Neighborhood Mapping and Evaluation: A Methodology for Participatory Community Health Initiatives

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Abstract:

Objectives: This paper describes the use of neighborhood mapping as a key element in an ecological study of a community-based urban infant mortality prevention program. We propose the use of neighborhood mapping in evaluation research to more fully examine the local context of community health programs. Mapping can be used to study community change and to describe community assets and structural, epidemiological, and social features of neighborhoods that may influence program implementation and outcomes.

Methods: Data on physical features were collected by community residents during street-by-street neighborhood walkthroughs. Other data sources included program records, Census, birth certificate, and state and city data. Analytic methods included geo-coding, exploratory factor analysis to create spatial density indicators of neighborhood features at the Census block group level, and analysis of associations between neighborhood features and outcomes.

Results: Point and chloropleth maps provide a powerful illustration of neighborhood features (e.g., vacant buildings), client distribution and participation, health outcomes, and change over time. Factor analysis indicated two salient clusters of non-residential land use: (1) legitimate daily usage (liquor stores and other businesses) and (2) non-legitimate daily use (houses of worship and vacant buildings). A composite scale was created to indicate overall risk related to physical neighborhood features.

Conclusions: Neighborhood mapping is a powerful tool that brings participants and residents into the research process. Moreover, it can improve understanding of the role of neighborhood ecology in program implementation and outcomes.

Keywords: Maternal and child health - Evaluation - Infant mortality - Mapping - Low birthweight - Urban health - Neighborhood - Community - GIS

Article:

Introduction

Although the "interconnectedness" of multiple domains, including social, behavioral, and contextual influences [*1*, p. 51], as well as broader ecosocial frameworks, are increasingly recognized in public health [e.g., *2*, *3*, *4*], many public health programs in the United States continue to take an individual-level, risk factor-based approach [*4*]. Traditional evaluations often mirror this individual-level focus, typically linking an intervention to hypothesized outcomes such as seat belt use [*5*], nutrition [*6*], physical exercise [*7*], or diabetes self-management [*8*].

Pawson argues that evaluations might do well to begin with "partial, provisional, pluralistic theories" that lead to multimethod, emergent designs to test those theories and result finally in refined, albeit incomplete, explanations that support incremental policy reform [*9*]. Evaluation designs can better reflect emerging program-community interaction by incorporating sophisticated quantitative and qualitative approaches [*1*, *10*, *11*]. However, there are few descriptions in the peer-reviewed literature of complex programs with similarly complex evaluation designs that support the ability to refine programs and policies in real time.

A number of current public health and related initiatives funded by government and private sources reflect interconnected determinants of health, including the World Health Organization's Healthy Cities projects, the Annie E. Casey Foundation's Making Connections initiative, comprehensive child development programs such as Head Start and Early Head Start, and the post-demonstration wave of Healthy Start grants. These programs target both families and communities and need evaluation designs that recognize the multi-leveled nature of the initiatives.

Neighborhood mapping is one way of systematically recording relevant physical features and locations of program sites and participants, and this can provide a sound basis for studying community settings. Neighborhood mapping uses observational or secondary data and geographic information systems (GIS) to plot exact locations of neighborhood features, disease incidence, and community resources.

Literature review

Analysis of geographic or spatial data has been used to study health-related outcomes for more than 100 years. Durkheim's study of suicide in France analyzed data at the department level to study spatial patterns related to suicide clusters [*12*]. In London in 1854, John Snow famously plotted the locations of cholera incidence and was able to track the disease to a single contaminated water pump [*13*]. Mapping is increasingly used to plan interventions based on the location of at-risk populations [*14*, *15*], to study geographic concentrations of disease [*16*, *17*], and to highlight the evidence that advertisements for tobacco and alcohol are disproportionately located in low-income areas [*18*].

Maps can also be used to better understand program implementation (e.g., location of participants and their proximity to service providers) and physical and social risk and protective risk factors (e.g., areas of high crime, problem-solving capacity). Moreover, spatial data can be used in combination with other community and program data to study complex program-related interactions, such as the relationship between areas dense with poor housing and low birthweight. Finally, neighborhood mapping data are often—though not always—collected using participatory research methods [e.g., *19*]. Such methods offer program participants and/or community residents opportunities for experiential learning and a chance to participate in and contribute to the research and the study itself with their insights about the neighborhood, its history and culture [*20*].

Mapping, alone or in conjunction with other methods, has particular applicability to the evaluation of community-based initiatives to address or prevent such problems as violence, child abuse and neglect, or substance abuse, or to promote healthy families and neighborhoods. This paper describes the use of neighborhood mapping as a component of the evaluation of Baltimore City Healthy Start, a federally funded infant mortality prevention program.

