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TECHNICAL
REPORT

Mapping the Gaps

Ideas for Using GIS to Enhance Local Health Department Priority Setting and Program Planning

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HEALTH

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Preface

Local health departments (LHDs) face many competing priorities, including provision of both routine and emergency services and addressing the public health needs of a changing population. Finding the right mix and level of services can be challenging for health departments, particularly in an era of shrinking public health budgets. To address this challenge, LHDs are encouraged to employ new technologies that will allow them to characterize emerging problems and identify potential solutions. However, many LHDs lack the resources to integrate these sometimes very expensive tools into their daily operations or to take full advantage of these new capabilities.

This report is intended to help LHDs by introducing some concepts for enhancing the use of geographic information systems (GIS) for planning LHD services. It includes options for accessing easy-to-use, no-cost GIS data and tools and suggests ways in which LHDs can integrate GIS approaches that may be new to them into their activities.

The report should be of interest to LHD executives, program managers, data analysts, and others who are concerned with applying GIS methods to planning services and identifying populations in need of services. The ideas and examples in the report were drawn from large LHDs but should also be applicable to smaller health departments and other levels of government. The study may also be of interest to community-based and/or nongovernmental organizations and advocacy groups that want to assess how their services can better meet the needs of the populations they serve. The techniques and strategies outlined here should be useful for all stakeholders interested in enhancing public health planning and evaluation through GIS techniques.

The report is best viewed either online or printed in color, since the maps in the text are in color and are not easily read in black and white or grayscale.

Funding for this report was provided by the Robert Wood Johnson Foundation (RWJF) Public Health Services and Systems and the Quantum Foundation. The research was conducted in RAND Health, a division of the RAND Corporation. A profile of RAND Health, abstracts of its publications, and ordering information can be found at www.rand.org/health.html.

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Summary

Local health departments (LHDs) play an important role in coordinating essential public health activities, such as monitoring community health, informing and educating the public about health issues, mobilizing community partnerships, and developing policies and plans that support individual and community health efforts (NACCHO, 2005). To determine whether these services are meeting local population needs, LHDs use a variety of formal and informal assessments, including community health assessments and communitywide health-improvement plans. Despite such efforts, the services offered by LHDs do not always meet local health needs. Mismatches can occur for many reasons, including competing funding priorities, political mandates, and natural shifts in population makeup and health concerns.

Geographic information system (GIS) mapping software provides a promising tool to enhance priority-setting and resource allocation. LHDs can use GIS technology to communicate complex geospatial information in an integrated and visual way, enabling staff to compare the geographic distribution of population health in a community (i.e., where services are *needed*) with the geographic distribution of LHD programs and expenditures (i.e., where services are *provided*). Using such an approach, LHDs can identify gaps between their program services and community health needs.

Although some LHDs have started using GIS, few have employed it for program planning and gap analysis, for a variety of reasons, including lack of data, resource constraints, and technological complexity. To address this need, the RAND Corporation worked with large health departments in four U.S. counties—Alameda County Health Department, Calif.; Los Angeles County Department of Public Health, Calif.; Palm Beach County Health Department, Fla.; and Duval County Health Department, Fla.—to explore options for expanding the use of GIS to display information that can assist LHDs with priority-setting, program planning, and resource allocation. Interviews were conducted with 65 key informants in the four LHDs, and case studies were made of three of them (excepting Duval County). We also reviewed relevant documentation provided by the LHDs, including data analysis reports, mapping reports, and examples of how GIS is currently being used for decision support and planning efforts. Each case study highlights a specific public health problem and presents a novel use of public health data for mapping.

Current Mapping Efforts Focus Mainly on Population Risk Factors

Our interviews revealed a continuum of mapping and program efforts currently under way at the LHDs, all four of which use GIS to assess community health needs. We found many examples of mapping efforts focusing on population risk factors such as proximity to a known

toxin, sociodemographic characteristics (e.g., racial composition, poverty), or the distribution of diseases or health conditions across a geographic area. It was less common, however, for LHDs to map the services they provide. When the LHDs did map their services, they typically focused on the location of publicly run or funded medical clinics and hospitals. Few LHDs reported using GIS to better understand service delivery by *simultaneously* mapping services (e.g., health-education activities, community engagement, policy development, and linkages/referrals to healthcare services) and population health needs.

Barriers to mapping LHD services together with population health needs include problems with the quality and availability of data and limited access to mapping resources. Facilitators include having "champions" within the organization who call for using GIS mapping techniques and identify the data needed. Programs or LHDs that do more of this type of mapping also tend to have access to outside resources (e.g., foundation funding or academic partnerships) for this purpose.

Interviews Pointed to Factors Contributing to the Use of More-Advanced GIS Technology

We used the findings from the interviews to develop a conceptual model of how maps can be used to address the gaps between public health needs and LHD services. This model, shown in Figure S.1, organizes themes from the interviews into discrete categories, focusing on the factors that contribute to the use of more-advanced GIS technology. We believe that these factors have the greatest impact on LHD use of GIS to map services and population needs together.

Priority-Setting and the Use of a Planning Process

An established planning process aids in the use of GIS as a tool in planning and priority-setting.

Planning with a Geographic Focus

GIS can be used to display the geographic reach of a problem and the extent to which LHD services are responding to it. Some issues are more likely than others to benefit from geographic display, especially those involving concepts that are difficult to understand in the abstract.

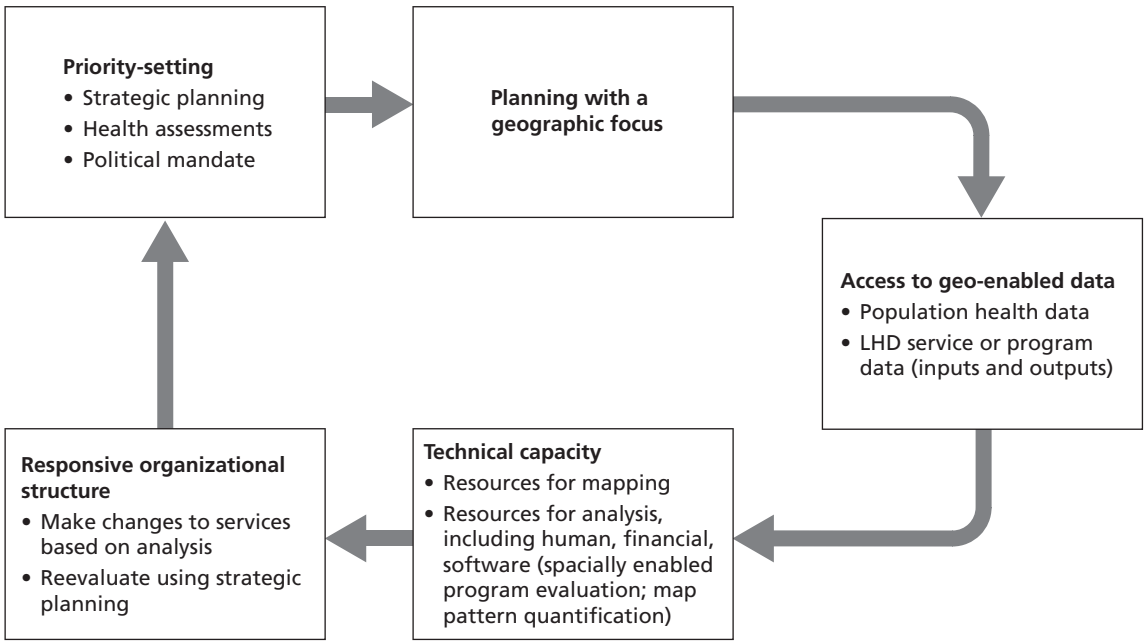
Access to Geo-Enabled Data

Having sufficient data is fundamental to mapping. Geo-enabled data are needed to map sociodemographic and health factors, as well as the location and reach of LHD programs or services.

Resources and Technical Capacity at LHDs

The resources possessed by an LHD, especially its technical capacity, will help determine whether and how it can use GIS and mapping in planning. Mapping involves use of specialized skills and tools such as mapping software, data management or statistical software, and trained staff. Free GIS software is available online, although financial resources are needed to support staff time required to access the necessary data, conduct analyses, and prepare maps.

Figure S.1
Factors Necessary for LHD Mapping of Population Health Needs and LHD Program Efforts



SOURCE: Dubowitz et al., 2011.
RAND *TR1146-S.1*

Responsive Organizational Structures

LHDs require the organizational capacity to use the information generated through GIS analyses or mapping to improve service provision and program efforts, adjust services and programs, and possibly shift priorities in response to new data and analysis.

Our conceptual framework presents mapping as a tool to support priority-setting. It can help LHDs to identify where they may be weaker or stronger on the factors that facilitate mapping. Identifying the factors that pose specific barriers to enhancing the use of GIS to map services with needs can help LHDs organize their work and identify solutions.

We identified several factors that might encourage LHDs to make greater use of mapping, including roadmaps, tools, and training for staff in GIS; methods to overcome technical and organizational barriers to implementation (e.g., variation in technical capacity, access to geo-enabled data); and tools for integrating sub–county-level data on LHD services with data on local health and healthcare needs.

Case Studies Highlighted Techniques for Expanding the Use of Mapping for LHD Planning and Priority-Setting

The case studies highlighted several techniques for helping LHDs expand the use of mapping for priority-setting, program planning, resource allocation, and visualizing community health issues. These techniques include identifying appropriate questions, utilizing available data, and finding the mapping approach that can best depict the data and questions of interest. We

found that allowing LHD staff to see the potential of concurrently visualizing services *and* needs was useful and, in many cases, eye-opening.

Palm Beach County

The Palm Beach County Health Department (PBCHD) case study provided an opportunity to better examine the gaps between healthcare services and needs through maps that displayed the geographic distribution of medically underserved populations and the uninsured alongside locations of primary-care and specialty health centers. The locations of the healthcare clinics were depicted, as well as the *level* of services they provide (i.e., clinical staffing ratios and staffing expenditures were shown for each of the clinics). Although the initial maps suggested to PBCHD senior staff and the RAND team that there was potential justification for providing an additional Federally Qualified Health Care (FQHC) clinic in the county, further maps showing the level of services shed light on what PBCHD staff felt was the larger issue of understanding how well the existing health centers were serving the population. The staff used the maps for discussions of the staffing/spending mix at "role model" clinics that might be replicated in other clinics. PBCHD is working with a broad range of community stakeholders to develop a communitywide approach to planning health services for the uninsured.

The primary lesson learned from this case study is that local health departments often do not use administrative data, such as human resources or finance data, to assess the cost-effectiveness of their services. LHD personnel who want to map these types of data will need to work closely with administrative units to design systems that link population health-needs data with service data.

Los Angeles County

The Los Angeles County Department of Public Health (LACDPH) case study provided an opportunity to explore a planning question in a novel area: health education. One important question for the LACDPH Nutrition Program was whether health-education outreach sites focusing on nutrition and physical activity were located in areas that matched population needs, as measured by income and/or race/ethnicity. We created maps that examined whether a better understanding of population health needs for nutrition services could be obtained by displaying program outreach activities along with differing cutoffs for income-based need for services and other population characteristics. These multidimensional maps, in which the geographic distribution of minority populations at different income levels was displayed in conjunction with information about obesity, highlighted areas in which multiple risk factors co-occurred, indicating that a greater number of communities could be reached if program guidelines were changed.

The primary lesson learned from this case study is that collecting and managing data on health-education outreach activities/services as completely and accurately as possible are important for many program evaluation activities, especially when employing a "mapping the gaps" approach.

Alameda County

The Alameda County Department of Public Health (ACDPH) knew that there was a high number of Emergency Department (ED) users in the county; however, they had no specific information on who the users were, where they were located, or what caused them to seek care in the ED. With data provided by ACDPH, the RAND team helped create maps to show the

locations of individuals who currently use ED services, the severity of conditions that those individuals present to the ED, and the location of alternative sources of care, such as community or public health clinics.

The maps suggested that there were potentially higher concentrations of ED users in several census tracts, as well as concentrations of users of ED services for non-emergent and otherwise treatable conditions. By examining all of the maps together, ACDPH and the RAND team were able to conclude that the main issues might be the residents' lack of knowledge about when and why to seek care in an ED versus a clinic, rather than the relative accessibility of the facilities. Additional maps showed that communication strategies might be split geographically between uninsured and low-income insured patients.

The Alameda case-study maps provided a foundation for examining use of the ED for conditions that were treatable in primary care. Other initiatives could also come out of this exercise, including approaches for planning new clinic locations, improving accessibility of existing clinics, and marketing the clinic sites to populations who would most benefit from using them.

The primary lesson learned is that LHD staff and data analysts may be able to employ geocoded county-level data from large healthcare and population-health datasets, including addresses for facilities and patients/clients.

GIS Has Multiple Potential Uses in Public Health Planning

The case studies we present here are intended to help LHD staff identify geographic questions that might inform their planning efforts and understand how maps might answer such questions. The case studies showed that GIS could be used internally as a management tool (i.e., to stimulate discussions about where efforts might best be allocated) and externally as a policy tool (i.e., to present the ways in which programs work within the confines of mandated guidelines). With the help of our partner LHDs, we were able to explore questions of interest; use novel sources of program activity or service data, such as financial data; map program activities or service data on the same maps with demographic or health data; and introduce mapping and analytical techniques. Creating visual pictures established a focal point for discussion of future programming and strategic directions.

At the same time, our study has several limitations. The work was undertaken with a small group of LHDs, so the data we present are only exemplary and the maps are current only as of the publication of this report. Further, the case studies are not meant to fully identify or analyze each problem; they are intended to serve as examples of novel approaches to summarizing data. Nonetheless, it is our hope that LHD program managers can learn from the examples and identify relevant options for using GIS to inform their own planning and resource-allocation efforts.

Acknowledgments

We sincerely thank the staff at each of our four partner health departments—Alameda County, Calif.; Duval County, Fla.; Los Angeles County, Calif.; and Palm Beach County, Fla.—for the time and resources they contributed to bring this project to fruition. The staff at each of these health departments provided open and honest responses to our questions, helped us track down and clean the data used to create the maps in this report, and provided maps of their own. The project would not have been possible without their vast knowledge of the issues pertaining to LHD planning, service delivery, and mapping.

We would also like to thank our former RAND colleague, Nicole Lurie, now Assistant Secretary for Preparedness and Response, U.S. Department of Health and Human Services, who provided input into the initial design of the study. Finally, we are grateful to our current colleagues Allen Fremont and Jeanne Ringel for serving as senior advisors over the course of this project. Their insights and thoughtful critiques helped us conceptualize the project and produce this report.

Abbreviations

ACDPH	Alameda County Department of Public Health
ARNP	nurse practitioner
CHA	community health assessment
DO	Doctor of Osteopathic Medicine, or physician
ED	emergency department
FPL	federal poverty level
FQHC	Federally Qualified Health Center
FTE	full-time equivalent
GIS	geographic information system
HRSA	Health Resources and Services Administration
IT	information technology
LACDPH	Los Angeles County Department of Public Health
LHD	local health department
MAPP	Mobilizing for Action through Planning and Partnerships
MD	Doctor of Medicine, or physician
MUA	medically underserved area
NACCHO	National Association of City and County Health Officials
NYU	New York University
PA	physician assistant
PBCHD	Palm Beach County Health Department
POD	point of dispensing
SCHIP	State Children's Health Insurance Program
SPA	service planning area
STD	sexually transmitted disease

CHAPTER ONE

Introduction

Local health departments (LHDs) are integral to improving health and supporting wellness in communities. They engage in such activities as monitoring community health, informing and educating the public about health issues, mobilizing community partnerships, and developing policies and plans that support individual and community health efforts (Croner, 2003; NACCHO, 2005, 2006). To evaluate whether these services are meeting local population needs, LHDs use a variety of formal and informal assessments. Many complete a community health assessment (CHA), which includes both a data report concerning countywide health outcomes and a profile of priority health issues selected by the LHD in partnership with community leaders. Some LHDs may also prepare formal communitywide health-improvement plans, which identify strategic activities that address specific needs over a defined period of time (usually three to five years). Such plans are usually implemented in partnership with community stakeholders.

Despite their efforts to ensure that communities' priority health concerns are being met, LHDs do not always offer services that match local population health needs (Hanchette et al., 2005; Pierce et al., 2007). In some cases, needed services are not provided, while in other cases, the needed services are provided, but there is a mismatch between the geographic distribution of sites providing them and the locations of need within the region. For example, in large LHDs (i.e., in communities with populations of 500,000 or more), there may not be enough funding to implement services in all neighborhoods that have high-risk populations. This can occur for many reasons, including funding priorities set by federal and state funding agencies, political mandates, and natural shifts in population makeup and health concerns (Hanchette et al., 2005; Pierce et al., 2007).

LHDs are often encouraged to employ new technologies that will enable them to characterize existing and emerging needs in their regions and to identify potential solutions (Caley, 2004; Hanchette et al., 2005; Scotch et al., 2006; Studnicki et al., 2007; Kothari et al., 2008; Scotch, Parmanto, and Monaco, 2008; Dreidger et al., 2007; Jankowski, 2009). One such new technology, geographic information system (GIS) mapping, provides a promising tool for enhancing priority-setting and resource allocation. LHDs can use GIS technology to communicate complex geospatial information in an integrated and visual way, enabling them to compare the geographic distribution of population health in a community (i.e., where services are *needed*) with the geographic distribution of programs and expenditures (i.e., where services are *provided*). Using such an approach, LHDs can easily identify gaps between their program services and community health needs. Such efficiencies are particularly important in the current federal, state, and local budget environment, where LHDs are increasingly trying to do the same work or more with decreasing budgets (NACCHO, 2011).

