



## Invited Commentary: Advancing Theory and Methods for Multilevel Models of Residential Neighborhoods and Health

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In less than 10 years, the field of epidemiology has been transformed. During this time, multilevel modeling has gone from a little-known and perhaps even unwelcome method of analysis to a household name. Multilevel models appeared much earlier in the fields of demography, sociology of education, and criminology (refer, for example, to Raudenbush et al. (1), Mason et al. (2), and Nuttal et al. (3)), but public health and epidemiology have lagged behind in conceptualizing and measuring how contexts affect individual-level health risks and outcomes. The growth in the publication of multilevel studies has paralleled and contributed greatly to the reemergence of social epidemiologic research (4–11). Multilevel models assessing the effects of neighborhood residential environments on health outcomes have been the most common type of contextual study to date. Research has examined associations between neighborhood characteristics, frequently socioeconomic position, and a variety of health outcomes, including perinatal health (12–15), mortality (16, 17), health behaviors (18, 19), women's health (20, 21), heart disease (22–24), disability (25), and child health (26) among others. Furthermore, many reviews have been published concerning the statistical methods and rationale for, as well as the quality of, the existing multilevel studies on health (27–34).

Yet, it is perhaps still premature to celebrate the exponential growth of multilevel epidemiologic studies on neighborhood residential effects on health. On the one hand, the growth in publication of these studies reflects increased interest in and support for social epidemiologic approaches. This increased support is encouraging in light of recent controversies about the legitimacy of social epidemiology as a subfield of epidemiology (35–40). On the other hand, these studies have emerged in public health and epidemiology without the appropriate theoretical and methodological foundations to guide their implementation. Hence, despite dozens of multilevel studies of neighborhoods and health, we still lack a clear picture of the intervention and policy implications of this body of work.

In this issue of the *Journal*, Buka et al. (41) examine whether levels of neighborhood social support affect the birth weights of African-American and White mothers residing in Chicago, Illinois. Their paper contributes to the small, but growing literature on multilevel analyses of neighborhood residential effects on perinatal outcomes (12–15, 42). It offers several methodological advancements over previous multilevel studies on neighborhood residence and health. Moreover, it highlights additional theoretical and methodological challenges that multilevel analysis, given its recent appearance in public health, must overcome if significant gains are to be made in understanding disease etiology and designing appropriate interventions and policies to prevent adverse health. These theoretical and methodological issues are the topic of this commentary.

### NEED FOR BETTER THEORY ON NEIGHBORHOOD EFFECTS

Perhaps the most pressing issue standing in the way of progress in multilevel research is lack of theory (i.e., system of hypotheses) on the mechanisms by which neighborhood environments affect health risks, protective factors, and outcomes. This is where researchers in other fields such as sociology of crime (43–45) and community psychology (46–48) have advanced well beyond public health scientists. While epidemiologists can draw from theories on mechanisms from these other fields, we epidemiologists will have to develop and identify our own theoretically informed mechanisms of how neighborhood environmental processes affect health. Moreover, given the lack of strong public health hypotheses regarding neighborhood effects, qualitative research should be undertaken and used to inform and identify mechanisms by which neighborhoods impact health risks and outcomes (49–51).

In their focus on neighborhood social support, Buka et al. (41) rely on the literature concerning individual-level social support and birth weight to inform their hypotheses

regarding how high levels of neighborhood social support are related to higher birth weights. While this step is a good start, we are still left with uncertainty regarding the conceptual and mechanistic links between neighborhood support—defined as social cohesion, trust, and reciprocated exchange—and increased birth weight. One limitation is that the literature used to inform these proposed mechanisms on social support at the individual level is equivocal (52, 53); some studies have reported no association, including several large randomized trials of social support and birth weight (54). As noted by Buka et al., increased fetal growth and birth weight were associated with intimate partner or family support only and not other types of support (e.g., instrumental support) (53). Given the inconsistent evidence among studies on birth weight and social support at the individual level, the lack of positive associations among African-American women in the Buka et al. study might have been expected.

Social support, examined by Buka et al. (41), and other neighborhood factors such as economic, political, cultural, and institutional processes are likely to involve complex direct and indirect mechanisms in their relation to health. Existing hypotheses regarding neighborhood processes in sociology suggest that indirect, mediational, and moderational mechanisms are important components of neighborhood effects on crime, academic achievement, and other behavioral outcomes (44, 45, 55–57). These mediating and moderating mechanisms are likely to be important in producing health risks, protective factors, and outcomes as well (27, 50, 58).

