Journal of Homeland Security and Emergency Management

Volume 4, *Issue* 3 2007 *Article* 16

GIS Maps to Communicate Emergency Preparedness: How Useable Are They for Inner City Residents?

Christina Zarcadoolas* Jennefer Boyer†

Arthi Krishnaswami‡ Andrea Rothenberg**

*Mount Sinai School of Medicine, christina.zarcadoolas@mssm.edu

†Mount Sinai School of Medicine, Jennefer.boyer@gmail.com

‡Consultant, arthi.krishnaswami@gmail.com

**Mount Sinai School of Medicine, andrea.rothenberg@mountsinai.org

GIS Maps to Communicate Emergency Preparedness: How Useable Are They for Inner City Residents?

Christina Zarcadoolas, Jennefer Boyer, Arthi Krishnaswami, and Andrea Rothenberg

Abstract

Despite the growing popularity of Geographic Information System (GIS) information maps as a public health tool, there are no published studies of low-average and low literacy adults' abilities to read and use GIS information presenting emergency preparedness information. We hypothesized that GIS maps are hard to read for at least the 50% of adults in the US reading at 8th grade level or lower (Kirsch et al., 1993). Using a current GIS map used in New York City's Office of Emergency Management Storm Surge Report researchers conducted interviews with 178 English and Spanish speaking residents of East and Central Harlem. Findings reveal that a majority of adults who have not completed high school could not read and use the maps for basic and vital information, including identifying if they lived in a hurricane evacuation zone, and locating where the nearest evacuation center to their home was. This study concludes there is a real and dangerous gap between the language and design of GIS and the abilities of millions of adults to interpret and use this information as currently presented.

KEYWORDS: emergency preparedness communication, health literacy, health communication, health education, public safety, GIS maps

GIS maps to communicate emergency preparedness: how useable are they for inner city residents?

Since Hurricane Katrina there has been a nationwide emphasis on getting emergency preparedness information and training to residents in coastal areas. New York City is no exception. The NY Office of Emergency Preparedness released the New York City Coastal Storm Plan (CSP) to the public as "Ready New York: Hurricanes and New York City Aug-Sept. 2006" (http://www.nyc.gov/html/oem/html/ready/hurricane_guide.shtml). The plan's central visual is a geographic information system (GIS) map indicating what areas of the city are designated hurricane evacuation zones, the degree of hazard in zones, and the location of evacuation centers. The map is available on the web in an interactive format. The print brochure version was mailed to residents living in designated hurricane evacuation zones in NYC in summer, 2006. Despite the growing popularity of GIS as a tool in public health, however, there is very little research done on the abilities of lay and low literacy publics to read and use GIS data as it is presently being displayed to them.

GIS data is primarily presented in the form of maps, with multiple layers of data, e.g. geographic information, population data, health or environmental data, construction information, etc. The maps are frequently used as a method of constructing an argument or illustrating alternatives in a decision faced by a community. Given that 50% of the adult population reads at the 8th grade level or lower (NALS 1993, NAALS, 2003), we expect these maps in their present form and presentation to be a high barrier for many low literate publics.

A geographic information system (GIS) is a database system with software that can analyze and display data using digitized maps and tables for planning and decision-making. A GIS can assemble, store, manipulate, and display geographically referenced data, tying this data to points, lines and areas on a map or in a table. GIS can be used to support decisions that require knowledge about the geographic distribution of people, hospitals, schools, fire stations, roads, weather events, the impact of hazards/disasters, etc. Any location with a known latitude, longitude, address, or other geographic grid system can be a part of a GIS (Lauden & Lauden, 2000).

GIS provides ideal platforms for the convergence of disease-specific information and their analyses in relation to population settlements, surrounding social and health services and the natural environment. They are highly suitable for analyzing epidemiological data, revealing trends and interrelationships that would be more difficult to discover in tabular format. GIS allows policy makers to easily visualize problems in relation to existing health and social services and the natural environment and so more effectively target resources (CDC, 2006). GIS maps have become a ubiquitous means of analyzing and presenting health and

emergency information at the global, federal and state levels (ATSDR, 1998; CDC, 2000, 2006; WHO, 2006; NLM, 2006; FEMA, 2005; CA Nutrition, 2006). Significantly 80-90 percent of all government databases, including public health, contain geo-referenced information (Cheves & Wang, 2004).

