

# Development of a Web GIS Application for Visualizing and Analyzing Community Out of Hospital Cardiac Arrest Patterns

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## Abstract

Improving survival rates at the neighborhood level is increasingly seen as a priority for reducing overall rates of out-of-hospital cardiac arrest (OHCA) in the United States. Since wide disparities exist in OHCA rates at the neighborhood level, it is important for public health officials and residents to be able to quickly locate neighborhoods where people are at elevated risk for cardiac arrest and to target these areas for educational outreach and other mitigation strategies.

This paper describes an OHCA web mapping application that was developed to provide users with interactive maps and data for them to quickly visualize and analyze the geographic pattern of cardiac arrest rates, bystander CPR rates, and survival rates at the neighborhood level in different U.S. cities. The data comes from the CARES Registry and is provided over a period spanning several years so users can visualize trends in neighborhood out-of-hospital cardiac arrest patterns. Users can also visualize areas that are statistical hot and cold spots for cardiac arrest and compare OHCA and bystander CPR rates in the hot and cold spots. Although not designed as a public participation GIS (PPGIS), this application seeks to provide a forum around which data and maps about local patterns of OHCA can be shared, analyzed and discussed with a view of empowering local communities to take action to address the high rates of OHCA in their vicinity.

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## Background

Each year, almost 300,000 individuals die from out-of-hospital cardiac arrest (OHCA) in the United States (Roger et al., 2011). Sasson et al. (2010) pointed out that the survival rate for OHCA varied between 6.7% and 8.4%, a statistic that had largely remained relatively stagnant for over thirty years. Geographically, Nichol et al. (2008) have shown that survival rates from out-of-hospital cardiac arrest vary tremendously by city in the US. For example, the survival to discharge rate in Seattle in 2008 was estimated at 8.1% while in Dallas, it was only 2.4% (Nichol et al., 2008). Given the wide geographic variability in OHCA survival rates, a major task is identifying communities that have high risk for OHCA and targeting them for CPR education

outreach, priority placement of automated external defibrillators (AEDs), and other intervention activities, as a means to help to improve overall survival rates in these communities.

The purpose of this paper is to report on an ongoing project to develop a user-friendly, interactive web mapping application that allows epidemiologists, policy makers, program managers, and the general public to quickly understand the geographic pattern of cardiac arrest rates, bystander CPR rates, and survival rates at the neighborhood level in selected U.S. cities. The selected cities are all cities in which the Cardiac Arrest Registry to Enhance Survival (CARES) has operations. CARES is a registry established in 2004 by the Centers for Disease Control (CDC) and the Department of Emergency Medicine at the Emory University School of Medicine to monitor OHCA events in the US (McNally et al., 2009). The goal of the web mapping application is to provide map-based information and raw data to health care professionals, policy makers, and members of the public to enable them to visualize and analyze the OHCA situation at the neighborhood level, and, where necessary, to take actions to address the high rates of OHCA in certain neighborhoods. In the following sections of this paper, we outline the application development process and the usability design considerations employed in building the web mapping application. We also describe the application itself as well as user evaluations of the website.

## Method

### *The Application Development Process*

To develop the OHCA web application, we followed, to a large extent, the five-stage user-centered design model put forward by Kinzie et al., (2002). The Kinzie et al., model was used to design a web application to assist patients in recording and maintaining their family health histories. These histories can be used by both patients and physicians to identify potential health problems, and by physicians for preventive or treatment recommendations (Kinzie et al., 2002). The five stages of application development set forth in the model are: (1) identification and assessment of client and users' needs, (2) goal/task analysis (3) initial prototype design, (4) evaluations and refining of prototypes and final stage application, and (5) project implementation and maintenance.

The client for our project was a researcher working with the CARES group (<https://mycares.net/>). In *Stage One* of application development, several meetings were held with the client to develop a clear picture of the conceptual requirements of the application from the client's perspective. Within these meetings, the goal of the application, a *Stage Two* requirement of the model, was clarified. The main goal of the application was stated as:

To provide interactive web maps and data to public health professionals, policy makers, and members of the public to help them to visualize and analyze the geographic pattern of out-of-hospital cardiac arrest rates, bystander CPR rates, and survival rates at the neighborhood level in different U.S. cities.

*Stage Three* of the application development process called for the development of an initial prototype. We used the documented goal of the research, the client's requirements of the

application's functionalities, and our own background research about similar type applications to design the initial prototype.

