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Using Geographic Information Systems to Promote Community Involvement in Comprehensive Cancer Control

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Geographic information systems (GIS) for cancer control present an innovative approach to health communication for comprehensive cancer control (CCC) planning. The ability to spatially depict multivariate views of cancer incidence, treatment site locations, transportation routes, and even environmental exposures within a map represents opportunities to involve communities in novel ways with cancer control. Communities may be involved strategically and/or as a goal in planning efforts. The experiences and perceptions of a near census of U.S. CCC program managers ($N = 49$) were examined to gain their insights about the compatibility of GIS mapping for CCC, the target audiences to be reached with maps as a CCC message, and relative advantages of this technology in its diffusion. Analysis includes a quantitative assessment of interviews and qualitative statements to illustrate these issues. Results suggest that GIS use for cancer control has the potential to build community capacity and social capital for communities as a way to reduce the cancer burden.

The U.S. Centers for Disease Control and Prevention (CDC) Division of Cancer Prevention and Control (DCPC) advocated for comprehensive cancer control (CCC) as an approach to integrate and coordinate a broad spectrum of ongoing efforts related to cancer prevention, diagnosis, and treatment (Abed et al., 2000). CCC programs, which build on the U.S. state and local health department public health infrastructure, emphasize community involvement via partnerships and networks, identifying a range of options to reduce the cancer burden and making decisions based on a range of values and resources (Abed et al., 2000). Geographic information systems (GIS), as a computer-based technology tool with unique capacity to visualize spatial and temporal dimensions of data, afford rich opportunities to involve communities and advance CCC aims. GIS maps may reveal innovative

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insights about multivariate relationships and risk patterns, literally generating "location hypotheses" relating to cancer. Some communities may be involved in promoting efforts to gather data to increase the validity of mapping, while other communities may be unaware that they are the focus of data gathering. In light of CCC's core function of working with communities, we assessed the compatibility of GIS for CCC activities, the audiences perceived to be likely users, and relative advantages of GIS use as a tool for CCC as perceived and experienced by U.S. cancer control program managers (CCPMs).

MODELS OF COMMUNITY INVOLVEMENT AND DIFFUSION OF GIS

Diffusion of an innovation is the process by which change occurs in the structure and function of a social system based on a new way of doing a task or viewing a situation (Rogers, 1995). Diffusion of GIS within the public health system in the United States, for example, affords an innovative approach to CCC. Using variables such as incidence, access to health care services, demographic information, environmental exposure, and/or behavioral risk factors in maps produced via GIS holds great promise to answer questions about risk, treatment, and more in cancer control (Olvingson, Hallberg, Timpka, & Lindqvist, 2003; Riner, Cunningham, & Johnson, 2004). Understanding the role of communities in diffusion of such tools as GIS for public health is critical to improve health outcomes (Fajans, Simmons, & Ghiron, 2006).

Community involvement has been conceptualized along two dimensions, strategy and goal, with differences for the roles of communities in working with public health systems resulting in four models (Guttman, 2000). A *service model* places little emphasis on community involvement as a goal or strategy. This model emphasizes community as the group public health hopes to reach with services (Guttman, 2000). An *augmentation model* places a strong emphasis on community involvement as a goal, such that public health looks to communities to determine both the issues to be addressed and ways to address them, but neglects a strategic focus on enhancing community capacity to achieve the aims (Guttman, 2000). A *collaboration model*, on the other hand, neglects a role for community involvement as a goal in selecting issues, while emphasizing community involvement as public health's strategy to achieve an aim, often via the adoption of consortia or formation of coalitions and community capacity building (Guttman, 2000). And finally, a *mobilization model* emphasizes community involvement as both a strategy and a goal, where community-based groups and individuals are involved in both the identification and addressing of issues (Guttman, 2000). Each model suggests unique insights about how strategic health communication may be employed, shaping CCPM perceptions and experiences with GIS in CCC activities involving communities. The models suggest differences relating to the tasks likely to be deemed relevant, the audiences expected to be targeted, and possible relative advantages of both towards improving cancer control. We examine each of these topics in relation to a range of community involvement models in the application and use of GIS for cancer control.

