Using Geographic Information Systems (GIS) in Environmental Public Health

2009 - 2010

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EXECUTIVE SUMMARY:

GIS (geographic informational systems) is defined as a computer supported software system consisting of hardware, software, data, and the corresponding applications. With the use of GIS, data can be digitally recorded, organized, analyzed and presented in alphanumeric and graphic mode. The implementation and maintenance of GIS within a local, county or state government structure presents a myriad of issues and requires long term planning. Therefore, this project was divided into three (3) phases with each phase containing multiple steps. To begin Phase I, an assessment of GIS use by a select number of county governments in Kentucky was conducted. As an exploratory project, the assessment was conducted using informal methods such as emails, phone calls, and electronic documents. Phase II will address lead exposure in children in a select group of Kentucky counties to showcase the value and importance of GIS in environmental public health. Phase III will involve more counties and provide assistance to those counties through local, state, or federal grants and private funding if available. A timeline for Phases II and III will be determined at the conclusion of the exploratory project in Phase I.

To assess the use of GIS in Kentucky in Phase I, an invitation to twelve (12) counties was extended for participation in the exploratory project. Of those twelve (12), four (4) provided useful information on how GIS is used in their counties. The initial results on how and why GIS was used varied greatly from county to county. While many counties understood the benefits of using GIS, the level of expertise needed to maintain this type of technology was a concern for some. Encouraging environmental public health professionals to seek knowledge on GIS and other technologies is one possible solution for addressing this concern. Training and awareness at various levels would also address this concern, and enhance the roles of environmental public health professionals as decision makers. This finding points to the need for environmental public health leadership in technology and other facets of disease prevention and tracking.

Further inquiry of the four (4) counties included examples of how GIS was being used in relation to the practices of public health. Some counties pointed out their concerns about old housing stock—especially those homes built before 1950 and before 1978 that might still contain lead. The latest concerns about lead exposure and the percentage of children screened for lead was also a concern. The prevalence for lead screening among children is lower in Kentucky than the national average. Lead exposure among children in Kentucky and nationally continues to exist and new forms of exposure from clothing, toys, ornaments, etc., are a concern for all children.

While Phase I of this exploratory project examined how geographic information systems (GIS) can be used to address environmental public health issues, it also demonstrated the strengths of GIS as a tool for preventing initial and subsequent lead exposure among children in the Commonwealth of Kentucky. Lead exposure is one of the many environmental public health problems that can be addressed with the use of GIS and other technologies. Although lead is the example used in this exploratory project, many other environmental public health issues such as methamphetamine lab exposures, arsenic, and pesticides have been addressed through the use of GIS and other mapping tools.
INTRODUCTION/BACKGROUND:

Lead exposure among children is both a national and international problem, especially among children living below the poverty line or in lower income brackets. In fact, lead poisoning is one of the most common environmental health problems for children. Examples of this can be found throughout many journals and scientific publications dedicated to environmental health issues. Lead poisoning is an entirely preventable disease among children in the United States and worldwide. Although children’s blood lead levels have decreased in the United States, nearly half a million children have blood lead levels equal to or more than 10 micrograms per deciliter (10 µg/dL). Ten micrograms per deciliter is the targeted level for most states and counties throughout the United States. Based on the goals for Health People 2010, the 10 µg/dL or less is the level targeted for elimination by 2010. This is the target as stated by the United States Department of Health and Human Services and the Centers for Disease Control and Prevention (CDC).

The National Health and Nutrition Examination Survey (NHANES) has collected blood lead data since 1976 and has used data to describe the blood lead levels of children. Children with the highest risk are non-Hispanic blacks who live in pre 1950s housing and whose families are poor. Most childhood lead poisoning prevention programs have focused on children that are six years of age or younger because children are more vulnerable to the adverse health effects of lead. Young children still practice hand to mouth behaviors at young ages and their nervous systems are still developing.