In *Stage Four* of the application development, we used several rounds of semi-formal evaluations to incorporate user perspective into the unpolished prototype designs. Participants in these evaluations were graduate students with knowledge of cartography, programming and GIS, and members of the general public. Convenience sampling was used to select the evaluators. Although the average sample size was 10 persons, the small sample size was considered more than sufficient as the usability evaluation literature points out that after the first five or six interviews, about 75 percent of the fatal design errors and problems will be identified (Nielsen 1994, Krug 2006, Shneiderman and Plaisant 2006). Open-ended questions via email were the main technique used to solicit feedback from evaluators. Users were directed to the project's website and asked to carry out various tasks using the application. They were then requested to comment on the degree of success carrying out the tasks, their satisfaction level, user-friendliness, and quality of output. Feedbacks from these semi-formal evaluations were used to update the prototype leading to a more improved product.

Indeed, user feedback in Stage Four of the application development process helped us to considerably improve the design of the application each time the survey was completed. For example, users suggested that hyperlinks should be created to provide access to technical discussions on the topics portrayed on the maps. Comments were made about legend design, color choice, the quality of dynamic labeling, interface layout, and the functioning of various tools. After each survey, we addressed users' concerns by incorporating their suggestions into the application. A more expanded user evaluation was done at the beta release of application development, when all the software functionalities were completed. This final beta evaluation will be described later in the paper.

### ***Incorporating Usability Design Considerations into the OHCA Web Application***

Given that many of the users of the application were not expected to be experts in GIS, we were particularly interested in incorporating state-of-the art usability ideas in the design of the OHCA web application. In web mapping application development, usability issues surfaced as important considerations since the early part of the last decade as researchers sought to create interactive web mapping applications that met user needs and expectations (MacEachren and Kraak 2001, MacEachren 1995). Usability problems associated with interactive web mapping applications include:

- Poor user interface design (e.g., too small map area; legend too large, incompatible colors information overload, and poor layout (Arleth 1999).
- Users unable to understand map tools or map tools being too difficult to use (Harrower et al., 2000).
- Motivated users not interpreting the published maps in intended ways (Ishikawa et al., 2005).
- Unreadable or badly placed text; poor visualization of search results; lack of useful help or guidance to use the software (Nivala et al., 2008).

User-centered design is recognized by many researchers as the best means of avoiding the design problems mentioned above. User-centered design is essentially a product development methodology that incorporates the views of users at all stages of the product development cycle in order to create a product that meets users' needs. The methodology forces designers to consider both the objectives of the design and the needs and preferences of users within the context of existing technology (Norman 2002).

While many cartographers have discussed usability issues in web mapping design, a few have concentrated on the usefulness of web mapping applications, arguing that applications should not only be easy to use, but that they should also serve useful ends (Fuhrmann et al., 2005). Norman (2005), the well-known usability researcher, has argued that focusing too much on usability often leads to the development of “cool” applications that fail to help people accomplish needed tasks. He called for designers to place emphasis on functionalities that meet the goal of the web application because these activity-centered designs are better placed than usability designs to deliver tools that effectively support users in real-world contexts.

In this project, we sought to achieve both ‘usability’ and ‘usefulness’ in web map design by working closely with both the client and the intended users of the application to incorporate their feedback into the project at every stage in the design process. We relied on the AGILE approach to software development to guide this process. This approach to software development is one that emphasizes consultations with the client at each of several iterations in the project cycle (Abrahamsson et al., 2010, Ambler 2002). Feedbacks from these consultations are immediately incorporated into the design process, thus the final product greatly reflects user concerns.

In addition to utilizing ideas from the AGILE approach to software development, we incorporated the traditional geovisualization concept of presenting multiple views of the same data into the application design (MacEachren and Kraak 2001). Our application provides downloadable cartographic representations of the data based on user-constructed queries. Raw data in the form of shapefiles and attribute data are also provided. Advanced user of the application can use these raw datasets to analyze and create their own representations of the OHCA problem in the various neighborhoods. In later versions of the application, we intend to include capabilities that would allow users with meaningful local knowledge of the OHCA problem to upload data to the web application and share the details of their differing perspectives with other users of the application.