Perceptions of Compatibility: CCC Task Domains and Target Audiences

The diffusion of an innovation is predicted by its compatibility with potential adopters' needs, experiences, and values (Rogers, 1995). As illustrated by CCC activities, by 2005, the CDC supported cancer control programs in all 50 states in the United States, the District of Columbia, six tribes, and six Pacific Islands/territories (Given, Black, Lowry, Huang, & Kerner, 2005). This has developed a foundation of experiences upon which perceptions relating to the tasks of public health in CCC formed. The CDC support contributes to establishment of broad-based CCC coalitions involved in assessing the burden of cancer, and suggesting that the "collaboration model" of community involvement may best describe the experiences of those working in public health as part of CCC efforts. The CDC's support prioritizes prevention and control activities through the development of an infrastructure for CCC, including planning and implementing state CCC plans (Given et al., 2005). At the end of the 20th century, U.S. CCC leaders acknowledged that growing collaborations and partnerships was the key to advancing their aims in the 21st century (Given et al., 2005). Barriers to forming coalitions include fragmented systems of state public health departments, a lack of resources for leadership and staff, and an absence of procedures linked to management, accountability, and communication (Given et al., 2005). Thus, the dissemination of GIS within public health systems to achieve CCC aims may depend on its utility in reducing barriers to coalition building and/or facilitating coalition efforts to achieve the aims linked to CCC. We thus considered the following question:

RQ1: What tasks do CCPMs perceive GIS mapping to be useful for in achieving CCC aims?

CCC activities and collaborations involve many groups, suggesting a wide range of target audiences as users of GIS maps. In 1997, for example, the U.S. National Breast Cancer Coalition (NBCC) advanced an innovative model of open communication between its members and the scientific community called Project LEAD (Leadership, Education, and Advocacy Development) (Liberati, 1997). The goal of LEAD is to train breast cancer advocates in the science related to their disease, so that they can influence the policies and practice linked to the disease (Liberati, 1997). LEAD represents one of many advocacy and/or survivor groups that public health CCC programs reach toward and

involve in their activities, with LEAD membership on state public health cancer control coalitions illustrating strategic community involvement. The endeavor to involve organizations such as LEAD illustrates the reality that CCC organized through state public health programs reaches toward many audiences to integrate ongoing activities. These audiences include policymakers, clinicians, and advocates, as well as internal public health working groups and other organizations linked to CCC. This led to a second question for consideration:

RQ2: For what audiences do CCPMs perceive GIS mapping to be useful in fulfilling CCC tasks?

Perceived Relative Advantages: CCC Outcomes

CCC aims may be achieved via many paths, with GIS perhaps affording an advantage in some situations. An innovation that is perceived to have a relative advantage over other approaches will be more likely to be adopted (Moore & Benbasat, 1991). Emphasis has been placed on GIS as a tool to map local cancer data geographically, suggesting new revelations about cancer diagnoses and treatments (Devesa et al., 1999). In New Mexico, for example, the mapping of ZIP codes for women receiving breast cancer diagnoses revealed that only 51% living more than 75 miles from the closest cancer treatment facility received follow-up radiotherapy; 69% received follow-up in the 50–74.9 miles range; and 82% within 50 miles travel distance (Athas, Adams-Cameron, Hunt, Amir-Fazli, & Key, 2000). Visualizing the geographic location of women diagnosed together with the geographic location of cancer treatment sites thus guided comprehension of an existing service gap. Talking with women who had been diagnosed may also have revealed similar insights, although there is precedence for communities in the midst of living their lives, failing to recognize or verbalize the limitations linked to their situations (Parrott & Steiner, 2003). We thus also considered:

RQ3: Do CCPMs perceive GIS mapping to have relative advantages for performing CCC activities?

METHOD

Participants and Procedures

Program directors from the U.S. CCC programs in 49 states (N = 49; Louisiana's director was not contacted due to Hurricane Katrina) with responsibility for leading state cancer control efforts were interviewed. This near census was attained via prearranged telephone interviews designed to assess perceptions relating to the use of GIS mapping as a tool in CCC planning and intervention activities. Participants had worked in public health for as much as 30 years and as little as 2 months. The mean length of time having worked in public health was nearly 12 years (SD = 8.5 years), while the mean number of years served in their current position was nearly 3 years (SD = 2.5 years). The level and areas of education of participants ranged from 12% who had PhDs, 8% with MDs, 25% with MPHs, 35% with a masters degree in areas other than public health, and all but one of the remaining participants holding bachelor's degrees; one participant had an associate's degree.

Data were collected from the summer of 2005 through the winter of 2006. Individuals were contacted via e-mail, using the subject line "CDC/AAMC Interview Request," to increase the likelihood that the e-mail would be opened and read. The e-mail consisted of a formal letter with institutional letterhead and included several strategic components: (a) an opening sentence to set a context for the request; (b) reference to the institution conducting the research, the investigators leading the research, and the funders of the research; (c) statement of the task request; and (d) reinforcement regarding the need for the director to respond.

