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Thinking About Place, Spatial Behavior, and Spatial Processes in Childhood Obesity

Stephen A. Matthews, PhD

Department of Sociology, The Pennsylvania State University, University Park, Pennsylvania

Place in Childhood Obesity Research

There is no single solution to the childhood obesity epidemic, but there is a need for transdisciplinary collaboration and approaches that consider the potential mechanisms that promote or reduce obesity at all levels of enquiry, from cells to society.^{1–3} In this theme issue of the *American Journal of Preventive Medicine*, we focus on place (obesogenic and leptogenic environments),^{4,5} specifically the use of geographic information systems (GIS), related technologies, and spatial analytical methods in the study of childhood obesity.^{6,7}

A proven technology, GIS facilitates the measurement, management, mapping, and analysis of the real world.^{6,7} GIS is not a panacea,⁸ but the integrative nature of GIS and its linkage with spatial statistical analysis offer an important means of better understanding and dealing with some of the most pressing problems of our time and provide valuable tools for researchers and policymakers alike. Not surprisingly, as GIS has matured (the ready availability of geospatial data, enhanced visualization tools, and advanced spatial analysis methods) there has been an explosion of interest in the application and use of spatial concepts and methods in health-related research.^{8,9} As illustration of the growing interest in GIS consider the recent grant requests for applications in the area of childhood obesity research in the U.S. that include an explicit emphasis on the development of new and/or validation of existing relevant community-level measures to assess the food and physical activity environments. The fundamental questions childhood obesity researchers (and policymakers) must now ask include: What is, and how do we measure, place? How can we measure children's exposure to and interaction with obesogenic and leptogenic environments? What place-based processes are associated with obesogenic and leptogenic environments? Inherent in recent attention to place is the acknowledgement of the complexity and multilayered nature of many health problems we face, including obesity.^{1,10,11}

Theme Content

In my day job, my role is to think creatively about how GIS can be used to investigate contemporary social issues such as childhood obesity research, to stretch the GIS technology and revise the methodologies we currently use. I have a similar role as a co-guest editor (with Celeste Torio), specifically to select papers that expose childhood obesity researchers

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Address correspondence to: Stephen A. Matthews, PhD, The Department of Sociology, The Pennsylvania State University, 211 Oswald Tower, University Park PA 16802-6211. sxm27@psu.edu..

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to the vast array of geospatial data that are available, encourage them to think critically and creatively about how different forms of geospatial data can be integrated in their research, and introduce them to spatial analytical methods. The papers in this online theme issue^{12–17} represent recent forays by leading researchers into the collection and use of geospatial data on people and places, and the use of spatial analytic tools. The authors and the author teams span several academic fields reflecting that a spatial perspective can be an incubator for interdisciplinary and transdisciplinary research.¹⁸

The diversity of approaches to studying obesogenic environments cannot be captured in six papers, but I hope they provide a flavor of the research arena as collectively they cover much territory. These papers raise conceptual and measurement issues surrounding obesogenic places; describe the development of new measures on new places and new types of places; discuss how we can take advantage of new developments in geospatial data, technologies, and methods; and outline the challenges and opportunities we face. For sure there are other issues and challenges not covered, some of which I will turn to in my conclusion.

From an upstream perspective, inequalities in neighborhood food and physical activity environments are by definition an historical phenomenon, but despite the relevance of the historical lens most studies are cross-sectional.^{10,19} Places conceal their histories and are not always easily seen in an assessment of present-day surface features or captured in census variables or other measures. We need perspectives that recognize that places have legacy conditions and also that focus on the reciprocal relationships between people and place. That is, in studies of health behaviors and outcomes, we must measure both neighborhood change and residential mobility. Few national data sets are as potentially important to understanding childhood health and behaviors in the U.S. as the National Longitudinal Study of Adolescent Health (ADDHealth). Individuals in ADDHealth can be coupled with a unique Obesity and Neighborhood Environment Database (ONEdata) that includes a rich set of contextual attributes at different spatial scales (a blend of egocentric buffers and administrative units) and across time. In our opening paper Boone-Heinonen and Gordon-Larsen¹² utilize the spatial and temporal coverage of ADDHealth/ONEdata to provide a concise review of both the main conceptual and methodologic challenges and highlight the potentials offered through longitudinal geospatial databases.