Recently, the web GIS design literature, taking its cue from developments in e-commerce, has begun discussing issues related to how the general public and expert GIS users develop trust in interactive mapping websites sufficient to enable them to confidently interact with the application's data and analytical output (Skarlatidou et al., 2011). To improve the trustworthiness of web GIS applications, Skarlatidou and her colleagues point out that the responsibility is on the person or organization supplying the web GIS application, the *trustee*, to establish the necessary trust attributes. According to the authors, there are two main types of trustee attributes which must be developed to foster increased trusts in web applications, perceptual attributes and functional attributes. Perceptual trustee attributes deal with the trustee's honesty, integrity and reliability. Functional attributes, on the other hand, deal with the application features, e.g. aesthetics and usability features that increase the trustworthiness of the application.

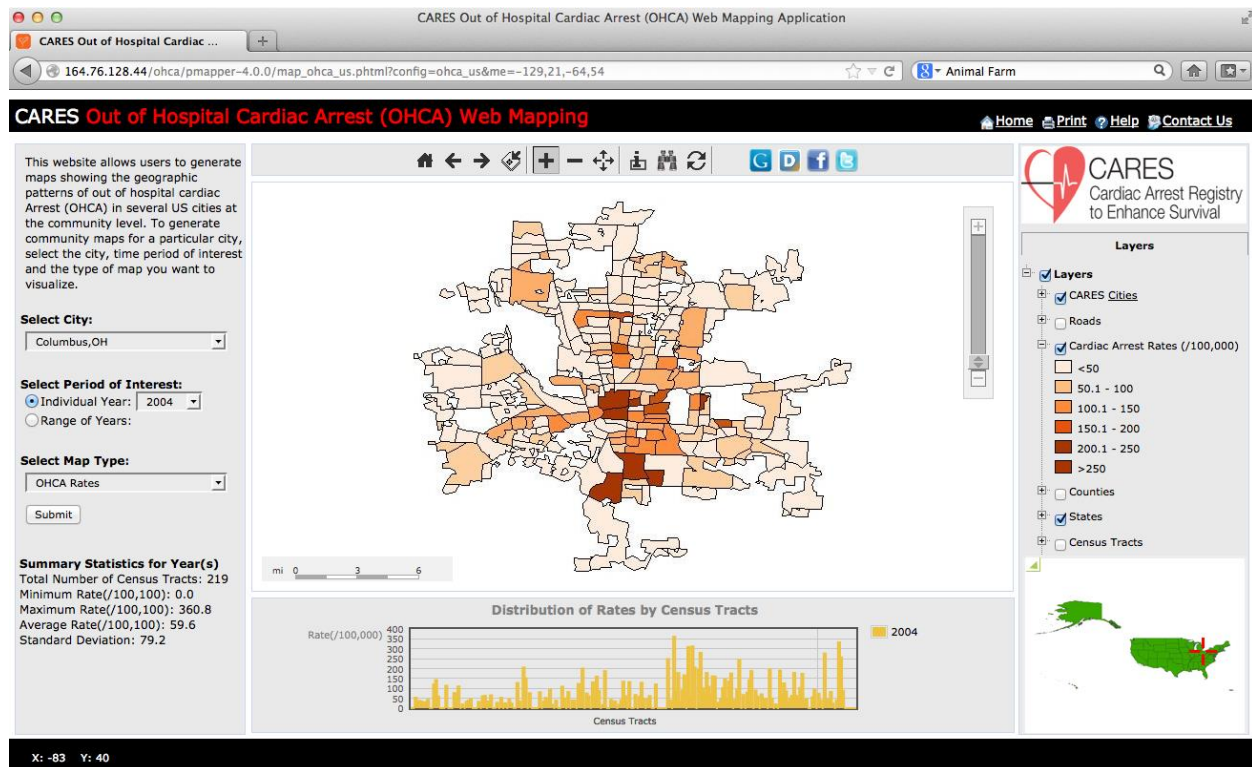
In designing our web application, we implemented both perceptual and functional trustee attributes. For example, we used trust cues such as the logo of the cardiac arrest agency that promotes strategies to reduce the rates of OHCA at the neighborhood level. We also included feedback mechanisms in the form of easy access to social media pages on Discus, Facebook and Twitter to enable users to comment on the validity of the official data that was presented. Two other trust cues we provided were information to contact the designers of the application, and hyperlinks to published online reports that supported the cardiac arrest patterns displayed on our maps. With respect to functional trustee attributes, we relied on addressing the usability concerns mentioned earlier, e.g., improved interface design, attention to color use, dynamic labeling, reliance on multiple views of the data, ensuring correctness of data, and correctness of algorithms and queries used to produce end-user maps, etc.