Since 1993, WHO's Public Health Mapping and GIS Program has been leading a global partnership in the promotion and implementation of GIS to support decision-making for a wide range of infectious disease and public health programs. "Who's Public Health Mapping Program" (http://www.who.int/health_mapping/en/). ESRI, the leading designer of GIS software, hosted the first "Annual Conference GIS in Public Health" (URISA May 2007). Signifying the growing importance of GIS to public health, ESRI also hosted their annual Health GIS conference in conjunction with their Homeland Security conference in Denver (October, 2006). This demonstrates the link between health and security interests.

GIS technology can aggregate statistics and overlay the data with digital maps to help public officials target and plan responses or focus clinical resources (Croner, 2003). CDC states, on its website *Public Health and GIS*,

> Researchers, public health professionals, policy makers, and others use GIS to better understand geographic relationships that affect health outcomes, public health risks, disease transmission, access to health care, and other public health concerns. GIS is being used with greater frequency to address neighborhood, local, state, national and international public health issues (CDC, 2006).

GIS is a very useful tool for many aspects of emergency management, including: emergency response, planning, exercises, mitigation, homeland security and national preparedness. In addition to its ability to manage and display data, GIS has robust modeling capabilities, allowing its users to adjust data and scenarios for prediction, planning and estimation.

Simultaneously, GIS maps are also becoming a common way of communicating information to lay publics (FEMA, 2005; NYOEM, 2006; Florida 2006). CDC's *Gather* tool (Geographic Analysis Tool for Health and Environmental Research) is a premier example of making GIS information available to provide the public health community and "general public access to spatial data that is pertinent to the analysis and exploration of public health issues." GIS maps are used by federal and state agencies, the media, academic communities, and community agencies working on health and environmental issues (WEACT, and CECHI, 2005).

Frequently audiences are asked to understand elements, such as the distribution of risk across space and the concentration of elevated risk in particular

communities. For example, GIS has been used in the Gulf states as an information tool for "identifying sources and routes of contaminants, evaluating the potential for future exposures, assessing human exposures that occurred in the immediate aftermath of the hurricanes, and assessing the immediate and longer term health impacts associated with these exposures" (NIEHS Katrina/Rita Response Portal http://balata.ucsd.edu:8080/gridsphere/gridsphere).

The current trend in GIS is on web-based mapping. This capability can allow users to view an already created map or create maps, based on their own specifications, on their personal computers. Web-based mapping is expected to widely expand the use of GIS in the workplace, in schools, and in homes (FEMA, 2005). An example of the growing adoption of GIS technology as a teaching and community advocacy tool can be seen with West Harlem Environmental Action (WE ACT). This leading environmental justice organization began creating and posting GIS maps on its website in 1999 in order to allow residents to work with the health and pollution data vital to understanding the relationship between the two and the advocacy and policy implications (http://weact.org/gis/samplemaps.html).

GIS Maps and Health Literacy

Over 30 years of evidence shows that a significant portion of the U.S. adult population has difficulty accessing, understanding, and using information about health (Rudd, 2002; IOM, 2004; Schwartzberg et al., 2004; Nielson-Bohman, 2004; Zarcadoolas et al., 2006; Zarcadoolas, 2006a). A disproportionate number of members of ethnic minorities and whites of low socioeconomic status have a higher risk of poor health and poor living environments, as well as risk from environmental health hazard.

The first NALS (National Adult Literacy Survey, 1993) and the latest NAAL (National Assessment Adult Literacy, 2003) reveal that at least 73 million adults in the U.S. have either basic or below basic health literacy. Below basic involves being able to do the most simple and concrete literacy skills, and basic refers to simple and everyday literacy activities. There were no significant changes in the populations' abilities to read documents and prose between the 1993 and 2003 surveys and some improvement in quantitative tasks. Eleven million adults could not participate in the survey because of language barriers or because they lacked the very basic literacy skills (National Center for Educational Statistics, 2006).

The negative consequences of low health literacy include compromised or poor abilities to make informed decisions about health issues, to respond to emergency preparedness messages, and to mitigate environmental health risks from chronic pollutants and toxicants. These directly lead to poorer health

outcomes, greater environmental injustice at the community level, as well as a variety of increased costs to society.

