Geographic Information Systems (GIS) In Health Organizations: Emerging Trends for Professional Education

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Abstract

An interdisciplinary research team conducted a study to inform the development of a GIS course focused on healthcare administration, management, and policy. An electronic survey of 134 (44.7% response rate, n=60) healthcare professionals from a variety of private and public organizations yielded data used in the analysis of organizational experience with GIS, user qualifications and training, and average salaries for new GIS analysts. Results of the survey indicate organizations have used GIS for five years or more, annual salaries are >$40,000, staffs are small, most are not certified GIS professionals, and the majority of organizations use ESRI's ArcGIS software.

Keywords: GIS, US, health organizations, professional education

Introduction

Geographic information system (GIS) is a geospatial tool that can be utilized to identify and display geographic patterns of disease; assess environmental exposures; estimate incidence, prevalence, and survival statistics; and expose health disparities to communicate clearly with the public, business, and political leaders (NCI, 2006). A trend in health policy, research, planning, and management is the increasingly important role of health informatics (Kurland and Gorr, 2006), broadly defined as "...the science that underlies the academic investigation and practical application of computing and communications technology to healthcare, health education and biomedical research" (University of Virginia Health System, 2006). As additional health data become available through automated and integrated systems, there will be more spatial health-related data available for storage, analysis, and communication through GIS. GIS allows analysts to frame spatial questions, select the data associated, choose an analysis method, process the data, and review the results as a map (NCI, 2006). This process, known as geovisualization, is

a particularly powerful method for displaying complex data with many variables (Huang et al., 2008). Examining the relationships between health access and outcomes to determine how healthcare delivery can be improved is an area where further research employing GIS is needed to address a persistent concern of health policy makers and administrators (McLafferty, 2003).

The literature on the use of geographic information systems for public health applications is becoming increasingly plentiful and robust (Cromley and McLafferty, 2002; Hay, Graham, and Rogers, 2007; Melnick, 2002; Ricketts, 2003). However, little information is available regarding the use of GIS in private-sector healthcare organizations and for health policy research and implementation. Much of the literature focuses on applications of GIS using health-related data. There are few published studies that focus on how GIS is used for healthcare business purposes and the workforce training needs associated with the use of this powerful analytical tool.

Higgs and Gould (2001) proposed an expanded role for GIS in the United Kingdom National Health Service (NHS), and noted that GIS applications in health geography fall into two broad categories, *epidemiological* and *health care delivery*.

> • "*epidemiological* work concerned with the nature of variations in health outcomes and possible reasons for observed patterns,
>
> • *health care delivery* with consideration of the effective organization and configuration of services and the consequences for health care utilization and accessibility." (p. 249).

Within a national healthcare system such as NHS, the use of GIS offers many opportunities for health planning that is strategic and comprehensive, and that integrates local health needs. The healthcare delivery system in the United States is highly fragmented, with myriad private- and public-sector organizational participants and programs (Proenca, Rosko, and Zinn, 2000). Therefore, the use of GIS for healthcare delivery is far less rational, complete, or coordinated. The National Health Planning and Development Act of 1974 created a two-tiered network of regional and state health planning agencies. The intent of this legislation was to coordinate the development of health services (Institute of Medicine, 1980). However, this legislation was phased out in the 1980s. Health planning today is a very limited function of the federal government. The resources devoted

to it vary tremendously among federal, state, and local governments, and the focus of health planning in these three levels of government is on public health rather than the distribution of personal health services (Williams and Torrens, 2002).

In United States governmental health agencies such as the National Center for Health Statistics, GIS is primarily used for epidemiological analyses. The Health Resources and Services Administration recently introduced an internet mapping application for community health status indicators that is available to the public (Heitgard et al., 2008). A growing number of emergency planners have begun to use GIS for developing disaster responses to terrorist attacks and natural disasters since the terrorist attacks of 2001 (Mullner et al., 2004).

GIS for Addressing Healthcare-Related Issues

Public healthcare service delivery GIS applications in the U.S. primarily focus on the disease distribution within a community, the location of providers, and the allocation of public resources for care to underserved populations (Ricketts, 2003). Academics, extending Wennberg's pioneering work in small-area analysis (Wennberg and Gittelson, 1982), have used GIS to study and illustrate geographic variations in the utilization, cost, and appropriateness of medical care and to investigate disparities related to age, gender, and location (Dartmouth Atlas, 2007).