As an example, the interaction of political and neighborhood characteristics was identified as being responsible for high rates of heat-related mortality among the elderly in selected Chicago communities in 1995. Specifically, neighborhood housing type (high-rise hotels with no cooling systems), low levels of neighborhood safety, and reduced social services all interacted to contribute to high rates of isolation among elderly in selected areas of Chicago. This isolation in turn was responsible for the epidemic of heat-related deaths in selected Chicago neighborhoods during the 1995 heat wave (51). In another example from perinatal health, early initiation of prenatal care, which usually affords protection against lower birth weight, was less protective among women residing in neighborhoods that had high versus low levels of unemployment in Baltimore, Maryland (13). In neighborhoods characterized by high unemployment, a multitude of economic, political, and social factors are likely present that may increase the risk of low birth weight. Prenatal care, primarily intended to manage medical risks, may not address the myriad social factors contributing to the risk of low birth weight. Hence, early initiation of prenatal care will not provide the same protection in high-unemployment neighborhoods that it does in low-unemployment communities. These two examples illustrate the need to get a comprehensive picture of the ways in which political, economic, cultural, and physical attributes and processes are related to health risks and outcomes and how we must examine relations between effect modification and mediation in future studies.

## NEED FOR METHODOLOGICAL ADVANCEMENTS

Buka et al. (41), similar to the authors of almost all other multilevel analyses, with few exceptions, used cross-sectional data to study individual health risks and outcomes. To establish causation, however, we need to begin to use longitudinal designs. Moreover, historical and longitudinal data on neighborhoods should also be used. Neighborhoods do not have fixed characteristics; rather, they evolve and respond to larger societal processes such as economic cycles, changes in the industrial and manufacturing sectors, demographic shifts, and migration, as a few examples. Thus, to generate and measure neighborhood processes and how they affect health and well-being, we must begin to examine longitudinal data on persons and neighborhoods (55, 56, 59).

Another long-standing debate in the multilevel literature concerns the definition of neighborhood. Specifically, concerns about a spatial versus social or “interactional” (e.g., interaction between social network members or members belonging to a political or social interest group) definition of neighborhood, or the size of the “neighborhood” to be examined when spatial definitions are used, have been the topics of debates (55, 60–62). Buka et al. (41) used census tracts as their neighborhood unit and even combined census tracts into clusters by using data on racial composition, household income, educational levels, and housing density to promote homogeneity within clusters. While census tracts have been used extensively in multilevel analyses of neighborhoods (13, 16–18, 20, 26, 63), others have used the smaller units of census block groups (19, 24, 64). Some have even argued for yet even smaller areas than census block groups because these smaller units may be more consistent with how residents themselves define their neighborhoods in qualitative studies (60).

When spatial definitions are being used, one concern is the level of heterogeneity of neighborhood characteristics, specifically, the relation of the within- to the between-neighborhood variation. Census tracts, on average comprised of approximately 4,000 residents, are more heterogeneous with regard to economic, political, cultural, or institutional features compared with census block groups, which contain on average 1,000 residents. When neighborhood sizes are large (e.g., clusters of census tracts), variation within neighborhoods may be high; consequently, variation between neighborhoods may be limited. When between-neighborhood variation is small, detecting neighborhood effects is difficult, especially if within-neighborhood variation is simultaneously large (56). Thus, considerations about neighborhood size go beyond concerns about how neighborhood residents may conceptualize their residential areas.

On the other hand, defining neighborhoods so they are too homogeneous will not enable us to assess the effects of important social factors such as segregation or income inequality on health outcomes, because it is necessary to have variation by race or income within neighborhoods to examine these particular factors (13, 65). The Buka et al. data (41) illustrate the high levels of racial segregation in Chicago. To use multilevel models to understand both class and race inequalities in health will require attention to the definition of neighborhood and the issue of heterogeneity.

Buka et al. (41), when creating their census tract clusters, grouped those census tracts that were similar regarding economic indicators. However, there may have been heterogeneity for noneconomic characteristics in these neighborhoods that were not considered in this matching process. Our prior work indicates that, in census tracts with similar levels of racial composition and poverty, housing quality and crime rates can vary considerably; correlations between economic, housing-quality, and crime characteristics in economically impoverished, primarily African-American census tracts in Baltimore City were 0.03 (26).

Other neighborhood-definition discussions have focused on the need to identify appropriate units to accommodate measurement of multiple processes—economic, political, cultural, and institutional—operating in the neighborhood environment (55). It is unlikely that social processes such as political participation, social support, psychological sense of community, or others will operate within the bounds of census denominations. For example, in studies of neighborhoods, parents, and the health of elementary school children, parents may be influenced by the Parent Teacher Association of their child's school, which is based on geographic considerations but would not correspond to a census tract or block group boundary. Their parenting may also be affected by immediate residential crime rates that may be more closely related to a census tract or block group boundary. Therefore, the ideal geographic units of analysis for neighborhoods concerning these two potentially important factors affecting parenting practices and children's well-being are not compatible.

