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Mapping as a Visual Health Communication Tool: Promises and Dilemmas

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In the era of evidence-based public health promotion and planning, the use of maps as a form of evidence to communicate about the multiple determinants of cancer is on the rise. Geographic information systems and mapping technologies make future proliferation of this strategy likely. Yet disease maps as a communication form remain largely unexamined. This content analysis considers the presence of multivariate information, credibility cues, and the communication function of publicly accessible maps for cancer control activities. Thirty-six state comprehensive cancer control plans were publicly available in July 2005 and were reviewed for the presence of maps. Fourteen of the 36 state cancer plans (39%) contained map images ($N = 59$ static maps). A continuum of map interactivity was observed, with 10 states having interactive mapping tools available to query and map cancer information. Four states had both cancer plans with map images and interactive mapping tools available to the public on their Web sites. Of the 14 state cancer plans that depicted map images, two displayed multivariate data in a single map. Nine of the 10 states with interactive mapping capability offered the option to display multivariate health risk messages. The most frequent content category mapped was cancer incidence and mortality, with stage at diagnosis infrequently available. The most frequent communication function served by the maps reviewed was redundancy, as maps repeated information contained in textual forms. The social and ethical implications for communicating about cancer through the use of visual geographic representations are discussed.

As a developing information technology and a distinctive visual communication mode, geographic information systems (GIS) have increased the frequency with which disease maps are used to communicate health information (Lawson et al., 1999). The promises of GIS mapping include the potential to reach a broad array of audiences, including health planners, policymakers, advocacy groups, and an interested public (Brewer, 2006). As a visual form of communicating health information, disease maps may bridge the gap between complex epidemiological presentations of statistics and the varied educational backgrounds represented by policymakers and other decision makers and users. The accessibility of disease maps has broadened, with many maps publicly available online. Although this movement promotes creative means of analysis and identification of at-risk populations for planners and researchers, such accessibility may pose dilemmas relating to labeling populations living in particular geographic locales. In this article, we report the results of a content analysis of maps used in publicly accessible online state comprehensive cancer control (CCC) plans, framing the review in terms of disease maps as a visual form of health and risk communication.

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DISEASE MAPS AS A VISUAL FORM OF HEALTH AND RISK COMMUNICATION

Visual risk communication comprises an omnipresent form of health communication and should be systematically examined for cognitive, affective, and behavioral effects across the spectrum of audiences (Parrott, Silk, Dorgan, Condit, & Harris, 2005). Among health communication scholars, understanding the effects of visual communication has primarily been based on studying images from television, film, print, or more recently, the Internet. These research programs often examine characteristics of the modality and the individuals exposed to a medium in predicting effects, but such efforts to understand the outcomes of using disease maps have not been undertaken. Displaying health data in visual map form calls attention to the salience and construction of *place* (Kearns & Moon, 2002), with the choices made about what variables to map and what strategies to use in maps strategically framing meaning. Maps thus comprise a tool to use in forming evidence about the disease or health condition portrayed. Their utility depends on accurate translation and comprehension by individuals in practice settings, as well as in public and policy realms. A visual model approach to CCC has been formally incorporated into federally supported state cancer control and prevention (Abed et al., 2000), providing the resources and motivation to use maps as a CCC tool, and warranting examination from a health communication perspective.

Cancer Statistics and Map Use as Evidence

The Cancer Registries Amendment Act of 1992 mandated that state health departments develop population-based cancer registries to monitor state and local cancer patterns to facilitate cancer prevention and control (Thomas, 2002) and make cancer statistics relating to such patterns readily available (Cromley & McLafferty, 2002). Data reduction and representation strategies are needed to promote the utility of disease registry information, with mapping affording one strategy. As a distinctive visual medium, mapping has the dual capability to convey predetermined health relationships and to stimulate exploration of unknown ones. Maps not only prompt attention, but arouse different expectations for evidence and modes of thought than alternative graphic, numeric, or verbal messages.

Mapping allows researchers to query large amounts of data in search of disease patterns and variances, prompting etiologic hypotheses with a goal of discovering better approaches to tackling complex public health challenges such as cancer control and prevention (Goodchild, Anselin, Appelbaum, & Harthorn, 2000). In California, a GIS used to identify women at greatest risk of developing breast cancer defined geographic service areas using zip codes, then applied the National Cancer Institute's consumer health profiles to narrow the geographic units, and identified three groups based on demographic, health care attitudes and use, media habits, and product preferences (Lubenow & Tolson, 2001). The screening program that developed as a result contributed to mammography and clinical breast exams rates 136% over the published statewide screening rates, more than double the county's goal (Lubenow & Tolson, 2001).

Mapping strategies applied to public health have also contributed to the discovery of links between geographic sites and cancer. For example, shipyards have been linked to lung cancer, with exposure to asbestos associated with time spent in shipyards representing an important multivariate relationship (Blot et al., 1978). In disease maps, the bivariate relationship between two variables, such as place and disease incidence, may be the one visually represented when the reality is more complex. This is particularly likely when the map is a static one, portrayed as a two-dimensional picture. In the previous illustration, for example, asbestos exposure and cancer incidence is the bivariate relationship of greatest importance in planning for cancer control. Shipyards, as a site for exposure to asbestos, denote the multivariate relationship between location, exposure, and disease. Thus, a finding that reflects that shipyards pose a high risk for exposure to asbestos supports the decisions to promote asbestos exposure prevention strategies to shipyard workers and to assess methods to limit direct asbestos exposures at shipyards. It is not intended, for example, to suggest that shipyards themselves cause cancer.