CCPMs were asked to choose three available times for a phone interview from a designated list of times. Individuals were also asked to provide alternate times of availability should none of those listed fit their schedule. Interviews were solicited in batches of 10 to facilitate scheduling. If participants provided an alternate date and time, efforts were made to accommodate these requests. Participants were recontacted to confirm availability. Using this method, all states were included in this research with the exception of Louisiana.

A verbal consent form was sent to the participant by e-mail prior to the interview and included the title of the project and contact information for the primary investigator. When the interviewer called, she read the Verbal Consenting Script prior to beginning the interview, obtained verbal consent to conduct and record the interview, and assured the participant that no personally identifiable information would be included in any analyses and write-ups. The script reinforced the interview's emphasis on GIS as a tool to derive maps for CCC activities. Participants were asked whether and how they currently use GIS mapping and then answered several questions focused on the audiences that interviewees would use maps with, what tasks mapping serve, and what advantages GIS mapping has as a CCC tool. Interviews were transcribed verbatim and then provided to the interviewee for review. By this method, interviewees were given a chance to correct content or extend discussion of any issues raised during the interview. Minor corrections were made by 18 interviewees, mostly based on the CCPM checking some details about a response. Three managers explicitly stated that they showed the transcript to a colleague with more direct responsibilities linked to mapping. The final transcribed interviews averaged 4.43 single-spaced pages (SD = 1.12) and totaled 217 pages of single-spaced textual data.

Coding Procedures

A codebook for analysis of the interview transcripts was derived and included codes for content being mapped and codes based on the diffusion of innovation concepts of task domains, audiences/users of potential maps, and relative advantages of GIS mapping (see Tables 1 and 2). Two researchers initially read the transcripts and evolved the codes for task domains, audiences identified as users of maps linked to CCC programs, and the relative advantages of GIS mapping for achieving the tasks identified in relation to audience/map users. In response to a question about what tasks GIS mapping enables CCC programs to achieve, 10 tasks were identified, as summarized with their definitions in Table 1. Audiences the interviewees regarded to be likely to use maps relating to CCC activities included direct inquiries about health educators, epidemiologists, the general public, public health nurses, the media, patients, and policymakers. In addition to these audiences, participant responses led to the addition of cancer coalitions, which included reference to planning groups comprised of such organizations as advocacy groups, the American Cancer Society, the American Heart Association, hospice care organizations, and insurers. Based on responses to the open-ended question "Do you see relative advantages to using maps for cancer control planning and implementation activities?" three general advantages relating to communication outcomes associated with GIS use were inductively generated by review of the interview transcripts. These included: increases awareness or attention with an audience, increases comprehension, and reaches different audiences (see Table 2 for codes and definitions).

TABLE 1
Task Domains Program Managers Related to GIS Mapping: Codes and Definitions

Task domain code	*Definition*
Identify visual patterns	Statements about how GIS mapping functions to reveal the presence of regional patterns, trends, or geographic differences.
Facilitate presentation	Statements about how GIS mapping functions as a visual aid to communicate information to an audience.
Allocate fiscal resources	Statements about how GIS mapping functions to guide decisions about where to spend monies allocated for CCC efforts.
Plan interventions	Statements about how GIS mapping functions to guide decisions about what to focus on and for whom when choosing to intervene.
Facilitate evaluations	Statements about how GIS mapping functions to reveal the effects and effectiveness of CCC efforts.
Educate communities	Statements about how GIS mapping functions to inform communities.
Support collaboration	Statements about how GIS mapping functions to reveal linkages, connections, and networks exist to assist CCC efforts.
Plan services	Statements about how GIS mapping functions to reveal what and where diagnosis and treatment services are needed.
Personalizes the message	Statements about how GIS mapping functions to make content relevant and involving.
Identify referral resources	Statements about how GIS mapping functions to identify where diagnosis and treatment services are located.

TABLE 2
Relative Advantages of GIS Mapping for CCC: Codes and Definitions

Relative advantage code	*Definition*
Increases awareness/ attention	Statements about how GIS mapping generates perception and recognition of CCC activities and aims.
Increases comprehension	Statements about how GIS mapping enhances understanding about CCC activities and aims.
Reaches different audiences	Statements about how GIS mapping increases exposure for CCC activities and aims.