Baltimore healthy start community evaluation

The national Healthy Start Initiative began in 1991 as a demonstration program targeting 13 cities and 2 rural areas across the United States [*21*]. When the demonstration phase ended in 1997, the Healthy Start Initiative continued in Baltimore and 96 other sites in the US. The goal of the Baltimore program during the demonstration phase was to reduce infant mortality by providing comprehensive, community-based services to pregnant women and new mothers, their infants, and their neighborhoods. The program was based on the notion that health problems such as infant mortality cannot be overcome by intervening with individuals while neglecting the contexts in which they live. Through comprehensive services to women, their children and their male partners, and a strategy of employing community residents, Baltimore City Healthy Start aimed to contribute to a process of neighborhood transformation that would produce changes in physical, social, and behavioral aspects of the neighborhood that increase risk for poor pregnancy outcome and infant mortality.

In Baltimore, Healthy Start efforts were focused at two levels with varying levels of program intensity: the "Project Area," encompassing two-thirds of Baltimore City including the highest risk communities where services were less intensive and included activities such as fetal and infant mortality review and a public information campaign; and two "Target Areas" composed of clusters of census tracts located in east and west

Baltimore where services were meant to reach the majority of the target population residing in those areas. The Target Areas represent under-served areas of the city where infant mortality rates were highest and the risks were greatest. It is in these two Target Areas where the most intensive infant mortality reduction initiatives were conducted, including the establishment of one-stop Neighborhood Healthy Start Centers. These centers employed community residents as outreach workers to canvas the neighborhood for pregnant women and women with young children. Women who were enrolled in the centers received case management, health education, and psychosocial services throughout their pregnancy and through their child's third birthday.

Evaluation of the program encompassed (1) a participant-level outcome evaluation, which examined participant reproductive health outcomes; and (2) a community-level evaluation, which used a participatory approach to study contextual variables hypothesized to influence program implementation and outcomes in the two target areas. The community evaluation sought to (1) understand the nature of the physical, social and cultural context of the target neighborhoods in which the Healthy Start program provided comprehensive services to program participants and (2) understand how these factors may act as facilitators or barriers to the success (or failure) of the Healthy Start program. The overall design of the multi-component Baltimore Healthy Start community evaluation is described elsewhere [*22*]. This paper focuses on the role of neighborhood mapping in the community-level evaluation, and uses data from the west Baltimore target area to illustrate the findings obtained.

Participatory research in the community evaluation

The overall evaluation of the Baltimore Healthy Start program followed a method we call "ethnographically informed community evaluation," or EICE [*22*]. EICE embraces participatory models of community evaluation [*23*–*25*] that stress collaboration for social change [*26*–*28*]. The goals of our participatory framework followed the entreaty of Hatch and colleagues to transfer knowledge and tools to the community and to learn from the expertise and experience of community members, thereby building both evaluation knowledge and community capacity [*29*].

It has been argued that levels of community participation in research vary depending on the epistemological assumptions of the investigators, objectives related to such notions as community empowerment, practical issues of community entrée and data validity, and even local political dynamics and the community's relationship to the scientific community [*30*]. This evaluation incorporated a high level of participation by neighborhood residents because the evaluation of the Baltimore Healthy Start program, and because the evaluation involved the exploration of contextual and cultural issues related to health behavior and health outcomes. Moreover, the architects of the evaluation were concerned that university researchers might not be well-received by the community, particularly given the strained historical relationships between the schools of medicine and public health at Johns Hopkins University and the surrounding neighborhoods. Thus, hiring community residents to collect data was intended to level the social distance between interviewer and respondent and facilitate rapport and thus improve the validity of the data [*30*]. It was also intended that resident-researchers would provide a unique and critical perspective to understanding community change. Finally, the investigators felt that they had an ethical responsibility to assure that some benefits would accrue to the community from the research and that participation could protect the population from any harm from the research and instill skills (e.g., community organization, interviewing) for future use [*30*].

