Applying Informatics to Improve Vulnerable Population Registration for Emergency Preparedness in the Gulf Coast Region of Texas

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Abstract
The application of information technology to improve public health programs has gained increased attention in recent years. This paper discusses an informatics-facilitated evaluation program for a federally supported vulnerable population registration system (also known as the 2-1-1 registration system) for emergency preparedness and response in the Gulf Coast region of Texas. This program is part of a larger project, “HealthQuilt,” which is an evaluation of the Harris County catchment area using emerging web-based technologies. The goal of this project is to assess registration system use, with a focus on how to use the information to improve enrollment in ZIP codes with low registration. We created three interactive map displays of 2-1-1 registrants and the location of participating clinics using a geo-reference service on the Google mapping system (a free web-based geospatial map service). The results show geographically diverse distributions of 2-1-1 registrants by ZIP code in relation to collaborating clinics in greater Houston. These displays provide potential insight into recruitment of service providers to meet the needs of registrants. This project presents a potential prototype system for monitoring the progress of 2-1-1 enrollment in the target area and for increasing the number of registrants. The lessons learned may provide a valuable reference for other jurisdictions with similar needs in implementing informatics in public health preparedness for vulnerable populations.

Keywords
GIS evaluation, emergency preparedness, Google maps, Web GIS

Background
Disaster events could disrupt large numbers of daily activities and have lasting effects on both people and property. Preparing for and responding to natural or human-made disasters such as hurricanes, earthquakes, extreme weather, flooding or terrorism are top public health priorities. Often, local governments and disaster-relief organizations target special needs communities for evacuation. Residents, particularly those with special needs, should have ready access to useful information and relief services when disasters occur. For emergency preparedness, particular consideration should be given to ensure that, when disasters happen, a plan is in place to support all residents, and especially the special needs population. However, there is an absence of literature that addresses the issue of whether plans and training activities for preparedness are closely aligned with the geographic areas of vulnerable populations who need transportation in high-risk target areas. The lack of literature inspired the development of this study. The following section summarizes the literature covering the use of Geographic Information Systems (GIS) in evaluation, in public health studies, the need of vulnerable people in emergency events, and Web-based GIS.

GIS provides a tool to visualize data via maps. In addition, GIS has been used to compare data in various demographic regions and to help formulate hypotheses on how the data closely align to the needs of emergency preparedness with supporting decision-making. Maps reflecting multiple data layers can reveal the spatial distribution of healthcare providers and vulnerable areas. Such information can help reveal opportunities to improve health programs. Applying GIS can help planners and responders visualize data through multiple geo-referenced layers, facilitating public health monitoring and surveillance. Studies supporting these points include those examining HIV/AIDS mortality disparities in Maryland, cancer disparities in Florida and prostate cancer in Texas.1,2,3 Many studies have considered the usefulness of GIS as a tool in emergency preparedness and response. For instance, one study examined the use of GIS to identify and characterize transportation schedules as well as the role of those schedules in efforts to reduce the time of recovery from a natural disaster.4 Researchers have also studied the effects on local emergency departments of large-scale urban chemical fires with hazardous materials spills. The study explored how integrating geographic features and ArcView GIS-created maps in the study areas could help identify populations most at-risk from potential smoke and chemical exposures.5 These examples demonstrate the potential utility of GIS technology for emergency preparedness.