Four coders not involved with deriving the codebook were trained and then coded a single interview using the initial codebook. After coding, they met with the researchers who developed the codebook to discuss their experiences, including possible content about which they were uncertain when trying to match it to particular codes. Via this process, revisions were made, and the coders then worked independently to code transcripts of five interviews before checking their reliability. Initial intercoder reliability was established using Cohen's kappa, a measure of intercoder agreement for dichotomous data that takes chance agreement into account (Cohen, 1960). Initial reliabilities ranged from .69 to 1.00 for the coders' identification of the presence of absence of content relating to each code. Audiences, for example, were most easily coded, while some task domains, such as "plan interventions" versus "plan services," required further discussion. The former included content related to activities such as health fairs or media campaigns or "walk-for-the-cure," while the latter included more permanent structural and/or organizational changes relating to cancer care. Consensus was achieved for coders' discrepancies via discussion. After coding 10 additional interviews, assessment of intercoder agreement revealed a range for Cohen's kappa of .89 to 1.00, with discrepancies again resolved to achieve consensus. The codes for "plan services" versus "identify referral resources" were refined with "plan services" identified as content that directly referenced aims to increase the availability of services, while "identify referral resources"

included content that directly references aims to increase awareness of existing services. The remaining transcripts were then coded with reliability reviewed after each set of 10 as a method to avoid coder drift or fatigue in the process. The final data set used in the analyses included a single consensus response for each coded variable and was analyzed with the Statistical Package for the Social Sciences, version 14.0.

Data Analysis

Count and frequencies were computed for interviewee responses regarding the compatibility of GIS mapping for the 10 CCC tasks identified from the transcripts, the target audiences for GIS mapping, and the relative advantages of GIS mapping. Contingency coefficients, *C*, were computed to explore the possible patterns in responses tallied from the interviews, with *C* deemed to be a conservative measure of associations for dichotomous data in 2-by-2 contingency tables. *C* may be viewed as the association between two nominal-level variables as a percentage of their maximum possible variation, when at least five cases per cell exist (Agresti, 1996). Quotes from the state managers are used to illustrate the tasks, audiences, and relative advantages mentioned.

RESULTS

Figure 1 integrates the participants' response across the domains of compatibility of GIS in performing CCC tasks, audiences likely to be targeted as users of maps for CCC, and the advantages perceived in using GIS mapping in relation to these tasks and targets. Figure 1 lists these in the order of most frequently mentioned to least frequently mentioned.

CCC Tasks Facilitated by GIS Mapping

The most commonly mentioned task related to use of GIS mapping was the ability to identify broad patterns, noted by 38 (78%) of the participants, while the least frequently mentioned was the ability to identify referral resources, identified by just 6 (12%) interviewees. The remaining tasks from most to least mentioned were the use of mapping to facilitate presentations (n = 23; 47%), allocate fiscal resources (n = 18; 37%), plan interventions (n = 16; 33%), facilitate evaluation (n = 15; 31%), educate communities (n = 12; 25%), support collaboration (n = 12; 25%) and plan services—each mentioned 12 times (25%), personalize the message (n = 10; 20%), and identify referral resources (n = 6; 12%). Percentage of the maximum possible variation for identifying support for collaborations as a task of GIS mapping was related to identifying "personalizes the message" as a task (C = .29, $p < .05$). Identifying facilitates presentations as a task of GIS mapping was related to intervention planning (C = .29, $p < .05$). Comments representing the participants' views coded into each of these task domains follow.

Identify broad patterns. The most frequent task associated with the use of GIS mapping for CCC activities

Task Domains:	Target Map Users:	Relative Advantages:
Identify broad patterns (n = 38)	Cancer coalitions (n = 49)	Increases awareness/
Facilitate presentation (n = 23)	Epidemiologists (n = 46)	attention (n = 31)
Allocate fiscal resources (n = 18)	Policymakers (n = 43)	
Plan interventions (n = 16)	Public (n = 39)	Increases comprehension
Facilitate evaluations (n = 15)	Health educators (n = 38)	(n = 28)
Educate communities (n = 12)	Media (n = 34)	
Support collaborations (n = 12)	Public health nurses (n = 32)	Reaches different audiences
Plan services (n = 12)	Health care professionals (n = 13)	(n = 28)
Personalize messages (n = 10)	Cancer patients (n = 1)	
Identify referral resources (n = 6)		

FIGURE 1 Cancer control program managers' reports of comprehensive cancer control tasks facilitated by geographic information systems mapping, target audiences, and relative advantages. *Note.* Tasks, audiences, and relative advantages are listed from most frequently to least frequently mentioned. Total is more than 49, as participants could name more than one task, audience, or relative advantage.

linked it to the literal vision afforded by mapping. As one manager noted, an important task of GIS mapping is "being able to respond and visually represent [answers to] questions concerning clusters, exposures, increased incidence, disparity and burden." Another manager said, "The next set of projects I envision as being useful for comprehensive cancer control efforts will be incorporating geocoded data with census data on local areas to integrate socioeconomic status (SES) and other variables from census data into an analysis set and then do modeling that includes both area and individual level variables to best understand cancer burden, cancer treatment, patterns in the state."