Given that the debate regarding the appropriate size of spatially defined neighborhoods will not be resolved easily and, more likely, that no single unit of neighborhood will simultaneously satisfy the needs for measuring multiple neighborhood processes, one possible solution is to promote the use of multiple definitions of neighborhood within the same study. This solution is already being implemented in some instances. For example, community psychology studies include measures of sense of community based on the respondents' notion of their own neighborhood as well as on economic characteristics of the census-based neighborhoods in which they reside (47, 66, 67).

A related issue is the need to identify the appropriate set of neighborhood residents to include in studies. Buka et al. (41) used a method common to almost all current studies of neighborhood residents and health. That is, all study subjects who have an address are included in the study without regard to the length of time they have lived in the neighborhood. However, it is doubtful that a woman who just moved to the neighborhood and has resided there for only 1 month would have the same exposure or opportunity to be affected by the social environment as someone who lived in the neighborhood several years. While information regarding length of residence is not included on the birth certificate and, therefore, Buka et al. could not have accounted for this factor, studies using survey data should consider including this information. Length of residence can then be an adjustment factor. Persons who have lived in neighborhoods for a very short while, such as those who have just moved, might be excluded from the sample or assigned to their previous

neighborhood of residence (58). This issue is particularly relevant for studies that include high proportions of very low income study subjects, because residential mobility can be quite high among that population (55). To avoid misclassification, future studies should strive to ensure that study subjects have been exposed to their assigned neighborhoods for a sufficient amount of time.

Buka et al. (41) drew data for their analyses from one of the most comprehensive high-quality community studies. Much research from this vast project has been published regarding the importance of concentrated poverty and neighborhood collective efficacy (refer, for example, to Sampson et al. (43, 44)). These data surpass the typical focus on neighborhood levels of income or poverty to include information that attempts to capture social processes contributing to poor health outcomes.

There is an urgent need for studies to go beyond the use of census or administrative data. First, although socioeconomic position continues to be the most consistent predictor of well-being (68), it is likely that political, cultural, and institutional processes at the neighborhood level, other than poverty or income, are also important contributors to health outcomes (59, 64, 69, 70). Specifically, political and structural features of neighborhoods such as political organization (69), housing quality (26, 71), racial discrimination (63)—including the neighborhood social support as documented by Buka et al. (41)—and neighborhood historical processes (55, 72) contribute significantly to the production of health (6, 27). Yet, few studies of neighborhood residence and health have simultaneously examined the role of economic, political, cultural, and institutional processes. The rich neighborhood-level data from the Project on Human Development in Chicago Neighborhoods are derived from not only observational videos taken of block faces (i.e., someone traveling down a city block while videotaping environments and residents) but also surveys of several thousand randomly selected residents. Confirmation of these findings in other settings will be important to gaining a greater understanding of neighborhood processes and health. Similar data collection efforts, perhaps on a smaller scale than the Project on Human Development in Chicago Neighborhoods, will have to be undertaken for future neighborhood research if information on these economic, political, cultural, and institutional processes are to be studied.

Buka et al. (41) obtained information on neighborhood social support by interviewing residents who were *not* part of their analyses on birth weight, which is a major strength of the study. When the same survey respondents are used to examine health outcomes as well as to report on neighborhood characteristics, including social processes, the possibility of same-source bias arises (59, 70). For example, those whose physical or mental health status is poor may rate their neighborhoods less favorably compared with their healthier neighbors. In this example, poor health and poor neighborhood quality will be highly correlated.

Availability of data is a significant barrier, because information on these political, cultural, and economic factors and on historical processes is not available from census or other administrative sources. Given that collection of observational or survey data is costly yet necessary, future research

might consider collaborative efforts across studies conducted in the same geographic area in order to obtain necessary data. For example, in Baltimore, investigators conducting ongoing multilevel research in diverse areas such as perinatal health, child health, adolescent health, human immunodeficiency virus, substance abuse, and aging are joining together to share different types of primary and administrative data across studies to maximize their ability to go beyond the typical census-based measures (Baltimore Neighborhood Research Consortium, Johns Hopkins Bloomberg School of Public Health, Baltimore, Maryland, 2002).

Multilevel analyses have contributed to a greater understanding of the social determinants of health. These studies have yielded important information about the impact of environments on health risks and health outcomes not available as recently as 10 years ago. Further work is needed in developing and testing sound hypotheses and applying rigorous study methodologies to advance the field. While we must continue to use methods of multilevel analysis, further gains in knowledge concerning etiology and the design of appropriate policies and interventions will not be made unless epidemiologists give greater attention to these specific challenges.

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