Although some LHDs have started using GIS to plan services for a range of health issues (Reissman et al., 2001; Miranda, Dolinoy, and Overstreet, 2002; Tanjasiri et al., 2004; Fulcher and Kaukinen, 2005; Borrell et al., 2006; Choi, Afzal, and Sattler, 2006; Geanurocos et al., 2007; Pierce et al., 2007; Ghetian et al., 2008; Kruger, Brady, and Shirey, 2008), few have employed it for program planning and gap analysis. Some LHDs are uncertain about which data are appropriate for mapping and whether they have sufficient data available. They also face challenges in determining how GIS should be applied at the sub-county level. Other barriers to leveraging the full value from GIS include resource constraints, technological complexity, and a lack of integration of financial and program information-technology (IT) systems (Mullner et al., 2004; Ruiz and Remmert, 2004; Studnicki et al., 2007; Kothari et al., 2008).

Purpose of This Study

This report addresses the deficit in LHD GIS activities by highlighting several techniques LHDs may employ to expand their use of mapping to display information that can assist in priority-setting, program planning, and resource allocation. It first describes findings from interviews with personnel at four large LHDs concerning current uses of GIS techniques in planning services, as well as facilitators and barriers that affect the ability to map LHD services with population health needs. Next, it provides mapping examples to illustrate how some of these barriers might be overcome, using questions and data from several LHD settings.

The mapping examples come from case studies of the Alameda County Health Department (Calif.), the Los Angeles County Public Health Department (Calif.), and the Palm Beach County Health Department (Fla.). Each case study highlights a specific public health problem and identifies data that can be used for mapping. Each presents a novel use of public health data and covers public health planning questions relevant to a broad set of LHD program staff.

This study is not focused on identifying new mapping tools or software programs, nor does it attempt to identify new ways of mapping population health needs or provide an exhaustive catalog of all the maps that LHDs should or could create. LHD staff who are already comfortable working with GIS and integrating it as a tool in their day-to-day work can find more-advanced software or mapping techniques in other trade resources, some of which are listed in Appendix A. The methods described here are intended to complement rather than replace current statistical analyses and program evaluation techniques used in planning resource distributions.

Although the use of GIS may not be feasible for every LHD, we think it is important to recognize that "mapping the gaps" should not be an activity only for those with extensive GIS resources. We therefore identify new ways to use or expand current GIS capacity, and we identify resources for mapping in low-capacity GIS environments.

Methods for Conducting Interviews and Developing Case Studies

Interviews

To examine current LHD planning practices and the role GIS plays in planning activities, we interviewed 65 key informants at our three case-study health departments, along with the Duval County Health Department (Fla.). We selected these four LHDs because their popu-

lation characteristics and data infrastructures provide a realistic picture of what is attainable with an expansion of GIS approaches. Each of the LHDs serves a remarkably diverse population, including high proportions of racial and ethnic minorities, immigrants, and individuals with low socioeconomic status. The need to serve such populations adds layers of complexity to public health planning.

We focused on large health departments because GIS mapping has typically required considerable resources, and all four sites spend more per capita than the median per capita spending for large LHDs in the United States as a whole ($34/person/year) (NACCHO, 2006). This level of spending indicated that these LHDs could provide a variety of illustrative maps and mapping strategies. While we focused on large health departments that had already reported using GIS, the lessons learned should be applicable to any organization interested in mapping services.

We interviewed from 12 to 24 key informants at each LHD, including staff at all levels (e.g., LHD directors; directors of programs within the LHDs; key program staff, including evaluation and data-collection directors; epidemiologists; GIS experts). The interviews were conducted in person by one lead facilitator from the RAND research team, accompanied by one note taker.

In the interviews, we asked about the LHDs' GIS infrastructure and about any planning methods that included a geographic component. We also tried to gauge the availability of geocoded data that could be used to define population health needs or to describe LHD program efforts and the ways in which both types of data are currently used, or could be used in the future, to inform program planning and resource-allocation decisions.

Critical questions included the following:

- What types of data are collected, and how often?
- How are data used to set priorities and influence the overall work of the LHD?
- Is GIS technology used to assess community health?
- If so, does it influence the way the LHD allocates resources or determine whether the funds are well spent?
- Does the LHD normally define an explicit or implicit geographic area to target health information or services?
- If so, does the LHD track expenditures by programs or by program sites that could be used to locate the geographical distribution of services?

In addition to the interviews, we reviewed relevant documentation provided by the LHDs, including data analysis reports, mapping reports, and examples of how GIS is currently being used for decision support and planning efforts.

Interviewees described the ways in which they currently use GIS for priority-setting, program planning, and resource allocation and the resources they felt they would need to extend their mapping efforts to create maps that present services and needs simultaneously. Interviewees also explained how they might utilize GIS technology in the future for service and program planning and described factors that would best enable concurrent mapping of population health needs and LHD services/program efforts. Information gathered in the interviews was used to identify the factors that facilitate or pose barriers to simultaneously mapping LHD services and population health needs and to highlight potential questions of interest to pursue in

the case studies. The case studies were conducted to focus special attention on methods used by the LHDs to overcome identified barriers to "mapping the gaps."

Case Studies

Case-study subject matter was chosen by each of the case-study LHDs, with input from the RAND team, considering feasibility in terms of time, expense, and the availability of geocoded data.[1]

The RAND team identified questions of interest to both our case-study partners and the broader field of public health systems research, including:

- Is building new health clinics the best way to meet the needs of the local population?
- Can LHD program guidelines be modified to reveal greater areas of need?
- Are there geographic areas that appear to have greater proportions of emergency department (ED) users than others?

Next, each LHD partner identified available data (e.g., clinic financial information, public health education-outreach activities, and ED visits) on the selected LHD services. The RAND team then worked with each LHD partner to refine the analysis questions and created a series of maps that would best depict the data and the questions of interest. We reviewed the findings with each partner LHD and ascertained how each might use the maps to enhance their planning around the identified issues. GIS tools were used to highlight geographic areas where the population health need and the location and delivery of relevant services were mismatched and/or aligned. Finally, an overall summary of the lessons learned was prepared for each case study.

While nearly all of the maps that appear in this report were created by the research team, several preexisting maps were made available for this report by the four partner LHDs. The source of each map and the data used are highlighted in Appendix A. Within each case study, we also highlight the mapping concept or use of data the maps are intended to illustrate.

Organization of This Report

The remainder of this report is divided into four parts:

- Chapter Two provides a brief overview of findings from the interviews and case studies.
- Chapters Three, Four, and Five describe the case studies.
- Chapter Six presents conclusions and recommendations from the study.
- Appendix A provides a set of resources that readers can use to enhance their use of GIS in planning services, and Appendix B presents an overview of the data used to create the maps in each case study.

[1] During the study, there was substantial staff turnover in key executive positions in the Duval County Department of Public Health (DCDPH). This turnover occurred while RAND was working with the health departments to identify suitable research questions for the case study. As a result, we were never able to come to a consensus with DCDPH on the appropriate questions, data sources, or mapping strategy.

CHAPTER TWO

Overview of Findings from Interviews and Case Studies

This chapter provides an overview of findings from our interviews with LHD personnel and the case studies. (The individual case studies are described in Chapters Three, Four, and Five.) We also present a conceptual model of the factors that we believe have the greatest impact on LHDs' ability to use GIS to map services and need together.

Findings from the Interviews

Use of GIS at the Health Departments

Staff at all four LHDs reported that mapping is a promising planning tool that can effectively be used to communicate with political decisionmakers, LHD executive staff, and community leaders. Interviewees said they had used maps to evaluate community health needs, the distribution of risk factors, and the locations of healthcare services.

We found a continuum of mapping and program efforts in use at the LHDs. All four of them use GIS to assess community health needs, focusing primarily on population risk factors such as proximity to known toxins, sociodemographic characteristics (e.g., racial composition, poverty), and the distribution of diseases or health conditions across a geographic area.

It was less common for LHDs to map the services they provide (e.g., measures of program efforts, including number of staff dedicated to a specific health issue in certain places; the location and counts of clinical services; financial data on programs and services). When the LHDs did map their services, they typically focused on the locations of publicly run or funded medical clinics and hospitals. Few LHDs reported using GIS to better understand service delivery by *simultaneously* mapping services (e.g., health-education activities, community engagement, policy development, and linkages/referrals to healthcare services) alongside population health needs. Although this use of GIS was infrequent, we highlight several such maps alongside those created specifically for the case studies. In doing so, we hope to encourage public health planners and evaluators to map a broader range of data (e.g., financial data, staffing data, multiple indicators of health need) and to expand their service datasets and mapping capabilities.

Facilitators and Barriers

The interviews revealed a number of facilitators and barriers to the use of GIS commonly experienced by LHD programs. Barriers included problems with data quality and accessibility, limited technical capacity, and organizational structures that are inconsistent with data sharing. Data are not always collected at sub-county level or do not have geographic identifiers, which makes it impossible to identify geographic variability in services. Also, programs within LHDs

have unequal access to mapping technology. In some cases, a mapping unit is centralized, and staff with less experience in mapping may not be aware of its existence, or the resources may be stretched too thinly among multiple programs to be useful. In other cases, there are no GIS experts. In several cases, data were isolated in separate administrative channels or programs or divisions within an LHD. If these programs do not ordinarily interact in setting priorities, staff may simply be unaware of the data that do exist.

Common facilitators include program staff who act as "champions," encouraging staff and managers to use GIS. These individuals also are likely to collect and manage data that are geocoded and available to multiple units. Finally, some programs or LHDs with a substantial history of mapping pursue outside funding or relationships with other academic agencies to support GIS projects.

The Conceptual Model

Researchers often call for LHDs to expand their use of GIS to include detailed mapping of public health services but fail to assess the barriers to doing so (Caley, 2004; Hanchette et al., 2005; Scotch et al., 2006; Dreidger et al., 2007; Studnicki et al., 2007; Kothari et al., 2008; Scotch, Parmanto, and Monaco, 2008; and Jankowski, 2009). We used the findings from the interviews to develop a conceptual model that illustrates how maps can be used to visualize and address the gaps between public health needs and LHD services. This model organizes themes from the interviews into discrete categories that focus on the factors that are likely to contribute to the use of more-advanced GIS technology (Figure 2.1). It highlights five factors which we believe have the greatest impact on LHD use of GIS to maps in planning. By extension, the conceptual framework may also be used to highlight how these factors affect LHD likelihood to map services and need together. The factors and their relationship to one another are described in more detail below.

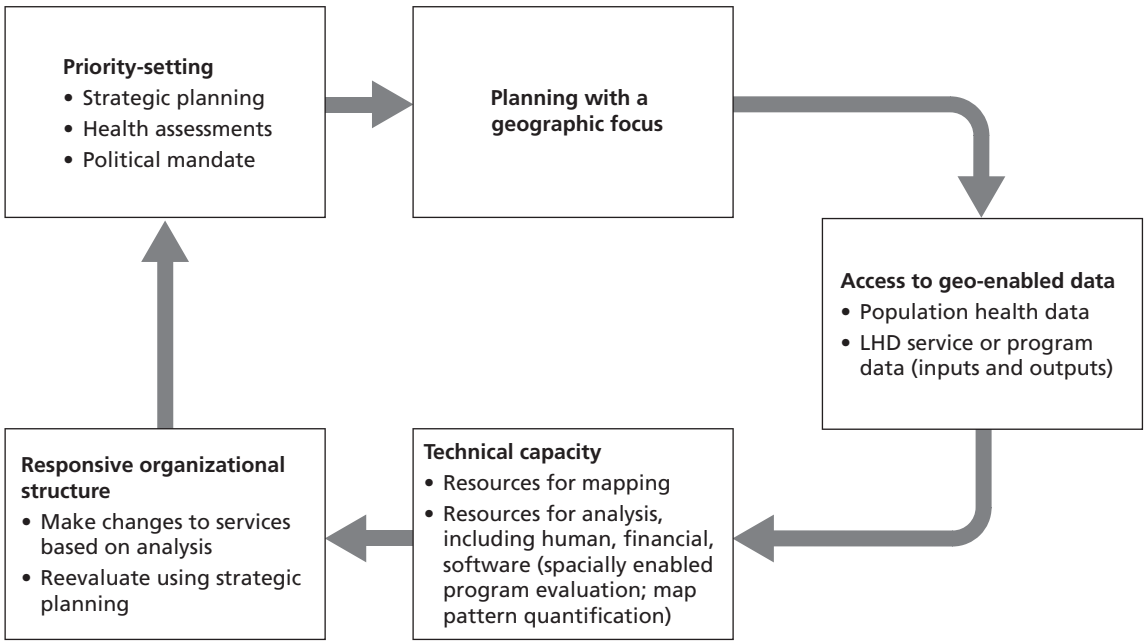
Priority-Setting and the Use of a Planning Process

All of the mapping we observed in the LHDs occurred in environments where there was an ongoing and systematic effort to set priorities. An established planning process aids in the use of GIS as a tool in planning and priority-setting, e.g., for communicating information about underlying population health needs and LHD services. Examples of priority-setting may include formal strategic planning activities, traditional health assessments, the National Association of City and County Health Officials (NACCHO) Mobilizing for Action through Planning and Partnerships (MAPP), and, for some LHDs, political mandates or requests from community organizations.

Planning with a Geographic Focus

GIS can be used to display the geographic extent of problems and the degree to which LHD services are meeting such need. For example, an LHD interested in understanding whether an immunization program is reaching children in high-poverty neighborhoods would benefit from viewing the problem on a map. Issues in which the key concepts are difficult to understand in the abstract are particularly likely to benefit from geographic display. Incorporating GIS planning requires that an LHD identify a specific purpose for mapping and that it be able

Figure 2.1
Factors Related to LHD Mapping of Population Health Needs and LHD Program Efforts



SOURCE: Dubowitz et al., 2011.
RAND *TR1146-2.1*

to plan with a geographic focus, using appropriate geographic units, such as small areas that reflect homogeneous communities.

Access to Geo-Enabled Data

Having sufficient data is fundamental to mapping. Geo-enabled data are needed to map sociodemographic and health factors, as well as the location and reach of LHD programs or services. All of the LHDs in this study used GIS to map outcomes such as life expectancy and disease prevalence, distributions of risk factors such as hazardous waste or poverty, and at least some healthcare services such as the locations of hospitals, clinics, or contracted service providers. Two of the LHDs used maps to evaluate whether the distribution of public health services met needs for services such as tobacco control policies or community education/advocacy efforts. One used GIS to evaluate mismatches between community health needs and LHD services.

Resources and Technical Capacity at the LHD

The resources of the LHD, especially its technical capacity, will help determine whether and how it will use GIS and mapping in planning. Mapping typically involves special skills and tools such as mapping software (e.g., GIS software, such as ArcView/GIS), data-management or statistical software (e.g., Excel, STATA, SAS), and staff who have the capacity to use this software. Free GIS software is available online and typically requires minimal training to use (see Appendix A). Even with free or low-cost software, financial resources are needed to support the staff time required to access the necessary data, prepare data for analysis, conduct analyses, and create maps or tables for display. Staff can use both GIS and spatial methods (in

spatially enabled program evaluation) to address important questions such as, How effective was the program? and How well are we doing? Effective use of spatially enabled program evaluation requires LHD investments in training and employment of staff with program evaluation and quality-improvement expertise. On a more specific level, LHD staff must be able to determine whether the apparent patterns on a map are statistically significant and require a plausible explanation in terms of services provided. For example, an LHD might be justified in deploying a program to increase colorectal cancer screening in a small area that has a significantly low proportion of its population screened for the disease.

Responsive Organizational Structures

LHDs require the organizational capacity to use the information generated through GIS analyses or mapping to improve the services they provide and in some cases to shift priorities when confronted with new information. Our interviews indicated that the mapping of services was most readily applicable in LHD programs that had the ability to relocate services, e.g., issue new requirements in requests for proposals when securing contracted services or providing community mini-grants. (For a detailed description of these elements, see Dubowitz et al., 2011.)

Our conceptual model is presented as a feedback loop in which each element contributes to LHD use of GIS maps both independently and through its dependent relationships with the other elements. If viewed as being centered on priority-setting, it indicates that LHDs that use mapping to inform their priorities will necessarily plan with a geographic focus. In turn, these LHDs require geographic data, and manipulating these data requires technical skills and capacity. The capacity to manipulate geographic data toward planning is useful only when the LHD has the capacity to act on new information. Finally, the ability to act on new information contributes to LHDs' ability to set priorities. In short, while mapping can help LHDs set priorities, priority-setting is necessary only when the LHD has the capacity to act on new information. These factors indicate the capacities necessary for routine mapping in LHD planning and, by extension, the capacities necessary for incorporating LHD services data in mapping efforts. Thus, this framework helps define the questions LHDs can ask and the areas where they may be weaker or stronger. Identifying factors that pose specific barriers or that enhance the use of GIS can help LHDs organize their work and identify solutions.