Facilitate presentations. CCPMs and staff communicate with many audiences in the performance of their duties, and CCPMs reflected this reality in naming the fulfillment of GIS mapping in roles linked to these presentations. One program manager noted, "I constantly look for ways to present data in ways that help planners clearly see how the state is doing . . . Maps is one way." Another affirmed that "For presentations, maps show descriptively cancer incidence and mortality rates in the state, because the visual presentation has much more of an impact than showing the rate." Another observed, "When you're presenting data to coalition members of various backgrounds, maps make it much easier, or showing something pictorially makes it easier than using just numbers or data." One manager noted, "I think maps are a great visual aid when you're giving presentations."

Allocate fiscal resources. Beyond the common tasks linked to identifying broad patterns related to CCC and making presentations, CCPMs identified tasks linked to critical decision making in their roles. Most common among these related to spending monies. As one manager said, "It [mapping] provides a pictorial resource to the public on a county-level basis for cancer resources." Another observed, "We have used [maps] to determine funding allocations for skin cancer education programs in targeting the areas that we know had significantly higher rates of melanoma." A third noted, "A very powerful visual image to put into someone's hands and say, 'look what's going on in the NW corner of our state. We need to direct some resources there.'"

Plan interventions. CCPMs play a vital role in leading intervention efforts in their states. This task emerged in responses as well. A program manager noted, "It allows for future planning efforts if you can see for example that you have a high rate of late-stage diagnosis in a certain part of the state." Another said, "We're starting new initiatives or we're looking for an area of the greatest need to try an intervention of some sort." Another manager commented, "It would be nice if they could map the geographic breakdown of the population. TV stations, radio stations, and the areas they cover for the purpose of campaigns." And another observed, "If they could study a map of tobacco usage . . . to see if it's young white males as opposed to 60-year-old farmers chewing tobacco. The people planning the CCC intervention need to be the ones to use the map."

Facilitate evaluation. The value of GIS mapping to assess performance of CCC activities emerged as well. A manager of one state's program observed, "I think we would use them [mapping] most to strategically plan maybe for a year where we target and then we would look at them again at the end of the year to see if there has been a change." Another state's manager noted, "I think mapping is very compatible particularly for the different parameters that you may be looking at in cancer control to help make specific decisions about . . . evaluating that intervention."

Educate communities. The broad range of topics that cancer control programs address in educating communities was represented in participant discussions about this task domain. One manager, for example, noted, "I also think it will be helpful to communities who start wondering well do we have an overabundance of a type of cancer." This comment implied that educating communities about the incidence of cancer in their area compared to other geographic locales is enhanced via map use. A manager in another state observed, "They use mapping to do effective outreach by targeting specific groups such as older groups (bingo halls, radio, churches), blue collar, different demographics." In this case, the reference relates to maps' utility in identifying the locations of sites associated with specific target groups for which CCC programs provide outreach and education.

Support collaboration. The value of GIS mapping in facilitating the linkages that define core CCC activities emerged in the interviews as well. A manager of one state's program noted, "We might also map various volunteers related to ACS and the services they offer like the WIG [with wigs, hair replacement], Road to Recovery. Locations of collaborators at a basic level [county level]. That's very useful at a basic level." Another manager observed, "We would use mapping to map out where our regional support is of partnerships around the state. The types of cancer control entities that are partners with the cancer coalition. We would like to map them out where they are located across the state. And we haven't gotten to this point yet, but if we know the types of partners (different levels), knowing where those different types of partners reside around the state might be helpful." Another noted, "We have work to do, 75% of our coalition members live in one county. Being able to say five months later, we've increased membership and now only 15% are from one county . . . using GIS concepts to show that we have more geographic diversity."