## Results

### *The OHCA Web Mapping Application*

The OHCA web mapping application developed for the project can be viewed at <http://geodata.acad.emich.edu/ohca>. Figure 1 shows the Graphical User Interface (GUI) of the application with a census tract level OHCA rates map for the City of Columbus, Ohio being displayed. In this project, census tracts were used as proxies for neighborhoods. The title of the application, “CARES Out of Hospital Cardiac Arrest (OHCA) Web Mapping Application”, a perceptual trust attribute, is prominently displayed at the top left of web page. Towards the top right of the application, an additional trust cue, the CARES logo, is prominently displayed and hyperlinked to the CARES website. Links to the project home page is also highly visible. A link to information to contact the designers of the application, which is another perceptual trust attribute, is placed at the top right of the page. Towards the top left of the user interface, a brief note informs the user about the purpose of the application and provides a general idea of how to start using it. Below this note, drop down boxes allow users to select parameters to build queries. Users select a city of interest, the period for which they want to display data, and the type of map desired, e.g., OHCA rates map, bystander CPR map, survival rates map, etc. Once the submit button is clicked, users can generate maps that show OHCA rates, Bystander CPR rates, etc., at the census tract level for the city.





**Figure 1:** The OHCA web mapping application showing OHCA neighborhood rates for Columbus, Ohio, 2004

Whenever the map for a particular city is displayed, the application automatically produces a histogram below the map showing the rates distribution for whatever is being mapped. This is part of the multi-view approach to presenting the data. In addition to the histogram, summary statistics are displayed to the lower left of the screen. The attribute table associated with the map layer is also displayed allowing the user to peruse the actual data used to create the map. If desired, users can download the attribute table in Excel, txt, or pdf formats. Each row in the attribute table is hyperlinked to the related feature on the map allowing users to explore locational aspects of the neighborhood. Users can explore the geography of census tracts by accessing an aerial imagery layer supplied by the National Agriculture Imagery Program (NAIP). The application also allows for each location on a thematic layer to be viewed directly in Google Map.

A set of navigation tools are provided at the top of the screen. Access to social-media software to foster discussion about local patterns of OHCA is placed right alongside the navigation tools for high visibility. To the lower right of the screen are the legend and an overview map to help users locate themselves in the US if they are zoomed into to a particular neighborhood.

The application was built using Mapserver, a popular open source platform for creating interactive web mapping applications (<http://mapserver.org/>). The default user interface for a basic Mapserver application is created using only HTML and CSS. This means that

functionalities such as panning, zooming, querying, etc., are implemented in simple, often inelegant ways. We used the p.Mapper framework to add dynamism to the static HTML user interface. For example, the p.Mapper framework allowed us to add a customizable navigation toolbar for panning and zooming the map, returning to previous or full extent, etc. The toolbar also contains functions for identifying map features and their attributes through point and click, and for selecting features through the use of select boxes. P.Mapper also facilitated the use of a slider to alternatively zoom the map. User-specified attribute queries of the map were implemented by writing several PHP and JavaScript functions to perform the queries.

The OHCA application displays the following types of maps at the neighborhood level: OHCA rates, bystander CPR rates, percent in-home cardiac arrest rates, and hot and cold spots. The rates were calculated outside of the application using ArcGIS, and Geoda, an open source spatial statistics software. Rates were smoothed using Geoda's routines for spatial empirical Bayesian rates. For the hot and cold spot maps, hot spots (i.e., high-risk census tracts) were defined as census tracts having a higher than expected OHCA incidence risks and lower than expected incidence risks of bystander CPR over a period of two consecutive years. Alternatively, cold spots (i.e., low risk census tracts) were defined as those having a lower than expected OHCA incidence risks and higher than expected incidence risks of bystander CPR over a period of two consecutive years. The actual spatial analysis to identify the OHCA hot and cold spots was done outside the web application using Geoda and ArcGIS software. The technical details of this process have been described in (Semple et al., 2012). Essentially, for any given year, Local Moran's I was used to separately identify clusters of OHCA rates and bystander CPR rates. The two sets of hotspots were then overlaid on each other to identify the tracts that had both high rates of OHCA and low rates of bystander CPR rates for that year. Because hotspots can be temporally unstable, we overlaid hotspots of one year on top of hotspots for the preceding year to identify what we called "persistent" clusters of high-risk communities.