Parrott et al. (2005) found that visual presentations of multivariate relationships are not comprehended as well as explicit verbal statements of these relationships, and that bivariate relationships between two variables, even in multivariate visual representations of statistical information, emerge as the remembered content. The effect of geography for health is complex and not to be reduced to bivariate relationships between the two predictors—of *place* and *disease incidence*. Disease incidence, for example, has been found to be an insufficient statistic to represent in a map as evidence to guide cancer planning activities. In Alabama, geocoded data from the state's cancer registry is linked to the National Cancer Institute's Consumer Health Profiles system to tailor health messages for outreach, education, and promotion of cancer screenings (Miner, White, Lubenow, & Palmer, 2005). One of the shortcomings in their initial design of cancer registry information for geocoding was the failure to include cancer staging data together with incidence data to better assess cancer burden (Miner et al., 2005).

In sum, the use of disease maps for CCC activities comprises a form of health and risk communication intended to convey a multivariate understanding of the role of place in relation to cancer. To reap the promise of using disease maps for CCC, maps may include multiple variables and provide multivariate images and overlays of these variables acting in concert. To examine the status of maps used for CCC, we considered whether

RQ1: In CCC maps publicly accessible online (a) is content represented as bivariate or multivariate relationships; and (b) what content variables are mapped?

Representations of source credibility in disease maps. As a form of statistical evidence, maps may be judged by criteria used to guide the design of evidence, including credibility of the source. Maps explicitly or implicitly persuade a viewer to accept a point of view (Wood, 1992), with judgments of source credibility contributing to influence outcomes. In the design of evidence, efforts to bolster the credibility of a source include explicit source citation and disclaimers (Reynolds & Reynolds, 2002). Cancer maps raise important ethical issues about the reliability of data being mapped (Grauman, Tarone, Devesa, & Fraumeni, 2000). Because choices are inevitably involved in mapmaking, cartographers frequently attach disclaimers to maps in an effort to inform users about a particular map's limitations. Thus, one way to consider the credibility of map content is to examine maps for the presence of disclaimers. A second strategy to consider in evaluating the credibility of disease maps relates to the citation of a source. Explicit citations of evidence sources within messages have been found to have a significant persuasive advantage (Eastin, 2000; OKeefe, 1998). In the absence of source information, individuals attribute a source to messages and judge the content in part based on the perceived expertness and trustworthiness of attributed source information (Hass, 1988). To examine source credibility issues relating to cancer maps, we considered

RQ2: Do maps display (a) disclaimers regarding the representation of health risk data or (b) source information?

Communication function served by disease maps. One strategy increasingly used to reach audiences with health and care information has been to substitute or add pictures, photographs, or other visual communication forms to the message (Parrott et al., 2005). Visually complemented message content has been found to contribute to deeper message processing and, as a byproduct of thought, increased knowledge (Slater, Karan, Rouner, & Walters, 2002). Empirical research examining the use of maps has focused on issues that parallel these outcome realms, judging the implications of symbolization (Li & Lewandowsky, 1995) and map design decisions (MacEachren, Brewer, & Pickle, 1995) such as the use of color schemes for depicting the categories (Brewer, 1997; Brewer, 2006; Brewer, MacEachren, Pickle, & Hermann, 1997) and layout design more generally (Brewer, 2001). Use of color often functions to emphasize content (MacEachren, 1995), but maps may also communicate information that verbal text does not include or elaborate on such content. The text may offer a concise summary statement such as information about cancer incidence that has been gathered for the state. A map may convey that the incidence varies by region in the state, thus substituting for the text in this case. The text may report that cancer incidence varies by region in the state, whereas the map reveals which regions have a higher incidence when compared to other areas, thus elaborating on the textual content. Or, text that makes a multivariate relationship apparent as compared to a map that represents a bivariate relationship may function to communicate an inconsistent message. We thus considered the following research question:

RQ3: How do maps function to communicate public health information as it relates to CCC and prevention efforts?

METHOD

Procedure

Identification of maps. A protocol to access maps used as a tool for cancer control planning activities included two main steps.[1] First, available state cancer plans as of July 2005 were accessed online at the following CDC Web site: http://apps.nccd.cdc.gov/cancercontacts/ncccp/contacts.asp. These documents were chosen because they represent a consistent and explicit strategy for communicating about cancer control at the state level, thereby representing an opportunity to use maps in state-level cancer control efforts. Second, to be sure that we captured the most current cancer planning activities of each state's cancer program, a follow-up search of each state's department of health Web site was performed. This process involved the following actions. The search engine google.com was employed to search the name of a state together with the search term "department of health." Once at the state department of health Web site, the top horizontal and vertical sidebar menus were searched for a link containing the words "comprehensive cancer control." If a link in the menu bar was visible, this was clicked to enter the CCC Web site. If a link was not visible from the home page, a search button was located within the home page. In the search query space, the words "comprehensive cancer control" were typed. Our aim was to identify *publicly* accessible online maps that media and other interested citizens or advocacy groups, as well as health policymakers might use based on their availability. Thus, although the maps in plans and at the state cancer control Web sites may be designed with the explicit intention of reaching program planners to provide a tool for cancer control, their availability, as with other health information posted online, brings them into the public sphere of influence.