Although the CDC has recommended blood lead screening based on housing age and zip code, the recent use of geographic information systems (GIS) technology along with other variables such as tax assessment data have also proven to be effective in determining which children should be screened for lead. GIS is defined as a computer supported software system consisting of hardware, software, data, and the corresponding applications. With GIS, data can be digitally recorded, organized, analyzed and presented in alphanumeric and graphic mode. While GIS may appear to be a new association with public health, the mapping of environmental health problems dates back to 1792 when Finke drew maps of the yellow fever occurrences in New York Harbor and when Peterman used maps to record the cholera epidemics on the British Isles from 1831 to 1833. John Snow and the mapping of the cholera outbreak in 1854 in London is well known among public health professionals, but it was not the first occurrence of disease mapping. In the last ten years, hundreds of studies have demonstrated the use of GIS technology to analyze various environmental health issues such as lead exposure and other heavy metals, asthma and air pollutants, sewage treatment, and pesticides. Many of these studies use recent or archival data along with metropolitan statistical areas, zip codes, and census tracts to demonstrate the location of critical areas for lead screening. Although most of the studies were conducted in various metropolitan areas of the United States, several have been done in other countries such as China, Belize, and Australia. GIS is a cost effective and accurate method of modeling lead exposure risk in children.

In previous studies, the age of housing and the location of children screened for lead along with the location of children confirmed with elevated blood lead levels were used to determine screening rates and prevalence ratios. Because the level of expertise is more advanced and the
knowledge of GIS is more common in universities, many of the studies were conducted by academic institutions in conjunction with local, state or federal agencies. In a study conducted at Duke University in 2002, the use of tax parcels led to a 600% increase in the capture rate of children with elevated blood lead levels (EBLLs) in Durham County, North Carolina. An updated study in 2008 by the same researchers showed that the model of using tax parcels could be further refined and replicated for other counties in North Carolina. Although the results are unpublished, these researchers have also conducted tax parcel level lead exposure risk models in Wisconsin and Michigan and the performance of the models in these states show that such a model could be replicated in other areas. In addition to helping public health officials in developing targeted screening programs, GIS has also proven useful in identifying areas of unexpected clustering from potential point sources.

Problem Statement:
The purpose of the project was to assess the GIS capabilities of a group of counties in Kentucky and then showcase those capabilities by addressing a current environmental health problem to demonstrate the strength of GIS. The following questions were developed to guide the research for the project:

How can we demonstrate the importance of using geographic information systems (GIS) in the field of environmental public health? Why don’t we have a system in place for using GIS and/or other technologies to assist with our focus on environmental public health issues such as lead poisoning prevention programs for children?
There are a number of variables that could be taken into account when considering new technology within environmental public health. The use of a GIS within a local or state setting would require assessing the knowledge and expertise of the workforce, the amount of funding available for the upkeep and maintenance of the system, and the determination on how data will be shared with the public.

The following variables were the focus of this project:  
1) Human health risks which are on the increase;  
2) An increase in data needs for surveillance;  
3) The use of GIS in public health once saw an increase in use in KY, but seems to be stagnated now;  
4) Public health funding has seen a decrease in funding especially for childhood lead poisoning programs in KY.
Causal Loop Diagrams and applicable Archetypes:

Mental Models in Using Geographical Information Systems (GIS) in Environmental Public Health

- Use of GIS
  - Reverting Back To Old Decisions & Allowing Old Mental Models To Dominate
    - “We are regulators not map makers”

- Timing & Quality of Public Health Decisions
  - “The local health departments should gather and present visual data”

- Expertise of Local/State Health Departments
  - “The state should provide GIS data and expertise to each county”

Data Maintenance
10 Essential Environmental Health Services:
This project fosters the growth and support of the following Essential Environmental Health Services:

1. **Monitor environmental and health status to identify and solve community environmental health problems.** The use of GIS to address lead exposure in children is an example of how technology can be incorporated into existing monitoring programs at the local and state levels. GIS can be used to identify and solve an infinite number of environment health problems for multiple communities and populations.