We identified several activities that might encourage greater mapping of services by LHDs, including the following:

- Creating and disseminating easy-to-use roadmaps and tools to aid in using GIS to plan services/program efforts
- Documenting validated methods to overcome technical and organizational barriers to implementation, such as variation in technical capacity and organization and access to geo-enabled data
- Publishing tools that show how to collect and integrate sub–county-level data on LHD services with data on local health and healthcare needs
- Providing training for staff on the application of GIS to planning questions and the technical aspects of using relevant software.

Case-Study Overview

Increasing LHD capacity to use GIS concepts may require addressing all or only some of the factors described in our conceptual framework. The case studies clearly illustrate this principle. The RAND team worked with each case-study LHD to expand its understanding of what might be included in a planning map. Specifically, we highlighted potential opportunities to map the gaps by considering LHD services in conjunction with typical maps of population health needs.

All of the case-study LHDs employed strategies to set priorities, and each demonstrated the capacity to redirect resources when gaps were identified. As a result, the RAND team was able to focus on addressing barriers to other domains of the conceptual model. The bulk of our work concerned barriers in two domains: (1) the LHDs' access to geo-enabled data and (2) their resources and technical capacity. Thus, our collaboration with each LHD involved the following steps:

1. Develop new planning questions or reframe existing planning questions to address LHD services and the gaps between the delivery of these services and the community's need for them
2. Identify and prepare GIS data that can be used to address the new or reframed questions, focusing on novel sources of data on services
3. Identify and implement the least resource-demanding GIS techniques that can be used to efficiently answer the new or reframed questions.

The lessons learned from this process, which are detailed in each of the following case studies and summarized in Chapter Six, provide a template for overcoming barriers to mapping the gaps.

For each case study, we describe what the LHD hoped to achieve and discuss how maps were used to address the issues identified. The case studies typically move through a demonstration of several types of maps: those that highlight population health needs, those that map LHD points of service, and those that map both services and needs. Within each case study, we begin with a basic map (i.e., a map showing population health needs) and then move to maps of increasing complexity to show the range of GIS mapping available for LHD planning and to highlight how the more-complex maps can reveal nuanced features of the problem and improve the capacity to ask more-sophisticated questions. Each case study includes a discussion of the process we used to identify a question of interest, barriers we encountered to incorporating GIS to help answer the question, and strategies we used to overcome these barriers.

The case studies are not intended to identify specific public health problems and solutions; our purpose is to illustrate ways in which GIS can be used to identify or highlight such conditions. While we discuss the types of questions LHDs can explore with particular maps, we note that the maps should be interpreted with caution. They illustrate the types of analysis that can be conducted with GIS, but the relationships identified and discussed may or may not meet standards of statistical significance. Maps are but one analysis tool that LHDs have at their disposal, and they should be used in conjunction with other tools to provide a comprehensive analysis. Maps can provide compelling information, but they may also lead to false conclusions about causality. Thus, our research team relied on staff at each LHD to identify

the relationships they thought were most important to highlight with maps and to help in interpreting the data.

Common Types of Maps Used in Case Studies

Some of the key types of maps presented in the case studies are described in this section. The case studies themselves are presented in the next three chapters.

Maps of Population Health Needs. Figure 2.2 illustrates how a map can be used to display the population health needs of a local community. It highlights the rate of H1N1 influenza vaccinations in each of the Los Angeles County service planning areas (SPAs), i.e., the geographic areas that the Los Angeles County Department of Public Health (LACDPH) uses to plan its services. This map clearly identifies areas where additional vaccination sites or outreach efforts might be directed, such as areas currently experiencing low vaccination rates.

Maps of LHD Points of Dispensing. One of the simplest ways to present information on LHD services is to place an indicator of each LHD point of dispensing (POD) on a map of a population of interest. PODs are locations at which an LHD service exists and is provided to clients. For example, Figure 2.3 depicts the location of PODs in Duval County, Fla., in relation to population size, by county zip code.

Figure 2.2
H1N1 Influenza Vaccine Coverage Rates in Los Angeles County SPAs

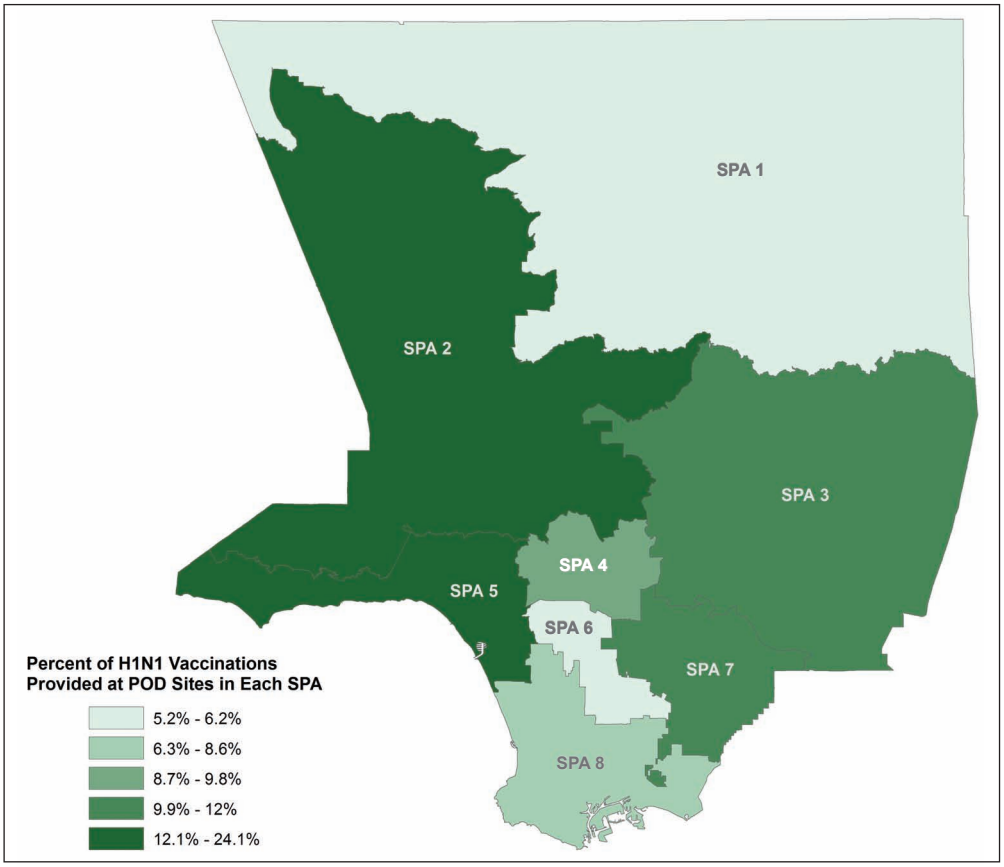


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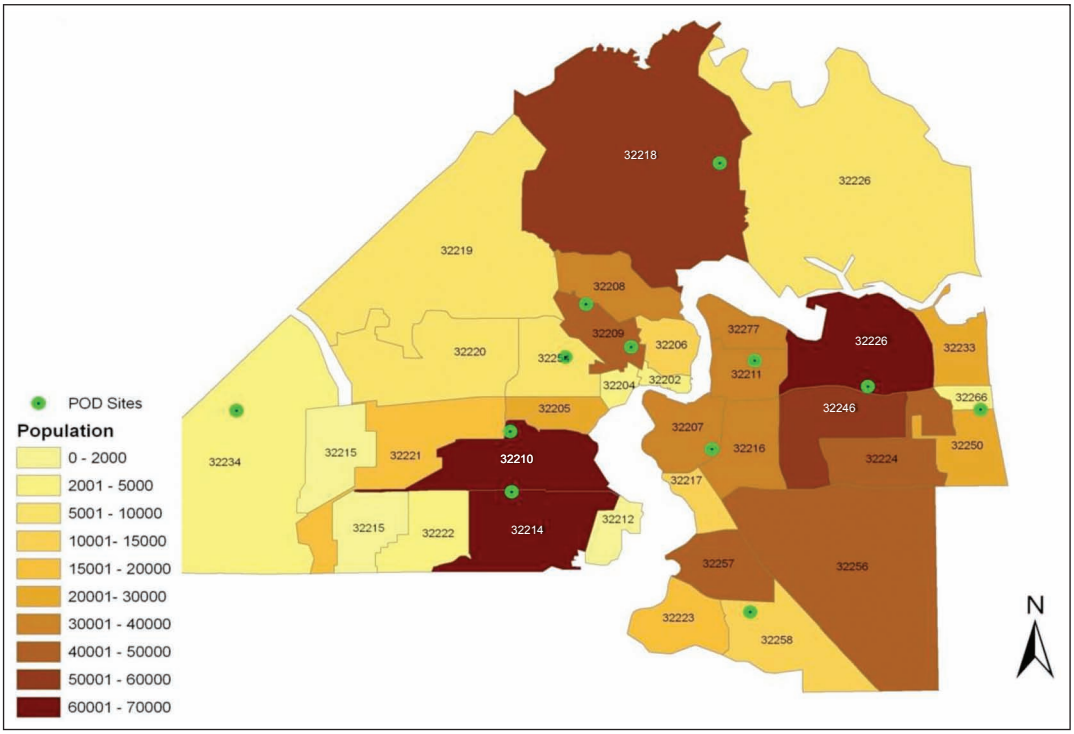
Figure 2.3
PODs, by Population, Duval County, 2008



SOURCE: Duval County Florida Health Department. Population data obtainable from publicly available Census files.

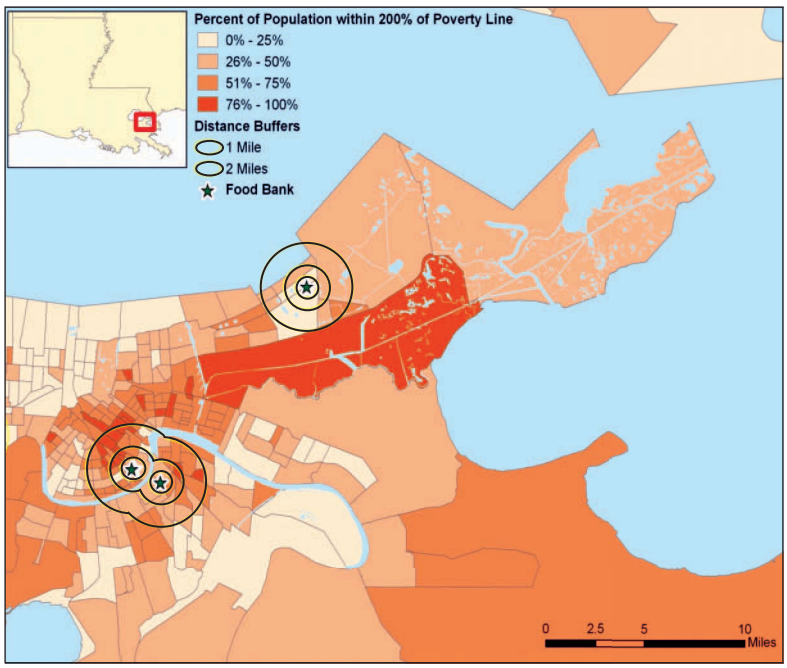
RAND *TR1146-2.3*

PODs are often used by LHDs to distribute medications or other items in an emergency. Maps showing PODs help illustrate whether the sites are located in highly populated areas where demand for emergency preparedness services is expected to be high. They can thus be useful in evaluating whether the LHD has appropriately located facilities to deliver such services.

These maps might be more useful if they displayed information about the services provided or the activities conducted at the PODs rather than simply indicating locations. For example, additional details on staffing capacity or financial resources at each POD could be mapped, as well as distinctions between provider types in designated sub-county regions. Alternatively, mapping additional details about the performance of potential or actual POD operations would help in assessing the degree of match or mismatch with the local population needs. Such maps might also assist in assessing POD outputs (e.g., the percentage of people seen and treated), the internal operations or staffing levels at the PODs, or potential barriers for persons who may need access to PODs.

Maps of Both LHD Services and Population Needs. Maps can more fully illustrate the reach of LHD services by showing services and population needs together. For example, Figure 2.4 shows how data on services and populations in need can be merged to highlight specific gaps in services delivered by LHDs. This map shows the locations of food banks in relation to concentration of poverty in New Orleans, La. The circles indicate one- and two-mile radii from the food bank locations, i.e., "reasonable" distances between the food bank

Figure 2.4
Communities Served by Selected Food Banks in New Orleans, La., by Distance to Site and Poverty Level



RAND *TR1146-2.4*

sites and low-income populations. The buffers in this map are measures of linear distance, i.e., "as the crow flies," and do not consider factors such as street networks, driving times, or modes of transportation.

Assuming that the measure of the population living within 200 percent of the federal poverty level (FPL) is associated with food insecurity, this map shows where new food banks could be located to meet the needs of this at-risk population. Alternatively, such maps could be used to identify populations in need of transportation support or other assistance to access the services that are already available. Additional information would be required to assess the characteristics of persons who rely on the food banks (e.g., race, ethnicity, homeless or working poor), those who use a specific food bank more frequently (e.g., individual client addresses), and utilization at each site.

Similar types of maps are shown in the three case studies. The case studies not only highlight new areas of potential need but also illustrate how various types of existing data can be used to address questions of interest through mapping.

CHAPTER THREE

Case Study: Locations of Primary and Specialty Healthcare Services in Palm Beach County, Florida

The Palm Beach County Health Department (PBCHD) was primarily interested in understanding whether uninsured county residents had adequate access to healthcare. They therefore wished to analyze whether adding new Federally Qualified Health Centers (FQHCs) would improve the department's capacity to provide healthcare to medically underserved populations, and they wanted the analysis to address two questions: (1) Is the current distribution of safety-net clinics meeting the healthcare needs of these residents? and (2) How well is each of the individual county-administered FQHCs reaching the medically underserved population? To help answer these questions, PBCHD identified data and created maps to illustrate the relationship between FQHC resources and healthcare needs in the community.

Do Clinic Locations Match Areas of Highest Need?

PBCHD created Figure 3.1 to evaluate whether there were mismatches between the locations of medically underserved populations—i.e., medically underserved areas[1] (MUAs)—and current and proposed clinic locations in the county.

To evaluate potential mismatches, department staff considered both FQHCs and other safety-net clinics. Figure 3.1 shows the locations of primary-care and specialty health centers in the county, using different symbols to distinguish between current and proposed health centers; FQHCs and non-FQHCs; and health centers run by PBCHD and those run by other non-PBCHD community providers.

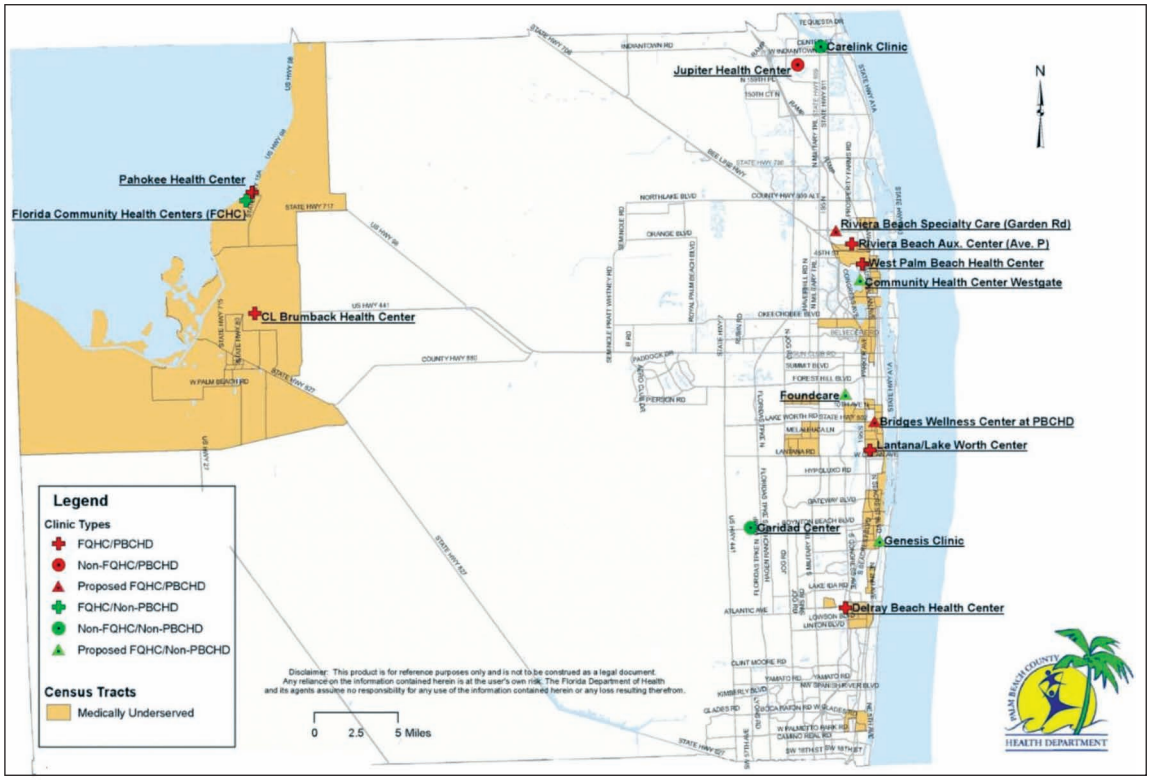
PBCHD staff reviewing this map felt that the MUAs between the West Palm Beach Health Center and the Lantana/Lake Worth Center, as well as those between the Lantana/Lake Worth Center and Delray Beach Health Center, might be underserved. The map shows proposed locations for new clinics that might improve access, although additional analyses might be needed to confirm that these would be the best locations.