The state cancer plans accessed via the CDC Web site and the state CCC Web sites were searched for (a) the

[1]The cancer plans were reviewed in July 2005. As of October 2005, NC was revising its plan and the cancer plan was temporarily unavailable based on procedures outlined in the methods section. Cancer plans are available by calling the state DOH and requesting it.

presence of maps in publicly accessible documents, as well as (b) interactive mapping tools. Online documents were searched for map use page by page. When static maps, those maps that are images that users cannot directly interact with but that could be viewed online, printed, and downloaded for use (e.g., publication by media), were used in documents, printed copies were made for use in coding. For the interactive maps/mapping tools, further analysis was conducted online via use of the interactive mapping tool. Available query options were systematically reviewed for (a) choice of cancer to map, (b) geographic level to map, and (c) remaining criteria (e.g., source, other content besides cancer), as discussed next.

Coding. Three coders examined all of the available maps. To address RQ1, relating to what variables were mapped and whether the maps reflected bivariate or multivariate relationships, an inductive list of the variables displayed in maps was created through the review of maps, map titles, and map legends. For the interactive mapping tools, the number of cancer types and other risk-related information in the dropdown menus were counted. Two coders generated the list of variables. A third coder used the list generated to review maps for the comprehensiveness of the list. As a result, maps were coded for presence or absence of reference to content observed to fit six categories: (a) cancer incidence, mortality, and diagnosis staging; (b) demographics; (c) health care service availability; (d) access; (e) behavioral risk factors; and (f) environmental health risk factors.

To address RQ2, maps were reviewed for (a) source citation and (b) use of disclaimers. Coding for source was performed by searching each map and its map frame for whether a source was explicitly cited; thus, the focus was on the presence of such information included as part of the map (e.g., map frame), not the presence of such information in the text of a document associated with the map. Coding for use of disclaimers was performed by navigating to reach the state CCC Web site and noting the presence or absence of disclaimer pop-ups for interactive maps, and review of static maps for any explicit statements about limitations in interpretation or use of the maps.

To address RQ3, we coded for the following based on Ekman and Friesen (1969): (a) redundancy, considered in terms of whether the map repeated/restated information about cancer incidence and relationships reported in the accompanying text of the cancer plan; (b) substitution, whether the map conveyed information that was not included in the text; (c) complementary, in which the map contained details about cancer incidence and relationships beyond what was reported in the text; (d) emphasis, in which the map highlighted or intensified a verbal message contained in the cancer plan through the use of color versus black and white versus shades of gray; and (e) contradiction, regarded as representing an inconsistent, incomplete, or mixed message when comparing the visual form with the textual form.

RESULTS

Agreement was unanimous for the geographic level of analysis being mapped; the content categories mapped; use of source citations; and use of disclaimers. Disagreements regarding the function served were discussed and resolved; refinement of definitions of five functions for maps as communication form contributed to resolution of differences. Internet Explorer was found frequently to be the preferred browser to view maps. The Macintosh-supported Safari browser, for instance, would not show legend information when viewing maps, thus inhibiting the ability to interpret maps via this technology.

Thirty-six states had CCC plans publicly available online at the time of the review in July 2005 (see Table 1). *Fourteen* of the 36 state CCC plans used static maps in their cancer plans to visually communicate about cancer and related risk information (see Table 2). In searching state health department Web sites for the cancer plans, *10* states had interactive mapping tools available to query and map cancer information. *Four* states had both cancer plans and interactive mapping tools available to the public on their state Web site.

In the 14 state cancer plans with static maps, a total of 59 static maps were identified, with the number of maps contained in a document ranging from one to 14 ($M = 4.21$, $SD = 4.57$; Table 2). The geographic unit of analysis used in maps included the following categories: (a) state/county, (b) regional or health service area (HSA), (c) census tract, (d) zip code, or (e) health professional shortage area (HPSA). As summarized in Table 2, 56 of the 59 static maps in the cancer plans used county-level data, three static maps showed state-level maps (New York, New Mexico), and four static maps displayed data by state regions or as HPSAs (Maryland, West Virginia). Interactive mapping tools had additional geographic units of analysis, which included census tract, public health district regions, or HPSAs. Two states' interactive mapping tools (New York, South Carolina) made maps available at the zip code level.[2]

Content Mapped

The first research question considered what content was being mapped in state documents addressing CCC planning and prevention. We coded for both topic and the type of statistical relationship (bivariate or multivariate) represented.

Cancer incidence, mortality, and diagnosis staging. The most frequent content category mapped overall was cancer incidence, mortality, and staging. In three fourths, or 15 of 20 states that included static and/or interactive maps (4 states having both), the content depicted addressed

[2]Details about the content identified for states with interactive mapping tools may be obtained from the first author at rlp18@psu.edu.