The careful construction of local geospatial databases incorporating built, physical, and social measures can help researchers better understand the contexts wherein people make eating- and physical activity-related decisions. Data set construction can be a long and complex task but this is one area in which GIS-related software and technologies excel. In companion papers, Frank et al.¹³ and Saelens and colleagues¹⁴ describe their work in the Neighborhood Impact on Kids (NIK) Study of children aged 6–11 years in San Diego CA and Seattle WA. Frank et al.¹³ describe a “multi-component obesogenic environment measure” that importantly draws on both physical activity and nutrition environment data inputs. Data validation is a key component of this type of work. These data are utilized to identify different obesogenic environments (based on a 2×2 matrix of high/low physical activity environment and high/low nutrition environment designations). Identifying variability in the obesogenic environment is critical for drawing samples so that researchers can assess the role of the environment on health behaviors. One interesting finding, and as the authors suggest quite alarming, is that in their study sites the newest neighborhoods perform worst and the oldest the best across both sides of the energy balance equation. Their work is residential-neighborhood based but could be adapted for school or other contexts of behavior. Saelens et al.¹⁴ is an empirical paper that utilizes the Frank et al.¹³ physical activity and nutrition environment typology to evaluate child and parent weight status at baseline in their longitudinal cohort.

Wall and colleagues,¹⁵ using data from the Eating and Activity in Teens (EAT) study based in Minneapolis/St. Paul MN also compile a unique geospatial database utilizing mostly objective measures of the environment. They examine different statistical approaches to develop classifications of neighborhood types and test associations with adolescent weight status in both boys and girls. An innovative component of their paper is the use of spatial latent-class analysis to identify geographically clustered obesogenic neighborhood profiles. The spatial latent-class analysis differentiates among six types of places within the metropolitan area revealing (as do Frank¹³ and Saelens¹⁴) the complexity and clustering of obesogenic and leptogenic factors.

Moreover, Wall and colleagues¹⁵ find differences in the associations of such factors in a gender-stratified analysis.

Fraser et al.¹⁶ use logistic geographically weighted regression (GWR)²⁰ to improve their understanding of how relationships between fast food and obesity vary over space on an adolescent cohort in Avon (Bristol and surrounding area) in southwest England. Most research assumes that the relationships between predictors and outcomes are stationary and do not test whether this is the case. As Fraser et al.¹⁶ show, knowledge of nonstationarity is important for policy decision making and designing interventions; indeed knowing what is stationary may be as important as knowing what is nonstationary. Their paper includes efficient visual representations simultaneously mapping both the local coefficients and local t-values for separate predictors; it measures accessibility via a classic proximity weighted measure of density²¹; and from a methodologic standpoint provides an appropriate treatment of edge effects. GWR is generally regarded as a useful tool for exploring spatial nonstationarity and interpolation but because it is a relatively new technique further testing is required,²² and researchers entering this area of spatial statistics need to stay up-to-date on the literature.

Across the health and social sciences we see a new generation of activity space studies that combine the collection of individual attributes 24/7 and across geographic areas, focusing on an individuals' spatial behavior not just their residential neighborhood, school, or workplace. In obesity research such studies couple physical activity data (via an accelerometer) with geospatial data (via a global positioning system), or they can use GPS-enabled personal data assistants (PDAs) or cell phones to engage in ecologic momentary assessments (EMAs) of self-reported measures of psychological health.²³ These studies are uniquely positioned to explore an individual's exposure to specific types of places, and the importance of specific contexts on behaviors. Rainham and colleagues¹⁷ describe a study of adolescents (aged 12–16 years) in Halifax, Nova Scotia that used accelerometer and GPS data to measure the frequencies of moderate-to-vigorous physical activity (MVPA) by location and examine how MVPA varies by urbanicity. The study of behaviors and measurement across multiple contexts is critical to the field and can inform the design of interventions. For example, an important finding from these authors is that journeys between locations are as important as both home and school contexts in contributing to increased MVPA.

Discussion and Challenges

The role of place(s) and how children interact with place(s) is just one part of the childhood obesity puzzle. As illustrated in these papers, future research on childhood obesity will depend on the collection and analysis of individual- and contextual-level data on diverse places, across a wide range of spatial and temporal scales. As we pursue this line of inquiry, childhood obesity researchers must pay attention to conceptual and methodologic issues and explore next-generation data, measures, and methods. While many have explored the use of

geographic information systems and geospatial databases to help manage data on people and places, we are only just beginning to think seriously about, and harness, the technologies, data, and methods that are already available to us *and* to anticipate other technologies, data, and methods that soon will be. Developments in data collection, the use of mobile computing wireless technologies and sensor devices, and what is called volunteered geographic information (VGI) foreshadow the innovative ways geospatial data will be used in the future to enhance the quality, scope, and flexibility of measures of the social, built, and physical environments.^{23,24} While there have been studies of social support and obesity,^{25,26} few have yet to explore social networks and characteristics of the built environment together with physical activity/body weight in the context of an intervention (Liza Rovniak and colleagues, Penn State Hershey-College of Medicine, unpublished observations, 2012).