Plan services. A prominent task linked to CCC activities relates to promoting screenings. GIS mapping was

perceived to be a tool that would help with identifying gaps relating to this task. One interviewee observed, "I've seen some mapping of breast and cervical cancer to show the eligible population, the mammography sites available, how many health care providers available. This certainly helps paint a really good picture of where the needs are." The manager of another state's program noted that "maps can be useful in saying, look there's a lot of poverty in this area and there's a lack of screening facilities in this area and a high proportion of cases that are diagnosed in this area are late stage . . . maybe we need to work on making screening available in this area . . . that kind of geographic presentation can be useful to help planners, if used properly I think." Another commented, "We're more interested in service capabilities, service saturation points, for instance, where hospice is provided and whether or not they have the capacity to meet the needs of the population in that area."

Personalize the message. The value of personalizing a message emerged in some managers' comments about reaching the public through using GIS mapping. One manager noted, "I think people related very much to looking at their own town, their own county on a map, and are intrigued, their interest is peaked." Similarly, another manager said, "Folks always say, 'there we are, look we're higher or lower than. . .' comparing their area of the map with another area." A third manager noted that, "maps knock it home what issues are . . . seeing this is where I live or the county I live in has a higher incidence."

Identify referral resources. Some participants emphasized mapping's role in literally locating existing sites for cancer care, with one participant observing, "If we had some kind of maps with accredited cancer centers, screening centers that we could refer these people to, it would be very helpful." Another state's manager said, "We'd like to see where providers are for certain cancer services." And a third observed, "Where are our mammography and provider facilities in location to the targeted audiences?"

Audiences Likely to Use CCC Maps

Interviewees were asked specifically about whether they thought they would use GIS mapping as a tool to communicate with the following audiences: health educators, epidemiologists, the general public, public health nurses, the media, patients, and policymakers. Among these audiences, the greatest number of participants, 94% (n = 46) regarded epidemiologists to be an important audience to use GIS mapping with for CCC activities, and 88% (n = 43) held policymakers as an important audience. Similarly, a high percentage of participants, 80% (n = 39), regarded the public to be an audience that would benefit from use of GIS mapping as a strategy to achieve CCC aims. Seventy-eight percent of the participants (n = 38) regarded health educators to be an important audience to use GIS mapping within CCC activities, while 69% (n = 34) agreed that the media would be well served by using GIS mapping in representing CCC activities to them, and 65% (n = 32) perceived public health nurses to be an important target group. Twenty-six percent (n = 13) considered health care professionals to be an audience to target in using GIS mapping, and just one participant viewed cancer patients as an audience to target in using GIS mapping. As one manager noted, "All of them would use maps for different purposes. Once they realize the power of this tool, I think they would jump all over it." The percentage of identifying planning services as a CCC task facilitated by GIS mapping was related to identifying health educators as a target audience (C = .29, p < .05).

In addition to the audiences that participants were explicitly asked about, 100% (n = 49) of the participants identified cancer coalitions as an important audience to use GIS mapping with in CCC activities. Notably, this was the only response given to the open-ended question, "Are there any other audiences you would use GIS mapping with in your CCC efforts?" Interviewees elaborated on this response by naming specific targets, including advocacy groups, the American Cancer Society, the American Heart Association, volunteer agencies, hospice care organizations, and insurers.

The percentages of variation in responses were related for audiences, such that identifying *media* as an audience was related to naming *public health nurses* (C = .53, p < .001), *the general public* (C = .48, p < .001), *health educators* (C = .36, p < .05), and *policymakers* (C = .28, p < .05) as audiences. The percentage of identifying *epidemiologists* as a target audience was related to identifying *policymakers* (C = .39, p < .05), and *public health nurses* (C = .33, p < .05).

Relative Advantages of Using GIS Mapping for CCC

The participants' responses regarding perceived relative advantages of using GIS mapping to achieve CCC goals revealed three common responses related to communication. The ability to increase awareness or attention regarding an issue related to CCC was identified by 63% (n = 31) of the directors. The potential for mapping to increase comprehension of the meaning of data and to expose or reach different audiences were also identified by the interviewees, with 57% (n = 28) of the participants in each case naming the benefit. The percentage of their maximum possible variation in identifying the relative advantage of increasing awareness or attention was related to mapping demographic content (C = .33, p < .05). Identifying increasing comprehension as a relative advantage was related to identifying educating the community as a task to be facilitated by GIS mapping (C = .29, p < .05). Identifying the relative advantage of increasing awareness or attention was related to identifying the advantage of increasing comprehension

(C = .34, p = .01) due to use of GIS mapping for CCC activities. Comments highlighting the relative advantages follow.

