key criticism of the neighborhood health literature has been the reliance on cross-sectional studies.[102] The lack of longitudinal data is problematic because neighborhoods are assumed to be static, and health behaviors and CVD risk factors are assumed to be shaped primarily by the current residential environment with little or no time lag. A longitudinal approach offers tools to account for environmental change or residential mobility, to evaluate whether these changes precede individual behavior or health changes, and to examine the potentially long latency period between initial exposure to a walkable environment and change in body weight or CVD risk. Temporal ordering of cause and effect is only one step towards establishing causation, but it is a necessary step. If disease onset precedes the first exposure, that exposure cannot be the cause of disease. Longitudinal studies that link changing neighborhoods with behavioral or health trajectories can help to overturn incorrect assumptions and establish whether neighborhood change precedes the health change of interest.

Analyses that rely on within-unit comparisons over time, including case-crossover[103] and quasi-experimental designs,[104] are particularly well suited to establishing the sequence of events. However, inference based only on temporal order alone is vulnerable to the classic error *post hoc ergo propter hoc*: after this, therefore because of it. Establishing temporal order does not alone establish causation. Longitudinal designs would often be vulnerable to the biases that most critically jeopardize inference from cross-sectional data. Confounding by a common prior cause is often plausible, and could generate both exposure and outcome simultaneously, at staggered times, or initiate patterns of exposure and outcome trajectories. Consider an association between street aesthetics and walking. Cross-sectional data showing that neighborhoods perceived as more pleasant and safe are associated with more neighborhood walking[105] would have several limitations. In particular, people who prefer to walk in their neighborhood may select neighborhoods that make it pleasant to do so, or walking may cause the adoption of more favorable opinions over time. Economic limitations and residential exclusions could likewise lead to confounding if individuals with little discretionary time to walk in the neighborhood are also unable to live in neighborhoods that they find pleasant and safe. Longitudinal data showing that positive neighborhood perceptions and neighborhood walking both increase in the same period[106] do not necessarily address the problems of confounding and reverse causation. Even studies that follow the residential relocation of individuals over time,[107] thus examining changes in both exposure and outcome, would be subject to confounding by demographic transitions such as marriage and having children, and by resources and preferences that have an ongoing influence. A generic call for longitudinal data is problematic because it excuses authors from making more specific statements about limitations, and from conducting analyses with available data that address the most likely alternative explanations for the observed results.

Studying self-selection

Causal inference about the relationship between walkability and CVD has been challenging. In addition to the usual issues with unobserved confounders, measurement error, generalizability, and statistical power common to many observational studies, a key concern in neighborhood health research has been the potential for bias from self-selection into neighborhoods. If healthier individuals self-select into more walkable neighborhoods,[107-109] the observed associations will not reflect the effect of walkability on individual health as assumed; the cross-sectional ecological association may simply reflect the sorting of individuals into neighborhoods by health status. While randomized trials could be designed to address these issues,[110] these are not often feasible due to major obstacles that include costs, ethical consideration of randomization, and cross-contamination of effects in social interventions.[110] Marginal structural models represent one strategy to reframe the time-varying data to better support causal inference.[111] Another possible analytic and study design option is to identify a natural experiment critically.[112]

Given the usual reliance on observational studies, self-selection is a significant threat to the validity of neighborhood walkability and health literature. A few studies have used reported neighborhood preferences to address self-selection concerns,[108,109] while other studies have assessed the influence of an individual's body size on residential choice and subsequent weight change.[107,113] However, the relative position of neighborhood walkability in the hierarchy of criteria that influence residential mobility and selection is unclear. For self-selection based on walkability preferences to seriously bias study results, such a preference would need to be prominent and its actualization would need to be relatively unconstrained by other considerations. Given the prominence of residential segregation along socioeconomic and racial/ethnic lines, the extent to which self-selection based on neighborhood walkability actually occurs is unclear. In a recent meta-analysis, those studies that included some adjustment for self-selection yielded slightly stronger associations between the built environment and travel behavior.[32]

Further research is needed to understand how preferences for neighborhood built environment characteristics fit with the hierarchy of considerations for selecting residential neighborhoods. Standardized methods for measuring preferences and attitudes for neighborhood characteristics are under development.[108,114] Handy and colleagues measured attitudes and preferences, using principal component analyses of attitudinal questions regarding travel and of questions regarding preferences for neighborhood characteristics.[108] Levine and colleagues developed a measure of neighborhood preferences for walkability by asking respondents to weigh seven tradeoffs between aspects of travel convenience and neighborhood design, assuming that price was constant across tradeoffs.[114] However, the degree to which preferences for walkable neighborhoods are deferred or actualized relative to other considerations in selecting a neighborhood is still an open question. In all likelihood, building an understanding of the hierarchies of factors that influence neighborhood selection and the ways in which these hierarchies vary across sociodemographic groups will require in-depth qualitative research.[115] Further work will then be needed to develop survey questions or scales that can be deployed in large epidemiologic and travel studies to measure the relative degree to which study subjects value neighborhood walkability when selecting neighborhoods.[108,114]

SUMMARY/CONCLUSION

When we select or construct the physical and social environments that surround us, we create a health context for our lives. To a large extent, the health relevant aspects of the contexts we experience are the unintended consequences of policies and actions designed for the pursuit of other social and economic goals. Nevertheless, we have the capacity to shape those contexts to enhance health and wellbeing. To do so, we need the health relevant aspects of context to be revealed and kept in perspective with regard to other competing or complementary social and economic goals. Without accurate information on the health effects of the local environment, investments may be misdirected.

While walkability has been linked to walking for transportation and body mass index, the implications for CVD prevention and disparities reduction are still under active investigation. Additional attention to measurement, mediation, effect modification and causation can inform the ongoing debate on whether and how walkable neighborhoods affect cardiovascular health.

Research on the environmental determinants of health and health behavior has shifted attention from individual risk factors to the broader contexts that shape risk behaviors. Although we have partitioned built environments from sociodemographic categories, social networks, and institutional settings, these types of context overlap, interact, and influence our health simultaneously. Ongoing research is quickly expanding our understanding, raising new questions, and generating tools to move forward. We do not yet have a complete understanding of how built environment change can be effectively used to prevent CVD and promote population health. Should public health professionals be involved in urban planning decisions? Do neighborhood characteristics disproportionately impact disadvantaged communities? Will modification to obesogenic environments result in changes in CVD incidence? As research on context continues, it will be important to assess how the multiple associations with cardiovascular health are related to each other and whether those associations are causal.

Acronyms list:
CVD = Cardiovascular Disease
GIS = Geographic Information Systems
SES = Socioeconomic Status

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