Utilizing trustworthiness interface design ideas, a hyperlink to the online paper describing how the maps were created was supplied. Also, to aid user interpretation of the maps, a note is provided on the screen when the maps display to indicate how to interpret the maps.

### ***Final User-Evaluation***

In this section, we describe and present results of the user evaluation that was conducted on the beta application. At this stage, we wanted to make a final determination as to whether users were able to use the application to carry out specific tasks with ease. We also wanted to carry out a usability assessment of the application, as measured on the System Usability Scale (SUS)(Brooke 1996). Although the SUS is a quick and easy way to conduct a usability assessment, its reliability has been confirmed by many writers (Bangor et al., 2008). Using the work of Brooke (1996) as a guide, the goals of the final evaluation were defined as follows: (1) to determine the ability of users to easily complete tasks for which the application was designed; (2) test the level of difficulty required to complete tasks; and (3) to determine whether the output of tasks were satisfactory to users.

Eleven persons were purposefully selected to participate in the evaluation. The sample reflected potential users of the application and consisted of both technical GIS users as well as members of

the general public without previous GIS experience. The URL of the application was again emailed to the evaluators along with login information to Survey Monkey, an online questionnaire survey site that hosted the questionnaire. A formal questionnaire was developed for this evaluation (Appendix 1). Evaluators were asked to perform specific tasks using the web application and then respond to a set of close and open-ended questions about the layout of the application, ease of use of tools, problems encountered, and the severity of the problems. Responses to the close-ended questions were measured on a 5-point Likert scale ranging from “strongly disagree (1)” to “strongly agree” (5). Evaluators were also requested to fill out the questions on the Systems Usability Scale (Appendix 1). Following Bangor et al., (2008), we used a slightly modified version of Brooke (1996) System Usability Scale. For the modified version, Bangor et al. (2008) suggested that the word “cumbersome” in question 8 be changed to “awkward” to read “I found the system very awkward to use”. Also, on three occasions, the word “system” was changed to “product” for greater clarity.

The response rate to the survey was 70%. This was considered to be good since the response rate for many web surveys is around 30-40% even with populations that have easy access to the web (Archer 2008). In terms of the overall ability of users to easily complete the seven tasks they were given, 67% agreed that they were able to complete all of them (Table 1). The two tasks that gave users the most difficulties were Task 3 – “Determine the OHCA rates for census tracts in Worthington, a community in Columbus, Ohio” and Task 4 – “Determine the three communities in Columbus, OHIO that had the highest rates of OHCA”. Only 44% of respondents strongly agreed that these tasks were easy to complete (Table 1). Evidently, the steps for performing these tasks were not intuitive. We subsequently addressed these issues by providing explanations on the Help page.

As to the questions about whether users were pleased with the output of the various tasks, only 36% strongly agreed, while 36% agreed (Table 2). Users did not like the quality of the output maps, particularly the quality of feature labeling and the placement of certain map elements. Also, while users were able to easily generate hot and cold spots from the application, they could not easily interpret the meaning of hot and cold spots. Users also complained that the fields in the attribute table should be formatted at each query to reflect only fields of information pertinent to the query and not display the entire set of fields in the table. These issues have since been addressed.

Responses to questions about user interface are shown in Table 3. Most users agreed that the application had a user-friendly interface and that the navigation tools and other control were easy to use. In terms of response to the individual SUS questions, the average SUS score from the respondents was 72.2, with a standard deviation of 6.23. Following Bangor et al. (2009), this score converts to an overall B when translated to a letter score. According to Bangor and his colleagues, the average SUS score is 68, so our SUS score of 72.2 indicates that most users had a fairly positive experience using our web application. Altogether, the values indicated to us that the participants felt that the web mapping application was a useful, user-friendly geovisualization tool, but additional work was needed to enhance output quality.