2. **Diagnose and investigate environmental health problems and health hazards in the community.** GIS is a tool that everyone can use to address environmental health hazards in their community. It can be a visual aid for community members who want to better understand the environmental health problems facing their community. It can also be a highly developed spatial tool that provides clinicians and other public health professionals more insight on preventing and treating environmental health problems.

3. **Research for new insights and innovative solutions to environmental health problems and issues.** Using GIS is not an entirely new concept, but there is room for its growth within public health. More and more, municipalities are using the tools and layers within GIS as visual aids to explain healthcare, economics, education, environmental health, and many other facets of life.

![Figure 1: Public Health Function Steering Committee (July 1995)](image-url)
National Goals Supported

1. Healthy People 2010. This project seeks to support one of the most important goals of the Healthy People 2010 Objectives related to children’s environmental health. The Healthy People 2010 document identifies a targeted elimination lead level of 10 μg/dL or less by the year 2010. When this goal was realized in 1999, researchers began using GIS to assist public health departments in making decisions about childhood lead poisoning. One of the early demonstrations in the use of GIS for this purpose was a study in the Louisville, Kentucky Metro Health Department. The objective this study was to show the usefulness of GIS in identifying children at risk for lead exposure, and one of the findings showed that significant numbers of children at risk for lead exposure were not being tested even if they were in prioritized areas.

2. Environmental Health Competency Project: Recommendation for Core Competencies for Local Environmental Health Practitioners

Data Analysis and Interpretation: The capacity to analyze data, recognize meaningful test results, interpret results, and present the results in a meaningful way to different types of audiences.

Elements:
- Read and summarize technical papers, understand tabular and graphical presentations of data, and translate them for a non-technical audience. An example would be reading papers published in academic journals and translating the data into public information materials.
- Analyze data generated internally using simple statistics (percentages, averages, medians, etc.). Understand how statistical surveys are performed and what results mean.
- Represent results in a meaningful way to different types of lay and practitioner audiences, using appropriate graphics. Examples would be: summarizing inspection reports for a particular location on a spreadsheet, then using Excel to create a graphic for a public meeting; developing slide presentations on well water contamination for homeowner meetings; or presenting graphs of daily results to the Board of Health.

Computer/Information Technology (IT): The capacity to utilize information technology as needed to produce work products.

Elements:
- Use software available within the agency to perform research, record keeping, communication (e-mail, word processing programs), data analysis and interpretation (including simple spreadsheet programs), and reporting tasks.
- Use Web-based applications as needed, such as searching and retrieving information.
**Goal:** To demonstrate the importance of using geographic information systems (GIS) in the field of environmental public health.

**Resources/Inputs**
- State and local health departments
- City and county governments with mapping expertise
- Non-Governmental Agencies
  - Private Industries (i.e. ESRI)
  - Non-Profits
  - Research Institutions
  - Academia
- Federal Agencies
  - CDC
  - USACE
  - EPA
  - ATSDR
  - US Census Bureau

**Activities**
- **Program Design**
  - Target current problems in environmental public health such as childhood lead exposure
  - Create awareness among environmental public health professionals about GIS and mapping technology
  - Incorporate GIS learning into various academic and professional settings
- **Assessing Competency**
  - Assess the number of environmental public health programs using GIS to perform essential environmental public health functions
  - Chart the various areas of environmental public health where GIS is currently used
  - Research the costs associated with developing and maintaining GIS competency

**Outputs**
- Environmental public health research papers and presentations showing how GIS is used or can be used to combat various problems such as childhood lead exposure
- Training curriculum for environmental public health professionals who want to use GIS for surveillance and/or research
- Educational materials that use mapping to establish needs for funding

**Short & Long Term Outcomes**
- **Short Term Outcomes**
  - Increased capacity of local and state health departments to map data that the public can use and understand
  - Improved delivery and availability of data to leaders who need to make decisions to protect the public
  - Increased number of leaders trained to use and understand GIS
  - Increased collaboration between partners
- **Long Term Outcomes**
  - Improved screening methods for various environmental public health problems (i.e. lead in children)
  - Educated environmental public health workforce that understands the use and importance of GIS and other technologies
  - Increased prevention in exposures to environmental public health problems
  - Reduction in exposures to environmental public health problems