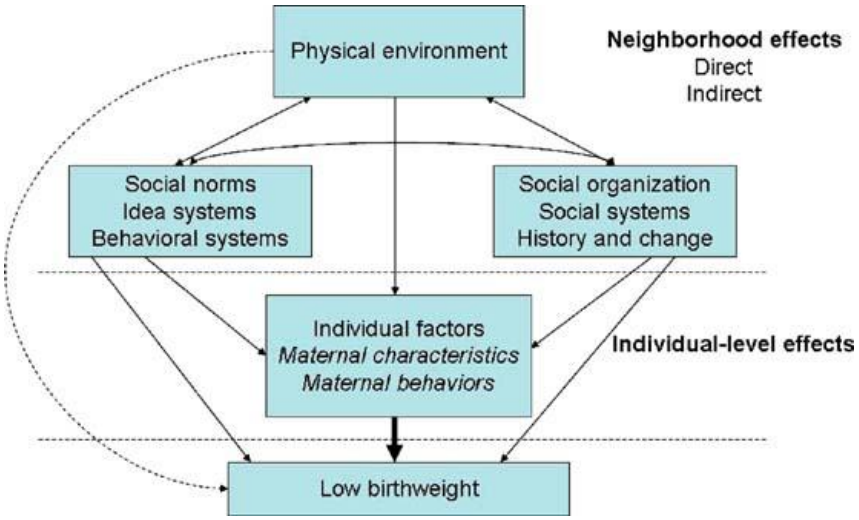

Fig. 1 ***Conceptual Model: The Neighborhood Milieu***

Table 1 ***Physical neighborhood conditions and possible links to health***

Physical conditions	**Possible mechanisms**
Vacant houses	Living in an area with a high concentration of vacant houses can expose individuals to direct health risks (rodents, fires, crime and violence), and indirect health risks (stress and lack of social support) [*34*, *35*], which may affect pregnancy, birth weight and infant mortality. High spatial concentrations of vacant houses may also decrease the likelihood that women will leave their homes to go to the Neighborhood Healthy Start Center for activities. The increasing presence of vacant houses and other non-residential space in neighborhoods has been shown to be associated with increasing levels of fear of crime and increasing crime rates [*33*].
Houses of worship	Houses of worship have been shown to serve as buffers to the stress of living in poverty, in that they provide much needed social support to members [*36*]. They may also be actively involved in addressing local social concerns. In many instances, however, their presence may only mean that rents are cheap and codes are not enforced, making it easier for them to locate or remain in the area. The constituency of the church, temple or mosque is another factor: many in urban settings have members from outside the community or outside the city who may have little commitment to the local neighborhood. Houses of worship may be grouped together with other non-residential space in neighborhoods, in that they occupy space in which local residents are less able to exert control over what activities occur.
Businesses	Availability of employment opportunities can serve as a supportive mechanism in the environment, depending on the number and types of jobs available to local residents. Lax requirements for zoning, however, may place more businesses in poor residential neighborhoods. Businesses may also be grouped together with other non-residential space in neighborhoods, in that they occupy space in which local residents are less able to exert control over what activities occur.
Liquor licenses	Presence of businesses with liquor licenses may affect the availability and use of alcohol. Alcohol and other substance use that interferes with proper nutrition is a risk factor for poor pregnancy outcomes, including fetal alcohol syndrome. Lax requirements for zoning may place more liquor stores in poor residential neighborhoods. Liquor stores may also be hangouts for people who can be threatening to the neighbors, affecting their ability to leave their homes and interact with others. These conditions may also affect the likelihood that women will leave their homes to go to the Neighborhood Healthy Start Center for activities. Contexts that are perceived as threatening may also influence the extent to which recruitment staff and outreach staff provide services to women. Liquor stores may be grouped together with other non-residential space in

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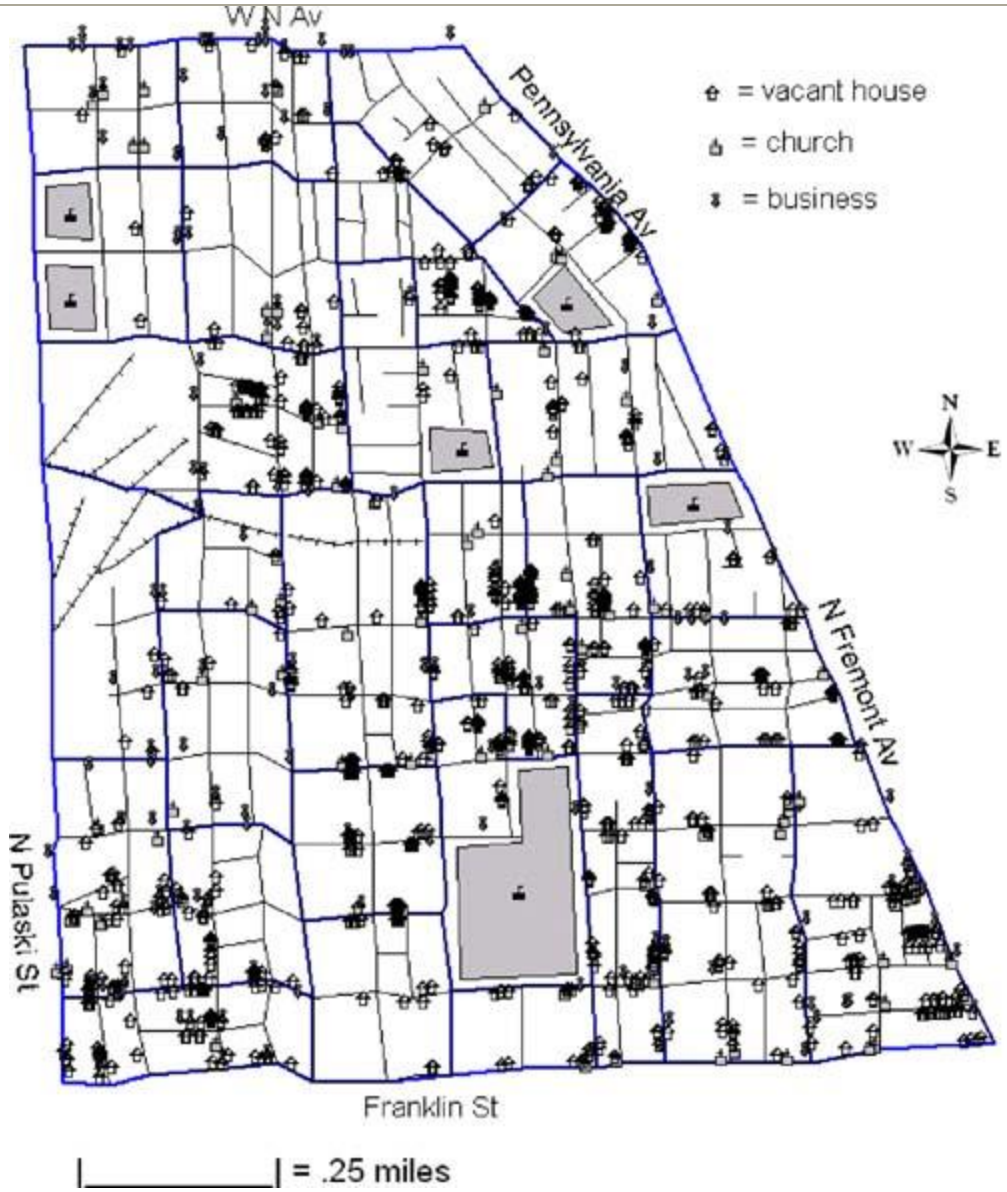