**Table 1.** Results for Ease of Accomplishing Tasks on the Web Application

	Was task easy to accomplish?				
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Task 1. Create a neighborhood rates map of OHCA rates in Columbus, Ohio for 2004.	83%	17%			
Task 2. Create a map showing percent "In-home" OHCA arrests by neighborhoods for Columbus, Ohio for the range of years, 2004 - 2006.	83%	17%			
Task 3. Determine the OHCA rates for census tracts in Worthington, a neighborhood in Columbus, Ohio.	33%		33%	33%	
Task 4. Determine the three neighborhoods in Columbus, OHIO that had the highest rates of OHCA.	33%	33%	16.7%	17%	
Task 5. Display maps of high-risk and low-risk areas for OHCA in Columbus for 2008.	83%	17%			
Task 6. Print a map of the neighborhood OHCA rates for Columbus, Ohio for 2006.	67%		33%		
Task 7. Download a csv file of OHCA rates for different communities in Columbus and open the file in Excel.	83%		17%		

**Table 2.** Results for “I was pleased with the map output of the OHCA rates map”

	Was task easy to accomplish?				
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Task 1. Create a neighborhood map of OHCA rates for Columbus, Ohio 2004.	33%	67%			
Task 2. Create a map showing percent "In-home" OHCA arrests by neighborhoods for Columbus, Ohio for the range of years, 2004 - 2006.	50%	50%			
Task 3. Determine the OHCA rates for census tracts in Worthington, a neighborhood in Columbus, Ohio.	17%	33%	50%		
Task 4. Determine the three neighborhoods in Columbus, OHIO that had the highest rates of OHCA.	33%	33%	17%	17%	
Task 5. Display maps of high-risk and low-risk areas for OHCA in Columbus for 2008.	20%	40%	20%		20%
Task 6. Print a map of the neighborhood OHCA rates for Columbus, Ohio for 2006.	33%	17%	33%	17%	
Task 7. Download a csv file of OHCA rates for different communities in Columbus and open the file in Excel.	67%	17%	17%		

**Table 3.** Results for User Interface Evaluation

	Responses				
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
The OHCA Mapping application has a user-friendly user interface.	16.70%	83%			
I was able to easily use the map navigation tools.	66%	33%			
I was able to easily use the zoom-in/zoom-out tools.	83%	17%			
I was able to easily use the "Select tool".	67%	33%			
I am comfortable with the color schemes used for the maps and legends.	33%	67%			
I was able to easily query the map using the "SQL" tool.		67%		33%	
Kindly click on the "Go to Google" button and investigate how this tool works. This tool was helpful in Excel.		33%	33%	33%	
For people who know how to use GIS software, we are allowing them to download our data to create their own maps of neighborhood out of hospital cardiac arrest patterns. This was a good idea.	Yes: 83% No: 17%				

## Discussion

In creating the OHCA web mapping application, we sought to depart from an application development model in which designers believe that they knew exactly what the users needed or wanted. We wanted to incorporate ideas from the web mapping usability literature to create an application that would allow users to effectively interact with the map information and quickly come to an understanding of the geographic distribution of OHCA events in their city and the risk of the event in their own neighborhood. While it is still too early to assess whether the goal of the web mapping application was achieved, a number of issues emerged from this project that may be of interest to others engaged in the development of similar type applications.

First, it was remarkable the amount of feedback information obtained from the intermediate evaluations as well as from the final beta evaluation. Members of the general public and experts in the field of cartography, programming and GIS contributed significant insights into the design

of the application and the usefulness of certain functionalities. For example, some users wanted to be able to click on the points that showed the location of CARES cities around the country and be taken to the main query window. There were also requests for the histogram that appears as part of map queries to be made interactive. Users wanted the bars in the histogram to be linked to the specific map features, so that selection of a bar would result in the selection of the map feature associated with the bar, as well as the record in the attribute table. Several noted that the names of fields in the attribute tables were unclear and that the application needed to provide more information about cardiac arrest victims, e.g. average age, race, gender, etc. From a cartography perspective, comments were made about the need for greater clarity in the legend text and better coordination in color choice. Some users pointed out that the dynamic text placement of Mapserver was not properly managed and resulted in clutter at certain zoom levels. These users called for greater finesse in labeling map features at all zoom levels. Although we were not able to incorporate all users requests into our design, we are strongly convinced that designing from a user-centered perspective is a superior way of designing web mapping software compared to one in which the major design elements are left entirely to the software developer or to a team of developers.