TABLE 1
United States: Analysis of State Comprehensive Cancer Control Plans' Content

State	*Pages*	*Maps/Charts Per Document*	*Year*
AK	46	0/13	1994
AL	141	14/25	2006–2010
AR	48	4/06	2001–2005
AZ	187	4/30	2005
CA	106	0/00	2004
CO	67	0/10	2005
CT	143	0/10	2005–2008
DE	64	0/05	2004
FL	62	0/14	2003–2006
IA	71	0/00	2003–2005
IN	68	0/06	2005–2008
KS	78	1/19	2005
KY	56	0/02	2001
LA	112	0/17	2004–2009
MA	63	0/00	1998
MD	343	7/65	2004–2008
ME	92	0/23	2001–2005
MI	43	0/00	2005
MN	66	0/12	2005–2010
NC	366	14/14	2001–2006
NJ	287	0/11	2002
NM	70	4/14	2002–2006
NY	55	2/09	2003–2010
OH	41	0/00	2003–2010
OR	254	2/08	2005–2010
PA	100	1/19	2001–2002
RI	116	0/10	2004
SC	94	0/13	1999–2004
TN	68	1/03	2005–2008
TX	100	0/00	2005
UT	48	0/17	2002
VA	133	0/07	2001–2005
WA	166	3/25	2004–2008
WV	134	3/40	2002–2007
WI	88	1/06	2005–2010
WY	26	0/25	2003–2006
M	*111*	*2/14*	*2003*
SD	*82*	*4/13*	*3*

Note. Charts include graphical representations of quantitative data such as maps, pie charts, histograms, frequency polygons or scatter plots. Tables, photographs and diagrams were excluded.

this category. However, only Oregon included information about stage of cancer in static maps, with percentage of early-stage diagnosis for all cancers included. Two states with interactive mapping tools, Georgia and Pennsylvania, included the ability to obtain staging information.

Nine of the 14 state cancer *plans* (64%) showed *cancer* maps to visually illustrate the burden of cancer. The most prevalent cancer types mapped included breast ($n=3$), colorectal (CRC; $n=3$), cervical ($n=$ 3), prostate ($n=3$), lung ($n=2$), malignant neoplasms ($n=$ 2), and melanoma ($n=1$). The cancer plans' use of maps showing overall cancer incidence without specifying a type was, however, the most frequently depicted relationship ($n=$ 8; Table 2).

Of the 10 states offering *interactive mapping tools*, 8 states had the option to query a cancer type and map it. The 8 states' interactive mapping tools had dropdown menu options to map cancer types ranging from 4 to 92 ($M=$ 38.3, $SD=$ 33.8) depending on the state. Only 1 cancer type could be mapped at a time. All of the interactive mapping tools included the choice to query the most common cancers (lung, breast, cervical, prostate, melanoma, and colorectal) with the exception of New York, which mapped 4 cancer types (lung, breast, prostate, and colorectal). Arizona provided 13 cancer types to map, explaining in a link from the Web site that these 13 cancer types were chosen for their *public health priorities*. This was defined in terms of being (a) the most prevalent cancers; (b) linked to evidence supporting the role of early detection for improving health outcomes; and/or (c) associated with public request and interest for information, with the latter including childhood leukemia.

Demographics. The second most common variable mapped among states was demographic information, with 14 of 20 states including this content as a focus in maps. Eight of 14 state cancer *plans* displayed maps of demographic information. Among the cancer plans, two states showed maps of ethnic makeup by showing percentage of African Americans or Hispanics in a state ($n=$ 5 maps), seven states showed maps of population density or percentage rural versus urban areas ($n=$ 9 maps), and one state showed a map of poverty rates (n = 1 map; Table 2).

Seven of the 10 states with *interactive mapping tools* had a dropdown query option to map demographic information in combination with cancer-related data associated with a geographic location. The interactive mapping tools included dropdown menus of race, gender, and age. Race dropdown menu options included all, White, Black, other, and unknown. Age dropdown menus ranged from just clicking age to choosing an age bracket, which ranged from 4- to 10-year spans. A broader range of demographic information was available with the interactive than with static maps. Examples of additional variables that could be mapped included socioeconomic status or primary non-English languages spoken in a neighborhood ($n=$ 2 states). These variables, however, could not be mapped in combination with cancer data even in the interactive maps.

Health care service availability. The third most frequent overall category of content shown in map form was health care service availability, with half (10) of the 20 states including information related to this category. Five of 14 state cancer plans (static maps), and 5 of the 10 states with interactive mapping tools mapped health care services. This content category included mapping federally designated health professional shortage areas (HPSAs) or health care underserved areas (HCUA; $n=$ 2 maps), accredited

TABLE 2
Content of Static Maps in State Comprehensive Cancer Control Plans

State/No. of Maps	*Cancers Mapped*	*Other Attributes*	*Unit of Analysis*	*Source*	*Year*	*Cancer Plan*
Alabama/14	Incidence and Mortality:	% AA, Hispanic AL Black Belt;	County	ASCR; U.S. Census;	2000; 2004;	pp. 12, 13, 17, 34 pp. 55, 65, 72, 102
	Breast, CRC cervical,	Obesity; radon		BRFSS	1993	(pp.18, 19, 24)[a] (pp. 41, 62, 72, 79)[a]
	prostate					(p. 109)[a]
Arkansas/4		% AA, Hispanic age, population density	County	U.S. Census	2000	pp. 3, 4, 5
Arizona/2[b]	incidence and Mortality malignant neoplasms		County	Arizona Cancer Registry	1999–2001	pp. 18, 22, 150 p. 151
Kansas/1		Cancer treatment locations	County			Final report: p. 34 (38)
Maryland/7	Mortality: Lung, CRC, Breast, cervical, prostate	% rural population	County; Geographic Area	Maryland Division of Health Statistics; U.S. Census	1995–1999 2000	pp. 29, 71, 110, pp. 193, 213, 239 p. 283
North Carolina/14	Prevalence;	Accredited cancer centers;	County	ACOS;	2000;	(pp. 61–74)
	annual No. of cases	population;		U.S. Census;	1996–2000	
		No. of cancer registries; radiation treatment facilities and options; oncology specialists and type; hospice services and type; home care services and type; diagnostic services and No. of patients; treatment services and No. of patients; transportation		NC Cancer Registry; NC Department of Environmental and Natural Resources; NC DOH; NCI Hospice for Carolinas		