The recent concern with increasing obesity prevalence has stimulated research employing GIS at various levels of analysis. The U.S. Centers for Disease Control and Prevention (CDC) conducted a nationwide spatio-temporal analysis of obesity and poverty (Holt and Sui, 2007) that analyzed trend data and displayed the median obesity prevalence by state. A study of food opportunities in the neighborhoods surrounding elementary schools in the city of Philadelphia, Pennsylvania, demonstrated the plethora of fast-food outlets available to students (FitzGerald, 2005). A more comprehensive analysis of childhood obesity and the built environment in Los Angeles County examined the childhood obesity rate by census tract. This study found no association of childhood obesity with fast-food outlet density, but a significant association with both economic hardship and low park acreage (Kwan, 2007).

A few hospitals are beginning to use GIS for emergency-response service coordination and rural health-service analysis and telehealth service delivery coordination (ESRI, n.d., Faruque, 2007). The more

advanced models, such as the Advanced Emergency Geographic Information System developed by Loma Linda University Medical Center, allow coordination of all emergency resources through systems that are accessible via the Internet, cell phones, or emergency service vehicle communication units, and have significantly reduced emergency response and transport time. Downey Regional Medical Center uses a GIS-based patient care and room management application to manage patients' physical movement throughout the hospital from admission to discharge and to outpatient care (Wiafe, 2007).

GIS in the Healthcare Industry

The U.S. healthcare system follows an entrepreneurial model (Fried and Gaydos, 2002) where private businesses and practitioners deliver the great majority of personal health services. In nearly all of these organizations, GIS is used as a tool for achieving business growth goals. For example, Zoltners and Sinha built upon their academic work in sales-force management (Zoltners, Sinha, and Lorimer 2004) to develop a proprietary GIS application for sales-force territory design. The GIS application is used by leading pharmaceutical companies throughout the world (ZS Associates, 2007) to more effectively deploy sales representatives. Retail pharmaceutical firm Walgreen employs a team of GIS analysts whose responsibilities include analysis to support pharmacy site location decisions (Whittaker, 2007). Health maintenance organizations in California are required to submit electronic maps of their provider networks to the state regulatory agency to ensure adequate member access to a specified set of healthcare services (Department of Managed Health Care, 2007). Researchers in North Carolina developed a model for tracking health professional mobility patterns over time that offers health professional recruiters and human resource specialists a method for evaluating the effectiveness of recruitment and retention programs (Baer, Gesler, and Konrad, 2000).

Because private-sector healthcare businesses are usually highly competitive, much of the information they produce or derive is proprietary. GIS analysts in these businesses are seldom encouraged to and may be explicitly prohibited from publishing or discussing how they employ GIS in their work. Perhaps this is the reason that information about public-sector health applications dominates the professional literature on GIS and health.

GIS industry analysts project strong growth in the private sector business segment in the U.S. (Michelson, 1994). The U.S. Bureau of Labor Statistics (2008) includes geographic information specialists in the occupational groups that are expected to grow by twenty-one percent or more from 2006 to 2016, much faster than average (seven to thirteen percent) for all occupations. According to the GIS Certification Institute (2007), median salaries for GIS professionals in 2007 in the U.S. were about $54,000 generally, and $65,000 for those certified by the institute who typically had more years of experience. No publicly available data were found for GIS professionals by industry.

As educators in a large public university in southern California, we became aware, through industry contacts and anecdotal information, of the increasing use of GIS in both public and private health organizations, and a related growing demand for these skills in the health administration workforce. In response, faculty from the departments of geography and healthcare administration jointly developed a new course on GIS in health. This course will equip healthcare administration students with basic GIS skills and expose geography students to a broader range of health applications.

To inform the development of this course, we conducted an online, Web-based survey of GIS users in a variety of public- and private-sector organizations in California. The primary objective of this survey was to obtain input from practitioners in a variety of organizations to ensure that students learn about many different types of applications and receive training of value to employers in the region. This paper reports the results of that survey.

Aims

The purpose of this survey was to determine the needs of the healthcare workforce related to the use, incorporation of, and training needs related to geographic information systems (GIS) within healthcare administration, management, and policy.

