FEATURES

# Environmental Health Screening with GIS: Creating a Community Environmental Health Profile

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## Abstract

In many communities, health care providers, public health officials, community groups, and individual citizens are concerned about potential connections between the environment and public health. The relationship between health outcomes and the environment is complex, and information in the form of a community profile can help concerned parties begin to understand how the environment may be affecting public health.

For this study, a profile was created with data on population and economic characteristics, environmental sources, and public health outcomes. The data were drawn from local, state, and national sources in a geographic information system (GIS) format. A critical component of this process was the collection of patient household data with an environmental health exposure form. The form was developed in a pilot project supported by the U.S. Environmental Protection Agency.

A community environmental health profile could be used on a limited basis for hypothesis building and as a catalyst for obtaining more information about individual patients, families, or neighborhoods. General relationships between the environment and health outcome data could be observed, and suggestions made for follow-up analyses and studies. Health care providers and public health officials could use data obtained from a GIS-based profile, along with data gathered from patients, to examine potential environmental exposures in a community and to justify screening tests or other interventions. In addition, profiling of neighborhoods according to environment-related health outcomes could help with medical diagnosis and treatment.

## Introduction

Health care providers, public health officials, community groups, and individual citizens are becoming increasingly concerned about potential connections between the environment and public health. The relationship between health outcomes and the environment is complex and may be influenced by any combination of the following factors:

- the rural or urban nature of a community;
- the extent of manufacturing and industrial services in a community;
- local weather conditions;
- proximity to environmental pollution sources, including rail and motor carrier transportation routes, airports, ports, and land used in agriculture;
- sources of food, sources of drinking water, and type of water treatment;
- occupations of adults in households;
- age, condition, and characteristics of housing;
- individuals' age, sex, race, general health, and genetic makeup;
- personal lifestyle factors, including hobbies, use of alcohol, smoking, and recreational activities;

- access to health care; and
- family income and other factors.

Concerned parties can begin to understand the potential relationships between the environment and public health at the community or neighborhood level by creating a community health profile. A profile that describes the variables listed above could clarify sources of pollution in the environment, factors affecting pollution pathways, and the ways in which these sources could affect specific individuals.

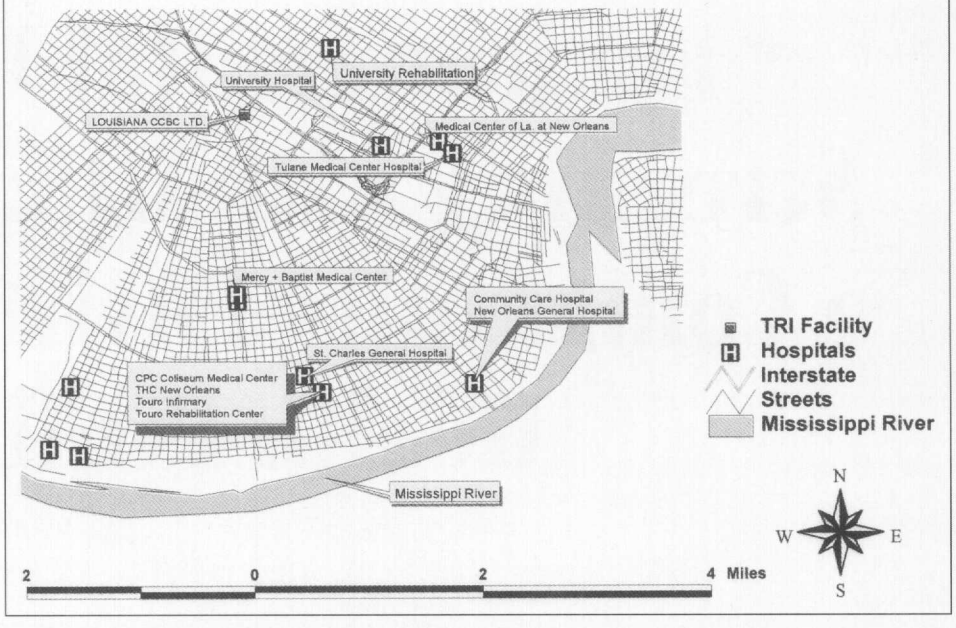
Current research suggests that there are enough connections between the environment and individual health to warrant changes in individual behavior in response to local smog alert warnings or fish consumption advisories (1,2). Studies have examined the relationship between individual health and the following environmental factors: hazardous waste sites, large manufacturing sites, nuclear-power and nuclear-waste sites, and landfills (3–7). Local television stations have recognized the potential impact of the environment on individual health by providing smog alert warnings, heat indices, wind chill factors, and ultraviolet alerts. More specifically, asthmatics, older adults, and those with chronic obstructive pulmonary disease often are encouraged to limit outside activities.