People, especially adults who have chronic diseases are more vulnerable than healthier or younger population when disaster occurs. Aldrich & Benson have studied the need of emergency preparedness for older adult people who have chronic diseases. They concluded that planning to help vulnerable population with chronic diseases is critical.6 Public health workers need to addressing need, planning for services and using mapping system for emergency responses. Lessons learn from Hur-
rricane Katrina evacuees in Houston shelters suggested that policy makers need to develop a better plan to help vulnerable population for emergency services.2

GIS software evolves continuously and a recent trend has seen the development of open source, web-based GIS software. Open source technology, which is generally free and has no maintenance fees, and web-based GIS systems have been used in many research studies and even customized GIS solutions can be integrated with web-based systems using Application Programming Interfaces (APIs) such as the Google API.3 8a  GIS-based modeling of spatially distributed data has been used for decision-making and maps can aid decision-makers in their emergency response capacity.9  Web-based GIS solutions can render relevant information effectively for emergency response.10 By following simple step-by-step instructions, users with no prior technical experience in web GIS or internet map servers can publish their own health maps on the web and add to those maps additional layers retrieved from remote Web Map Servers (WMS).11

In this study, we used open source technology from Google geographic reference services to map Keyhole Markup Language (KML) files and display information to the Internet. Ours was developed to identify special needs populations in the Gulf Coast region of Texas and the number of clinics that are collaborators in the HealthQuilt project.

Population and Methods
To evaluate the level of 2-1-1 registration and its geographic relation with participating voluntary healthcare providers, we created two layers of maps. The Federal Emergency Management Agency (FEMA) has identified several “special needs” populations and makes recommendations to help mitigate the effects of disasters for these groups. FEMA identifies populations that are visually or hearing impaired, have no transportation, those who are non-English speakers, have disabilities and existing medical conditions as “special needs populations.”11a

Two types of data were collected for geographic reference:
1. Attribute data include registrants, clinics, and the registrants by different clinics, by different levels of special needs and geographic boundary data that include state, county and ZIP code. Table 1 shows he levels of people with special needs in the greater Houston area (i.e., Chambers, Harris, Galveston County), which is the geographic area in focus for this study.
2. Spatial boundary data were represented by different ZIP code areas. ArcView 9.3 geographic application software was applied to map the registrants in different demographic locations.

The maps were then exported to KML, a standard Extensible Markup Language (XML) language schema used to visualize geographic data on web-based maps, and overlaid those with Google maps.12 We analyzed data and applied geocodes to show the number of registrants by ZIP code locations. The number of clinics participating with HealthQuilt projects were depicted using Google maps. Each map layer was overlaid to see which areas had the highest numbers of 2-1-1 registrations and how many HealthQuilt project partner clinics were located in those areas. All KML map files were uploaded to web servers.

Results
The GIS map (http://healthquilt.healthinformaticsthai.com/maps) shows the spatial distribution of 2,762 registrants with special needs enrolled in the 2-1-1 system. Populations with special needs who enroll in the 2-1-1 system are geocoded and presented by ZIP code location. Figures 1, 2 and 3 show different layers of the GIS map, including number of 2-1-1 system registrants by ZIP codes (Figure 1), participating clinics (Figure 2), and number of 2-1-1 system registrants by clinic location (Figure 3). Geo-referenced data layers show that the number of registrants and the clinics’ locations are not closely related, suggesting a need for more recruitment of healthcare providers in the ZIP codes where more registrants are aggregated. The five ZIP codes that have the highest number of registrants are:

1. 77016 (NE Houston, n=104)
2. 77093 (NE Houston, n=98)
3. 77020 (Houston, n=93)
4. 77036 (SW Houston, n=89)
5. 77026 (Houston, n=88).

The five ZIP codes that have the lowest number of registrants are:

1. 77550 and 77551 (Galveston, both n=0)
2. 77554 (Galveston, Jamaica Beach, Tiki Island, n=0)
3. 77617 (Gilchrist, n=0)
4. 77623 (High island, n=0)
5. 77510 (Santa Fe, Alta Loma, n=0).

The findings show that despite residing in high-risk areas such as Galveston, Jamaica Beach, Tiki Island and in coastal ZIP codes people were not registering with the 2-1-1 system (see Table 1). This finding presents interesting policy and community health research questions as to why these historically hurricane prone regions had lack of 2-1-1 registrants.