Methods

A survey instrument was developed and validated with key informants in the healthcare industry. The draft of the survey was compiled in collaboration between the Geography and Health Care Administration departments at a California public university. Once initial elements of the survey were constructed, key informants in

the medical geography and academic communities within California were contacted to provide feedback on the survey instrument. Input was compiled and a final instrument was completed. The survey was then uploaded to a Web-based survey tool, SurveyMonkey™. Survey methods using the Internet are gaining popularity, and research on the validity of such a method supports the use within this type of construct (Schonlau, 2004). The proliferation of the Internet continues to enable this low-cost method of gathering data. As of December 2007, approximately 1.3 billion people worldwide use the Internet; the percentage of the population ranges from 5 in Africa to 71 in North America (Internet World Stats, 2007). North America has experienced a 119 percent increase in Internet usage during the timeframe of 2000–07 (International Telecommunications Union, 2008).

Issues surrounding confidentiality are of concern when using Web-based surveys to collect data. As Sills and Song (2002) found in their research, there are opportunities to put the respondent at ease by employing security methods. The researchers in this study utilized a link containing the universal resource locator (URL) to the survey within the welcome e-mail. Participants were redirected to the *GIS Health Care User Survey* instrument on the Internet. Informed consent was obtained, and they were redirected to a secure site to complete the survey. No identifiable data were collected unless the participant voluntarily included his or her information. Participants had the option to refrain from answering any question or to end their participation at any time. Protocol for data collection was approved by the University's Institutional Review Board (IRB).

An open-ended, multiple-choice, and dichotomous-question questionnaire was developed based on a total of nineteen statements (Table 1). Items 18 and 19 on the questionnaire were excluded from the data analysis, as the questions were optional and elicited participation in final syllabus review, data for labs, and opportunities to guest lecture. See appendix A for full questionnaire. Topic areas included data use and sources; qualifications, salaries, and training of GIS users in the respondent's organization; information about membership in professional organizations; and availability of GIS work products.

Table 1: Survey Questions

1. What information does your organization use GIS to display?
2. If you use publicly available data sets for your GIS work, what are the most common sources?
3. If you purchase or subscribe to commercial data sets for GIS work, please briefly describe them.
4. If you use or develop your own data sets for GIS work, please briefly describe them.
5. What geographic subdivisions do you use in your work?
6. How long has your organization used GIS?
7. How many people in your organization use GIS as a key function of their work?
8. What educational qualifications does your organization require for GIS users?
9. What is the average annual salary for a newly employed GIS user in your organization?
10. How did you personally learn to use GIS?
11. What do you think is the best way to learn to use GIS?
12. Do you or any members of your organization belong to any of the following professional GIS organizations?
13. Are you or another member of your organization certified as a GIS Professional (GISP) by the GIS Certification Institute?
14. What type of GIS software does your organization use?
15. Does your organization provide GIS products or services to other organizations?
16. Are there publicly available documents containing maps produced by your organization?
17. Can you recommend one or more healthcare organizations as examples of "Best Practice" healthcare organizations using GIS?

The researchers identified potential participants through cold calls and e-mails to healthcare organizations, public health departments, and health systems. Once a list of participants was identified, an e-mail was sent to a convenience sample of 134 healthcare industry professionals working both in the public and private sectors. Sixty respondents participated in the confidential survey, resulting in a response rate of 44.7 percent; 34 percent of respondents completed the entire survey. According to Schonlau (2004), when participants are contacted and recruited through use of the Internet, they have a higher likelihood of completing an online survey. No incentives were provided for participation in the survey. Survey respondents consisted of a convenience sample confined to healthcare organizations within California; Table 2 displays the breakdown of respondents by organization type.

Table 2: Respondent Organization Type

Organization Type	% of Total
HMO	21%
Local Health Department	21%
CBO	14%
HHS	13%
Government	7%
Education	7%
Consultants	7%
Physician/Medical Group	5%
Trade Associations	4%
State Health Department	1%

Results

GIS allows organizations to display geospatial data related to their business sector. The majority (eighty-four percent) of respondents used GIS to display service-area population demographics; the use of GIS to display provider locations and customer or member/patient's place of residence ranked as second and third, respectively. Through analysis and understanding of these data, market share and strategic marketing can be assessed for purposes of strategic planning, resource allocation, staff deployment, and service delivery. The most commonly used publicly available data sets used in GIS analysis (Figure 1) were from the U.S. Census Bureau and California Office of Statewide Health Planning and Development (OSHPD), a unit of the Department of Health Services.