Does the Mix of Staff and Expenditures at Safety-Net Clinics Match Areas of Need?

PBCHD staff were not satisfied with the level of detail illustrated in Figure 3.1, because it does not provide information about the *level* of services provided or specific population health

[1] *Medically underserved area* is a term used by the U.S. Health Resources and Services Administration (HRSA) to designate areas that have fewer healthcare providers and resources, such as hospital beds and equipment, than other areas.

Figure 3.1
MUAs and Locations of Current and Proposed Safety-Net Clinics in Palm Beach County



SOURCE: Palm Beach County Health Department.
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needs that must be addressed. Both types of information could help staff target the placement of new clinic sites or to streamline the delivery of healthcare services at selected sites. Further, PBCHD staff were interested in determining whether the clinical staffing and resource levels were appropriate for the healthcare demands of the uninsured population.

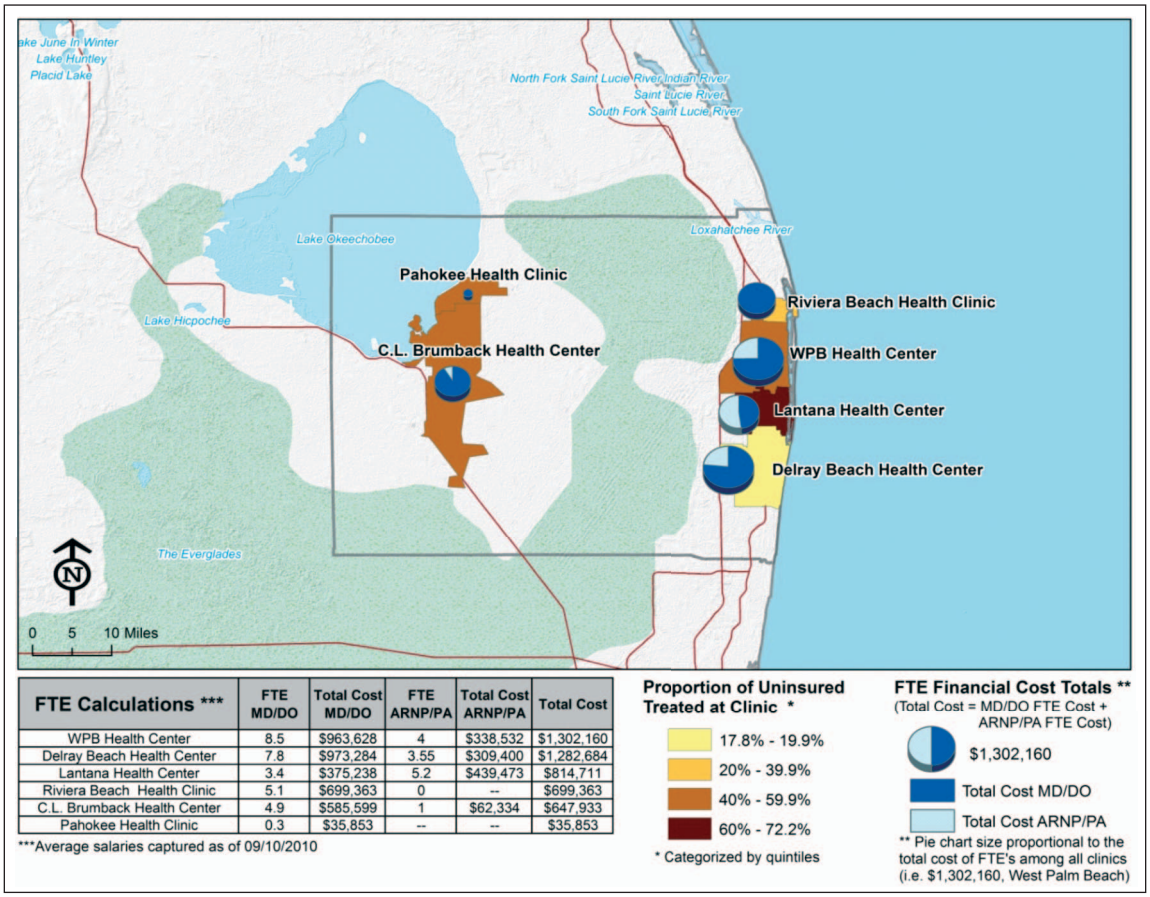
To address these concerns, RAND created an additional set of maps (Figures 3.2 and 3.3), which provide a fuller picture of LHD services, including staffing ratios—e.g., physicians (MD/DO) to Advanced Registered Nurse Practitioners (ARNP) and Physician Assistants (PA)—and costs, as well as population health needs, including rates of utilization of healthcare services. The new maps help answer the question of whether the mix of staff and expenditures at safety-net clinics is adequate to meet the geographic distribution of need.

Data for these measures were provided by PBCHD and are described below.

Figure 3.2 shows the LHD clinic staffing levels for each of PBCHD's current FQHCs in relation to the care provided to the uninsured in the community.

The map illustrates in gradations of color the proportion of the uninsured population in the community surrounding a health center that has received services at that site, with darker areas indicating a higher percentage of uninsured persons receiving care. The measure of clinical staffing levels is the number of clinical staff working a full compensable work year, i.e., clinical full-time equivalents (FTEs). The map and charts display both the total number of clinical FTEs at each clinic and the ratio of FTE doctors to ARNPs/PAs. The map can be used

Figure 3.2
Communitywide Percentage of Uninsured Treated at Selected Clinics in Palm Beach County, by Clinic Staff Size and Mix



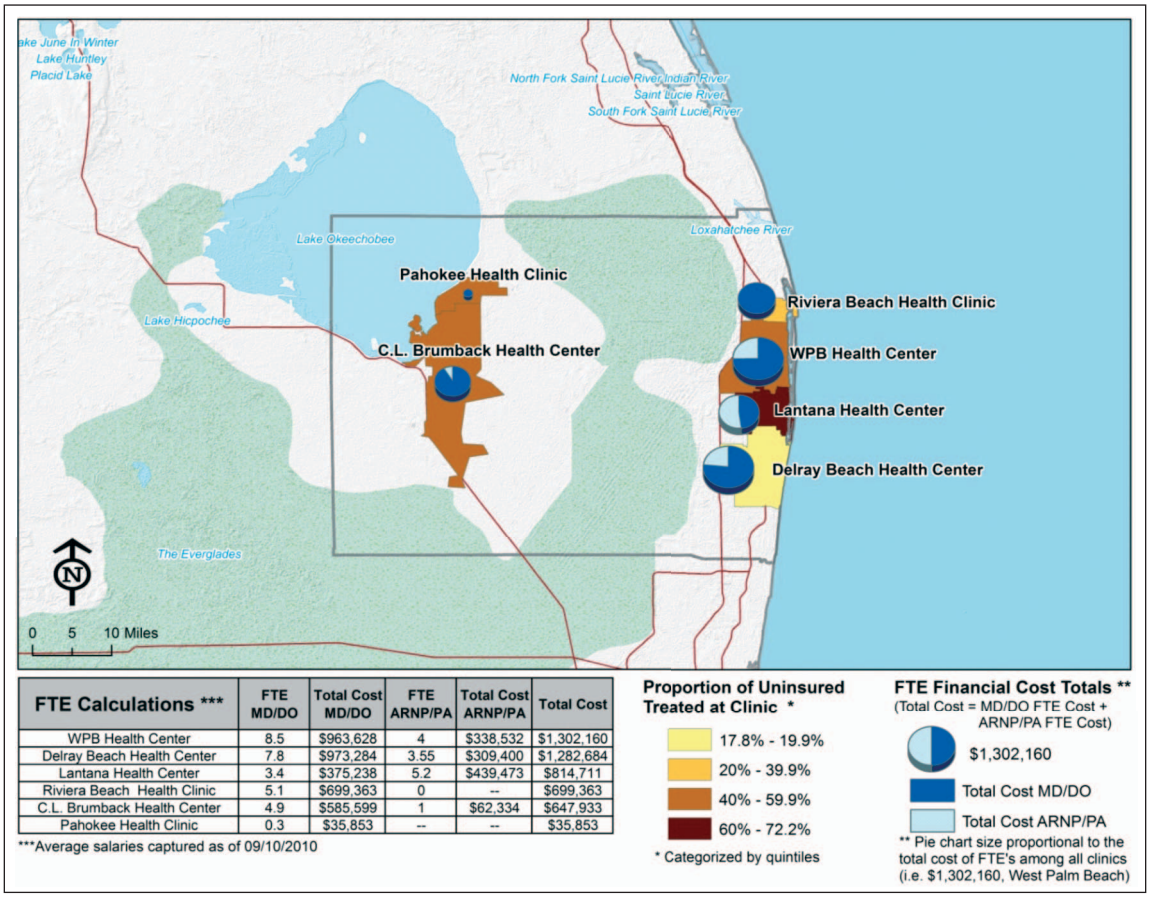
RAND *TR1146-3.3*

to assess the distribution of clinical FTEs, overall and by type, and the potential relationships between the mix of clinics and/or clinic staff to LHD efforts to provide services to the uninsured population. These maps focus on a specific targeted population—the uninsured who are receiving care in each clinic—rather than the broader indicator of medically underserved, which the PBCHD had previously considered.

In their review of this map, LHD staff were first struck by the relatively lower proportion of uninsured patients reached by the Delray FQHC but believed the figures might be unusually and temporarily low because Delray was a new clinic. Staff also noted that the Lantana/Lake Worth FQHC served the greatest proportion of uninsured and had the largest relative proportion of ARNPs/PAs. This observation suggested, provisionally, that clinics with higher proportions of ARNPs/PAs might have better capacity for serving the uninsured.

Figure 3.3 depicts the same basic information as Figure 3.2 (clinical services and utilization by uninsured persons) but adds information on PBCHD's expenditures for clinical staffing at each of its safety-net health centers.

Figure 3.3
Communitywide Percentage of Uninsured Treated at Selected Clinics in Palm Beach County, by Clinic Staff Costs



RAND *TR1146-3.3*

The map and charts show total expenditures for all clinical staff at each clinic and the proportions of expenditures for doctors and for ARNPs/PAs. PBCHD staff felt that the relatively lower costs of the Lantana FQHC indicated that addressing staffing mix might be an efficient way to increase access to healthcare services. However, a more sophisticated analysis of the relationship between clinic staffing and outreach to the uninsured would be required to confirm the accuracy of this interpretation.

How Can These Types of Maps Be Used by LHDs?

LHDs can use maps such as those presented in this case study to assess the relationship between the distribution of LHD spending on clinical staff and the effectiveness of LHD efforts to provide services to the uninsured population.

PBCHD is using these maps for several purposes. They are being used to identify and stimulate discussions about replicating the staffing/spending mix at role-model clinics in other clinics. For example, Lantana/Lake Worth is the only clinic that employs more ARNPs/PAs than physicians, but it treats a higher proportion of local uninsured than any other clinic

in the study. PBCHD is also working with a broad range of community stakeholders (e.g., faith-based organizations, hospitals, non-PBCHD clinical providers, nonprofit organizations, business partners) to develop a communitywide approach to planning health services for the uninsured. The overall conclusion PBCHD staff drew from the maps is that adding new clinics may not be as effective as identifying improvements that can be made at current clinics or as establishing relationships with other safety-net clinics that can be leveraged to improve access across the county. Thus, the maps helped to highlight the healthcare needs of the uninsured and identify areas where greater and more efficient partnerships are needed, rather than competition among healthcare providers.

While these maps have been useful, they do not provide all the information that PBCHD needs to make planning decisions. Additional analyses or maps would be needed to assess health-center outputs (e.g., cost per patient seen, average patient waiting time, patient satisfaction), the range of healthcare services offered at each site, and potential barriers to receiving care, such as travel distances, transportation, and the times of day services are offered.

Case-Study Conclusion

This case study illustrates how new sources of data on expenditures and clinical staffing can be used to help characterize a problem, using GIS. The initial map produced by PBCHD showed services and population health needs simultaneously by pinpointing the locations of clinics but was of limited usefulness, since LHD staff who work in other programs (e.g., health education) may measure their reach into the community not by the location of their offices but rather by the contacts they have made. Moreover, maps that focus on specific "pinpointed" locations do not provide information about the capacity or reach of services. The other maps produced for this case study advance the use of clinical data beyond simple points on a map and help provide important contextual information to address the questions PBCHD is asking about how best to organize and deliver healthcare services to medically underserved populations in the community.

The primary barriers to engaging in this mapping exercise were related to PBCHD's limited technical capacity to produce maps and limited experience in identifying geo-enabled data. There are few in-house staff experienced in using GIS, and data on population health needs are collected and maintained primarily by the state rather than PBCHD. Consistent with the state-level centralization of data collection, resources for local-level data collection and evaluation activities are limited. As a result, GIS-based planning was not a routine activity at PBCHD.

Despite PBCHD's limited resources, its director was a champion of data-based planning and evaluation, and the department employed an accounting system that could be creatively employed to obtain geographically relevant service data. An important lesson learned in this case study is that LHDs may collect data relevant to GIS-based assessment of service gaps and that recognition and leadership in the application of GIS for planning purposes may be all that is needed.

CHAPTER FOUR

Case Study: Locating Chronic-Disease-Prevention Education Activities in Los Angeles County, California

The Los Angeles County Department of Public Health (LACDPH) participates in a chronic-disease-prevention program called Network for a Healthy California. Funded by the U.S. Department of Agriculture (USDA) and administered by the State of California Department of Public Health, the program provides resources to LHDs (among other organizations) to implement state-mandated educational programs for low-income populations on the benefits of healthy eating and physical activity. Educational activities for children and families include promoting fruit and vegetable consumption and physical activity through participation in community events, demonstrations, taste testing, and marketing to targeted participants. Information is provided through games, informational brochures, and live demonstrations conducted by LACDPH staff at retail food locations, farmers markets, health fairs, community events, churches, worksites, and school sites throughout the county. In addition, the state requires LACDPH to use a train-the-trainer approach (called the Toolbox in this report) in which it trains members of its partner organizations to deliver the same educational activities in the low-income neighborhoods they serve.

Activities funded through Network for a Healthy California must be delivered in census tracts where 50 percent or more of the population has an income at or below 185 percent of the FPL. Two campaigns in the project are focused specifically on African-American and Latino communities.

LACDPH staff noted that there may be geographic areas in which many families have incomes at or below the mandated threshold, but the proportion of low-income families in the community does not reach the mandatory 50-percent cutoff required for program participation. Further, using specific health information from community residents might produce a more precise measure of risk of future chronic conditions than can be ascertained by income and race alone. For example, childhood obesity is an important predictor of poor health later in life. Thus, communities that are characterized by low income and high obesity (but do not otherwise meet the mandated guidelines of the program) probably still have many families at increased risk of developing a chronic condition. This raises questions about whether modifying current program guidelines would reveal additional areas of need.

The question that we posed then is, Could a program such as Network for a Healthy California be refocused geographically to meet the needs of a larger proportion of the population that is at greatest risk for chronic illnesses?

To address this question, we looked specifically at two potential changes:

- How might changes in the threshold affect the geographic profile of need?

- How might adding new data on additional measures of population health (e.g., childhood obesity) affect the geographic profile of need?

In addition, we explored whether there were differences in these results among racial and ethnic minorities. Because Network for a Healthy California services can be located only in communities that meet the mandated income threshold, this exercise has greater advantages as an exploratory tool that might be used to discuss potential changes in the program's mandated structure rather than as a specific program-planning tool to relocate services, activities, or partner sites in Los Angeles.

Would Changes in the Program Guidelines Affect the Location of the Targeted Population?

Figure 4.1 is the first in a series of maps that the RAND team created for LACDPH to help answer this question. It depicts the current populations of interest *(*e.g., low-income population, defined as having an income at or below 185 percent of the FPL) and the locations of current Network for a Healthy California activities and service providers.