New Mexico/4		Population density and U/R, women receiving financial assistance for cancer services; PCP services; poverty rates; underserved areas	County; State	New Mexico DOH; Rural Health Bureau; Atlas of Primary Care Access	2001	pp. 11, 26, 27, 28 (pp. 25, 40, 41, 42)
New York/2		Population	State/city density; community forums	U.S. Census	2000; 2003	pp. 8, 50 (pp. 9, 51)
Oregon/2	% early stage diagnosis of all cancers	U/R	County	Cancer in Oregon	1998–2002	pp. 13, 16 (pp. 17, 20)
Pennsylvania/1	Cancer mortality observed and projected		County	Pennsylvania Department of Health Statistics	1999–2001	p. 47
Tennessee/1	Overall incidence of cancer		County	Tennessee Cancer Registry	1997–2000	p. 67 (p. 69)
Washington/3	Incidence and high-risk areas: lung and bronchus; melanoma	Radon	County	U.S. Census, Washington Cancer Registry, Washington Department of Environmental Health	1997–1999; 2000; 1994	pp. 32, 33, 75 (pp. 34,35,77)
Wisconsin/1		Palliative care providers	County	ABHPM	2004	p. 59 (p. 75)
West Virginia/3	Cancer mortality overall	Rural areas; medically underserved; health professional shortage areas; ACOS accredited facilities	County; DOH-defined regions	ACOS	1993–1999; 2001	pp. 3, 18, 97

AA = African American; ABHPM = American Board of Hospice and Palliative Medicine; ACOS = American College of Surgeons; ASCR = Alabama State Cancer Registry; BRFSS = Behavioral risk factor surveillance system; CRC = colorectal cancer; DOH = Department of Health; HPSA = Health professional shortage areas; PCP = Primary care provider; U/R = urban/rural; NC = North Carolina. [a]Page numbers in parentheses are the pages to enter when printing because page numbers visible in cancer plans are not necessarily consistent with the page numbers for printing.[b] Arizona used two maps twice (a second time in the appendix) in the cancer plan.

hospitals (accredited by the American College of Surgeons, ACOS) indicating hospitals that offer comprehensive cancer care (n = 1 map), diagnostic cancer centers ($n=2$ maps), treatment facilities ($n=5$ maps), number of specialists ($n=2$ maps), hospice and home care ($n=3$ maps), and schools providing primary health care ($n=1$ map).

Accessibility. The fourth most common variable to be mapped by states that used maps was accessibility-related information, although only 4 of the 20 states that had maps included this content. One of 14 state cancer plans contained maps of access. North Carolina included nine such maps. Three of the 10 interactive mapping tools (Arizona, Washington, California) showed access-related information. Accessibility information included mapping of transportation routes, including public transportation/bus routes and/or major/interstate highway routes; and distance to reach acute care centers, including barriers, such as mountains that need to be circumvented, that increase travel time. Washington's interactive mapping tool showed multivariate maps of rural areas, specifically areas more than 30 minutes away from a retail pharmacy, and access routes to hospitals, retail pharmacies, or acute care centers. Both Washington and Arizona mapped Indian reservations. However, Washington mapped reservations together with access routes to tribal clinics, whereas Arizona mapped reservations and depictions of interstate highways.

Behavioral risk factors. Overall, 3 of the 20 states mapped behavioral risk factor data. One state's cancer plan used maps to show behavioral risk factor data for obesity, whereas 2 states with interactive mapping tools (Florida, Georgia) mapped screening behaviors for adult women who have had a pap smear test in the past 2 years and other behavioral risk factor data that included adults who currently smoke or adults who have a body mass index over 30. This information could not be mapped together with cancer data.

Environmental health risk factors. Two state cancer plans included static maps of radon (Alabama, Washington). Both states showed geographic areas known to emit elevated radon levels. No states with interactive mapping tools in the context of CCC had dropdown menus to map environmental health risk data. Although environmental health maps may exist outside of CCC venues, the focus of this content analysis was to examine the content of visual CCC messages.

Statistical Relationships Depicted

Fifty-five of the 59 static maps reviewed (93%) in cancer plans included bivariate relationships, showing incidence *or* a demographic variable based on a geographic location. The exceptions were maps in North Carolina's and West Virginia's cancer plans. Three maps in North Carolina's cancer plan showed multivariate relationships between estimates of cancer incidence; availability of accredited cancer centers, treatment facilities, or oncology specialists; and geographic region. One map in West Virginia's plan showed rurality, HPSAs, and medically underserved areas in a single map using hash marks and shading to visually make apparent areas of overlap.