The Office of Emergency Management (OEM) in New York City developed and circulated an 8.5x11in printable PDF map in July of 2006 to be used by the public in the case of a hurricane-related evacuation. The OEM released the New York City Coastal Storm Plan (CSP) to the public as "Ready New York: Hurricanes and New York City Aug-Sept. 2006." (http://www.nyc.gov/html/oem/html/ready/hurricane_guide.shtml).
The Plan uses a GIS map to tell New Yorkers about the level of hazard of hurricanes in their neighborhood and where to go if they need to evacuate. The brochure version of the plan, which is also available on the web, was mailed to all residents living in designated hurricane evacuation zones in NYC. The Plan includes a large, fold-out map indicating what areas of the city are designated hurricane evacuation zones, degree of hazard of zone, and where the evacuation centers are located in these areas. The readability of this map was tested in a pilot study conducted by Mt. Sinai School of Medicine in East Harlem.

Study Population

According to the 2000 US Census, close to 260,000 people reside in East and Central Harlem, with an average household income of approximately $20,000 a year ($18,564 for East Harlem and $21,508 for Central Harlem) (NYC Dept of City Planning). More than a third of the residents are living in poverty. Almost one-third of residents in East Harlem (31%), and Central Harlem (22%) report being in fair or poor health (versus very good or good), (Manhattan 18%; NYC 21%) (Olson, 2006). In 1996, Central Harlem had the highest crude death rate of any health district in New York City, that is, 14.1 per 1,000 population compared to a city-wide rate of 9.1 per 1,000 population (New York City Dept. of Health). In 1996, there were 423.4 coronary heart disease deaths per 100,000 people, in contrast to the Healthy People 2000 goal of 115 for blacks. There are higher rates of STIs (Sexually Transmitted Infections), adolescent pregnancies, depressive disorders, and homicides as well. A study based at the Harlem Hospital Center found that 25.5 percent of children in central Harlem have asthma, double the expected rate and one of highest ever documented for an American neighborhood. East Harlem tops the city in childhood asthma hospitalizations, with 170.2 hospitalizations per 10,000 population for children aged 0-14 in the year 2000, compared to a citywide average of 64 per 10,000, and a national average of 33.6 childhood asthma hospitalizations per 10,000 people in 2000.

Harlem is a very diverse community with a wide range of ethnic backgrounds and languages. Eighteen percent of East and Central Harlem residents are not proficient in English (NYC Dept Planning). Of those who do not speak English,

82% speak Spanish (Healthy Harlem, 2006). Due to the high density of Hispanics, the southern portion of East Harlem is referred to as Spanish Harlem or El Barrio. Harlem also has very low literacy levels. Forty-six percent of East Harlem residents and 33.5% of Central Harlem residents have not graduated high school (NYC.gov). Community residents of northern Manhattan have a rich history of organizing to promote health and challenge environmental exposures that pose health hazards in the community, but have often lacked access to the technical and informational resources to help them in their efforts to understand and prioritize health risks.