Increases awareness or attention. A primary outcome for the various target audiences linked to GIS mapping was the ability to garner recognition for CCC efforts. Among the program managers, one indicated, "Maps provide a quick visual. You can see where you are at a glance." Another noted, "Mapping just seems to bring the subject to life a little bit more," and another said, "From the reaction we got just exploring a little bit with a few maps we have done we can tell you how helpful it is for people to look at the situation graphically and come out with implementation plans accordingly." Another manager's comment was, "It gives a visual depiction to some of the evidence that we collect in a variety of ways." One of the manager's stated, "I think the visual representation of numbers, and using different colors or icons, pictorials . . . people respond to that very quickly."

Increases comprehension. A vital advantage identified in relating GIS mapping to CCC tasks was its ability to enhance understanding. As one manager observed, "I think the message is more readily understood. In this day of modern technology, people expect that you use all these newer tools. People know about geocodes. People have systems in their car that tell them where they are and where they need to go so there is an expectation that people in state government have access to newer kinds of technology." Another noted, "Anytime you can explain something in layers and show that on one map and divide it into segments . . . it helps comprehension." And a third declared, "I think it's easy for people to understand the information visually." Another manager stated, "We are very cautious because of our experiences with maps. They can cause a lot of trouble, a lot of misunderstanding . . . People do seem to take in more things when they're done visually." Another suggested the significance of choices made in the design of maps to attain the advantage of increased comprehension, noting, "A map, particularly one that has other reference points (e.g., cities, roads) can be understood more readily."

Reach different audiences. The importance of exposing various audiences to CCC information emerged in the discussion of the "reach" of GIS mapping. One CCPM noted that "For communicating to the public, maps may be useful." Another manager stated, "Maps offer another way of looking at data so that not only a lay person, but a trained professional can get a different view of the extent or the specific focus of the problem." Another declared, "It depends on the audience. I can see an advantage to presenting our table incidence mortality by county into a geomap for our legislators and for a community-based audience." And one noted, "Looking at maps is a common language that we can use, between the different professions (doctors, epidemiologists, health educators, managers), it speaks a common language." Another cautioned, "Maps are better for the public, but there are also a great deal of challenges."

DISCUSSION

The primary aim of CCC is for state public health programs to lead efforts to integrate disparate programs and resources and groups, avoiding redundancies, reducing conflicting messages to various audiences, and harnessing the synergy that positive linkages to communities makes possible. The diffusion of technology and other means to reduce the barriers to achieve this primary aim often depends on visionary approaches and insights. Leading these efforts will be the program managers who sit at the helms of state CCC programs. Their insights, as revealed in this project, are rich in implications for community involvement via use of GIS mapping as a means to reform and reframe resources aimed at reducing cancer's incidence and mortality rates. Taken as a whole, the suggestions about community involvement that emerged are far-reaching.

CCPMs regard GIS as a complex science that integrates geography and information systems technology, to be compatible with many aims of CCC. At the broadest level, CCPM affirmed the value of GIS mapping in identifying patterns and facilitating presentations. The nuances of making presentations about these patterns are conveyed in other tasks CCPMs associated with using GIS mapping. The broad patterns that might be mapped and presented may, for example, show that higher rates of mortality are related to an absence of services. This may spur efforts to "plan services" if policymakers are reached as an audience and comprehend where citizens are underserved. This application illustrates a "service model" of community involvement. The very same maps could be used to reveal service gaps in a story reaching the *general public* through the *media*, with these two audiences linked in CCPM reports of target map users. In such an event, communities might raise the issue of service gaps, an "augmentation model," or join existing public health cancer coalitions to enhance capacity, a "collaboration model," or both, illustrating a "mobilization model" of community involvement as theorized by Guttman (2000).

The data gathered in this project strongly suggest that use of GIS mapping has diffused through most of the public health system linked to CCC activities, but seldom in ways that go beyond a "service model" of community involvement. The interviewees expressed their vision of how the tool could communicate in far-reaching ways to personalize the message and enhance collaboration, two tasks related in the reports of compatibility of GIS mapping for CCC activities. Enhancing collaboration suggests that the core functions of CCC in working with communities, and GIS mapping in revealing innovative patterns linked to location,

might marry in ways that reduce barriers to growing collaborations to advance CCC aims. Both the "mobilization model" and the "collaboration model" of community involvement represent ways to frame the opportunities of GIS mapping's dissemination to reduce fragmentation within and between systems of state public health department approaches to CCC, to ignite leadership, and to suggest innovations linked to management, accountability, and communication. Too few resources for too many tasks is a common concern, but with input from communities based on educating them via use of maps that reveal their status compared to others, the allocation of resources can be based on input from informed communities.