Nine of the 10 interactive mapping tools (90%; Iowa was the exception, as only patient resources were mapped) provided information that could be mapped as multivariate data. Although California's and Washington's interactive mapping tools did not map cancer, they did map health care access data and place. Six states with dropdown menus (Florida, Georgia, Kentucky, New York, Pennsylvania, and South Carolina) gave the option to map multivariate information including geography; a cancer type; and demographics like age, gender, or race. One state's interactive mapping tool (Florida) had the option to map cancer screening behavior by gender. Arizona's and Washington's interactive mapping tools did offer multivariate maps, but not with cancer. Maps showed multivariate relationships between rurality, mapped as tribal reservations, interstate highways, and access to clinics or pharmacies.

Credibility of Content Mapped

Credibility of maps was assessed in two ways. Maps were examined for (a) disclaimers relating to use and (b) source citation. Coding for use of disclaimers, defined as informing the reader of the purpose, limitations and conditions of map use and interpretation, was performed by navigating to reach the state CCC Web site and noting the presence or absence of disclaimer pop-ups. In addition, maps were coded for disclaimers by searching each map and its map frame for the presence of disclaimers. Nine of the 10 states with interactive mapping tools used disclaimers in the form of pop-ups before being able to download a map. Some disclaimers would not allow the user to continue unless the "agreed" button was clicked. South Carolina's mapping tool disclaimer pop-up appeared only when trying to map zip code-level data. The pop-up noted that data should be used with caution due to the small population base of cases. Disclaimers informed the reader that the purpose of available maps was for informational and educational needs to improve service delivery, evaluate health care systems, and monitor health outcomes, but should *not* be used for diagnosing health problems. Disclaimers also prohibited, by allowing the user access only if the agree button was clicked, as well as explicitly stating so, the determination of the identity of any reported cases, stating that individual cases are private health information. Half or 5 of the 10 states with interactive mapping tools (New York, North Carolina, Kentucky, California, and Arizona) offered mapping primers as links, explaining what information maps can and cannot provide and how to interpret and understand maps. Florida's tool stated that maps supported health problem analysis and decision making for communities conducting health assessment and improvement activities.

Only 1 of the 14 state cancer plans using static maps had an explicit disclaimer in the map frame (Washington, $n = 1$ map). Washington's map of radon levels had in its map frame, in verbal form, that the state does not warrant the accuracy, reliability, or timeliness of any information published in the map and assumes no responsibility for errors in content of the information provided. It stated that persons who rely on information obtained from this map do so at their own risk. Furthermore, the name of the individual who had prepared this particular map was also in the map frame. No other maps provided explicit names of individuals who had prepared a map.

Coding for source was performed by searching each map and its map frame for the explicit statement of a source citation for the data presented. Results for static maps are summarized in Table 2 within the source column. All 20 states that used maps in public documents provided sources for their mapped data. All states' sources were government (e.g., U.S. Census) or state health authority sources (e.g., state cancer registry).

Map Communication Functions

Maps were coded for their function, which revealed that although maps often functioned to repeat information that appeared in verbal form, they also may appear to contradict the verbal content when used alone as a reference to statistical relationships. The latter represents the reality that the verbal content often referred to multivariate relationships relating to cancer, whereas visual representations mostly showed bivariate relationships, as will be elaborated below.

Redundancy. Cancer maps functioned to repeat information provided in the text of cancer plans in 10 of the 14 states using static maps to convey cancer risk information. Because *map* function was coded, the number of maps will be reported here. From a total of 59 static maps in the 14 cancer plans, 53 maps (90%) functioned to repeat information in the accompanying text. Interactive mapping tools functioned independently of the state comprehensive cancer plans. Thus, none of the interactive maps were coded as repeating information that appeared in the cancer plans, because they functioned independently.

Substitution. Five of the 14 state cancer plans used maps that substituted for information in the accompanying text. That is, maps conveyed information that was not explicitly included or stated in the cancer plan text. In these five state cancer plans, 6 of 59 *maps* (10%) substituted for verbal or textual information. Washington's cancer plan text, for example, addressed intermittent but intense exposure to the sun as a known risk factor for melanoma. The text mentioned that *certain* areas of the state, without explicitly mentioning which locations, appear to be at greater risk than others, and that the burden for cancer is not equally distributed among regions of the state. A melanoma map adjacent to the text of the cancer plan showed the *eastern* region of the state as having significantly high relative risk for melanoma. In this example, visual information thus informed about details not specified in the text. In another example, Kansas's cancer plan text referred to *access* to cancer care, whereas the adjacent pin map, literally showing color-coded pins, revealed the *locations* of cancer treatment around the state. Wisconsin's cancer plan text discussed how many patients must travel great distances to see a palliative care provider. The adjacent map of certified palliative care providers showed that providers were concentrated in urban areas.

Complementary. Six of the 10 states offering interactive mapping tools (60%) were coded as visual information functioning as complementary, defined as representing the content provided in the text and elaborating on the information. The interactive mapping tools provided links to more detailed information. Hypertext links allowed map viewers to seek more in-depth information about a county, including such issues as population size. The static maps, by contrast, did not either repeat information contained in the text in combination with extension or elaboration of the information.

