

Spatial Analysis in a Public Health Setting

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INTRODUCTION

Spatial methods are an increasingly important tool in understanding public health issues. Spatial analysis addresses an often forgotten or misunderstood aspect of public health, namely, studying the dynamics of people in places. As advances in computer technology have continued apace, spatial methods have become an appealing way to understand the manner in which the individual relates to larger frameworks that compose the human community and the physical nature of human environments (streets with intersections, dense vs. sparse neighborhoods, high or low densities of liquor stores or restaurants, etc.). Spatial methods are extremely data-intensive, often pulling together information from disparate sources that have been collected for other purposes, such as research, business practice, governmental policy, and law enforcement. Although initially more demanding in regard to data manipulation compared to typical population level methods, the ability to compile and compare data in a spatial framework provides much additional information about human populations that lies beyond typical survey or census research. We will discuss general methods of spatial analysis and mapping which will help to elucidate when and how spatial analysis might be used in a public health setting. Further, we will discuss a practical research example focusing on the relationship between alcohol and violence.

BACKGROUND: GIS CAPABILITIES AND PREVENTION

A basic understanding of the capabilities of geographic information systems (GIS) is critical to the development of prevention activities because alcohol-related problems are not evenly distributed across space. GIS can be

defined as a combination of computer hardware, software, spatial data (digital maps), and data with a geographic reference (e.g., alcohol outlets, crime locations) that facilitates spatial analysis. The key functions of GIS provide access to the broad spectrum of potential spatial analyses that can support the simple targeting of resources as well as the development of more complex models of spatial interactions. Both simple maps of problem rates or clusters and spatial interaction models may be useful for targeting traditional individual-based prevention programs or environmental interventions. Spatial interaction models, however, may be more appropriate for identifying the locations of events (e.g., assaults or crashes) that may be most amenable to environmental or regulatory prevention. In addition, GIS capabilities promote the development of a basic spatial/geographic epidemiology of alcohol use and related consequences, which is critical to the development of prevention programs (see Wieczorek, 2000, and Wieczorek & Hanson, 1997, for more details).

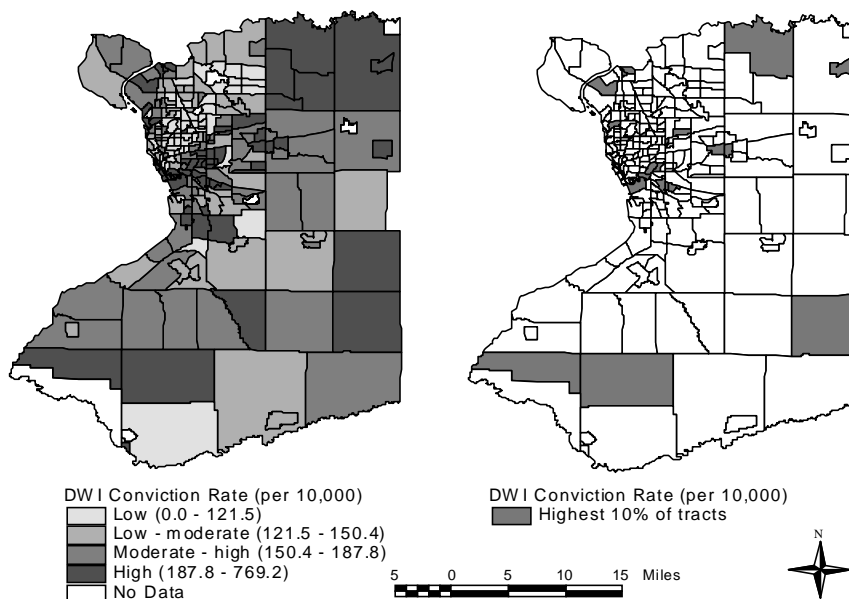
The key functions of GIS include: geocoding, data overlays, reclassification functions, and distance/adjacency measures. Geocoding is a generic term used to describe the GIS function of providing a specific location to descriptive data. Geocoding applies to point data (e.g., alcohol outlet) as well as to area data (e.g., number of assaults in a census tract). Sometimes geocoding is known as address matching because the process of matching points to addresses is very common. The advent of the Census Bureau's TIGER system has made geocoding a relatively low cost and widely available GIS function. However, professional geocoding services have developed to assist persons who are not comfortable in geocoding their own data or because of the high cost of updating digital maps based on TIGER in areas of changing population. Geocoding is the most basic of GIS functions because it transforms descriptive information into a format suitable for spatial analysis.

A GIS-based map may consist of multiple sources of data. The ability to combine multiple layers of information is known as the overlay function. An example of an overlay function is to place geographic boundaries (such as the outline of a town) on top of individual points (such as residences of DWI offenders). The points within each area can then be automatically counted to create rate-based maps such as those shown in Figure 1. To create rate-based maps from relevant point information, at least three layers of data are necessary (i.e., map of the points, a map with relevant boundaries, and census data on population). The ability to perform an intersection between separate maps, to aggregate data into meaningful geographic areas, and to link data to standard sources, such as census data, highlights some of the processing capabilities of GIS overlay functions, processes nearly impossible to accomplish by non-automated methods (see Wieczorek & Hanson, 2000, for an example using regions and mortality data).

One major contribution of GIS to prevention is its ability to provide useful visualizations of spatial data. The reclassification function of GIS allows the user to easily manipulate the number of categories or select specific information (e.g., crashes by time of day or day of the week) for display. Figure 1 shows how the reclassification function can assist in the targeting of prevention by reclassifying the same data to emphasize highest rate areas.

A second major contribution of GIS to prevention is that the technology enables the development of models of spatial patterns and interactions within and between populations and environments. These models require accurate information on the distance between individual objects (e.g., bars and traffic crashes) and their spatial relationships to one another. Distance and adjacency functions of GIS allow assessments of these relationships. Data generated from these assessments of spatial relationships can be exported from the GIS and used in spatial modeling software. Information about adjacencies of different geographic objects can be used to assess contributions of environmental features (e.g., bars) to problematic public health outcomes in surrounding areas (e.g., assaults) (Gruenewald et al., 1996; Lipton & Gruenewald, 2002). Other important GIS functions are based upon the assessment of distance relationships: neighborhood functions calculate the number of a specific characteristic (e.g., assaults) within a specific radial distance (e.g., 300 yards) of point features (e.g., bars). Buffer functions use the distance function on a complex feature such as the road network to identify points within a set distance of the feature (e.g., homes of DWI offenders within 400 yards of a bus line). These GIS functions can also be combined in complex ways to provide new insights for targeting prevention activities to areas with the greatest need (see Harding & Wittman, 1995, for additional applications in support of prevention).

Figure 1. Reclassification and targeting prevention



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