The findings of this project also emphasize a critical distinction that needs to be made in relation to a role for GIS mapping in planning and evaluating interventions linked to CCC activities. CCPMs spoke about looking at maps as a means to chart their progress, literally, from one year to the next. Seen in the context of GIS mapping's ability to reveal where coalition partners exist, "a picture is worth a thousand words," as CCPMs and the programs that they manage can ascertain where sites for collaboration exist and overlay sites where actual collaboration is ongoing. This enhances their ability to involve communities strategically, "a collaboration model." With the addition of sites such as TV and radio stations, also mentioned by CCPMs in their interviews, overlaying a view of where organizational partners exist together with sites such as TV and radio stations, a view toward building capacity for communities begins to emerge. With the addition of community input, maps may bring attention to issues that garner community input, a "mobilization model." The risk in this equation is that change in such issues as cancer incidence or the presence of structural resources from one year to the next is an unrealistic expectation to chart the progress of CCC activities. Thus, care must be taken when envisioning the use of GIS mapping to chart the course for evaluations.

While only exploratory in nature, the patterns revealed among the audiences identified by the CCPMs as users of GIS maps for CCC are suggestive. There were direct relationships among the frequencies that epidemiologists, policymakers, and public health nurses were named. Additionally, there were direct relationships among the frequencies of naming media, the public, health educators, and public health nurses as users. In reaching the former, maps that use epidemiological data may reveal broad patterns that suggest new hypotheses associated with cancer causation or service gaps. As a result, policymakers may comprehend the significance and be persuaded to allocate more fiscal resources to CCC activities aligned with planning services to reduce the gaps. At the same time, in reaching the latter group including media and the public, the very same maps may educate communities and increase their awareness of or attention to possible causes of cancer and geographic locations of underserved citizens. This may enhance willingness to collaborate with groups and organizations volunteering time and other resources to CCC activities. Thus, a web of influence linked to GIS potential to fulfill tasks aligned with CCC and achieve important outcomes may be enhanced.

Limitations and Future Research

The results of this project rely on the experiences and perceptions of just one group with responsibilities for managing possible applications of GIS in public health. The exploratory nature of these relationships and the desire to ascertain how the patterns appear collected through interviews are limitations of the generalizability of results. While a near census sample provides support for the validity of conclusions in relation to CCC, the same conclusions may not apply to other chronic disease activities organized within state public health departments. However, there may be consistency in the task domains, target audiences, and relative advantages of GIS use, as, for example, the incidence of diabetes may suggest broad patterns linked to an absence of safe places for exercise or an abundance of fast food locations. The generalizability of this study's findings and possible explanations constitute research topics for the future.

CONCLUSION

The diffusion of GIS mapping tools within state-level CCC programs in the United States has reached the point of dissemination when novel insights to support increased adoption of this innovation are needed to enhance its efficacy. The utility is great and the promise even greater with GIS, as revealed in statements by the CCPMs. In essence, CCPMs are asking for GIS to make "mapping capacity," a metaphor used to describe the assessment of resources available to achieve health promotions aims (Mittelmark et al., 2006) a literal rather than figurative reality. This could occur via translations and GIS representations of where resources such as key contacts or successful interventions exist. GIS communicate about data in novel ways, visualizing temporal and spatial relationships that might otherwise remain hidden. In doing so, the vision of their utility for "health planning, particularly at the community level . . . to recognize spatial data patterns that suggest where cost-effective public health interventions can be applied" (Richards, Croner, Rushton, Brown, & Fowler, 1999, p. 359) has been recognized. The potential of GIS to communicate novel insights about CCC has been built on focusing careful attention on epidemiologic principles and methods to guide GIS displays, a value of utmost importance (Richards et al., 1999). At the same time, the potential of GIS to communicate novel insights about CCC has often neglected to apply community capacity principles and

methods, missing some opportunities to build social capital and a community pool of resources.

While prior research relating to GIS diffusion supports several conclusions relating to organizational and individual user barriers, CCPMs' perceptions regarding the relative advantages of use suggest a novel approach to use that may increase its dissemination. This requires a transition from emphasizing the disease in applying GIS to CCC aims and instead focusing on community involvement, capacity building, and social capital to build trust between organized systems such as public health organizations and groups from different backgrounds who may benefit through their involvement.

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