Community health profiles could provide a basis for comparing the characteristics of one community with those of another. Profiles also allow comparison of a city or a county with even smaller geographic units. Those units could include incorporated places, zip codes, census tracts, census block groups, and census blocks. A community health profile thus provides baseline information from which to identify potential health-related problems in a community.

For health care providers and local public health officials who may increasingly be interested in information on patient and family environmental exposures, a community profile could help identify neighborhood areas with higher incidences of child lead exposure rates or other specific health outcomes influenced by an environmental source. The profile would use census data to provide a comprehensive description of the community, including social and economic characteristics. Both clinical health care providers and the public health community have recognized a strong relationship between social and economic conditions and health outcomes (8,9). Local environmental and health outcome data also could be incorporated when a community profile is being created.

**FIGURE 1**

**Map of New Orleans**




Thus, a community profile provides a basis for hypothesis building and a catalyst for more questions about an individual patient, family, or neighborhood. Health care providers and public health officials could use a community profile to examine potential environmental exposures and justify screening tests and other interventions for children and adults in a given neighborhood. More effective diagnosis and treatment could help reduce the adverse consequences of preventable disease. In addition, profiling of neighborhoods according to environment-related health outcomes could be part of the medical diagnosis and treatment process.

## Profiling with GIS

A critical tool in the creation of a community health profile is a geographic information system (GIS). A GIS can display and analyze information in ways that help users to spatially describe and thus to understand the environment and health of a community (10). Thus, it can be used to screen for risks and potential health problems. Figure 1 shows a map of New Orleans with roads, water features, hospitals, and a toxic release inventory (TRI) site. Depending on the user's needs, the GIS can display whole communities or individual neighborhoods.

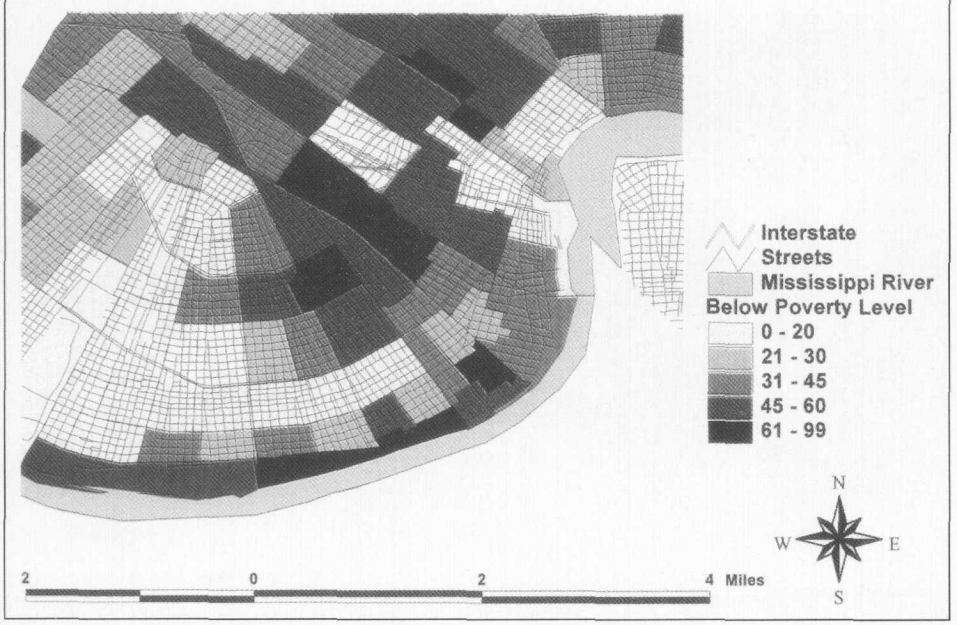
In addition, a GIS may display major traffic routes, water intake and treatment plants, and industrial sites. For each feature, information could be given in layers like that displayed in Figure 1, including the name and address of sources that affect the environment, available emissions data for each source, air or water discharge emissions information by location, drinking-water quality data by site, and fish warnings by water feature.