Map. 1 ***Point Data Showing Location of Vacant Houses, Businesses and Religious Institutions***

Four to five residents were chosen from each of the target communities based upon their residence in and commitment to the community and personal skills and qualities related to ethnographic data collection, such as communication skills, ability to read and write, and analytical abilities. Team members were trained in basic social science and ethnographic research techniques through role plays, discussions, and experiential exercises. One person from each community research team was selected as the community research coordinator; the coordinators were employed half-time and were responsible for coordinating data collection activities, supervising the other team members, and interviewing. The other team members were volunteer assistants contributing about five hours per week; in appreciation for their time and commitment they received a monthly honorarium of $100.

Conceptual framework

We used a conceptual framework based on Whitehead's Cultural Systems Paradigm (CSP) [*31*] that we named "The Neighborhood Milieu" (see Fig. 1). The Neighborhood Milieu defines neighborhood- and individual-level

factors that can contribute to pregnancy outcomes such as low birthweight and preterm delivery. Neighborhood factors include (1) the physical environment; (2) social norms, idea systems, and behaviors; and (3) the social organization and systems of the neighborhood, including local manifestations of broader historical trends. For the mapping component of the evaluation, we refined the Neighborhood Milieu framework to articulate the role of the urban physical environment in shaping reproductive health outcomes. This was informed by interviews and focus groups with residents, who provided insight into salient physical characteristics that might be related to reproductive health in the target neighborhoods, including the presence of vacant houses and liquor stores.

Table 1 lists physical characteristics and the mechanisms through which they might be related to reproductive health.

Methods for mapping intervention neighborhoods

In the evaluation, "neighborhood" was defined as a geographic setting describing the immediate area within which people reside and share exposures to various environmental conditions or risks (including physical and social). Boundaries were defined as the geographic area coinciding with Census block groups (CBGs) as defined by the U.S. Census Bureau. CBGs are a smaller geographic unit than Census tracts, containing about 500 people, and they tend to be more homogeneous than Census tracts in demographic, social, and economic indicators.

Data sources for mapping activities

Data collection forms were created to guide neighborhood walkthroughs. These walkthroughs were conducted by community residents hired and trained by the evaluation team. Residents used specific forms to record the date, street, and block; the overall condition of each block; the addresses of vacant and boarded-up houses or buildings; the names and addresses of businesses (including stores, nightclubs, social clubs etc.); and the names and address of healthcare providers, schools, recreational centers and parks. They also made notes on places where people congregated such as in front of liquor stores or in parks, or other features of note.

Other data collected included program information on Healthy Start participants, such as demographics, address, degree of participation, loss to follow-up, and pregnancy outcomes. To protect confidentiality, participant addresses were aggregated to the CBG level so that individuals could not be identified. These data were used to study relationships among client participation, outcomes, and the physical characteristics of the environment.

Other data were obtained from the City of Baltimore and the State of Maryland. Housing inspection data, including violations, were obtained from the Baltimore City Department of Housing and Community Development. Liquor license data were obtained from the Baltimore City Board of Liquor License Commissioners. Birth certificate data containing information on pregnancy outcome were obtained from Maryland Vital Records.