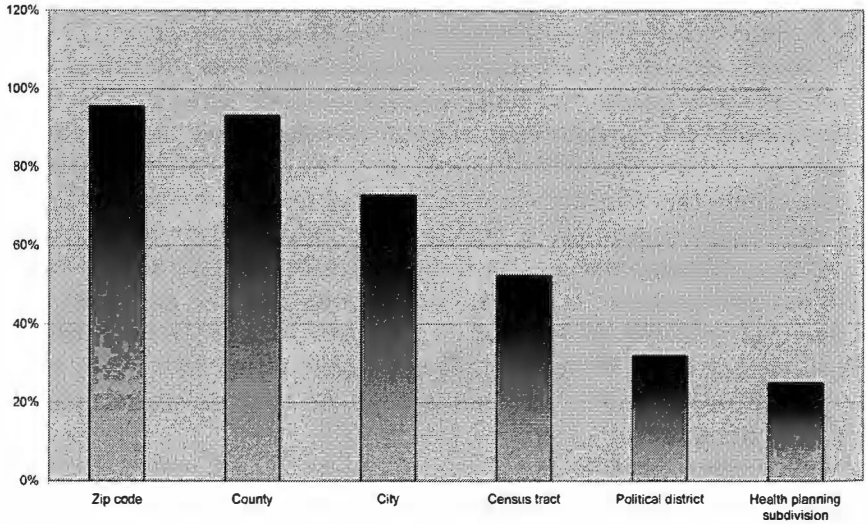

Figure 1.—Geographic subdivisions used.

Thirteen respondents purchased or subscribed to commercial data sets for GIS analysis, which include but are not limited to shape files, birth and death statistical master files, locations of alcohol retailers in a county, etc. Twenty-three of the respondents developed their own data sets for GIS analysis, which include such topics as communicable diseases, flu-clinic utilization, school-district boundaries, Veterans Administration patient databases, ZIP code density of patients within system, ZIP code defined service areas, etc. Utilization of geographic subdivisions such as ZIP codes, counties, and city boundaries were reported by ninety-three percent of the sample.

Thirty-seven percent of the respondents (*N*=16) acknowledged the use of GIS within their organization for more than five years and up to ten years (Figure 2).

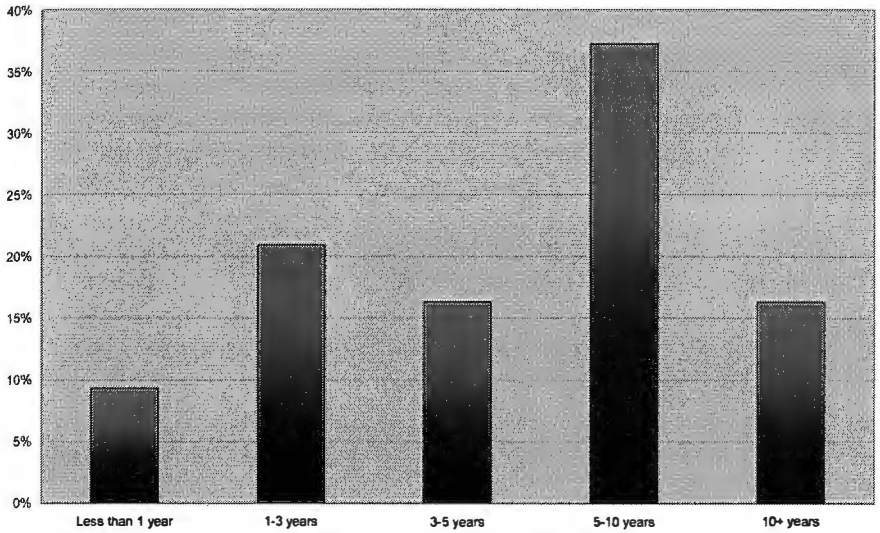

Figure 2.—Length of time using GIS.

