Improving an outreach service by analyzing the relationship of health information disparities to socioeconomic indicators using geographic information systems

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INTRODUCTION

The use of geographic information systems (GIS) with US Census data provides libraries with the power to combine, analyze, and present information in new ways. GIS is a valuable tool capable of “capturing, storing, analyzing, and displaying geographically referenced information” [1]. GIS software combines maps with layers of associated data to provide a visual picture that allows greater understanding and analysis than static figures and tables. Although the software was expensive in the past, GIS has become increasingly more affordable for libraries since it has become available in web-based applications, including open source options [2].

Libraries began incorporating US Census data with GIS when the 1990 census materials were given to the US federal depository libraries as Topologically Integrated Geographic Encoding and Reference (TIGER) files [3]. TIGER files are a set of geographic base files that contain features of the United States down to the street level and census boundaries for census statistical areas. TIGER files are designed for use with GIS software and include geographic codes that can be linked with demographic and socioeconomic data from American Fact Finder (AFF) and the American Community Survey (ACS) [4, 5]. All TIGER, AFF, and ACS files and data are free to the public.

Combined with US Census data, GIS is particularly useful for libraries in the area of service planning. For example, the Public Library Geographic Database has compiled US Census demographics on all 16,000 public libraries in order to assist decision makers in library planning [6]. Other examples of the use of GIS and US Census data include analyzing service maps for proposed branches [7], mapping service areas [8], analyzing demographics of populations surrounding the library [9, 10], analyzing market segmentation [11], and establishing a public library consumer health collection [12].

In 2011, the Preston Medical Library, in Knoxville, Tennessee, conducted research using GIS and US Census data. Our goal was to analyze demographic and socioeconomic patterns in order to improve health literacy information outreach through our free telephone-based Consumer and Patient Health Information Service (CAPHIS). The library’s free telephone-based CAPHIS has been in place for over two decades, and call data are maintained in an SQL database. The library staff responds to calls to the CAPHIS by mailing packets of health information at the appropriate literacy level to the caller. The Preston Medical Library provides a useful alternative for those individuals who do not have Internet access or may need additional assistance because of limited health literacy and socioeconomic disparities.

Several studies have examined the relationship of socioeconomic factors and limited health literacy to increased health costs, chronic disease, and morbidity [13–16]. Health information through libraries is valuable and can affect consumer health care decisions. Consumers who use libraries for health information report positive health actions such as lifestyle changes and compliance with physician instructions [17, 18]. However, consumers with low health literacy and compounding socioeconomic factors are often not aware of the services provided by libraries. Outreach is conducted by libraries to address these disparities and provide information services to those surrounding communities most in need.

RESEARCH BACKGROUND

In 2003, an SQL database was created that contains information regarding consumer calls to CAPHIS. Data on calls from 1998 to the present include the caller’s name, address, and health information request. Although the names and addresses are kept in separate tables for privacy, the zip codes of the addresses can be used to establish geographic locality that can be plotted on a state map and calculated to establish a rate and area of calls by zip code. The requested health topics, which are in keyword form initially, are subsequently indexed by library staff using the National Library of Medicine’s (NLM’s) Medical Subject Headings (MeSH) in order to be cross-referenced with existing information regarding prevalence of diseases in the state that is made available by the Tennessee Department of Health [19].

Supplemental Figures 1, 2, 3, 5, and 6 are available with the online version of this journal.
In 2008, Preston Medical Library began research using its CAPHIS data and Esri’s ArcMap software. The library utilized both the zip codes and the health topics requested by users to create choropleth maps that reflected the rate of calls to Preston’s CAPHIS as related to disease prevalence in the state of Tennessee [20]. A choropleth map is a map that shows the distribution of a phenomenon by graded shading to indicate the density per unit area of that phenomenon [21].

Findings from this research indicate that although there is no apparent correlation between rates of calls and counties with higher mortality of a specific disease, the overall rates of calls to the CAPHIS match the ranking of the leading causes of death in Tennessee. In addition, these maps enabled the library to identify counties exhibiting a high prevalence of specific diseases and low rates of calls, which may signify opportunities for outreach. In 2011, the library again initiated research using the data from the calls to answer the research question: Is it possible to visually associate the rate of calls to CAPHIS with the socioeconomic factors of age, poverty, and disability in order to determine health information disparities in discrete geographic areas?

METHODOLOGY

Using Microsoft Access, a query, by zip code, of the calls to the database was completed for the period from June 30, 2009, to July 1, 2011. Addresses for each zip code were then geocoded, or given latitude and longitude values, so that they could be imported into Esri ArcGIS. Next, a county shapefile map of Tennessee was downloaded from the US Census TIGER files, and the geocoded addresses were plotted as unique points and joined with the county shapefile map using Esri ArcGIS. Once the data were joined, a baseline rate of calls by zip code and population was established. Using zip code tabulation areas (ZCTA) of the US Census Bureau, the baseline formula was total calls multiplied by 100,000 or population total in order to get a rate of total calls per 100,000. Once the calculations were performed, we were able to join layers of information and produce a visual representation of the 2-year rate of calls to the CAPHIS from Knox County throughout the state (Figure 1, online only).