LACDPH provided the RAND team with several sources of data, including program tracking spreadsheets that showed the location of all activities provided by Network for a Healthy California in the past year, addresses of partner organizations, sites where additional health-promotion activities might be conducted, and the number of activities completed at each site. Different symbols on the maps depict the following health-promotion activities:

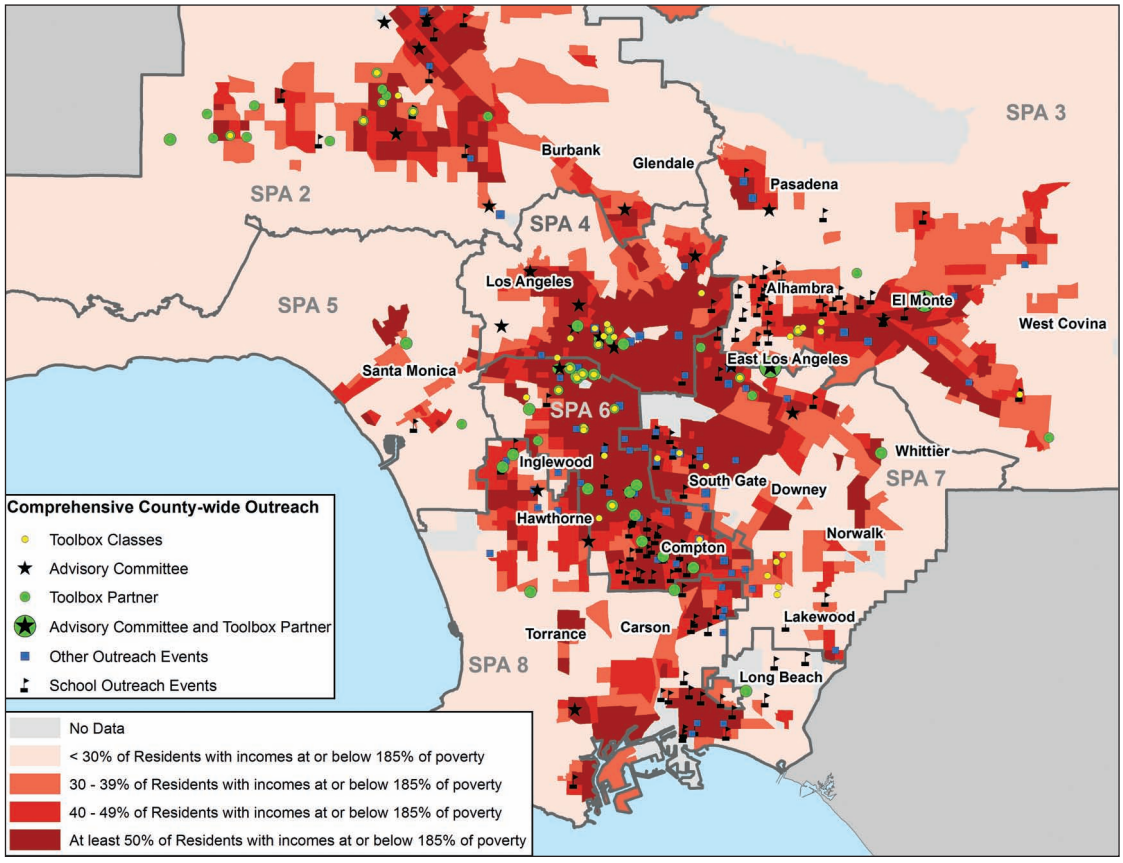
- Outreach events at food retail sites (e.g., large/small grocery chains, farmers markets, health fairs) to promote healthy food choices
- Train-the-trainer classes provided to partner organizations that agree to provide the outreach activities in their communities
- Locations of community organizations and school districts that have agreed to participate in any of the aforementioned activities.

Additional data on neighborhoods in which a large proportion of residents have incomes at or below 185 percent of the FPL are also added. Specifically, it highlights areas where 30 to 49 perccent (in addition to 50 percent or more) of residents have incomes at or below 185 percent of the FPL.

When LACDPH staff reviewed this map, they found that because so many partners and activities are located in and around communities in which 50 percent of the population has incomes at or below 185 percent of the FPL, the map identifies virtually no mismatches between the communities in which they are able to conduct activities according to program guidelines and the actual communities where their activities take place. In other words, the program is working exactly as it is designed in terms of the geographic reach of services.

However, highlighting census tracts where 30 to 49 percent of residents have incomes at or below 185 percent of the FPL does show some additional communities that would meet the new guideline and that do not currently receive services. These are in SPA 3—the communities east of El Monte; in SPA 4—the communities east of downtown and north from there to Burbank; in SPA 5—a few census tracts near Santa Monica and Venice; in SPA 7—between

Figure 4.1
Nutrition and Physical Activity Outreach Events in Los Angeles County, by Census Tract and Income Levels



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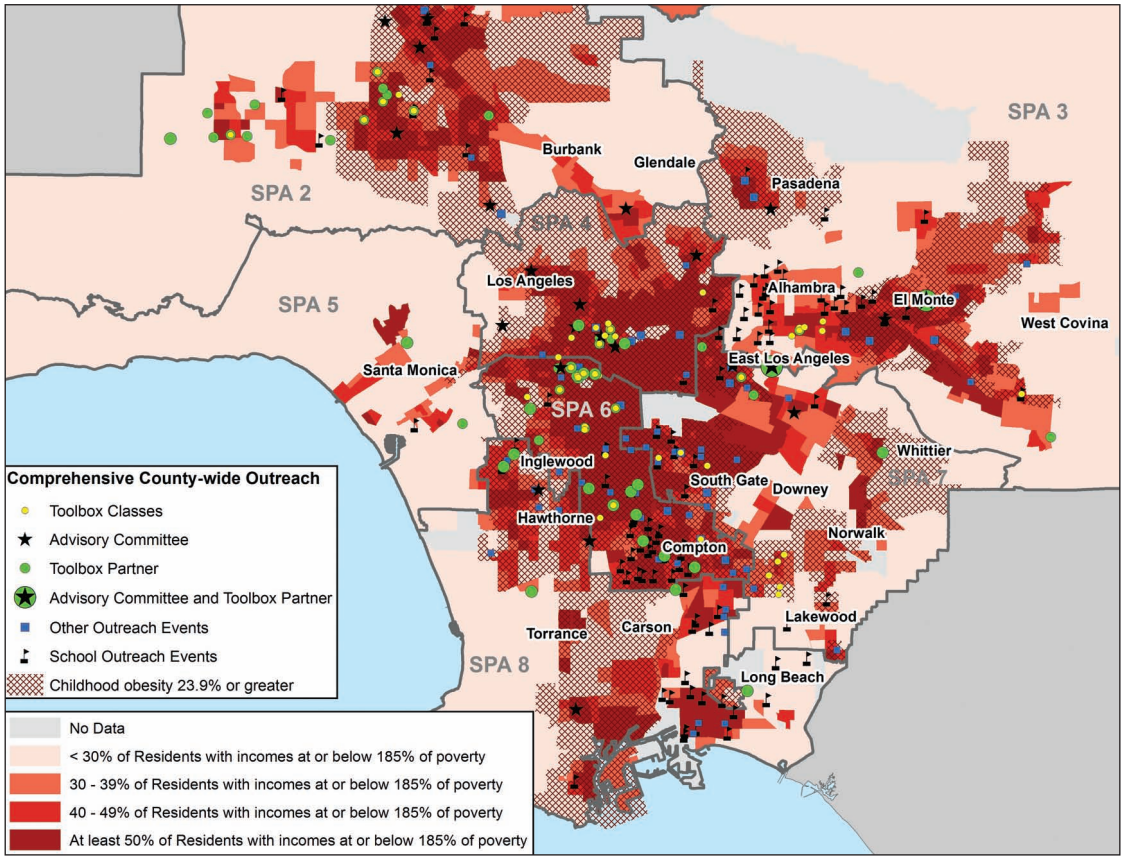
Norwalk and Whittier; and in SPA 8—near Torrance and north to Inglewood, as well as west of Long Beach to Carson.

Figure 4.2 highlights the same information as in Figure 4.1 but includes data on the communities with at least 23.9 percent of all children in the county identified as obese in 2005. We chose this threshold because it represents the point at which half of all communities in Los Angeles have lower obesity rates (LACDPH, 2007).

Figure 4.2 shows that if obesity prevalence were included as a mandated determinant of services, new communities of need would be revealed. Some of these areas overlap with those identified in Figure 4.1 that have a large (30 to 49 percent) proportion of residents with incomes at or below 185 percent of the FPL. These include the area in SPA 8 between Torrance and Carson and west of Long Beach; the area in SPA 7 between Norwalk and Whittier; communities east and north of El Monte in SPA 3; and the area north of Burbank in SPA 2. The identification of these communities might indicate that the current income threshold undercounts the number of communities in need of nutritional education in Los Angeles County.

Figure 4.2
Nutrition and Physical-Activity Outreach Events in Los Angeles County, by Census Tract Income Levels and City or Neighborhood Childhood Obesity



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How Might Changes in the Program Guidelines Affect the Location of Health-Education Outreach Sites Targeted Toward Racial and Ethnic Minorities?

The next series of maps created by the RAND team show the locations of concentrations of minorities, different income ranges, and areas with a high prevalence of childhood obesity. The program's focus on minority communities means that several services and activities are targeted toward Latinos and African-Americans. The maps shown in Figures 4.3 and 4.4 were therefore created to address the question, Are there Latino or African-American communities that may have a need for nutritional-education services but are not reached because they do not meet the income thresholds?

Figure 4.3
Latino-Targeted Nutrition and Physical-Activity Outreach Events in Los Angeles County, by Percentage of Latino Population in Census Tract and Income

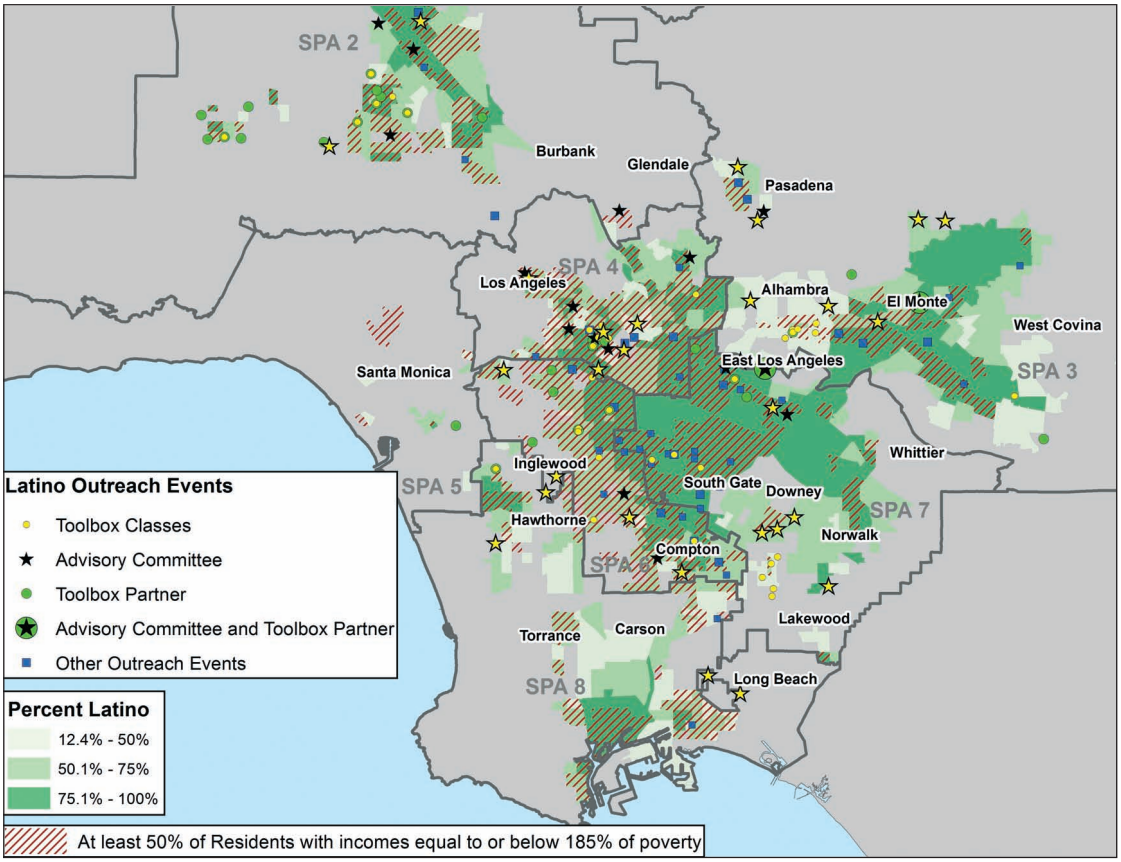

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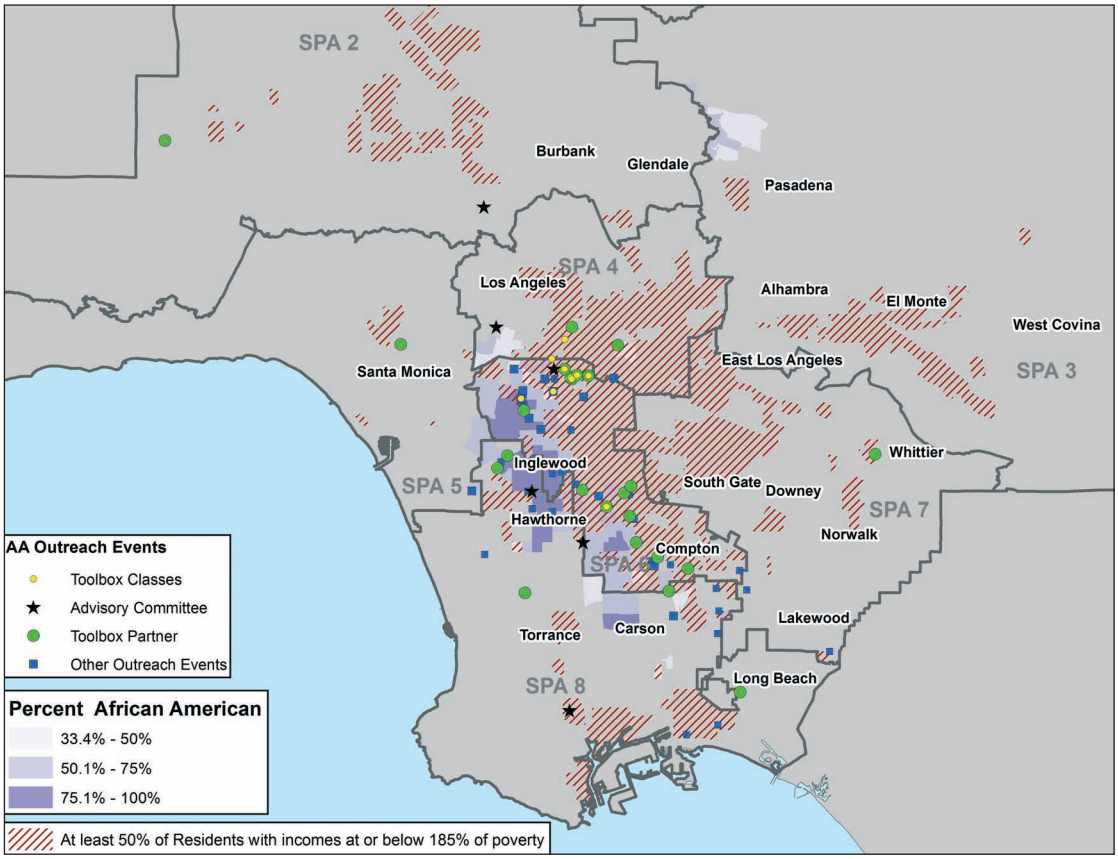
Figure 4.3 depicts the distribution of ethnically targeted health-promotion and education outreach sites and activities for Latinos living in communities that meet the income threshold. It also displays the communities with increasing proportions of Latinos. It highlights communities in SPA 8 south of Carson; SPA 7 north of Downey; and SPA 3 east of El Monte, in which Latinos are the predominant ethnicity but there are fewer Latino-directed services. The income information was added to the map to highlight the fact that these areas do not receive services, because they fail to meet the mandated income threshold. Figure 4.4 highlights areas with large populations of African-Americans, as well as locations of African-American-targeted outreach events. Although not all of the African-American communities meet the income threshold, they are in close proximity to those that do, and as a result they are all close to targeted outreach events.

Figure 4.5 adds data on the obesity prevalence to the map of Latino communities in Figure 4.3 to highlight additional ways of considering how mandated program requirements might be changed to meet the needs of the targeted population.

Figure 4.4
African-American-Targeted Nutrition and Physical-Activity Outreach Events in Los Angeles County, by Percentage of African-American Population in Census Tract and Income



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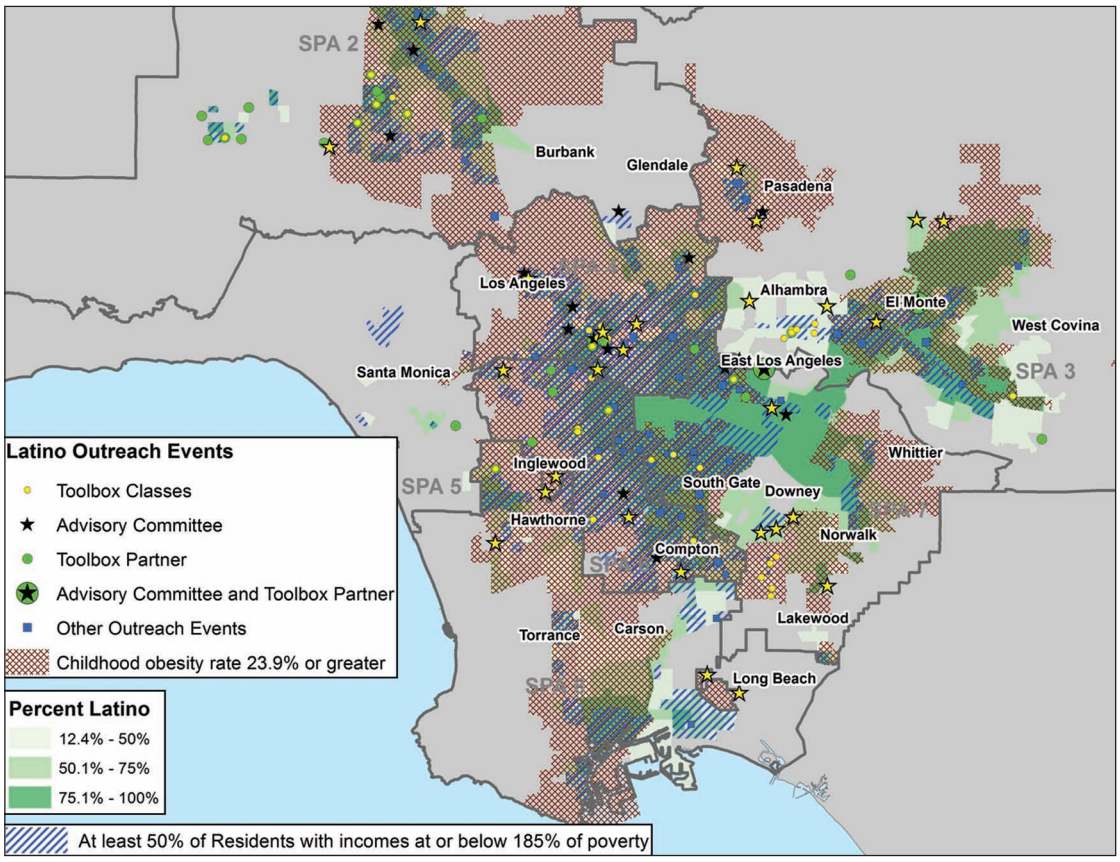
Combining these data produces a picture of "hot spots" of multiple risks in which many children are obese and residents have incomes that are at or below the mandated income threshold. The addition of race shows whether the use of obesity as a risk factor within Latino communities would help identify potentially new communities of need. The combination of these factors indicates a high need for obesity-related education and services targeted at Latinos. In this map, the three Latino communities highlighted in Figure 4.3 that displayed very little overlap with Latino-targeted outreach activities are nevertheless high in childhood obesity. As a result, these areas could potentially be in need of nutrition services and prevention activities.