In organizations that use GIS, between one and three people use GIS as a part of their job function (Figure 3).

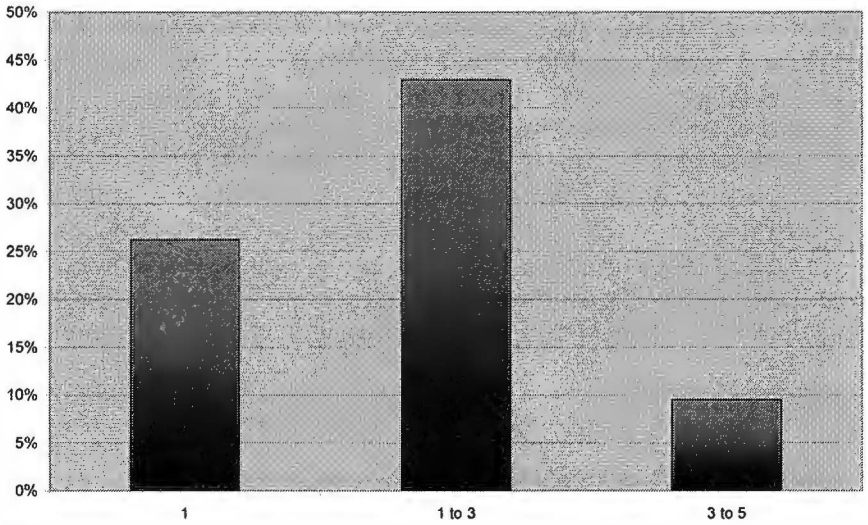

Figure 3.—How many people in your organization use GIS?

The average salary for new GIS employees in these organizations was reported to be between $40,000 and $50,000 annually, followed by $50,000 to $70,000 or more (Figure 4).

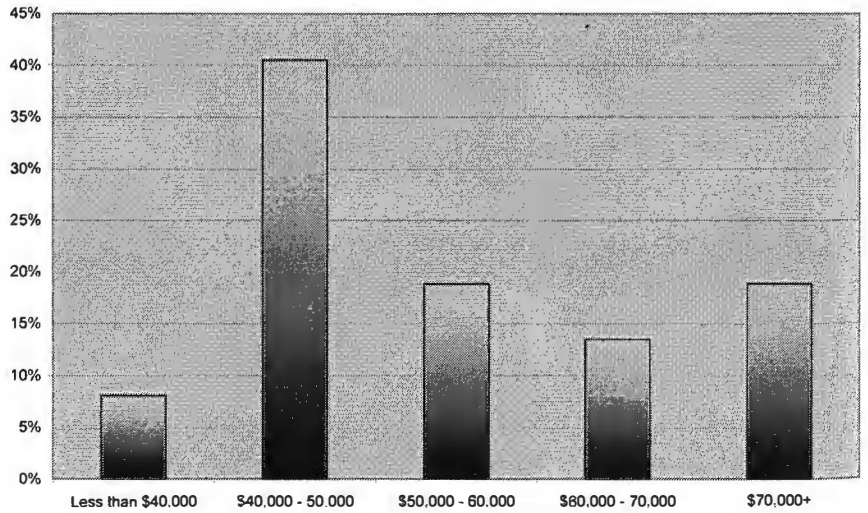

Figure 4.—Salaries for GIS employees.

According to fifty-four percent of the survey respondents (*N*=22), as long as the employee can use the technology, no additional qualifications were required in the job function; however, thirty percent do require a college degree. On-the-job training was

the most common way people learned to use GIS within their organization (*N*=32), followed closely by vendor training (*N*=21) and tutorials (*N*=15). Only seven percent of the respondents were certified GIS Professionals (*N*=3) and seventy-five percent (*N*=6) of those responding to the question belong to the Center for Disease Control and Prevention (CDC) Public Health GIS Users Group. The software of choice, according to those surveyed, is ArcGIS by ESRI (*N*=27) and GeoAccess by Ingenix (*N*=10). Other software packages included MapInfo and Map Point.

Most organizations reported keeping their GIS documents for internal use only (*N*=30). The majority of respondents (seventy-four percent) did not provide GIS products or services to organizations outside of their own.