Inevitably there are holes in the coverage of substantive topics in childhood obesity (e.g., all papers in this theme supplement focus on behaviors among middle school-aged children and adolescents, most papers focus on only the residential environment) and many GIS and spatial analysis-related challenges lie ahead.⁷ Handling geographic data is a methodologic minefield (whether analyzing point patterns, movement along networks, the connections [spatial lags] between polygons, the dynamic tracking of individuals through space, a static or dynamic analysis of neighborhoods). While there are technical challenges associated with issues such as precision and error,²⁷ incomplete data,²⁸ and ethical challenges in an age of ubiquitous location and surveillance²⁹ arguably the larger challenge is promoting a clearer understanding on fundamental spatial concepts and critical thinking about how we use, analyze, and interpret geospatial data. As several of these papers reveal, the choices we make about neighborhood definitions and the lack of attention to scale, autocorrelation, and nonstationarity may lead to the misinterpretation of relationships, the attribution of significance to nonsignificant findings, and the neglect of significant relationships.

A major challenge for obesity research is the need for flexibility in allowing for the multiplicity of individual exposures that stretch in many directions across different spatial and temporal scales. Individuals' exposure spaces are typically bimodal in time and space with clusters of time and activities around specific hubs or nodes (such as home and place of work, or for children, school) and journeys. As research in behavioral geography³⁰ has repeatedly shown, we live in a *continuous* world not one bounded by arbitrary (not always objective) boundaries, and we also live in an *anisotropic* world in which knowledge and movement are easier in some directions than in others.^{31,32} This is important, as attributes calibrated for experienced exposure areas may be less correlated with each other than at the residential or neighborhood level, potentially allowing researchers to differentiate among obesogenic mechanisms.³³ While there are challenges, an area of considerable promise for exploring extra-local effects lies at the intersection of multilevel analyses and spatial analysis.³⁴ Multiple membership models that permit assigning individuals to multiple non-nested contexts could also push the field forward.³⁵

Next steps for the field might include the development of resources to enhance skills in spatial thinking and analysis. This must include even more work to integrate information on the vast array of geospatial data that are now available. Launched in early 2011, the National Collaborative on Childhood Obesity Research (NCCOR) Catalogue of Surveillance Systems (www.nccor.org/css) is a useful start in thinking spatially about obesity in the U.S. NCCOR provides access to relevant data resources at, and encourages data linkage across, multiple scales from the individual to macro policy-levels. The potential offered by NCCOR and

³For two different views of the food environment in the same place compare the map views derived from the USDA Food Environment Atlas (www.ers.usda.gov/foodatlas) with ESRI's Food Desert site (<http://imagecity.esri.com/fooddeserts/>).

similar resources are both an opportunity and a challenge. We also need coupled resources that help obesity researchers to think critically and creatively about whether and how different forms of geospatial data can be integrated in their research. Moreover, we need better training in how to integrate geospatial data, how to present these data (geovisualization or cartography), and in advanced spatial analytical methods. Included below as Appendix A is a limited selection of websites for starting out on such a journey.

While there remains a need for further conceptual development on defining places of exposure to obesogenic environments, this collection of papers¹²⁻¹⁷ provides examples of how spatial thinking can inform study design and the collection of geospatial data on both people and places, how geospatial data can be integrated to create unique measures, and how these measures are utilized in analysis. These papers are a reflection of our rapidly changing field, and one that I hope stimulates new conversation and dialogue that promotes transdisciplinary approaches to studying the obesity epidemic.

Appendix A

Selected Websites

Measuring the built environment and training resources

National Collaborative on Childhood Obesity Research (NCCOR)

Measures – http://www.nccor.org/measures_other_resources.html

Catalogue of Surveillance Systems – <http://tools.nccor.org/css>

Active Living Research: Built Environment for PA

<http://www.activelivingresearch.org/resourcesearch/toolsandmeasures>

BEAT institute – <http://www.med.upenn.edu/beat/>

GPS in Health Research Network – <http://www.gps-hrn.org/>

Spatial data mapping, analysis and training resources

Teach Spatial – <http://www.teachspatial.org>

Geospatial Analysis Online – <http://www.spatialanalysisonline.com/>

Color Brewer – <http://colorbrewer2.org/>

The Geoda Center, Arizona State University – <http://www.geodacenter.asu.edu>

GIS and Advanced Spatial Analysis workshops – <http://csiss.ncgia.ucsb.edu/GISPopSci/>

Geostatistics website – <http://www.ai-geostats.org/>

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