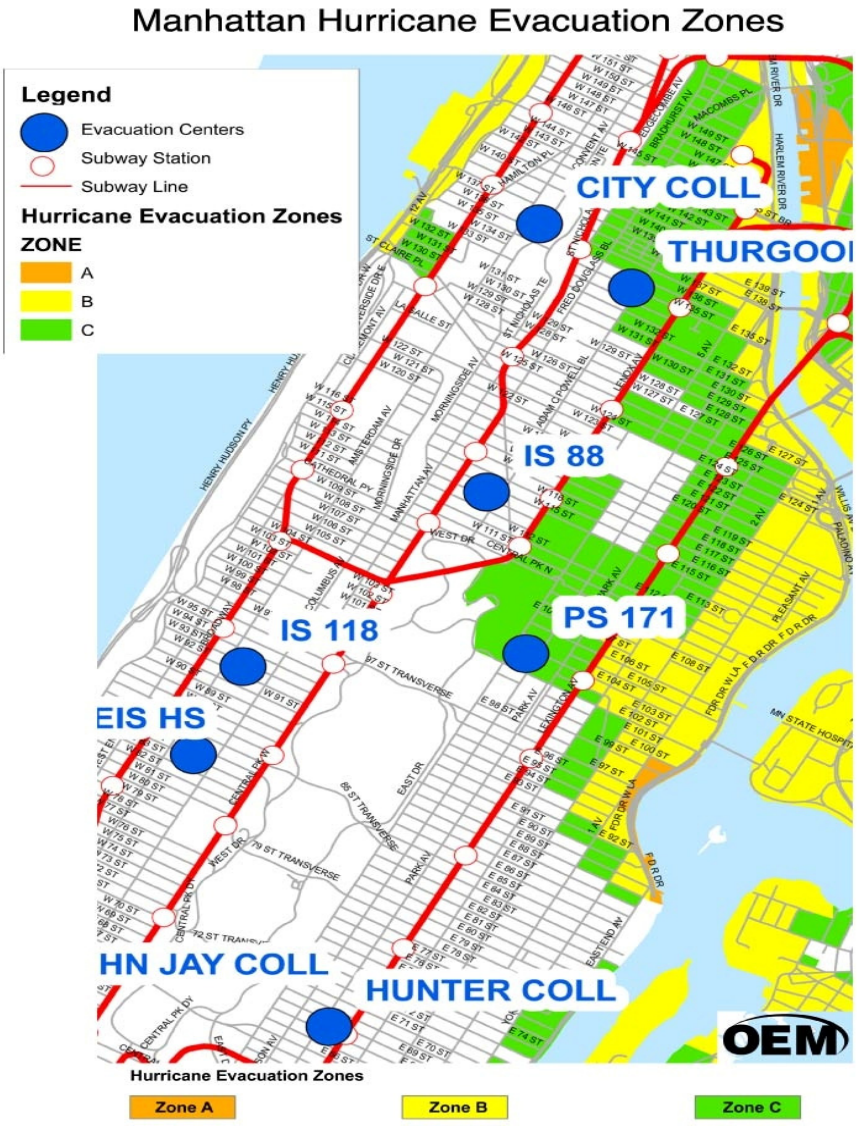
Methods

The study design was a cross-sectional survey consisting of face-to-face interviews throughout the community. To be eligible, a person had to be age 18 years or older. No personal identifiers were used. Survey participants consisted of 178 residents (134 English-speaking, 44 Spanish-speaking) randomly selected and interviewed at various locations throughout East and Central Harlem including New York City Housing Projects as well as the Prenatal Clinic at the Mount Sinai School of Medicine. Seniors were accessed at nine senior centers and three senior residences in East Harlem. Spanish interviewers were staff of the health education department, fully bi-lingual native speakers of Spanish with extensive experience in community relations. English interviewers were trained ethnographers, supervised by a sociolinguist specializing in health literacy.

Survey questions were designed, pilot tested and revised, and included a series of questions, which required the respondents to refer to a street-readable sized version of the CSP Hurricane Evacuation Zone map. Other survey questions sought demographic information and information on current knowledge, attitudes, and preparedness with emergency situations. Surveys were administered during August and September of 2006. Of the respondents, 40% (n=72) had not graduated high school, a number very representative of the U.S. Census statistics that maintain 39% of East and Central Harlem adults have not graduated high school (New York City Department of City Planning, 2006).

Data were analyzed using SPSS version 13.0 (SPSS, Inc.). Odds ratios (ORs) and 95% confidence intervals (CIs) were calculated for the relationships between demographic variables and outcome variables. The demographic variables considered were age, sex, educational attainment, language, and length of time living in NYC.

Figure 1 Map of Manhattan Hurricane Evacuation Zones



Findings

Findings reveal that the current map used to communicate vital information about hurricane emergencies to the public is not readable and usable by a significant portion of the Harlem community. The vast majority of surveyed residents who had not completed high school could not correctly determine if they lived in a hurricane evacuation zone, which zone, and the correct location of the nearest Hurricane Evacuation Center. Furthermore, 40% [OR: 5.65 (2.58, 12.35)] of those who had not graduated high school could not use the map to locate where they lived (see Table 2). Forty-six percent of the adults in E. Harlem have not graduated high school (NYC Dept. of City Planning, 2006). Furthermore, 38.2% live in poverty. After adjusting for education, the other variables (age, sex, language, and length of time living in NYC) were not found to be significant.

Table 1: Ability to answer questions correctly while looking at map (based on education level)

		Incorrect *n* (%)	Correct *n* (%)	OR (CI)*
Can you point to where you live?	Low Ed	29 (40.3)	43 (59.7)	5.65 (2.58, 12.35)
	High Ed	11 (10.7)	92 (89.3)	1.0
Judging from these maps, do you live in hurricane evacuation zone?	Low Ed	51 (73.9)	18 (26.1)	6.58 (3.32, 12.99)
	High Ed	31 (30.1)	72 (69.9)	1.0
What zone do you live in?	Low Ed	57 (82.6)	12 (17.4)	9.35 (4.44, 19.61)
	High Ed	34 (33.7)	67 (66.3)	1.0
Which hurricane evacuation center is closest to your home?	Low Ed	46 (65.7)	24 (34.3)	5.32 (2.75, 10.31)
	High Ed	27 (26.5)	75 (73.5)	1.0
Do you know how to get there?	Low Ed	57 (82.6)	12 (17.4)	5.15 (2.46, 10.75)
	High Ed	47 (48.0)	51 (52.0)	1.0