How Can These Types of Maps Be Used by LHDs?

These maps demonstrate new ways to consider defining the mandated communities in which Network for a Healthy California activities can be conducted. Because LACDPH cannot change where it directs services, the maps cannot be used to guide current program planning. LACDPH might be able advocate for changes to the program only based on findings from this

Figure 4.5
Latino-Targeted Nutrition and Physical-Activity Outreach Events in Los Angeles County, by Percentage of Latino Population in Census Tract, Income, and City or Neighborhood Childhood Obesity



RAND *TR1146-4.5*

analysis. However, other LHDs conducting analyses with similar data could use these maps as a tool to prioritize and plan services. For example, the maps could be used to make preliminary assessments of how well the LHD and its partners are currently targeting their health-education and health-promotion activities. They could also be used to determine a more optimal mix of service locations and services for selected sub-county areas. One way to do this might be to find and recruit new partner organizations in areas where gaps are identified. The maps could also be used externally as a communication tool to influence state and federal policymakers to change threshold FPL requirements to meet unmet needs in Los Angeles County.

Additional maps would be required to assess the effectiveness of targeting the health-education and health-promotion outreach activities in these areas and to determine whether the highest-risk individuals and families are actually accessing and receiving the information. Details on the frequency and intensity of outreach at each site in relation to population size (e.g., numbers receiving outreach per 1,000 persons) and cost per site would also be quite helpful for program planning and resource allocation.

Case-Study Conclusion

It is important to display data on county-sponsored outreach events, locations of community partners, and the activities of those partners, because LHD programs often collect and maintain these types of data but may not consider using them to map the reach of their services. By combining LHD service data (e.g., locations of train-the-trainer classes and retail outreach events), specific health risk factors (e.g., obesity), and demographic risk factors (e.g., income and race or ethnicity) on *the same map*, well-matched or mismatched areas can be identified. We found it interesting that additional areas of unmet need could be identified by viewing hypothetical changes in the definition of need (e.g., revising the income thresholds and adding information on obesity). These maps provide a useful way in which staff in many different programs within LHDs can highlight the services they provide.

LACDPH staff face several barriers to mapping services and population health needs. Although the Nutrition Program staff is familiar with using GIS to identify state-mandated areas for chronic-disease-prevention activities, they do not typically use GIS to communicate the importance of the geographic distribution of needs and services to decisionmakers and community stakeholders during the planning process. Rather, the mapping they conduct is focused on finding communities that met the mandated definitions of need. LACDPH has a centralized data unit that provides mapping support and training. Thus, the Nutrition Program can request mapping support when needed and does not necessarily need to hire GIS-trained staff to create maps. A challenge remains; however, in that the demand for GIS assistance from the centralized data unit could potentially reach maximum capacity. Accordingly, technical assistance and/or training might not be available when it is needed by the requesting program.

At the department level, many LACDPH program directors approach planning geographically, because program funding is almost never adequate to fund interventions in all areas of the county. Thus, program planners, including Nutrition Program staff, are quite comfortable with targeting and prioritizing high-need areas. In addition, Nutrition Program personnel are looking forward to using the maps to assist with their annual strategic planning process, and State of California Department of Public Health personnel are open to using these new approaches to assess matching of needs and services. The Nutrition Program also has staff who are experienced users of a variety of *population health* datasets and know where to find relevant health-outcomes data. A very helpful aspect is that the Nutrition Program maintains data spreadsheets that track all partners and *program activities/services* (addresses, counts of activities) by address/location. However, mapping these data presents some challenges:

- Activity tracking spreadsheets have some areas with gaps in completeness; therefore, mapping of *services* is limited to mapping the location of services as points on a map rather than mapping capacity or utilization.
- Geocoded data for sub-county regions smaller than SPAs (those with populations of 1 to 2 million people) require special calculations and may increase the costs of mapping.
- Addresses of persons who attend the chronic-disease-prevention activities cannot be collected, according to USDA grant guidelines. Therefore, address-specific analyses of populations who use particular sites is not possible. This makes any potential targeting of activities less specific than it could be if such detailed data on service utilization were available.

For this case study, the RAND team concentrated on reframing the questions of interest to include information on the services that LACDPH and its partners are providing and to highlight how the geography of need changes as the definitions of need is expanded. To overcome the challenges posed by the data, staff at RAND and LACDPH worked together to geocode the location of contacts made by program staff and partners, and RAND produced the new maps used in the analyses.

CHAPTER FIVE

Case Study: Locations of Individuals Who Use Emergency Department Services in Alameda County, California

Research has shown that some persons who might otherwise use a community health center for basic healthcare services often go to the ED for assessment and treatment of medical conditions (Billings, Parikh, and Mijanovich, 2000a, 2000b; Ballard et al., 2010). Unnecessary use of the ED is a concern to the Alameda County Department of Public Health (ACDPH), since persons with inadequate or no insurance may seek care in EDs only after delaying primary care for so long that a condition becomes an emergency. Such delays in care can have severe consequences, including poorer quality of life and worsening health (Billings, Parikh, and Mijanovich, 2000a, 2000b; Ballard et al., 2010). Ensuring that all residents in Alameda County have a primary-care clinic that they can call a "medical home" could help decrease ED costs and save lives.

ACDPH staff knew that the number of ED users in their county is high, but they had no specific information on who these users are, where they are located, or the conditions that caused them to seek care in the ED. Thus, the primary question of interest for the ACDPH was, How do we identify patterns of utilization and prevent overuse of the emergency room by persons who do not need emergent care? To address this question, the RAND team created maps that highlight

- The locations of people who use ED services
- The conditions that bring these individuals to the ED or the level of severity of these conditions (e.g., non-emergent, emergent but primary-care-treatable, truly emergent)
- The locations of alternative sources of care, such as community or public health clinics.

This information can help health departments target outreach efforts so that messages on appropriate use of EDs and the primary healthcare system reach and can be understood by the populations in greatest need of them.

While the ACDPH staff were interested in understanding ED utilization patterns for all persons in the county, they were particularly concerned with the ED utilization patterns of residents who do not have private insurance (e.g., those who are completely uninsured and those who have insurance coverage from state plans such as MediCal, the State Children's Health Insurance Program (SCHIP), or county-sponsored public health-insurance plans). ACDPH staff wished to ensure that public resources are used appropriately and that populations that rely on the public system for healthcare needs are appropriately targeted. Thus, a second question of interest to the ACDPH was, How do we redirect persons who are uninsured or publicly insured to sources of care other than the ED for non-emergent medical conditions?

To help answer these questions and develop strategies to address overuse of county EDs, the RAND team and ACDPH identified data and created maps to illustrate the relationships between ED use and the locations of community health centers that might address the healthcare needs of the community in a more cost-efficient manner. This case study is unique in that data on the persons who used EDs in the county over a three-year period between 2005 and 2007 were available, along with specific information on the conditions for which these populations sought care. These data are particularly interesting for mapping because they allow ACDPH to expand its definition of the population in need. The data, which came directly from hospital and ED discharge information from all but one of the hospitals in Alameda County, allow ACDPH to measure the relationship between county healthcare facilities and ED use directly. In addition, data on the locations of these healthcare facilities can be used to identify alternative sources of primary care available to all patients, especially the uninsured and low-income insured.

Where Are the Highest Concentrations of Emergency Department Utilization in the County?

Figure 5.1 shows the relative proportion of ED users residing in each census tract in the county. Increasingly dark colors represent higher proportions of ED users in each tract. Figure 5.1 also shows the locations of the major cities in the county, as well as the supervisorial districts, which are the geographic boundaries used to plan LHD services.

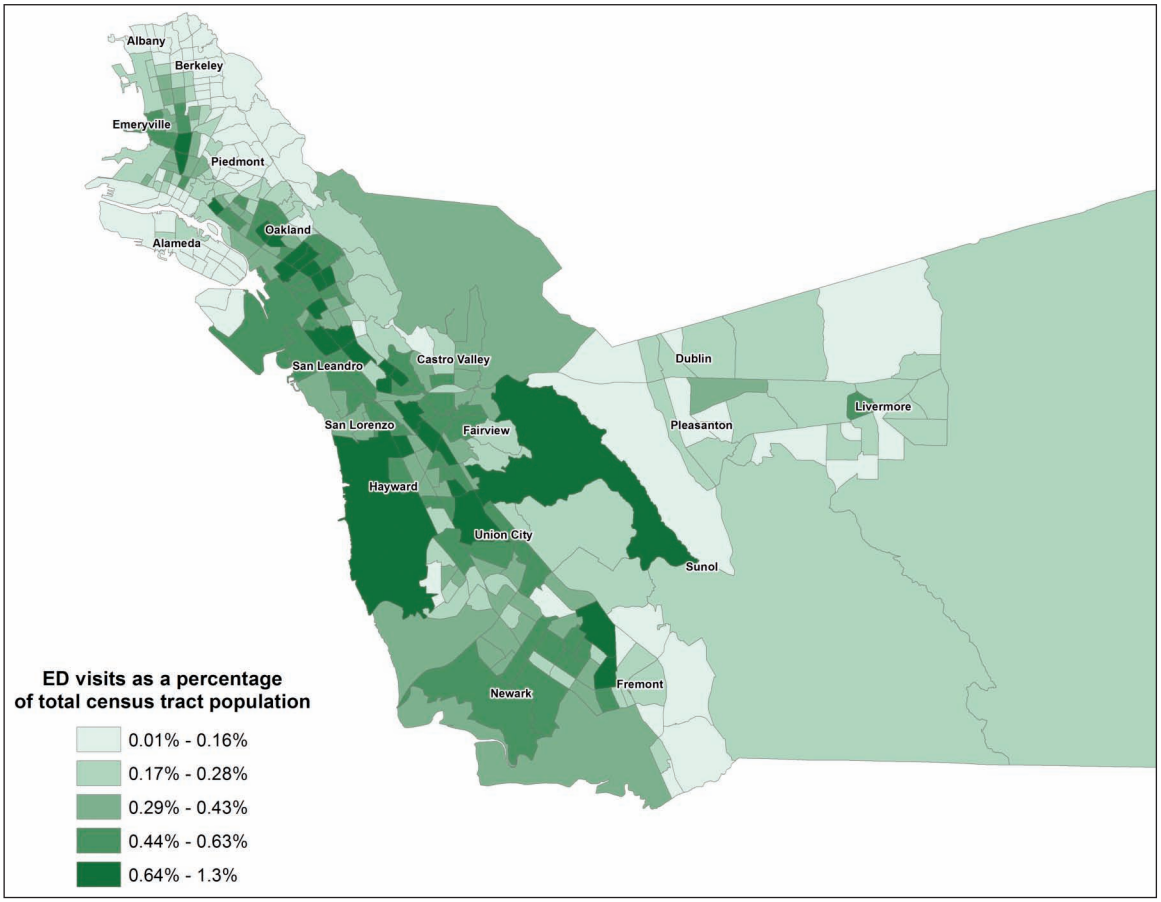
This map shows that there are potentially higher concentrations of ED users in several census tracts in the city of Oakland, in a few tracts in and between the cities of Hayward and in Fairview, and in a few tracts between Oakland and these communities. The map shows only whether an ED visit was made; it does not distinguish necessary (emergent) from unnecessary (non-emergent) visits.

To address this gap, we used an algorithm that transforms data on ED visits into four classifications: (1) non-emergent; (2) emergent, but treatable in primary-care settings; (3) emergent and the ED is needed, but the need to seek care in the ED was avoidable or preventable; and (4) emergent and the ED is needed, and the condition was not preventable or avoidable. (For a more detailed description of this algorithm and its use, see Billings, Parikh, and Mijanovich 2000a, 2000b; Ballard et al., 2010.) ACDPH could substantially reduce the proportion of unnecessary ED visits by concentrating on diverting or preventing non-emergent or otherwise treatable conditions to other facilities.

The breakdown of ED conditions into these categories in Alameda County is as follows:

- 29 percent non-emergent
- 43 percent emergent, but treatable in primary-care settings rather than the ED
- 14 percent emergent and the ED is needed, but the need to seek care in the ED was avoidable or preventable
- 14 percent emergent and the ED is needed, and the condition was not preventable or avoidable.

Figure 5.1
Percentage of All ED Visits in Alameda County, by Census Tract, 2005–2007



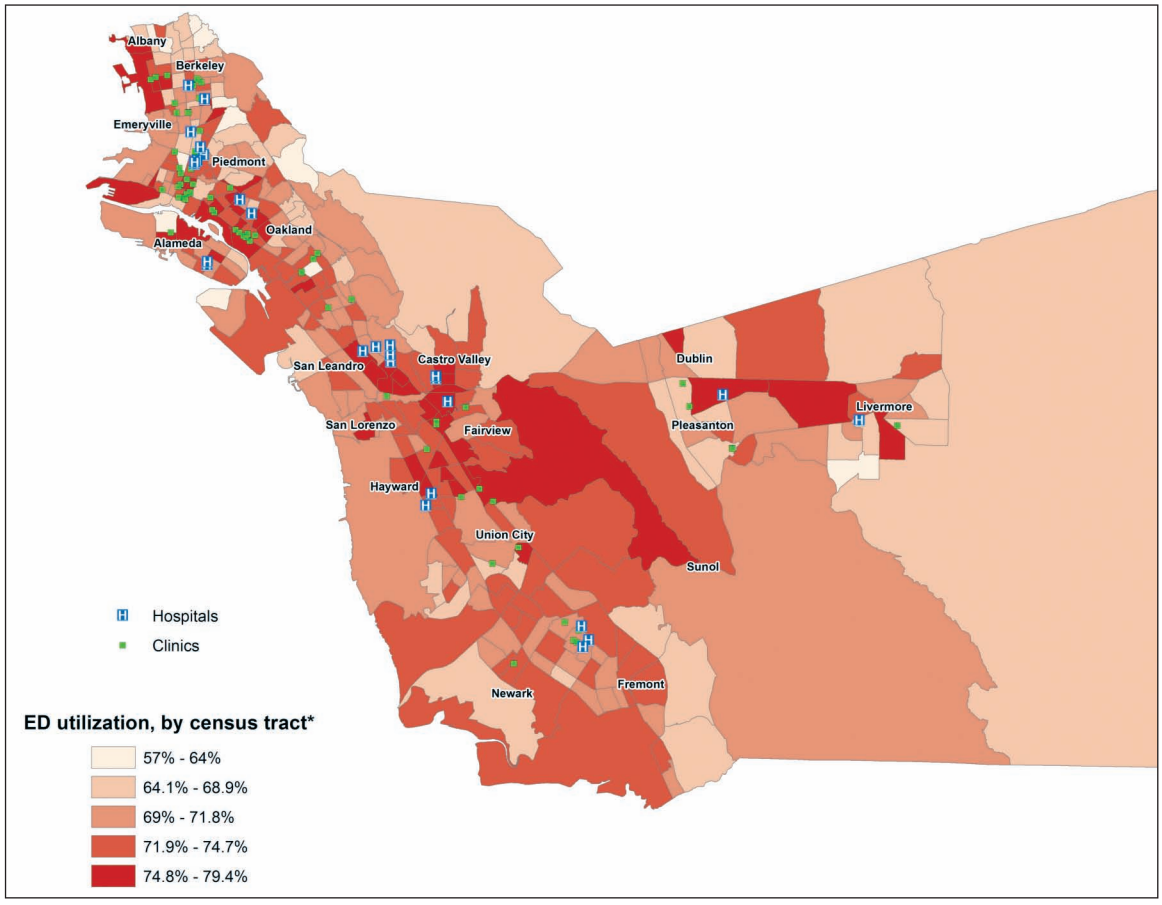
RAND *TR1146-5.1*

Are Non-Emergent Emergency Department Visits Concentrated in Particular Parts of the County?