**Impacts**
- **Behavior**
  - Increased use of technology in environmental health
  - More informed decisions that address environmental public health problems

**Overall Results**
- More efficient and effective public health system
- Improved health of populations
PROJECT OBJECTIVES/DESCRIPTION/DELIVERABLES:
Encourage the use of Geographical Information Systems (GIS) among public health professionals in Kentucky via conferences, meetings and other public health events.

Establish new and better relationships with key state personnel on issues related to the use of GIS environmental poisoning of children will be established (i.e., lead exposure).

Program Goal To identify new and innovative solutions to environmental health problems such as screening children for lead via the use of GIS

Health Problem The rate of children screened for lead exposure in Kentucky is below the national average

Outcome Objective With the help of GIS and other interventions, lead exposure screening rates will increase in Kentucky by 15% of the 2008 baseline.

Determinant The number of children with blood lead levels above 10 ug/dL

Impact Objective The number of children exposed to lead in Kentucky will be reduced by 10 % or more and a model that encompasses property tax values, age of housing, and zip codes will be available for use.

Contributing Factors
1. Lack of public awareness on the importance, effectiveness and health benefits of screening children in targeted areas.
2. Lack of technology at local and county levels.
3. Lack of enforcement by schools, daycares and the state health department.
4. Lack of local residents and health professionals being able to see and identify with the county’s targeted screening areas.

Process Objectives
1. Phase I – By December 31, 2009, contact ten (10) or more counties to determine their interest in the project
   Event: Conduct informal interviews
   Activities:
   Contact counties to determine their interest in using GIS for public health programs
   Follow-up with the interested counties to learn more about their use of GIS
   Determine how to bridge the use of GIS with addressing lead exposure in each county

2. Phase II - By September 30, 2012, five (5) counties in Kentucky will demonstrate a higher awareness of the importance, effectiveness, and health benefits of childhood lead screenings through the use of GIS.
   Event: Awareness campaign implemented
Activities:
Develop procedure guides for parents in targeted areas
Conduct surveys monthly to monitor screening rates
Create an awareness program through educational activities, billboards, public service announcements, presentations and pamphlets.

3. Phase II - By September 30, 2014, a model for screening children in Kentucky for lead exposure before entering kindergarten will be developed.

Event: Implemented screening program
Activities:
Draft policy document on the best procedures for screening children 6-60 months.
Present policy and statistics to county commissioners, county health departments and area clinics.
Gain local health board approval of new policy.

4. Phase III - By December 31, 2016, the counties participating in the project will increase their use of innovative technologies such as GIS by at least 10%.

Event: Form an environmental public health tracking system
Activities:
Present maps showing targeted screening areas of Fayette County based on Census data, age of housing and tax information
Determine funding possibilities from federal agencies such as CDC and ATSDR
Develop cooperative plan with Kentucky Department for Public Health

METHODOLOGY:

Phase I of the project began with creating a systems thinking analysis on why GIS is an important tool in addressing environmental public health problems and concluded with how its importance could be demonstrated. A logic model was created to better define the short and long term outcomes of the project. Following those steps, twelve (12) counties in Kentucky were contacted based on their current use of GIS and other digital technology at the county level. Before each county was contacted, a review of how these counties already use digital mapping technology was noted. The counties were contacted via email and responses were recorded for follow-up. Data on the number of children screened for lead exposure in these counties was also obtained from the Kentucky Childhood Lead Poisoning Prevention Program (CLPPP). A letter of request was submitted to the KY CLPPP to obtain lead data on all Kentucky counties. The data cover the years 2000 through 2007 for children ages 0-72 months. Phases II and III of the project will build on the methodology from Phase I. Phase II and III will require formal request and agreements from the counties and the Kentucky Department for Public Health.
RESULTS:

Of the twelve (12) counties contacted in Kentucky for Phase I of the project, four (4) were interested in the exploratory project. Each county currently uses GIS for property valuation and taxation purposes and would be interested in providing technology support to address environmental public health problems such as lead exposure in children. Although the digital information is available to the public, there is an administrative fee structure for the use of any and all digital records containing addresses, age of housing or tax parcel data. Addresses, age of housing and tax parcel data are three of the variables that will be used to build the model (Phase II) for screening children in Kentucky for lead exposure.

The next step of Phase I is to obtain specific information on how these counties can provide assistance to the county health departments and other public health agencies to address the lead exposure problems in their county. Once this determination is made, Phase II of the project can begin. Phase II involves showcasing the benefits of using GIS in each county.

CONCLUSIONS:

The use and popularity of GIS in Kentucky has gone through several cycles, but there are environmental public health professionals who see the value in the use of GIS to combat issues such as lead exposure in children and in many other environmental health problems. The starting point of this project was to use lead as an example of how GIS can be used in today’s world. The initial response from the counties contacted in Kentucky was both positive and enlightening. Based on initial conversations and observations, the main concerns about using GIS are the knowledge and expertise required to maintain data, and the cost of software and hardware. There are pockets of availability in the use and expertise of GIS, however, bridging those resources with the needs of local and county health departments will be a challenge.

Next steps for the project are as follows:

- Phase II - By September 30, 2012, five (5) counties in Kentucky will demonstrate a higher awareness of the importance, effectiveness, and health benefits of childhood lead screenings through the use of GIS. By September 30, 2014, a proposed model for screening children in Kentucky for lead exposure before entering kindergarten will be developed. Activities for this phase include, but are not limited to: presenting proposed policy and recommendations to County Commissioners, Fayette County Health Department and area clinics developing procedure guides for targeted screening areas, conducting surveys monthly to monitor screening rates, and creating an awareness program through educational activities, billboards, public service announcements, presentations and pamphlets.

- Phase III - By December 31, 2016, the counties participating in the project will increase their use of innovative technologies such as GIS by at least 10%. Activities for this phase include, but are not limited to: presenting maps showing new targeted screening areas of
each county based on a proposed model using age of housing and tax information, and determining funding possibilities from federal agencies such as CDC and ATSDR.

**LEADERSHIP DEVELOPMENT OPPORTUNITIES:**

*Sheila Davidson Pressley*

My participation in EPHLI was an intriguing experience for me personally and professionally. The knowledge and insight I gained about myself and the other EPHLI Fellows was wonderful. I learned a lot about others and their leadership styles, but most importantly, I learned about my leadership style and how I can improve my skills as a leader in environmental public health. I truly appreciate the expertise and patience of my mentor and all of the other individuals who provided information or played any role in providing the best leadership opportunity available in public health today.
ABOUT THE EPHLI FELLOW(s)

Sheila Davidson Pressley is an Assistant Professor in the Department of Environmental Health Science (EHS) at Eastern Kentucky University (EKU) in Richmond, Kentucky. She teaches and advises undergraduate students who are EHS majors as well as those who seek a minor in EHS. She currently teaches the following courses: Diseases, Infections and Hazards of Leisure, Solid and Hazardous Waste, African/African American Health Issues, and Bioterrorism. In addition to teaching, she is also involved with recruiting students and serves on a number of university committees. On the national level, Professor Pressley serves as section chair for the National Environmental Health Association and she is a member of the Association for Environmental Health Academic Programs Board. She has professional experience with environmental health and safety training, mediating public health concerns related to risk assessment, public involvement, and environmental policy analysis. She has also worked on behalf of environmental justice communities in the private, nonprofit and government sectors. In addition to her tenure track position as a professor, Ms. Pressley is doctoral candidate in the University of Kentucky’s College of Public Health in Lexington, Kentucky.
REFERENCES