Discussion

Based upon the data gathered, many organizations are using GIS for rudimentary purposes, focusing on density of patients within a particular service area or the distribution of disease. While some organizations reported utilizing GIS in their organizations for five or more years, this discipline is still in its infancy within the healthcare sector. According to the literature, the use of GIS is expected to grow significantly over the next decade. As the general public becomes more aware of geospatial applications, there will be an expectation by the general public to display health-related information in a spatial format.

When contacting various healthcare organizations in preparation for this study, a common routing point to determine the correct contact within the organization resulted in a call to the business development or marketing department, or the information systems department. The larger organization was frequently unfamiliar with the term *geographic information systems*, or GIS.

According to the High Growth Job Training Initiative, the health services sector is targeted as an area where geospatial technology skills are needed (U.S. Department of Labor, 2005). As the use of GIS within healthcare organizations continues to grow and develop, formal training and education specifically targeted to healthcare problems, data, and personnel will be required. Workforce readiness in this evolving technology will continue to demand more than on-the-job training to utilize GIS to its full power and capabilities.

For most GIS health industry users, GIS is another software tool that enables them to analyze and display data in the course of conducting their organization's business. While industry users' focus will be on learning how to use the software, educators need to incorporate a broader perspective into their instructional activities, imparting knowledge as well as conducting skills training, in order to ensure that GIS is used responsibly. This broader perspective includes an appreciation of scholarly critiques of GIS, in particular those expressing concerns about intrusion of privacy and surveillance (Schuurman, 2000; McLafferty, 2004). These are ongoing issues in health delivery and health policy, and warrant ongoing attention in the academic arena.

Limitations

The survey participants were drawn from a convenience sample within the state of California and therefore results may not be generalizable to the greater population.

Conclusion

Health geoinformatics is an emerging discipline that uses GIS as an innovative scientific and geospatial technology to investigate health issues. GIS allows the analysis and display of complex information in a visually exciting format to help improve health delivery systems, policies, and practices. Continued growth and development of the workforce in the healthcare sector with exposure to and ability to use GIS technologies in a responsible manner will be required to adequately address the health challenges of the twenty-first century. A few examples that provide a multi-level analysis and where GIS is a valuable tool are: Healthcare utilization and the effects or impacts of transportation availability involving a service-area analysis (drive times, public transit) and where resources are available versus where constituents reside. Additionally, in the case of H1N1 Influenza A, GIS is used for surveillance and as a model to determine where those most at risk for contracting this flu (<5 & >65 w/chronic conditions) and as a decision support tool to place clinics, staff hospital emergency rooms (ERs), determine vaccine supplies, and prepare for a potential public-health emergency. Harnessing the power of GIS to its full potential will enable users to address issues in healthcare delivery and service planning, and feedback from current and prospective GIS users from a variety of healthcare organizations will help to ensure that future health professionals receive training in the appropriate GIS skills and applications.

In response to this need, faculty at a southern California public university collaborated to develop a GIS course specifically focused on the healthcare sector. The course was offered for the first time in spring 2009 and was open to all health care administration, health science, and geography majors, or anyone interested in using GIS technology to solve spatial questions related to healthcare, public health, and health services. Non-geography majors in health disciplines who use GIS require efficient training in geographic concepts upon which the technology is based. This course will provide that training using examples from the health field to aid in decision-support activities.

To train future administrators and managers of health data, the survey was used to elicit categories of data that are currently used (ZIP codes, county and city data), focused communicable diseases, flu clinic utilization, etc. Based on these answers, the lectures address how to locate and interpret data to analyze these types of topics, as well as the lab exercises use real-world data from the California Office of Statewide Health Planning and Development (OSHPD) as a basis for the analysis versus using canned data, which comes with the textbook that was selected. This provided a hands-on approach to coding, cleaning, and displaying publicly available health data within a map.

There continue to be opportunities for future research in utilization of GIS within the healthcare sector and associated training needs to support further development and use of geospatial technology.