To help assess whether these conditions have a geographic component, the RAND team mapped the proportion of ED visits in each tract that were either non-emergent or treatable in primary-care settings (Figure 5.2) and found that non-emergent and otherwise treatable conditions display a different pattern than that seen for all ED visits in Figure 5.1: Populations using ED services for non-emergent and otherwise treatable conditions are concentrated in a geographic area throughout the central portion of the county. Figure 5.2 also shows that there is inappropriate use of hospitals in the most urban areas of the county in the northwest section.

High concentrations of these users are clustered in communities north and west of Oakland, such as Alameda City, Emeryville, and Berkeley, as well as communities south of Oakland, including Union City, Newark, and Fremont. Additional concentrations seem to be located near Pleasanton and Dublin.

Figure 5.2
Percentage of Non-Emergent or Primary-Care-Treatable ED Visits, by Census Tract in Alameda County, 2005–2007



*Non-emergent or primary care treatable ED visits as a percentage of all ED visits.

RAND *TR1146-5.2*

We added the locations of clinics and hospitals to this map to explore whether residents in communities that tend to overuse the ED have access to clinics as well as hospitals. The number and distribution of the clinics suggest that they are located near the communities that have higher proportions of ED users.

Taken together, these points suggest that non-emergent use of the ED may be due less to lack of access to a primary-care clinic than to a need for outreach and education about the location and accessibility of nearby clinics. However, information about the capacity of these clinics to serve the needs of the populations that overuse the ED would be needed to make that determination.

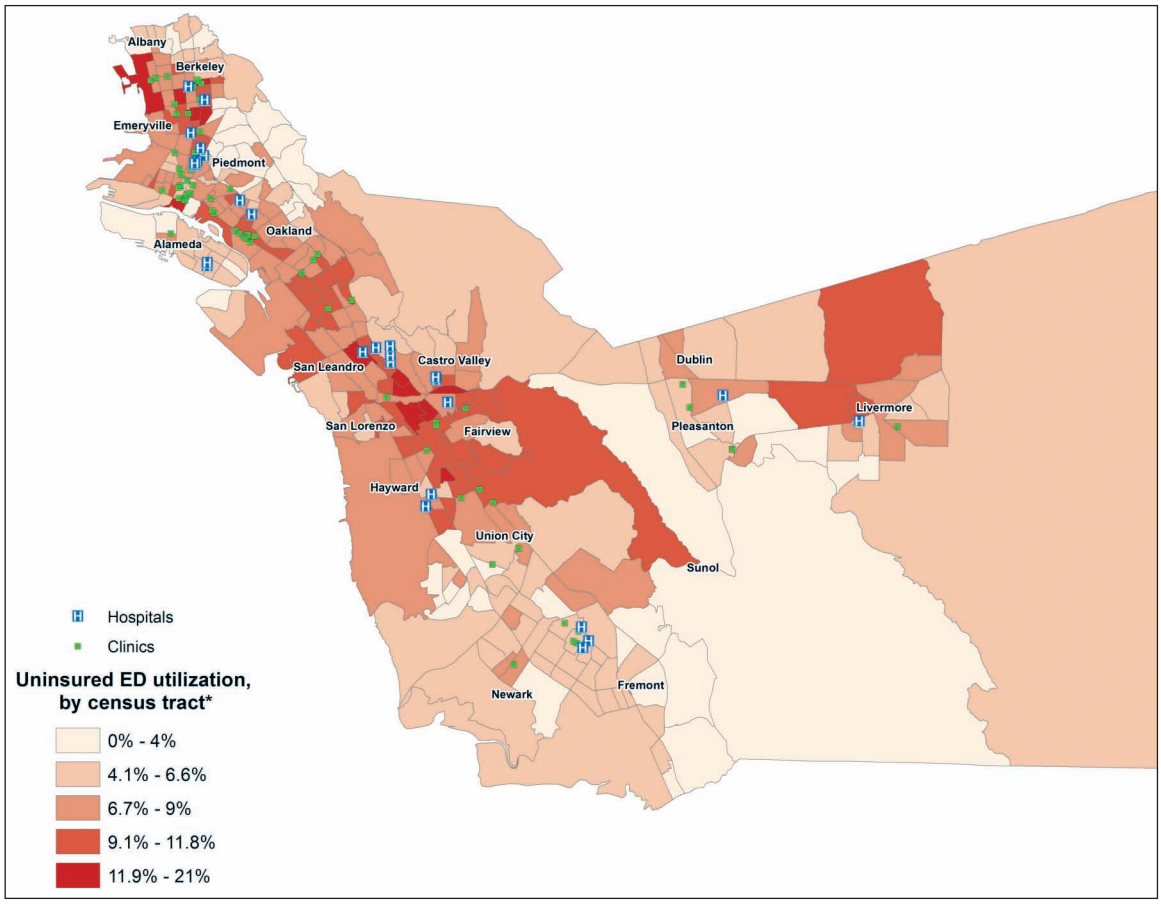
What Percentage of Uninsured and Low-Income Insured Are Presenting at Emergency Departments with Non-Emergent Conditions?

Because ACDPH was particularly interested in populations who were uninsured or low-income insured, we further stratified the sample by these characteristics and mapped separately the

proportion of the uninsured and the low-income insured who were presenting at EDs with non-emergent or otherwise treatable conditions.

These data are shown in Figures 5.3 and 5.4. Figure 5.3 shows concentrations of uninsured populations mainly in the central and eastern communities of the county. Figure 5.4 displays the same information for the low-income insured. Concentrations of those in this group who use the ED inappropriately are located in the north and west sections of the county. ACDPH staff thought that one of the reasons for this split was the higher proportions of undocumented immigrants in the communities in the central part of the county. Because these individuals are not eligible for Medicaid, they are more likely to be in the uninsured category. Together, Figures 5.3 and 5.4 suggest that communication strategies might be split geographically between uninsured and low-income insured patients, since each group is concentrated in different communities.

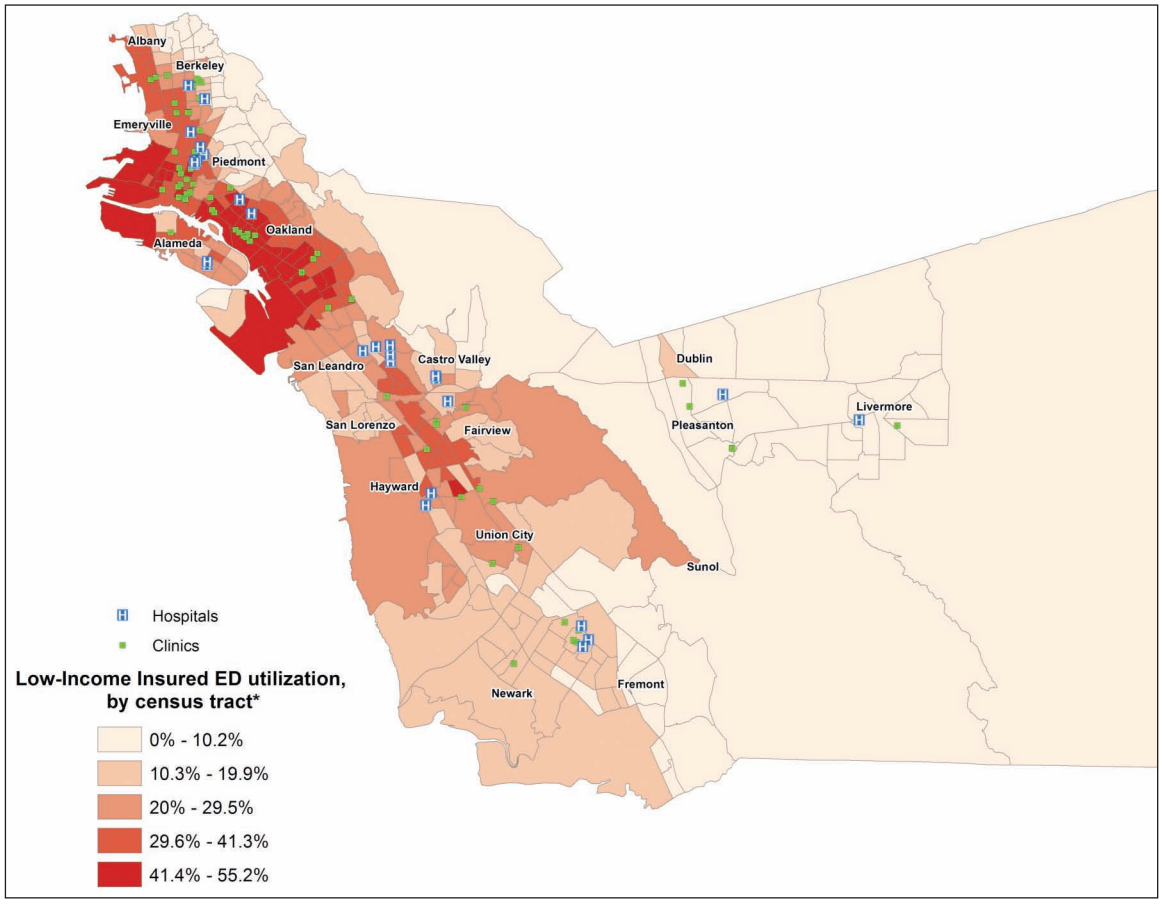
Figure 5.3
Percentage of Non-Emergent or Primary-Care-Treatable ED Visits Among Uninsured Patients in Alameda County, by Census Tract, 2008



*Non-emergent or primary care treatable ED visits by uninsured patient as a percentage of all ED visits by uninsured patients.

RAND *TR1146-5.3*

Figure 5.4
Percentage of Non-Emergent or Primary-Care-Treatable ED Visits Among Low-Income Insured Patients in Alameda County, by Census Tract, 2008



*Non-emergent or primary care treatable ED visits by low-income insured patient as a percentage of all ED visits by low-income insured patients.

RAND *TR1146-5.4*

How Can These Types of Maps Be Used by LHDs?

These maps are a good starting point for understanding overall use of the ED for conditions that are treatable in primary care. ACDPH could use them for several purposes, including planning new clinic locations, improving accessibility of existing clinics, and marketing the clinic sites to populations who would most benefit from using them. The maps also help illustrate how data on individual patients and their conditions can be used to create maps that highlight the specific needs of the community as a function of the public health or healthcare services they receive.

Additional maps would be needed to show the average distance to each clinic to determine if the clinics are located within a "reasonable" distance for uninsured and low-income insured persons. An assessment of clinic hours, including evening and weekend hours, staffing levels, wait times, aesthetics, and other characteristics related to patient satisfaction, would also

be needed to fully address accessibility and future marketing of the clinics to nearby populations. ACDPH staff pointed out that there is a rich network of community clinics in Alameda County where the uninsured and underinsured could seek care. However, these resources are stretched beyond capacity. From the ACDPH point of view, improving the availability of care might also reduce the proportion of residents that seek ED care. However, additional analyses on capacity would need to be conducted to determine this.

Case-Study Conclusion

The maps that display data on the underlying population health needs in ACDPH also highlight how geocoded data on actual patient encounters with local ED services can be used to more fully describe a problem. LHDs often rely on census or survey data to broadly define and map at-risk populations. Sometimes they also have data on individual residents who have specific conditions. The availability and use of these data demonstrate that a finer level of geographic resolution (i.e., census tract and point) greatly increases the LHD's ability to identify areas of urgent need.

The maps in this case study simultaneously display actual patient encounters at county EDs and the geographic distribution of safety-net primary-care services. This is especially important when an intervention has not been developed and there are no "service" data to display. The maps provide a useful way for staff to track the progress of any developed interventions over time by creating a benchmark geographic pattern against which to compare them.

ACDPH had a number of important facilitators to the use of GIS mapping. Executives in charge of departmentwide strategic planning efforts use a variety of data reports to set priorities, and mapping is often used to help communicate areas of prioritization. Further, mapping services are actively pursued by the data unit, which has staff dedicated to preparing maps for sub-county comparisons. Staff also have extensive knowledge and the ability to locate additional possible datasets to use to represent services.

As a result, there were few barriers to overcome at this health department. RAND staff worked with ACDPH primarily to identify additional methods to help recharacterize and prepare the data for mapping. Introducing data on specific ED use patterns enabled us to highlight nuances in an existing problem.

CHAPTER SIX

Conclusions

Coordination of essential public health activities in communities, including monitoring community health, informing and educating the public about health issues, mobilizing community partnerships, and developing policies to support these efforts, is no small responsibility for LHDs across the country. LHDs typically have competing priorities and limited and often stretched resources. At the same time, LHDs are charged with assuring that their services are meeting local population needs.

As our case studies demonstrate, communicating complex geospatial information in an integrated and visual way has the potential to help LHD staff integrate information and plan programs in an innovative way. Further, comparing where services are *needed* with where services are *provided* is a relatively simple way for LHDs to identify gaps between their program services and community health needs. Although this approach may seem straightforward, we found that the LHDs in this study and the programs within them rarely employ GIS for this purpose. Lack of clarity about which data are appropriate to use, how GIS can and should be applied at the sub-county level, who can use GIS (and help to prepare the data that go into comparisons), and how financial and program IT systems can be better integrated has already been identified in the literature as a major challenge for LHDs (Mullner et al., 2004; Ruiz and Remmert, 2004; Studnicki et al., 2007; Kothari et al., 2008).

Although we found various mapping efforts under way at each of the LHDs, most LHDs were looking at *the needs* side of the equation (e.g., distribution of poverty or health conditions across a geographic area), rather than the *services* side. Information on the services that LHDs provide (e.g., counts of staff persons dedicated to a specific health issue in certain places, the location and counts of clinical services, and/or financial data around programs and services) has the potential to expand LHD staffs' understanding of the extent to which those services are meeting population needs.

We have highlighted several techniques LHDs can use to expand the use of mapping for priority-setting, program planning, resource allocation, and visualizing community-based health issues. Implementing these techniques requires several steps, including reframing questions to include a service component (e.g., asking whether services meet the need rather than asking what the need is), identifying available data to characterize the service component, and identifying the ways in which maps can best depict the data. Additionally, LHDs will have to assess whether their processes for priority-setting and responding to the new information the maps produce are adequate to support expanded GIS techniques. We found that allowing LHD staff to see the potential of concurrently visualizing services *and* needs was useful and, in many cases, eye-opening.

Uses of GIS in Public Health Planning

Through the case studies with our LHD partners, we found that GIS could be used internally as a management tool (i.e., to stimulate discussions about where efforts might best be allocated) or externally as a policy tool (i.e., to present the ways in which programs work within the confines of mandated guidelines). By using GIS to explore questions of interest to the LHDs, using novel sources of program activity or service data (such as financial data), mapping program activities or service data on the same map with demographic or health data, and using mapping and analytical techniques not currently in use by the LHDs, we created visual pictures that served as a focal point of discussion to evaluate and consider future programming and direction.

Our case studies were intended to help LHD staff identify geographic questions that might help inform their planning efforts and illustrate how maps might answer such questions. Our hope is that LHD program managers and staff will eventually be able to identify geographic questions that can inform their planning and resource-allocation efforts.

Palm Beach County

The PBCHD case study showed how new data sources on expenditures and clinical staffing can be used with GIS to help characterize problems. It also showed the limited usefulness of maps that only pinpoint service locations. The primary lesson learned from this case study is that LHDs may underutilize administrative data, such as human resources or finance data, to assess the cost-effectiveness of their services. LHDs that want to map such data may need to work closely with administrative units to design systems that link population health-needs data with program-service data, and this may require purchasing enhanced accounting and billing software. It should come as no surprise that when the health officer of an LHD champions GIS mapping, such mapping may get done more frequently and comprehensively. LHDs in states that prioritize and fund large population health- and healthcare-utilization surveys with county-level data will have more mapping options if they choose to develop or contract the technical capacity to implement them.

Small to medium-sized health departments will likely need to use free online mapping resources and/or establish academic, nonprofit, and state-level partnerships to pursue GIS analyses.

Los Angeles County

The LACDPH case study identified ways to display data on county-sponsored outreach events, the locations of community partners, and the activities of those partners. This was important, because many LHD programs collect and maintain these types of data but do not use them to map the reach of their services.

The primary lesson learned is that collecting and managing data on health-education outreach activities and services as completely and accurately as possible is important for program-evaluation activities, especially when employing a "mapping the gaps" approach. Public health program directors who are interested in mapping should provide the addresses of service deliv-

ery sites and should attempt to get attendee addresses to enable map preparation and review for strategic planning and evaluation purposes.

Preparing valid sub-county estimates at the city or neighborhood level often requires the specialized expertise of data analysts or epidemiologists. Such expertise may not be available in every LHD, and it may be necessary to find academic, nonprofit, or state-level partners to perform such analyses. All of our partner LHDs used a combination of in-house and external data expertise to provide city-level data for health outcomes.

It also became clear that technical capacity for GIS mapping can be highly variable not only across but also within LHDs. Pursuit of innovative uses of GIS mapping appears to be highly dependent on program champions who seek training and proactively apply mapping in their planning and evaluation activities.

Alameda County

In Alameda County, we found that data displaying the location of persons with specific conditions can be more valuable than data using population characteristics alone to describe risk factors. The primary lesson learned is that LHD staff and data analysts may be able to employ geocoded data that contain addresses for facilities and patients/clients from large county-level healthcare and population-health datasets. ACDPH's advanced mapping capability indicates that there may be benefits to investing in a centralized data unit that incorporates a variety of analyses, including GIS, to present "big picture" issues and help direct department planning and resource-allocation activities.