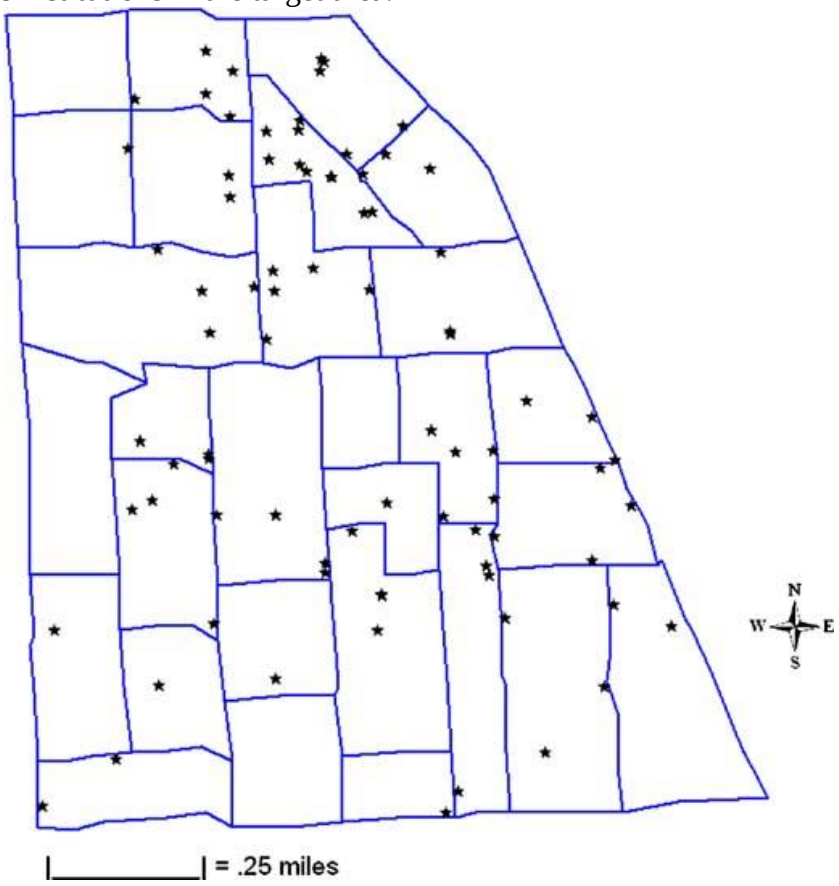
Analyses of the mapping data

Geocoding and map generation

Physical features were assigned a street address that could be geocoded as a precise latitude and longitude, permitting their representation as a point on a map (e.g., playground at 1625 N. Carey Street). We used digital boundary files provided by the Census Bureau for each entry, assigning CBGs as the geographic unit of analysis. All of the data collected for the physical mapping of the Healthy Start target areas were geocoded using MapInfo desktop mapping software.

The research team generated two types of maps: (1) point data maps and (2) choropleth maps. Point data maps show the locations of neighborhood features such as vacant houses, licensed liquor stores, businesses, and houses of worship. Point data maps are helpful in describing the specific context in which program participants live, including detailed descriptions of the street and block. They also help to identify how different physical

features cluster together within a neighborhood. Map 1 is a point data map showing locations of vacant houses, businesses, and religious institutions in the target area.