Appendix A

Survey Instrument

GEOGRAPHIC INFORMATION SYSTEMS (GIS) HEALTHCARE USER SURVEY

1. What information does your organization use GIS to display? Please check all that apply:
   - ☐ Service area population demographics (e.g., number of people 65+)
   - ☐ Provider locations (e.g., primary care physician office locations)
   - ☐ Disease incidence or prevalence (e.g., percent of obese children)
   - ☐ Competitor facility locations
   - ☐ Customer/member/patient place of residence

☐ Customer/member/patient place of employment
☐ Shortest distance paths/networks (e.g. ambulance routes)
☐ Other (please specify)

2. If you use publicly available data sets for your GIS work, what are the most common sources? Please check all that apply:
   ☐ U.S. Census Bureau
   ☐ Center for Medicare and Medicaid Services
   ☐ California Office of Statewide Health Planning and Development (OSHPD)
   ☐ California Health Interview Survey (CHIS)
   ☐ Centers for Disease Control and Prevention (CDC)
   ☐ Other (please specify)

3. If you purchase or subscribe to commercial data sets for GIS work, please briefly describe:

4. If you use or develop your own data sets for GIS work, please briefly describe:

5. What geographic subdivisions do you use in your work? Please check all that apply:
   ☐ County
   ☐ City
   ☐ Census tract
   ☐ ZIP code
   ☐ Political district
   ☐ Health planning subdivision
   ☐ Other (please specify)

6. How long has your organization used GIS?
   ☐ Less than 1 year
   ☐ 1–3 years
   ☐ 3–5 years
   ☐ 5–10 years
   ☐ 10+ years

7. How many people in your organization use GIS as a key function of their work?
   ☐ One
   ☐ 1–3
   ☐ 3–5
   ☐ 5–10
   ☐ 10+

8. What educational qualifications does your organization require for GIS users?
   - ☐ None, as long as they can use the technology
   - ☐ High school graduate
   - ☐ Some college
   - ☐ College degree
   - ☐ Some post-graduate education
   - ☐ Master's degree
   - ☐ GIS certificate

9. What is the average annual salary for a newly employed GIS user in your organization?
   - ☐ Less than $40,000
   - ☐ $40,000–50,000
   - ☐ $50,000–60,000
   - ☐ $60,000–70,000
   - ☐ $70,000+

10. How did you personally learn to use GIS? Please check all that apply
    - ☐ College/university course(s)
    - ☐ College/university certificate program
    - ☐ Technical school
    - ☐ Vendor training
    - ☐ On-the-job training
    - ☐ Online training
    - ☐ Tutorial
    - ☐ Other (please specify)

11. What do you think is the best way to learn to use GIS? Please check all that apply
    - ☐ College/university course(s)
    - ☐ College/university certificate program
    - ☐ Technical school
    - ☐ Vendor training
    - ☐ On-the-job training
    - ☐ Online training
    - ☐ Tutorial
    - ☐ Other (please specify)

12. Do you or any members of your organization belong to any of the following professional GIS organizations? Select all that apply
    - ☐ Association of American Geographers (AAG)
    - ☐ Urban and Regional Information Systems Organization (URG)
    - ☐ Public Health GIS Users Group, Centers for Disease Control and Prevention
    - ☐ UNIGIS International
    - ☐ Other (please specify)

13. Are you or another member of your organization certified as a GIS Professional (GISP) by the GIS Certification Institute?
    - ☐ No
    - ☐ Yes

14. What type of GIS software does your organization use?
    - ☐ ArcView (ESRI)
    - ☐ GeoAccess (Ingenix)
    - ☐ MapInfo
    - ☐ MapPoint
    - ☐ Other (please specify)

15. Does your organization provide GIS products or services to other organizations?
    - ☐ No
    - ☐ Yes (please specify)

16. Are there publicly available documents containing maps produced by your organization?
    - ☐ No
    - ☐ Yes (please describe and explain how to access)

17. Can you recommend one or more healthcare organizations as examples of "Best Practice" healthcare organizations using GIS?
    - ☐ No
    - ☐ Yes (please specify)

18. Would you be willing to (check all that apply)
    - ☐ Review a draft of the "GIS in Health" draft syllabus
    - ☐ Suggest or provide data for student lab assignments
    - ☐ Give a guest presentation to the class

19. If you answered yes to question #18 or if you would like to receive a summary of our findings, please provide your contact information:

Name:_____

Company:_____

E-mail:_____

Phone:_____

Thank you so much for taking the time to complete this survey!

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