Figure 4 shows a breakdown of the special needs population in greater Houston, definition based on State of Texas Hurricane Evacuation and Mass Care Plan, 2007, as the following in these categories:13

- Level 0: Persons who have no medical needs, but require transportation assistance for evacuation.
- Level 1: Persons dependent on others or in need of others for routine care (eating, walking, bathroom visits, etc.) and children under age 18 without adult supervision.
- Level 2: Persons with physical or developmental disabilities such as deafness or blindness, those who have significant hearing impairment, those who have had am-
putations, or those who are mentally retarded.

- Level 3: Persons requiring assistance with medical care administration, those who require monitoring by a nurse, those who are dependent on equipment (including dialysis), those who need assistance with medications, or those with mental health disorders.
- Level 4: Persons living outside an institutional facility care setting but who require extensive medical oversight such as those on ventilators or other life support equipment, those whose medical conditions require continuous intravenous (IV) therapy, those who are fully or mostly confined to a hospital bed for their total care, and those who are morbidly obese.
- Level 5: Persons living in institutional settings such as hospitals, long-term care facilities, assisted living facilities, and state schools.

Figure 4: Breakdown of Greater Houston Special Needs Population by Special Needs Category

Discussion

We investigated whether the number of special-need populations is closely aligned with baseline data in FY2008. The results of attribute and boundary data were joined and presented on the web using the emerging open API from Google maps and KML files exported from ArcView. The geographic information system provides a virtual representation of clinics and the special needs population in the Gulf Coast region of Texas. Presenting geospatial information in two- and three-dimensional views allows for emergency planners and other disaster preparedness and response workers to easily obtain and use this information. This program provides easy to understand maps depicting which areas have special needs populations registered and the location of clinics based on ZIP codes.

The development of these maps and the results of this study demonstrates the potential capability of web-based GIS for ‘non-experienced GIS users’ because it enables disaster response managers to model different events, making it easier for them to make informed decisions. Web-based technology was used to model and visualize map data on the Internet. Even novice users can easily understand this information and use it to make informed decisions for emergency preparedness. The potential application of these methods to better serve special needs populations is promising and an area seemingly not documented in the literature. In addition, the potential and powerful tool such as the free service from Google allows investigators to overlay map data from various sources, which offers tremendous potential for further application.

Our approach, as documented in this paper, has some limitations that warrant attention. We are using open source technology, but not all of the data we use is openly accessible; we store map files in a server that may not be accessible in certain situations due to file size, age and internet download speeds and limits. In addition, our KML data cannot be larger than three megabytes (3 MB) because, currently, that is the largest file size that can be overlaid successfully with Google maps.14 Additional development may allow storage in a database such as PostgresSQL or MySQL and integration with Open Map server.

Conclusions

Preliminary findings indicate a low number of registrants and participating clinics have fewer than expected people with special needs who enroll in that area, especially in ZIP codes 77550, 77551, 77554, 77617, 77623 and 77510. These clinics may be able to focus on outreach efforts to encourage participation in the 2-1-1 system, especially in high-risk areas such as evacuation zone A, B, C of Texas (see Table 1). Overall, the findings of this study provide useful information for disaster and emergency managers and planners that allow for planners to improve 2-1-1 registration and enrollment programs.

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References


Table 1: Houston Evacuation Zones

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Figure 1: Number of 2-1-1 System Registrants by ZIP codes

Figure 2: HealthQuilt Project Participating Clinics
Figure 3: Number of Registrants by Clinic Location

For complete figure, please refer to http://healthquilt.healthinformaticsthai.com/maps/

Figure 4: Breakdown of Greater Houston Special Needs Population by Special Needs Category

LEVEL 0, 56.77, 57%
LEVEL 1, 19.01, 19%
LEVEL 2, 4.42, 4%
LEVEL 3, 13.98, 14%
LEVEL 4, 5.32, 5%
LEVEL 5, 0.54, 1%

LEVEL 0
LEVEL 1
LEVEL 2
LEVEL 3
LEVEL 4
LEVEL 5