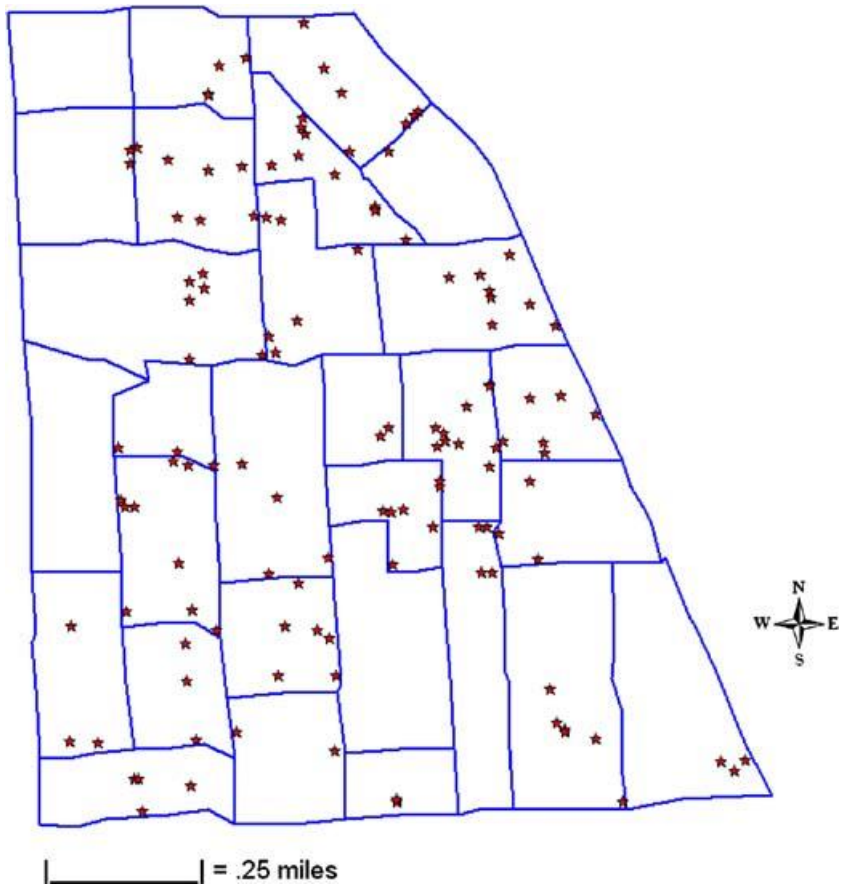


Map. 2 ***Healthy Start Participants, Program Year 1 (n=85)***

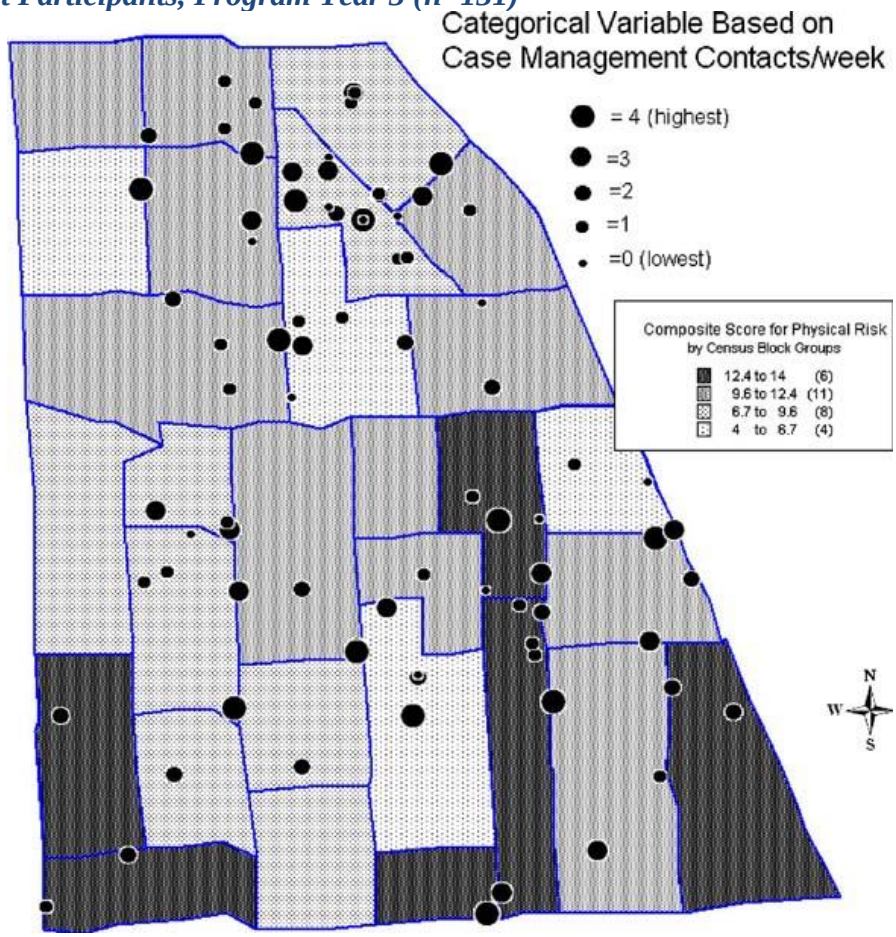
Choropleth maps aggregate and present data in the form of counts, rates, or percentages across a defined geographic space, such as a Census tract or block group. These aggregate data are usually indicated by shaded, colored, or textured areas on a map. Point data can be presented on top of choropleth maps.

Maps like these can play a role in both process and outcome evaluation; moreover, they are useful to program planners and staff. Maps can illustrate the target area and are particularly helpful when they show economic, social, and health trends across block groups or other neighborhood boundaries. More complex maps can be used to display demographic or other aggregated data (e.g., unemployment rates) with locations of program participants, service providers, landmarks, roads, parks, and other neighborhood features. These combination maps are a powerful means of displaying important community data and demonstrating such problems as, for example, the fact that in some cities areas with higher rates of poverty have fewer healthcare providers. Such correlations are easy to see when shown on a map.

Maps can also be used to demonstrate change. That is, by placing maps visually side by side, it is possible to see how neighborhoods change in key domains over time. The Baltimore Healthy Start Office of Management Information Systems provided data on all program participants in the target area, and these data were geocoded and mapped to show the distribution of Healthy Start clients across the target area. Maps 2 and 3 show changes in participant numbers and distribution in the Baltimore program between program years 1 and 3.