Low Ed = Less than High School; High Ed = At least High School graduate / GED
*OR = Odds Ratio; CI = 95% confidence interval

Eighty-three percent (83%) [OR: 9.35 (4.44, 19.61)] of less-educated participants could not correctly identify which evacuation zone they lived in. Conversely, those who had completed high school were 9.4 [OR: 9.35 (4.44, 19.61)] times more likely to be able to correctly identify their zone. The vast majority, 83% [OR: 5.15 (2.46, 10.75)] of those with less education reported that they did not know how to get to the evacuation center closest to their home. Even of those who had higher education (High School or some/college), 48% said they did not know how to get to the closest evacuation center.

When it comes to trust in emergency preparedness officials, there is reason for concern. Even before residents determined that the map was not clear and decipherable, 40% said they do not (somewhat/a little/not at all) trust emergency directions from city officials. And in terms of overall preparedness, only 16% of all those surveyed said they have a "Go-Bag" ready in their home. Many of these individuals listed very few items that are recommended to include in the bag. While 69.1% said they would include water in a Go-Bag - 64.6% included non-perishable food, and 44.4% a flashlight, only about a third, 38.8% said they would include medicine, and only 23.6% thought to include important documents.

Potential limitations of this study are that findings may not be generalizable to a different population, as this was solely focused on East and Central Harlem . In addition, seniors in the sample were accessed at Senior Centers, where they may be more likely to receive formal orientation and education about emergencies. Indeed, more seniors in our population had "Go-Bags" recommended by the City, and these had been distributed to them by Senior Center personnel.

Conclusion

There is growing recognition that pursuing health literacy in the realm of public health contexts is necessary in creating a safer, healthier public (Zarcadoolas, et al., 2005, 2006a, 2006b, IOM, 2005). Post-Hurricane Katrina, there has been national attention given to ensuring the public has clear and understandable emergency preparedness information it can act on. This study of the usability of GIS map information in the New York City Coastal Storm Plan identifies serious problems among the public and raises serious doubts that information in this format meets the objectives of informing the public. Although the OEM has produced the Plan in 11 languages, this study indicates that, as written, the plan requires reading tasks that are beyond the abilities of many residents. Based on this research, we estimate that roughly 160,000 residents of Central and East Harlem would not be able to find the evacuation center closest to their home, according to their own understanding of the hurricane evacuation maps.

Future research should focus on analyzing the specific text complexity of GIS maps so that we can create more accessible, easy to read and use Geographic

Information System maps. These revised tools can then be added to a suite of public health communications that will enable lay community members to participate in more meaningful dialogue and informed decision-making processes about public health and safety issues. Improved maps can play an important role in presenting and advancing the public's understanding and engagement in a wide range of health and safety information, from emergency preparedness information, to other epidemiologic information, such as asthma rates, diabetes prevalence, and exposure to toxicants. Central questions for future research include:

- What is the linguistic and design structure of complexity in GIS information for vulnerable populations (low literate/low SES/ethnic minorities)?
- What does usability testing of GIS maps with low literate adults tell us about how GIS presentations can be adapted for greater readability and usability among the target audience?
- What are optimal templates for designing GIS maps to advance the use of these maps among low literate populations?
- What are best practice guidelines in writing, designing, and using GIS map information with general and low literate publics?

References

Center for Disease Control. "GIS and Public Health." Available at http://www.cdc.gov/nchs/gis.htm.

Center for Disease Control. Gather Geographic analysis Tool for Health and Environmental Research.2006. Available at http://gis.cdc.gov.

Center for Disease Control. Using Mapping and Spatial Analysis Technologies for Health Protection: A Public Health Training Network Satellite Broadcast Originally aired May 11, 2000. http://www2.cdc.gov/phtn/gis/relatedlinks.asp

Cheves, GI, Wang, JTL. Database-driven Web-enabled Public Health GIS Using XHTML, SVG, ECMAScript, DOM and a Three-tier Architecture. Abstract 2004, SVG Open Conference. http://www.svgopen.org/2004/paperAbstracts/WebEnabledPublicHealthGIS.html

FEMA. Mapping and Analysis Center "How FEMA Uses GIS in Disaster Management Response" 2005. Available at http://www.gismaps.fema.gov/gis04.shtm

Florida (2006). "Florida Surge Zones". http://floridadisaster.org/PublicMapping/hernando_surgezone.pdf (Last accessed 2/16/07).