Emphasis. The use of color schemes in cancer maps emphasized the *relative* cancer burden related to geographic location by visually highlighting differences in state maps. Colored geographic units (e.g., counties) visually qualified the relative cancer burden in the state either with respect to how the cancer burden fared among counties *within* the state or how the state cancer burden compared to the *national* cancer burden. Eight of the 14 state cancer plans used color maps ($n = 28$ maps; 28/59, 47%). Nine of the 10 states with interactive mapping tools (90%) generated color maps. The use of color visually emphasized relative differences in cancer burden or risk factors contributing to cancer. Washington used a map in their cancer plan titled "Access to Nearest Acute Care Hospital," in which areas more than 30 min from an acute care hospital were made *visible* with the use of color. Color was also used to highlight relative differences in demographics or access to health care services.

Contradiction. In coding for contradictions between visual and verbal presentations of information, we considered that users often rely on visual forms of evidence when they are present and ignore verbal content, a shorthand processing strategy (Parrott et al., 2005). Thus, we included in our coding of *contradictions* those cases that acknowledge that maps illustrating bivariate relationships are often only partial representations of multivariate information provided in the text. We observed this dynamic in 5 of the 14 (36%) state cancer plans' use of maps. Discussions in the text for lung cancer burden and the link with smoking in Washington's state cancer plan integrated the reality that cancer burden is partially accounted for by behavior. The accompanying map juxtaposed to the text showed a map of cancer incidence. Because maps were principally used to show either cancer incidence *or* screening practices *or* demographic information (e.g., age distribution, ethnic makeup in states), the information needed to comprehend a relationship among more than two variables was absent in the visual message, although often present in the verbal message. The text often clarified the more complex picture behind the static visual message. The visual alone, which emphasized geographic differences, thus has the potential to be misunderstood if the accompanying verbal explanation is not read.

While 8 of the 10 states with interactive mapping tools did have dropdown menus to generate cancer maps by gender, age, or race, the complex picture that tells the *complete* story of cancer was not manifest in these maps. Having said this, we also acknowledge that interactive maps may not directly correspond to a specific text addressing an aspect of cancer. Hence, the variety of maps that interactive mapping tools make possible might also function to substitute for text.

Another instance of possible contradiction occurred in relation to the issue of rurality and its known links with underserved areas. Maps most often depicted bivariate relationships with respect to showing health care service availability. They displayed either health care service availability in varied geographic locations *or* rurality and frontier areas, but seldom did they overlay these attributes in a single map, which would make the multivariate connections visually explicit. Exceptions to this occurred with two states (West Virginia and Washington). West Virginia had a map in their cancer plan that overlaid rural areas, HPSAs, and medically underserved areas. Washington's maps illustrated the distance people must travel *and* the locations of pharmacies.

Comparing maps with text and finding missed opportunities to convey content found in the text illustrates another possible contradiction. No maps reviewed, for example, integrated cancer staging (percentage late or early detected cancer) by ethnic group, even though five states (Maryland, Washington, Alabama, Arizona, and North Carolina) discussed this important point in detail in the text, relating it to addressing cancer disparities. Maryland's and North Carolina's cancer plans explicitly stated that minority and rural residents were more likely to be diagnosed at later stages of disease and have higher cancer mortality rates. Washington's cancer plan noted that breast cancer incidence is higher among high-income women, but that risk for late-stage breast cancer is higher among poor, minority, urban women. These states showed demographic information in maps but did not visually link cancer stage detection rates with socioeconomic status or ethnicity, a missed opportunity to represent these relationships in ways that might emphasize the connections.

DISCUSSION

Countless forms of visual health and risk communication, including disease maps, are available to Internet users. The Internet extends public and policymaker access to such information, which may then be used in decision making about how to allocate scarce resources to benefit citizens' health and well-being. One purpose of this research was to assess the extent to which and for what purposes maps are accessible online to portray the scope of state cancer burden. Maps were found to be accessible online in many state cancer plans, often depicting predominantly bivariate statistical representations of regional or state cancer distribution, and functioning to repeat information that appeared in the text of state cancer plans.

The most frequent content category displayed in maps was cancer incidence and mortality, with geovisual evidence forms used less often to communicate messages about other factors contributing to the picture of cancer (e.g., access, demographics, health care service availability, behavior, environment) as a public health issue. For instance, stage of cancer at diagnosis and its relation to screening as an intervention was seldom accessible in maps. The Alabama Department of Public Health reported that initial analyses using GIS were limited by a lack of staging information (Miner et al., 2005). Lack of available data likely explains in part why other factors than cancer burden were seldom shown in maps. As information (i.e., datasets) about factors contributing to the national cancer burden become available, states will be less limited in representing other aspects of cancer. Maps of service availability, access, and lifestyle behaviors may provide evidence for solutions and not just the extent of burden, offering a more balanced and optimistic message.

A shorthand method for representing broad strategic needs at the population level, maps may assist users in comprehending the complexities of a disease like cancer. The connection between place and disease incidence, death rates, or stage of disease at diagnosis is not a simple one, however. Viewers of maps, which function to direct attention, may draw inappropriate conclusions about the quality of the environment in a given location to explain the data. The depiction of health care service availability offers an alternative explanation for why incidence may be high in one place as compared to another. If maps overlay incidence and service availability, or include side-by-side images to emphasize that high incidence occurs in areas with low service availability, this may better convey that valid explanations for cancer incidence in given regions are multifaceted. In this analysis, maps seldom included overlays of data to enrich their meaning or appeared in side-by side frames to promote understanding.