After creating the rate-of-calls map, we began adding socioeconomic data from the US Census ACS for age, poverty, and disability [22]. Because an additional layer of information was added to the map with each socioeconomic factor, the rate of calls was changed to graduated circles to better reflect the rate of disparities in each county against the rate of calls. Each socioeconomic factor was also separated out into an individual map to avoid excess visual data and confusion. The US Census ACS data were first normalized in Excel and then saved as a dBase file so that the variables for each socioeconomic factor would join with the existing rate-of-calls and county shapefile. US Census ACS data chosen for this study include “Presence of People 60 Years and Over by Household Type for Households” (Table B11006), “Poverty Status in the Past 12 Months by Sex and Age” (Table B17001), and “Sex by Age by Ambulatory Disability” (Table B18101). The resulting maps establish a visual representation of the rate of calls to CAPHIS by zip code and the selected socioeconomic factors.

RESULTS

Six maps were created showing outreach needs related to health information disparities as indicated by socioeconomic indicators. Results indicate that, for the time period examined, there were zip codes in Knox County and neighboring counties that had a high prevalence of people who were aged sixty or older (Figure 2, online only), who were poor (Figure 3, online only), or who had an ambulatory disability (Figure 4) who were not using Preston’s CAPHIS. Once we completed the socioeconomic maps, we created a map of the ZCTAs and joined it with the rate of calls to better visualize specific zip code areas for outreach (Figure 5, online only). A final map illustrating the areas of outreach was also created (Figure 6, online only). A total of fourteen counties in east Tennessee were chosen, six of which border Knox County.

Mapping the rate of individuals aged 60 and older showed the highest rates of individuals clustered in 6 counties, 3 of which were contiguous and 4 of which had not placed any calls to CAPHIS in the study period (Figure 2, online only). The rate of poverty map showed the highest rate of poverty per 100,000 individuals clustered in 1 county; no calls to CAPHIS had been placed from this county (Figure 3, online only). The second highest rate of poverty was found in 9 counties, 6 of which had not placed calls to CAPHIS. Mapping the rate of disability showed the highest numbers of disabled individuals in 3 counties, 2 of which had placed few or no calls to CAPHIS (Figure 4). The ZCTA map showed 6 zip codes in Knox County where no calls to CAPHIS had originated (Figure 5, online only). Although Knox County is mid-range on the poverty and age scale, we decided that these zip codes should be included for outreach because of their proximity to the Preston Medical Library. When ranked by socioeconomic criteria, we determined that a total of 31 zip codes in 14 counties in East Tennessee had unmet health information needs and were candidates for outreach by the Preston Medical Library’s CAPHIS.

LIMITATIONS

This study used the 5-year 2005–2009 ACS data sets. At the time that this research was initiated, the available 2010 data sets for disability were for populations of 100,000 or greater. We chose the data from the 2000 census because it allowed for disability statistics for populations 65,000 or greater. Tennessee
has numerous rural countries, and providing an accurate representation was important. To maintain data consistency, all US Census data were taken from the 2000 census. Future research will include recalculation of the disability data when the new 2010 US Census information becomes available.

**DISCUSSION**

By utilizing US Census Bureau data combined with GIS, the library has created maps that show socioeconomic characteristics in surrounding counties and zip codes in comparison to the use of a library service. While the results could have been determined using only numeric formulas, visually represented data present a richer picture that can be employed for more significant service planning. For example, we were unaware that there were six zip codes in Knoxville that were not utilizing CAPHIS. Seeing this information represented geographically in the ZCTA map (Figure 5, online only) made it much easier to determine where outreach efforts should be focused. In addition, GIS offers efficiencies as the size of data sets increase, because the use of numerical formulas to analyze geographic location would become increasingly difficult.

Preston Medical Library plans to continue collecting information about the rate of calls during our future outreach efforts and then create new maps to reflect the rate of change over time, thereby measuring the impact of our outreach on the rate of calls to the CAPHIS. In addition, based on the success of using GIS software to analyze the CAPHIS, Preston Medical Library plans to do future research for outreach to underserved health care professionals by utilizing Designated Health Professional Shortage Areas (HPSAs) [23] to identify areas of greatest need.

**CONCLUSION**

GIS and US Census data offer libraries a wealth of possibilities. Librarians can create maps to assist...
in-house planning such as developing collections for material on prevalent diseases, targeting outreach services through demographics analysis, or developing marketing campaigns directed at low-use areas. GIS can be combined with nearly any type of data that a library can collect. The cost of GIS has become more affordable for libraries, and open source GIS is available. While there is a learning curve in mastering the software, GIS empowers the library with more knowledge to better meet patron needs and serve its community. The message contained in the maps, combined with the data, tells a compelling story that is much more meaningful than static tables and graphs.

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