Secondly, we are convinced that displaying data across multiple views (map, tabular, chart, summary statistics, and raw data) is a superior way of presenting cartographic data compared to a style of presenting only one view. We believe that this presentation style addresses the needs of different types of users. For example, those with only a need to view available maps and summary statistics can simply view these products online. Others with the need to do their own analysis on the data can download the data and analyze it using their own techniques and thus create their own view of the geography of OHCA events.

Thirdly, despite the fact that web maps allow us to easily understand geographic disease patterns, a review of web sites dedicated to discussing public health issues reveal that these sites are generally not designed as a forum around which local health issues can be discussed. Most use a tabular or interactive map presentation paradigm and do not provide tools at the website to foster discussions about the tabular or geographic patterns inherent in the data and their health significance to local communities. Such discussions often occur elsewhere in social media websites. During the course of this project, we began exploring the idea of building a web application that links tabular data provision and interactive geovisualization with social networking and social bookmarking tools to allow users to discuss, at the particular website, the significance of different disease patterns from a local community perspective. Our attempts to do so in this project has been simply to create Twitter, Discuss and Facebook pages and link these to buttons from within the web application so that users can easily access the online forums where the local OHCA patterns are being discussed. In future versions of this application, we hope to add a volunteered geographic data component to allow users to supplement the official data presented on the website with local, user-generated data. This is an idea already present in the public participation literature, but combining these capabilities within a container that facilitates discussion using social media software can yield significant benefits.

## Conclusion

The application development process described in this paper allowed us to focus specifically on what OHCA researchers and potential users of the web mapping application felt were important to them in a web mapping application created to disseminate OHCA information and data. The application was built based on detailed analysis of client and user needs and careful selection of available technology based on cost considerations and software capabilities. Incorporating state-of-the-art usability concepts into the application design was also an important consideration. Although this first version of the application is effective in supplying a wide range of maps and datasets to aid in the identifying of high-risk areas for OHCA events at the neighborhood level, we feel that there is scope for enhancement of the application in many areas. In later versions of the software, we will increase the interactivity between histograms and the maps, allow for greater integration of multimedia in the design and generally expand the paradigm of building a public health web mapping application that is centered around interactive maps, summary statistics, use of social media technology to discuss patterns inherent on the map, and the ability of users to add local information to the map to supplement and add richness to the official data used to create the basemaps.

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## Appendix 1

Please use the OHCA web mapping application (<http://geodata.acad.emich.edu/ohca>) to carry out the tasks below and then report your satisfaction level for each task.

### Task 1

Create a map showing neighborhood OHCA rates for Columbus, Ohio for 2004.

1. The above task was easy to accomplish.

(1) Strongly disagree (2) Disagree (3) Neutral (4) Agree (5) Strongly Agree

2. I was pleased with the map output of the OHCA rates map.

(1) Strongly disagree (2) Disagree (3) Neutral (4) Agree (5) Strongly Agree

3. If you were displeased with the OHCA rates map, what were you displeased with?

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### Task 2

Create a map showing percent "In-home" OHCA arrests by neighborhoods for Columbus, Ohio for the range of years, 2004 - 2006.

4. The task describe above was easy to accomplish.

(1) Strongly disagree (2) Disagree (3) Neutral (4) Agree (5) Strongly Agree

5. I was pleased with the "In-home" OHCA arrests map by neighborhoods for Columbus, Ohio, 2004-2006.

(1) Strongly disagree (2) Disagree (3) Neutral (4) Agree (5) Strongly Agree

6. If you were displeased with the "In-home" OHCA rates map, what were you displeased with?

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### Task 3

Determine the OHCA rates for census tracts in Worthington, a neighborhood in Columbus, Ohio.

7. The task described above was easy to accomplish.

(1) Strongly disagree (2) Disagree (3) Neutral (4) Agree (5) Strongly Agree

8. I was pleased with the map and table output of the above task.

(1) Strongly disagree (2) Disagree (3) Neutral (4) Agree (5) Strongly Agree

9. If you were displeased with the Worthington rates map, what were you displeased with?

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Task 4

Determine the three neighborhoods in Columbus, OHIO that had the highest rates of OHCA.

10. The task described above was easy to accomplish.

(1) Strongly disagree (2) Disagree (3) Neutral (4) Agree (5) Strongly Agree

11. I was pleased with the rates information I obtained from the above task.

(1) Strongly disagree (2) Disagree (3) Neutral (4) Agree (5) Strongly Agree

12. If you were displeased with the rates information you obtained, what were you displeased with?

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Task 5

Display maps of high-risk and low-risk areas for OHCA in Columbus for 2008.