Map. 3 ***Healthy Start Participants, Program Year 3 (n=131)***



Map. 4 ***Client Participation Levels and Neighborhood Physical Risk Scores***

Map 4 shows participant distribution using circle icons that represent levels of program participation. Participation level was determined based on the number of case management contacts per week, and these were then categorized by quintiles of participation. These circles overlie shaded areas indicating the level of physical risk in the CBG as determined by factor analysis of physical features. Other uses for maps include helping stakeholders understand outcomes related to context by showing how particular variables are distributed geographically.

A goal of the Baltimore program was to enroll 80% of eligible women into the program. Using vital records data to determine the total number of births in the denominator, recruitment rates were calculated for each block group. With this knowledge, the program was able to intensify recruitment efforts in block groups with lower rates of participation. Further, when physical conditions in each block group were known, clients were linked to data about their residential environment to permit analysis of how the environment might diminish or enhance the effects of the program activities, and to give direction to program staff about specific needs of women living in different block groups and to communities about improvements needed, such as the elimination or recovery of vacant houses.

Creating indicators of physical environment risk

In order to compare the density of key neighborhood characteristics (e.g., liquor stores) within the target area, we created spatial density (SD) indicators. Spatial density is the count of a particular characteristic (e.g., number of liquor stores) divided by the area of the Census block group in square miles. Using spatial density as an indicator of a given characteristic, the maps created show rates controlling for the size of the geographic area covered. Thus, this indicator is more precise than either simple rates or point data, because it accounts for geographic space and provides a clearer picture of where and how to locate services.

Indicators can also be created adjusting for population size or the number of housing units. In the case of vacant housing, we divided the number of vacant houses by the total number of housing units in a census block group. Map 5 shows the resulting density of vacant housing.

We conducted an exploratory factor analysis to understand whether and how neighborhood characteristics expressed in terms of spatial density would cluster across block groups within the target area. We first conducted a principal axis analysis using oblimin [*32*] rotation since we expected that all of the neighborhood indicators used represented non-residential space usage, which may be correlated with one another [*33*]. The analysis revealed two factors with eigenvalues greater than 1. One factor corresponded to the spatial density of liquor stores and businesses (non-residential land use with legitimate daily usage); and the second factor linked houses of worship with vacant and boarded-up housing (non-residential land use with no legitimate daily usage in general). The results of the factor analysis are shown in Tables 2 and 3.

Table 2 ***Initial statistics and variance explained***

Factor	Eigen value	Percent variance	Cumulative percent
1 (Liquor stores-businesses)	1.490	37.3	37.3
2 (Vacant buildings–churches)	1.107	27.7	64.9
3	0.826	20.7	85.6
4	0.577	14.4	100.0

Map. 5 ***Density of Vacant Housing***

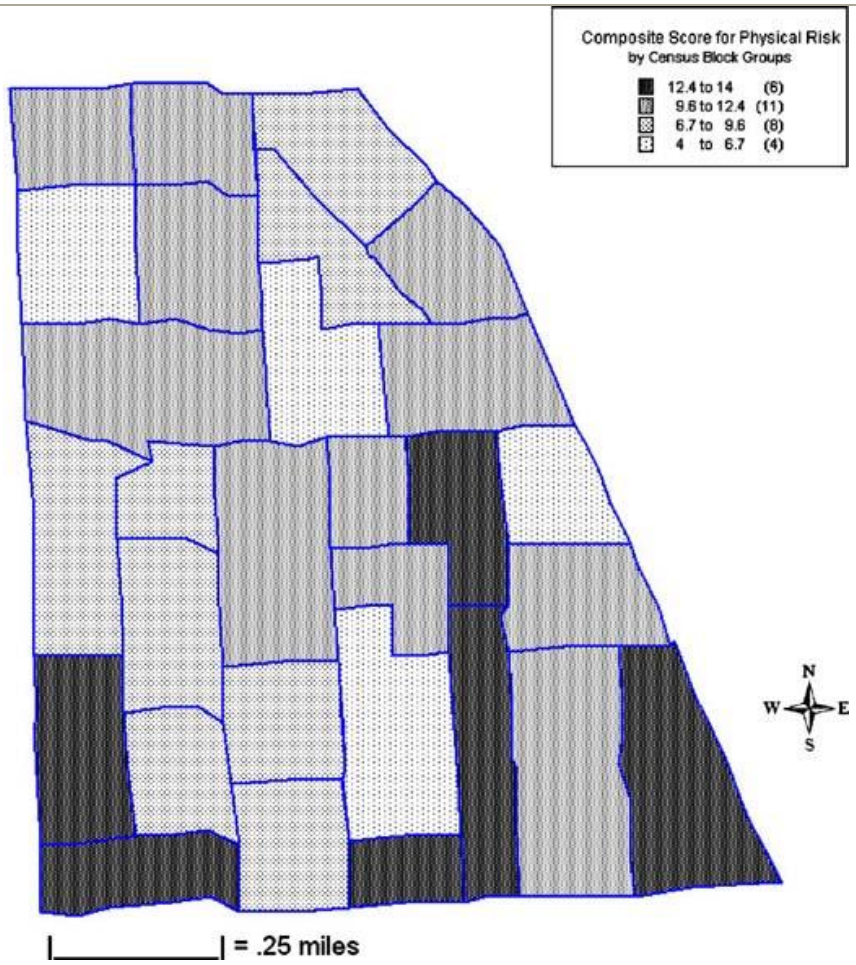
Based on this two-factor solution, we calculated factor-based scales for every CBG. To create the scales, we first calculated the quartile rank for each CBG for each of the SD variables. Then we added the scales together for each factor (i.e., liquor license density quartile + business density quartile, and vacant housing density quartile + houses of worship density quartile). We saved these factor-based scales for each CBG and used the variables to create choropleth maps representing different levels of the physical characteristics represented in the neighborhood. A composite score combining the two factor-based scales was calculated to represent overall risk related to physical characteristics, shown in Map 6.