Healthy Harlem. http://www.healthyharlem.org/pdfs/statistics/Demographics.pdf (Last accessed 2/15/07).

Healthy People 2010 Understanding and Improving Health. (USDHHS). Available at http://www.healthypeople.gov/ Last accessed 2/15/07.

Institute of Medicine (IOM). (2003). *The Future of the Public's Health in the 21st Century*. Washington, DC: National Academic Press.

Institute of Medicine (2004). *Health Literacy: A Prescription to End Confusion.*

Kirsch, J. S., Junegeblut, A., Jenkins, L., & Kolstad, L. A. *Adult literacy in America: a first look at the results of the National Adult Literacy Survey (NALS)*. Washington, DC: Department of Education. 1993.

NAAL "The Health Literacy of America's Adults: Results from the 2003 National Assessment of Adult Literacy". National Center for Educational Statistics. Available at http://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2006483

NAS. 2000. *Clearing the Air: Asthma and Indoor Air Exposures.* National Academy of Sciences Institute of Medicine, Division of Health Promotion and Disease Prevention. National Academy Press, Washington, D.C. 438 pp,

National States Geographic Information Systems (NGIS) (2006). Available at http://www.nsgic.org/

National Center for Educational Statistics. *The Health Literacy of America's Adults: Results from the 2003 National Assessment of Adult Literacy* (2006) http://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2006483

NYC Dept. of City Planning. "Demographic Profiles: Portrait of New York City's Community Districts from 1980 to 1990. http://www.nyc.gov/html/dcp/html/pub/demograp.shtml Last accessed 2/15/07.

NYC Dept. of City Planning, *2000 US Census*. 2006. http://www.nyc.gov/html/doh/html/stats/stats-demo.shtml

New York City Dept. of Health and Mental Hygiene. "Epidemiology Sortable Statistics." http://www.nyc.gov/html/doh/html/stats/stats-demo.shtml. Last accessed 2/15/07.

New York Office of Emergency Management (OEM). 2006. Available at http://www.nyc.gov/html/oem/html/home/home.shtml

Nielsen-Bohlman, L., Panzer, A. M., & Kindig, D. A. (Eds.) *Health literacy: A prescription to end confusion*. Washington, DC: Institute of Medicine of the National Academies. 2004. Available at http://www.iom.edu/report.asp?id=19723.

National Library of Medicine. "ToxMap" Available at http://toxmap.nlm.nih.gov/toxmap/combo/select.do;jsessionid=3DD11C64F27D38FB97011B219AC2DDF3 Last Accessed 2/10/07.

URISA. "GIS in Public Health Conference URISA. May 2007 http://wwww.urisa.org/health/workshops Last Accessed 2/10/07.

Olson EC, Van Wye G, Kerker B, Thorpe L, Frieden TR. "Take Care Central Harlem (/East Harlem)." NYC Community Health Profiles, Second Edition; 2006; 20(42):1-16. Central Harlem: http://www.nyc.gov/html/doh/downloads/pdf/data/2006chp-302.pdf. East Harlem:http://www.nyc.gov/html/doh/downloads/pdf/data/2006chp-303.pdf

Pastore, Michael (2001). "Interest High, But Internet Too Costly for Inner City." ClickZStats. 2001. www.clickz.com/showPage.html?page=561201

SPSS, Inc. SPSS for Windows, version 13.0. Chicago, IL, 2004

WEACT, West Harlem Environmental Action, GIS Maps. Available at http://weact.org/gis/samplemaps.html No date.

World Health Organization (WHO) (2006) "GIS and Public Health Mapping." http://www.who.int/health_mapping/gisandphm/en/index.html (last accessed 2/17/07).

WHO(2006)."Who's Public Health Mapping Program" http://www.who.int/health_mapping/en/

Zarcadoolas, C. (2006a). "Advancing Health Literacy Through an Expanded Model." Paper presented at Surgeon General's Workshop on Improving Health Literacy. Sept.7, 2006 Bethesda, Maryland

Zarcadoolas, C., Pleasant, A. & Greer, D.S. (2006b) *Advancing Health Literacy: a framework for understanding and action.* San Francisco, CA: Jossey-Bass.

_____. (2005). Understanding health literacy: An expanded model. *Health Promotion International*. 20:195-203.