Using Geographic Information Systems to Solve Community Problems

Jane L. Garb
Baystate Medical Center, USA

Richard B. Wait
Baystate Medical Center, USA

INTRODUCTION

This article describes how the technology of geographic information systems (GIS) can be used as a tool to integrate various types of community-level data to address local problems. The purpose of the article is to present an approach that can be replicated by others. This approach is based on community-wide collaborative sharing of resources, data, and research applications with an aim to enhance the health and well-being of the local area population. Although the example used relates to health, the approach can be used to deal with any "event" or series of events in the community.

BACKGROUND

A GIS is a set of hardware and software for inputting, storing, managing, displaying, and analyzing geographic or spatial data or any information that can be linked to geographic location, such as events, people, or environmental characteristics (Bailey & Gatrell, 1995; Burrough & McDonnell, 1998). The advantages of GIS as an information system pertain to its ability to handle spatial data; integrate data from many sources; uncover spatial patterns and relationships by superimposing different data layers and viewing data at different levels of aggregation; and conduct spatial analyses to test hypotheses and make predictions. Significant advances in the field of GIS and spatial statistics in the last 20 years have enabled researchers to undertake a more extensive examination of the spatial component of a wide variety of applications. The visualization and analytic capabilities of a GIS enable the user to examine and model the interrelationship between spatial and nonspatial etiologic factors in a variety of events ranging from house sales to crime activity to breast cancer.

The American Community Survey (ACS; 2002) is an ongoing survey conducted by the U.S. Census Bureau. Data are collected monthly and are used to provide annually adjusted estimates of the current population based on an approximate 2.5% sample, with oversampling for small governmental units, such as American Indian Reservations. Full implementation of the survey will begin in 2004 (Census, 2003). ACS data forms the source of population data for the current study.

Despite the fact that ACS does not provide complete population counts, it can be used to derive community profiles, emphasizing relative proportions in each population subgroup. It can also be used as a mechanism for measuring changes and trends in the population in the interval between decennial census counts.

The Health Geographics Program at Baystate Medical Center in Springfield, Massachusetts, takes a comprehensive approach to the implementation of services, research, and community applications utilizing GIS. Because of its collaboration, giving access to community and hospital data, the program was contracted by the U.S. Census Bureau to undertake two case studies to demonstrate the utility of annually adjusted data from the American Community Survey.

The case study described here utilizes the ACS population and housing data in a GIS to improve breast cancer intervention programs. Previous research has clearly established that by lowering the rate of late-stage disease with increased mammography screening, breast cancer mortality can be reduced (Feig, 1988; Marchant, 1994). Furthermore, there is evidence that socioeconomic and cultural disparities in breast cancer screening exist (Katz, Zemencuk, & Hofer, 2000; O'Malley, Kerner, Johnson, & Mandelblatt, 1999; Phillips, Kerlikowske, Baker, Chang, & Brown, 1998). Several investigators have applied GIS and spatial analysis in the past to identify etiologic factors in breast cancer and late-stage breast cancer (Brody et al., 1997; Gardner, Joyce, & Melly, 1999; Kulldorff, Feuer, Miller, & Freedman, 1997; Lewis-Michl et al., 1996; Melly, Joyce, Maxwell, & Brody, 1997; Roche, Skinner, & Weinstein, 2002; Selvin, Merrill, Erdmann, White, & Ragland, 1998; Sheehan et al., 2000; Timander & McLafferty, 1998).

THE GIS APPROACH

The main functions of a GIS are *data integration, visualization, exploration, statistical analysis*, and *modeling* (Bailey & Gatrell, 1995). These functions can be combined in a systematic approach to solve problems. This approach can be outlined as follows:

1. **Integrate** data from multiple sources
2. **Visualize** the data with maps
3. **Explore** patterns further with spatial statistics
4. **Generate** hypotheses
5. **Test** hypotheses with mathematical modeling

We will describe how this approach was applied to the case study referred to above.

CASE STUDY: INVESTIGATING LATE-STAGE BREAST CANCER

The aim of the study was to create a profile of communities in Springfield in need of increased breast cancer screening. Specifically, we wanted to identify parts of the city with high rates of late-stage disease as well as identify socioeconomic and demographic factors in late-stage disease. This information would aid resource allocation by focusing intervention efforts on high-risk areas. Furthermore, it would allow the design of "culturally appropriate" (Healthy People, 2000) screening programs.

Applying the GIS approach, the first step was to gather and *integrate data* from three different sources. Geographic data were obtained from the City of Springfield Planning Department. This consisted of geographic boundaries and street locations that would be used in the geocoding process described later. ACS housing and population data provided aggregate information on demographic and socioeconomic characteristics of women over 40 by police sector (Table 1). Police sectors were used for this case study, because this was the smallest geographic unit for which ACS data were available. There are nine police sectors in Springfield. Breast cancer case data from the Springfield's two hospital oncology registries gave information on the dates and stages at diagnosis and home addresses for all patients diagnosed at these two hospitals. Together, these registries capture 95% of all cases of breast cancer in the city.

Cases were staged according to the American Joint Cancer Committee (AJCC; AJCC, 1997). Cases were defined as "late stage" if they were Stage 2 or greater. This definition captures all cases that should have been detected earlier had mammography been performed. A total of 891 breast cancer cases were diagnosed during 1995–1999, with 194 of these defined as late stage.

All data for the study were converted to dBASE IV format to be read into the GIS. Geographic data was in the form of ArcView (ESRI, 1999) shapefiles. Geographic and tabular data were imported into the GIS using ArcView. ArcView was used for all GIS functions. Geocoding of case locations was based on the patient's street address, using the City of Springfield streets shapefile as the reference database. Mapping of case locations was based on patient's home address. Mapping was done at a small enough scale so that individual patient addresses could not be determined from the map, in order to preserve patient confidentiality.

The next step in the GIS approach was to visualize the data. This was done by mapping the data in ArcView. We

Table 1. ACS variables

Variable	Universe
Proportion for each race (white, black, etc.)	Women > age 40
Proportion Hispanic	
U. S.-born, foreign-born, Puerto Rican born	
Naturalized citizens, noncitizens	
Linguistically isolated	
Married, unmarried	
Unemployed	
Employing public transportation to work	
High school diploma	
Below poverty level (12.5K)	
Using food stamps	
Receiving public assistance	
Median income	Households
Vacant	Housing
Median value	

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