Some variables may be better suited to bivariate depiction than others in efforts to promote comprehension. These decisions should be made with care, as it seems less likely that map users would conclude that the environment caused health care service shortages than would conclude that the environment caused cancer. Yet the former may be a reality in situations where a map depicts access to cancer treatment centers but fails to depict transportation routes. Few states mapped access routes to service destinations, representing a possible dilemma associated with mapping content. The topography associated with geographic location comprises a critical component of accessibility. Maps *can* convey this reality. However, maps that depict sites for hospitals offering comprehensive cancer care but do not include information about transportation routes may appear to depict adequate coverage for citizens who must travel great distances, navigating mountain ranges or other barriers, to reach an actual site for care.

Multivariate relationships were rarely depicted. Mapping cancer incidence and/or mortality while *visually overlapping* health care service availability and access routes, for example, would be likely to present a more valid picture than images of only one of these variables mapped in a single visual image. The multivariate image may also be more memorable than a text that conveys the same information. In fact, although 14 of the states with cancer control plans online at the time of this analysis included at least one static map as part of the plan's content, only 2 states included any maps that represented statistical information as a multivariate rather than a bivariate relationship. Cancer mapping thus raises the question of whether an emphasis on geography contributes to or distracts from tasks relevant to cancer control planning.

In the case of cancer control activities, visual representations may facilitate planners' efforts to prioritize some activities in lieu of others. For example, what cancer to focus on, what age group appears most at risk, what resources are needed to support prevention and detection, and in what areas do these issues seem to be more versus less relevant. Disease maps provide a strategy to visualize combinations of variables in ways that make some patterns for risk more evident. This well illustrates the need, however, for care in translating statistical findings to be communicated in efforts to guide resource allocation and policy decisions, as well as public understanding. Although disease mapping may offer some advantages over verbal translations of data when maps present overlays of data displays for multiple variables, the image may limit the scope of understanding when multivariate relationships are represented as bivariate relationships.

There is promise associated with the communication potential of disease mapping when maps are used for emphasis or to repeat content contained in a verbal message, and these functions often emerged as salient in this analysis. There are inherent dilemmas, however, when maps represent information in an incomplete, inconsistent, or contradictory fashion. The analysis presented here suggests a need for prudence on the part of the end user, and for map creators and cancer plan developers who disseminate the information. There may be valid reasons for using primarily bivariate maps given that there are trade-offs when deciding how much information to present in any one map so as to optimize its visual impact. If maps become too cluttered with information they may lose their power to make a favorable or memorable impression.

Limitations and Future Research

The actual effects of maps on users remain to be ascertained in future research, as the potential effects are projections from research with other forms of visual communication used to represent statistical information about health. The reasons that organizations adopt GIS as tools for visually representing evidence to be used in decision making also suggest an important pursuit. This project relied on publicly accessible documents relating to state CCC activities to evaluate the role of disease mapping for planning cancer control activities. It is noteworthy that within the 36 accessible state cancer plans online, 20 of these had publicly accessible maps to communicate information about this disease relative to their state. Although clearly significant, it is also noteworthy that 30 states did *not* have these visual representations of evidence about cancer in their state available for public viewing. Although this does not necessarily mean that decision-makers were not making use of maps, the public could not access the information online. This content analysis also only examines one particular context—communication about cancer burden and the associated relative risk factors.

Maps as evidence form distill complex epidemiological information in this context into a more parsimonious form. Numeracy skills have proven to be barriers to understanding probability estimates in the presentation of health information (Adelswald & Sachs, 1996) and may relate to the abilities and motivations of map users. This may also have significant implications for the subsequent utility of GIS tools for cancer planning. Additional ethical concerns are associated with disease maps, which may promote labeling of some areas as sites of high cancer risk. An ethical framework considering the impacts of making cancer maps available to the public should be integrated to guide efforts associated with policies promoting use of GIS and communication related to GIS results.

In sum, this first decade of the 21st century purports a wide range of information science and technology options to expand opportunities for the dissemination of knowledge gained from prior medical research and the facilitation of informed decision-making about the allocation of resources to derive even greater understanding that would benefit the greatest number of potentially affected citizens. As GIS literally comes online in the health planning process, a visual case may be made to support the relationships between such environmental encouragers as fast food restaurants, obesity, and perhaps breast or colon cancers, as well as green space, bicycle trails, and perhaps a lower incidence of these diseases. Applied to public health, GIS mapping carries powerful utility because its form as geographic frame and its medium as interactive information technology mediate thought to "see" links that are not evident in other forms.

GIS represents an information technology tool with the promise to reveal both (a) potential audiences who need to be reached with prevention and screening information and services, and (b) other influencers who might be targeted within an ecological model of public health, including individuals, families, communities, and societal-level factors (Gebbie, Rosenstock, & Hernandez, 2003). The effects of maps as a communication strategy, as with other forms of evidence, will likely encompass both positive and negative outcomes, with the description of use afforded by this analysis suggesting both the promise and related dilemmas. Caution regarding map use to depict statistical information is warranted, as it may essentialize geography in unwarranted ways. Although *environment* has emerged as a significant harbinger of well-being, health communicators consider this construct to include social, access, policy, message, and ecological components. Efforts to use maps in ways to emphasize geography, as with other forms of evidence, should be appropriately contextualized.

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