The factor analysis provided a more complete understanding of how physical features operated together in neighborhoods. By understanding the structure of domains related to physical features (e.g., existing features aggregate as residential and non-residential features), we learned more about the mechanisms that might be related to downstream health and health-related issues. For instance, neighborhood geographic space that is residential may not exert the same level of risk as geographic space that is non-residential. Also, non-residential space that has a legitimate daily use (such as a store or business) may not exert the same level of risk as non-residential space that has no legitimate daily use (such as a vacant lot or house, or a church that offers no activities during the week). An understanding of these relationships can be helpful to program and policymakers, who can design interventions that focus on specific factors related to or upstream of a public health problem.

The spatial distribution of risks within a community can be further quantified by studying relationships between outcomes and neighborhood contextual variables. Depending upon the number of variables, sample size, and variability across neighborhoods, it is possible to construct multivariate regression and multilevel models to study how structural factors operate in neighborhoods and how they may influence outcomes across neighborhoods and over time.

Table 3 ***Pattern matrix***

	Factor 1 (Liquor stores-businesses)	**Factor 2 (Vacant buildings – churches)**
Liquor licenses per square mile	0.65582	−0.08912
Businesses per square mile	0.62640	0.13996
Vacant houses per square mile	0.01412	0.42388
Houses of worship per square mile	−0.00910	0.408151



Map. 6 ***Neighborhood Physical Risk using Composite Score***

Discussion

Neighborhood mapping provides a powerful tool for understanding how community-based public health programs work, as shown in this Healthy Start example. In addition to the usual way of summarizing the demographic characteristics of communities, our visual depiction of neighborhood physical characteristics using maps provided a clear way of identifying sections of a target area at increased risk. We were also able to illustrate possible recruitment gaps, so that those could be addressed by staff. Even in a target area at high risk, mapping of physical characteristics can show the heterogeneity of risk in neighborhoods This information can be an important tool for program staff as they decide where and how to focus resources and efforts and/or decide what mid-course corrections may be needed to improve targeting and recruitment.

The data collected in the neighborhood mapping component of the Baltimore City Healthy Start community evaluation enabled us to identify neighborhood conditions of concern to residents that might be associated with poor pregnancy outcomes and to low rates of program recruitment and participation. Our visual depiction of

neighborhood physical characteristics using maps was a useful way to identify sections of the target area that might be at increased risk.

Maps produced in studies such as this one can be used in community settings, focus groups, or meetings with community representatives and service providers to stimulate action. As residents discuss the problems they experience in their neighborhoods and view data depicting these concerns in the form of maps, they become motivated to seek solutions. Policymakers can use maps to target programs and policies aimed at neighborhood transformation.

The technology needed for the widespread application of neighborhood mapping is now quite accessible. Numerous computer software packages are available and accessible to users without formal training in cartography or geography. MapInfo is one such package; others include ArcGIS and EpiMap. The widespread use of such programs and the technical assistance available make the use of mapping technology an attractive and cost-effective evaluation tool, as well as a tool for epidemiologists, public health researchers and public health practitioners.

Despite the promise of neighborhood mapping in evaluating program context and outcomes, there are limitations and challenges to its widespread use. First of all, these software programs can be quite expensive and may require considerable time for training staff. Secondly, the use of mapping for improving program implementation requires real-time processing of data collected (such as recruitment numbers or participation rates), so that maps can be created while they have the most potential to be useful. Finally, mapping can be a useful companion to outcomes measured at the individual level, but by their very nature present data that are ecological, including aggregates of individual-level measures or representations of community-level characteristics. Exclusive use of mapping for evaluating programs aimed at individual-level change is not appropriate.

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