13. The task described above was easy to accomplish.

(1) Strongly disagree (2) Disagree (3) Neutral (4) Agree (5) Strongly Agree

14. I was pleased with the map output of the above task.

(1) Strongly disagree (2) Disagree (3) Neutral (4) Agree (5) Strongly Agree

15. If you were displeased with the hot or cold spot maps what were you displeased with?

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Task 6.

Print a map of the neighborhood OHCA rates for Columbus, Ohio for 2006.

16. The task described above was easy to accomplish.

(1) Strongly disagree (2) Disagree (3) Neutral (4) Agree (5) Strongly Agree

17. I was pleased with the appearance of the map.

(1) Strongly disagree (2) Disagree (3) Neutral (4) Agree (5) Strongly Agree

18. If you were displeased with the appearance of the printed map, what specifically were you displeased with?

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Task 7

Download a csv file of OHCA rates for different communities in Columbus and open the file in Excel.

19. The task described above was easy to accomplish.

(1) Strongly disagree (2) Disagree (3) Neutral (4) Agree (5) Strongly Agree

20. I was pleased with the format of the data I downloaded.

(1) Strongly disagree (2) Disagree (3) Neutral (4) Agree (5) Strongly Agree

21. If you were displeased with the csv file you downloaded, what specifically were you displeased with?

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### User-Interface Evaluation

22. The OHCA mapping application has a user friendly user interface.

(1) Strongly disagree (2) Disagree (3) Neutral (4) Agree (5) Strongly Agree

23. I was able to easily use the map navigation tools.

(1) Strongly disagree (2) Disagree (3) Neutral (4) Agree (5) Strongly Agree

24. I was able to easily use the zoom-in/zoom-out tools.

(1) Strongly disagree (2) Disagree (3) Neutral (4) Agree (5) Strongly Agree

25 I was able to easily use the "Select tool".

(1) Strongly disagree (2) Disagree (3) Neutral (4) Agree (5) Strongly Agree

26. I am comfortable with the color schemes used for the maps and legends.

(1) Strongly disagree (2) Disagree (3) Neutral (4) Agree (5) Strongly Agree

27. I was able to easily query the map using the "SQL" tool.

(1) Strongly disagree (2) Disagree (3) Neutral (4) Agree (5) Strongly Agree

28. Kindly click on the “Go to Google” button and investigate how this tool works. This tool was helpful

(1) Strongly disagree (2) Disagree (3) Neutral (4) Agree (5) Strongly Agree

29. For people who know how to use GIS software, we are allowing them to download our data to create their own maps of neighborhood out of hospital cardiac arrest patterns. This was a good ideas.

(1) Strongly disagree (2) Disagree (3) Neutral (4) Agree (5) Strongly Agree

### Overall System Usability Evaluation

1. I think that I would like to use this system frequently.  
(1) Strongly disagree (2) Disagree (3) Neutral (4) Agree (5) Strongly Agree
2. I found the system unnecessarily complex.  
(1) Strongly disagree (2) Disagree (3) Neutral (4) Agree (5) Strongly Agree
3. I thought the system was easy to use.  
(1) Strongly disagree (2) Disagree (3) Neutral (4) Agree (5) Strongly Agree
4. I think that I would need the support of a technical person to be able to use this system.  
(1) Strongly disagree (2) Disagree (3) Neutral (4) Agree (5) Strongly Agree
5. I found the various functions in this system were well integrated.  
(1) Strongly disagree (2) Disagree (3) Neutral (4) Agree (5) Strongly Agree
6. I thought there was too much inconsistency in this system.  
(1) Strongly disagree (2) Disagree (3) Neutral (4) Agree (5) Strongly Agree
7. I would imagine that most people would learn to use this system very quickly  
(1) Strongly disagree (2) Disagree (3) Neutral (4) Agree (5) Strongly Agree
8. I found the system very cumbersome to use.  
(1) Strongly disagree (2) Disagree (3) Neutral (4) Agree (5) Strongly Agree
9. I felt very confident using the system.  
(1) Strongly disagree (2) Disagree (3) Neutral (4) Agree (5) Strongly Agree
10. I needed to learn a lot of things before I could get going with this system  
(1) Strongly disagree (2) Disagree (3) Neutral (4) Agree (5) Strongly Agree