Limitations

This work has several limitations. Our data are exemplary and represent a small group of large LHDs. Moreover, the maps presented here are current only as of the publication of this report. The case studies are not meant to fully identify problems; they are intended to serve as examples of novel approaches to summarizing data. They are also not meant to replace additional tools such as spatial analysis. To support the possibility that the case studies may motivate new mapping strategies in other LHDs, we present a list of resources in Appendix A.

While the case studies and the information provided by this project were productive for each of the LHDs involved, calls to extend GIS approaches into LHD planning need to consider the barriers that other LHDs face in implementation, such as variations in technical capacity and organization and access to geo-enabled data. This is especially true of smaller LHDs, which typically have limited resources for mapping. In addition, tools are needed to assist LHDs in collecting sub–county-level data on LHD services and integrating them with data on local health and healthcare needs, as well as training staff on the application of GIS to planning questions and the technical aspects of using it. As our conceptual framework shows, the ability of any LHD or nongovernmental public health agency to use maps depends on its capacity to set priorities and react to new information. This report presents only limited information on addressing these potential barriers.

Although GIS and related statistical methods and capabilities exist that are much more developed than many of the approaches presented in this report, these methods do not appear

to be implemented frequently in LHDs in the United States. Nevertheless, we believe that using GIS to map both supply (LHD services) and demand (population health needs) can assist LHDs in meeting their responsibility to improve and protect the public's health.

APPENDIX A

Techniques and Resources for Mapping

The maps in this report were produced using ArcGIS 9.3 (Ormsby et al., 2008). They employ a range of mapping techniques, which are briefly discussed below. For more information on specific techniques, please review the online ArcGIS Help documents located at http://webhelp.esri.com/arcgisdesktop/9.3/index.cfm?TopicName=welcome.

Geocoded Points

Geocoding is the process of assigning the geographic coordinates of latitude and longitude to buildings or other points of interest. Once a point of interest has been geocoded, these locations can be depicted by symbols on a map. Sets of geocoded points can be assigned the same symbol and mapped as a single layer in a map to depict similarity across the points. For example, all public health clinics offering sexually transmitted disease (STD) services could be mapped with the same symbol. Multiple layers of these sets of geocoded points can be displayed on the same map. This can be useful, e.g., to depict the range of clinical services offered by an LHD.

Chloropleth Polygons

Chloropleth polygons are used in maps to display the geographical distribution of rates, counts, or other variables of interest. The polygons demarcate geographic regions that are determined by administrative boundaries (most commonly, counties, zip codes, census tracts, or census blocks) or are unique to a specific organization or project (e.g., service planning areas). Color gradients, grayscale, or shading and patterns are used to distinguish the range of values for the variable of interest. Multiple layers of chloropleth polygons may be employed to identify areas where two or more variables of interest overlap. For example, two layers of chloropleth polygons may be used to depict both the regions in which a heath condition (e.g., obesity prevalence) is common and a characteristic of vulnerable populations (e.g., poverty prevalence).

Assigning Unique Symbols to Geocoded Points

Mapping one symbol type (e.g., hospitals) can provide a basic context of what is available in terms of care; however, adding other unique points (e.g., clinics, pharmacies, or mobile clinics) can enrich the map to show alternative points of care. When adding in extra data points

by category, it is important to select symbols that are distinct and easy to interpret—a clutter of many symbols can confuse map users and make it difficult to discern patterns. Those using mapping in their work must be cognizant of the number of symbols as well as the geographic zoom that is set for the map.

Adding Pie Charts

Bar, column, stacked, and pie charts are a few of the many charts that can be used to depict variable quantities succinctly. Adding this type of information to a map can help communicate a relationship or trend among various attributes. In GIS, two types of values can be communicated using pie charts. The first is simply the relative sizes of the slices within the pie chart, and the second is the overall size of the pie itself, which can vary in relation to the magnitude of the data element the pie chart represents. These types of variation allow for comparisons not only of the data within the pie charts, but also of the proportion represented by the pie chart that otherwise might be lost or only loosely associated with the area/polygon it covers. Use of pie charts can be ideal when trying to communicate such information as the number and types of staff available in a clinic or a hospital.

Creating a Point Density Layer

Some point-level data should not be aggregated because the level of detail is important to the map (e.g., address-level geocoded patient detail). In such cases, a point density layer can be used to represent the data. A point density layer can also be used when there are too many points on a map to accurately discern trends or clusters.

Importing Freely Available GIS Data

There are a number of sources of geographic data and spatial layers that can easily be incorporated into maps. Federal, state, and local government agencies; universities; and individual mapmakers offer various web services, online mapping capabilities, and data resources that can provide greater context on maps to better inform decisionmaking. Available data include census-type neighborhood layers, locations of hospitals or clinics, and environmental hazard areas that can help inform communities of possible natural risks and options for responding when a facility or area is compromised.

Resources

A number of online and written documents are available to help users become more familiar with mapping software and techniques. These resources range from general support documents to tutorials on specific techniques. Some resources are listed below.

Books and Documents

Allen, David W., *GIS Tutorial II: Spatial Analysis Workbook*, Redlands, Calif.: ESRI Press, 2009.

Brewer, Cynthia, *Designing Better Maps: A Guide for GIS Users*, Redlands, Calif.: ESRI Press, 2005.

Cromley, Ellen K., and Sara L. McLafferty, *GIS and Public Health,* 2nd ed., New York: The Guilford Press, 2011.

Kurland, Kristen S., and Wilpen L. Gorr, *GIS Tutorial*, Redlands, Calif.: ESRI Press, 2005.

———, *GIS Tutorial for Health*, 3rd ed., Redlands, Calif.: ESRI Press, 2009.

Mitchell, Andy, *The ESRI Guide to GIS Analysis – Volume 1: Geographic Patterns and Relationships*, Redlands, Calif.: ESRI Press, 2001.

———, *The ESRI Guide to GIS Analysis,* Volume 2*, Spatial Measurements and Statistics*, Redlands, Calif.: ESRI Press, 2005.

Ormsby, Tim, and Jonell Alvi, *Extending ArcView GIS: Teach Yourself to Use ArcView GIS Extensions*, Redlands, Calif.: ESRI Press, 1999.

Shah, Gulzar H., Vivian Levy, Carolyn J. Leep, Rachel Willard, Nathalie Robin, Fatema Mamou, Arlesia Mathis, and Priscilla Anne Barnes, "Enabling Integration of Local Health Department (LHD) Infrastructure, Community Characteristics, and Health Outcomes Data by Constructing GIS Shape Files for LHD Jurisdictions," Presented at American Public Health Association (APHA) Annual Meeting, Denver, Colo., November 10, 2010.

Websites

ArcGIS 9.2 Desktop Help: Network Analyst Tutorial Exercises:
http://webhelp.esri.com/arcgisdesktop/9.2/index.cfm?id=3549&pid=3542&topicname=Network_Analyst_tutorial_exercises

ArcGIS Spatial Analyst Overview:
http://www.esri.com/software/arcgis/extensions/spatialanalyst/index.html

Best Practices—Preparation of Excel Data for Use in GIS:
http://www.dhss.mo.gov/data/gis/pdf/Tip-DataFormat_BestPractices_Excel.pdf

Creating Simple Maps with Microsoft Excel:
http://gislounge.com/creating-simple-maps-with-ms-excel/

Video—Thematic Pie Chart Map Using Maptitude GIS:
http://www.mapcruzin.com/maptitude-thematic-pie-chart.htm

Visualizing Urbanization with GIS and Data Graphics (LeGates):
http://bss.sfsu.edu/nsfgis/download/legates_AAG_article.pdf

Spatial Data:
http://www.arcgis.com/home/groups.html
http://www.census.gov/geo/www/tiger/tgrshp2009/tgrshp2009.html
http://www.hrsa.gov/data-statistics/index.html
http://gos2.geodata.gov/wps/portal/gos
http://www.nationalatlas.gov/maplayers.html

Governmental organizations, LHDs, private corporations, and universities are among the many resources that offer interactive online mapping capabilities. These interactive tools enable users with little or no experience to create and export customized thematic maps. The range of types of thematic maps is broad—for example, a user might map demographic data, economic data, health and safety data, or housing data with these online tools. However, these sites restrict use to preloaded data, which restricts the user's flexibility.

Interactive online maps can be found on the following sites:

http://gis.oshpd.ca.gov/atlas/healthcareatlas/mapframeset.aspx

http://factfinder2.census.gov/faces/nav/jsf/pages/searchresults.xhtml?ref=geo&refresh=t&tab=map&src=bkmk

http://www.healthycity.org/c/map

http://www.dartmouthatlas.org/

For LHDs with data available for mapping, many universities and independent companies offer geocoding services online; however, there are limitations to using an outside geocoding service; e.g., many such services have a cap on how many addresses can be geocoded in a day. There might also be speed limitations based on Internet connections and restrictions on how data coded by a free service can be used. Some free online geocoding services are

http://www.esri.com/software/arcgis/arcgisonline/world-geocoding.html

https://webgis.usc.edu/Services/Geocode/Default.aspx

http://www.batchgeo.com/

Some sites allow users to upload their own data and create maps free of charge or after simply registering with the site. One example is

http://processtrends.com/pg_google_earth.htm

RAND Special Needs Mapping Tool

http://www.rand.org/health/projects/special-needs-populations-mapping/tool.html

RAND Health Literacy Tool

http://www.rand.org/health/projects/missouri-health-literacy.html

APPENDIX B

Data Sources

Data Used in Palm Beach County Case-Study Maps

Five types of data were used in the maps created for PBCHD: MUAs, clinic type and location, clinic staffing by FTE, clinic staffing by cost, and the proportion of uninsured receiving care at each FQHC. Detailed information on the sources of these data and how they were derived is presented below.

Medically Underserved Areas. MUAs are geographic areas identified by HRSA as regions in which residents have a shortage of personal health services (http://deais.nci.nih.gov/glossary). They may be groups of contiguous census tracts, counties, or a county in its entirety. The regions are designated as MUAs on the basis of four criteria: the ratio of primary-medical-care physicians to the region's population, the infant mortality rate, the percentage of the population below the federal poverty level, and the percentage of the population aged 65 years or older (http://bhpr.hrsa.gov/shortage/muaps/index.html). These data are updated, maintained, and made publicly available free of charge by HRSA (http://datawarehouse.hrsa.gov).

Clinics. Six types of clinics were identified to distinguish between public and private clinics that have and have not been approved as FQHCs and that are either currently in operation or proposed: PBCHD clinics approved as FQHCs (FQHC/PBCHD); PBCHD clinics that are not FQHCs (non-FQHC/PBCHD); proposed sites for new PBCHD FQHCs (Proposed FQHC/PBCHD); non-PBCHD clinics approved as FQHCs (FQHC/non-PBCHD); non-PBCHD clinics that have not been approved as FQHCs (non-FQHC/non-PBCHD); and proposed sites for new non-PBCHD FQHCs (Proposed FQHC/non-PBCHD).

Distribution of Clinical FTEs, by Clinic. PBCHD identified FTE as the most relevant measure of the personnel resources at its FQHCs. The FTE can be used to combine information on part-time and full-time employees into a single metric. It is calculated here as the ratio of the total number of compensable hours worked by all clinical staff in a calendar year (January 1, 2009, through December 31, 2009) to the total possible compensable hours for the calendar year (i.e., 2,080 hours). PBCHD FQHC clinical staff include MDs, DOs, ARNPs, and PAs. Total FTEs, physician FTEs (MDs/DOs), and nursing FTEs (ARNPs/PAs) were calculated for each clinic. The proportion of total FTEs that were physician FTEs and the proportion of total FTEs that were nursing FTEs were also calculated for each clinic. The counts of MD, DO, ARNP, and PA compensable hours were compiled by the PBCHD Finance Office and included contract group providers.

Distribution of Expenditures for Clinical FTEs, by Clinic. The definition and calculation of the clinical FTEs were described in Chapter Three. An estimate of the expenditures for these FTEs was calculated using data on the average salaries of physician and nursing clinical

staff, respectively, at each FQHC. The total estimated FTE expenditures were calculated as the quotient of the estimated yearly salaries (from average salaries for the month of September 2010) and the estimated yearly FTEs. Estimates were calculated separately for MDs/DOs and ARNPs/PAs at each FQHC. Salary estimates were calculated by the PBCHD Finance Office.

Proportion of Uninsured Receiving Care at FQHCs. An estimate of the proportion of the uninsured population surrounding each FQHC who receive care at that FQHC was calculated using data from two sources. First, the PBCHD Information Technology Department provided an unduplicated count of the total number of uninsured patients within the "client base" of each PBCHD FQHC who received care at that FQHC for a one-year calendar period (January 1, 2009, through December 31, 2009). PBCHD identified the geographical region (zip code) most proximal to each FQHC that it felt best identified the FQHC's client base. Second, the RAND team compiled data on the total number of uninsured persons in each FQHC's client base for a time period corresponding to the PBCHD patient count. The most recent data on the uninsured population by zip code were obtained from a report of the Florida State Planning Grant program of the HRSA.

Data Used in Los Angeles County Case-Study Maps

The case-study maps of Los Angeles County display data on race and ethnicity, poverty, obesity, and indicators of program outreach events and locations. These are described in greater detail below.

Racial/Ethnic Distribution. We used U.S. Census data on race and ethnicity to identify census tracts in which the majority (or plurality) population is non-Hispanic black, Hispanic, or non-Hispanic white. For each census tract, the proportions of each of these racial/ethnic groups in the total census tract population were categorized as less than 50 percent, 50 percent to 74 percent, or at least 75 percent.

Poverty. Data from the U.S. Census were used to identify census tracts that meet the Network for a Healthy California poverty threshold for community participation (i.e., more than 50 percent of the households in the census tract have an income below 185 percent of the FPL). For this project, we also considered an expanded set of thresholds for categorizing census tracts by household poverty levels. An indicator was constructed to identify census tracts in which more than 50 percent of the households reported an income between 185 percent and 300 percent of the FPL for a household of their size and composition, and indicators were created for census tracts in which 30 to 39 percent of residents or 40 to 49 percent of residents had incomes of 185 percent of the FPL.

Obesity. Data on the prevalence of childhood obesity were collected through the State of California Department of Education FitnessGram, a school-based assessment of physical fitness of all students in grades 5, 7, and 9 who attend public schools. FitnessGram measures student aerobic capacity, body composition and muscular strength, endurance, and flexibility. The testing includes measured height and weight for students. County-level data from 2005 are provided on a state-sponsored website. A centralized data unit within LACDPH provided the city-level estimations used in the case-study maps.

Outreach Events. The LACDPH Nutrition Program maintains a variety of Excel spreadsheets that track the names and addresses of all Network for a Healthy California partner sites;

the addresses of all participating retail food sites, farmers markets, and school districts; and the addresses of all organizations that participate in the Toolbox program.

Data Used in Alameda County Case-Study Maps

The primary data elements in the Alameda County case study were outpatient encounter records for all patients treated in licensed EDs in the county between 2005 and 2007. In 2008, ACDPH conducted a pilot project, the Hospital Surveillance Project, to collect inpatient and ED data directly from 13 acute-care facilities in order to examine patterns of morbidity and injury with fine geographic resolution. Under the California Health and Safety Code (Section 128736), hospitals are required to report ED, inpatient, and ambulatory surgery data to the Office of Statewide Health Planning & Development. Facilities currently report on a quarterly basis and are required to report only patient zip codes. ACDPH requested from each facility a limited set of data elements, a subset of those they already report to the state, with the addition of patient street addresses. Most of the data were obtained by implementing memoranda of understanding with business associate agreements with each facility in order to conform to Health Insurance Portability and Accountability rules. Addresses were geocoded, either by ACDPH or facility staff.

All ED encounters in the dataset were classified as non-emergent, emergent but primary-care-treatable, or emergent and ED care needed, using the previously validated New York University (NYU) ED algorithm, detailed elsewhere. Non-emergent encounters are defined as those in which "the patient's initial complaint, presenting symptoms, vital signs, medical history, and age indicated that immediate medical care was not required within 12 hours." Emergent but primary-care-treatable encounters are defined as encounters in which "treatment was required within 12 hours, but care could have been provided effectively and safely in a primary care setting, [and] the complaint did not require continuous observation, and no procedures were performed or resources used that are not available in a primary care setting (e.g., CAT scan or certain lab tests)." Emergent encounters for which ED care was needed were defined as encounters in which "emergency department care was required based on the complaint or procedures performed/resources used." The algorithm excludes injuries and conditions related to mental health, alcohol, or substance use.

These classifications were then mapped to the discharge diagnosis of each case in our sample to determine the percentage of sample cases that fell into these four categories. Since few diagnostic categories are clear-cut in all cases, the algorithm assigns to each case a probability that it belongs in each one of the emergent categories. We then assigned every case to the emergent category for which it had the highest probability.

After classifying the data, using the NYU ED algorithm, we extracted as our analytical sample the set of ED visits that were non-emergent, emergent but primary-care-treatable, or emergent for which ED care was needed. We calculated for the total analytical sample the proportion that were non-emergent and the proportion that were emergent but primary-care-treatable, by census tract. Then we stratified the analytical sample by payer, classifying as uninsured those patients whose payer type was "self pay" or "other federal" and classifying as low-income insured those whose payer type was MediCal or other non-federal.

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