A GIS also may be used to describe demographic characteristics such as income levels or poverty levels, age distribution, age of homes, and educational makeup. Figure 2 provides an example of how a GIS could describe population information for a community profile. A thematic map of New Orleans shows the percentage of households below the poverty level by census tract.

Census tracts are small geographic areas with 2,500 to 8,000 inhabitants. They are relatively permanent subdivisions of a county, created by the Bureau of the Census for the purpose of presenting decennial census data. The boundaries of a tract normally follow visible features, but may follow governmental unit boundaries. A tract is designed to be relatively homogeneous with respect to population characteristics, economic status, and living conditions at the time it is established.

## FIGURE 2

**New Orleans Census Tracts–GIS Display Showing Population Percentages Below Poverty Level**




The spatial size of census tracts varies widely, depending on the density of settlement. When census tract boundaries are delineated, the intention is to maintain them over a long time so that statistical comparisons can be made from census to census.

Figure 2 also illustrates the ability of a GIS to display data layers such as highways, water features, local landmark features, and thematic census information. This capability is critical if one wants to display and examine the potential association between health outcome data and environmental data, census housing data, or family information. A GIS can help determine if geographic proximity is a factor in an association between data layers.

### Obtaining Environmental Health Outcome Data

Public health outcome data sets may be included in a GIS for the development of a community risk screening profile. Generally, state and federal agencies maintain vital-statistics programs that record and monitor individual birth and death records. Also, some state and federal programs monitor environmental and health outcomes such as water quality and the results of lead screening in children.

Data on health outcomes may be obtained from national, state, or local sources. Sorting the data by county and census tract may present problems since public health agencies may limit access and distribution of data. For example, the Centers for Disease Control and Prevention (CDC) reports mortality data for the United States in the *Atlas of U.S. Mortality* and the *Multiple Cause of Death File* (11,12). The first of these is of limited use in comparing mortality rates at the county level. Since rates are published only for jurisdictions with populations greater than 100,000, the data allow for a comparison of mortality rates only between larger jurisdictions. Counties with populations of less than 100,000 are combined. In addition, the *Multiple Cause of Death File* is calculated at the level of the health planning district. In many cases, a health planning district comprises several counties. Thus, a comparison of death rates by county is not always possible. The health agencies limit access to more precise health outcome data to protect the privacy of individuals. This concern is shared by national, state, and local public health organizations.

Information on environmental sources that could affect public health is available from several sources. Public health, environmental, or wildlife agencies have a variety of monitoring programs that involve testing of the soil, air, water, watershed, animals, fish, and shellfish. A formal request, in writing, may be necessary to obtain data on a local community from these agencies. The GIS may then be used to display the data.

Figure 3 provides an example of how a GIS may display health outcome data. Incident rates for premature births were obtained from the Vital Statistics Section of the Louisiana Department of Public Health. The Vital Statistics Section geo-coded the addresses; this process added the geographic coordinates of the address, census tract information, and block group information to each record. For each census tract in New Orleans, the total number of premature births (gestation period of less than 37 weeks) was calculated by age, race, the number of office visits the mother made, and education of the mother. An incident rate according to census tract was determined for each category by dividing the number of premature births in a census tract by the number of all births.

Thus, Figure 3 shows the rate of premature births in the New Orleans area for the period 1988–1993. Providing health outcome data over a multiyear period addresses the concerns of public health agencies about maintaining the confidentiality of individual medical records.

A GIS allows users to examine health outcome data to determine if patterns exist. For example, the information identifying which New Orleans census tracts have the highest premature birth rates may be compared with census tract data on population, housing, and income.

By comparing premature birth rates and personal household income by census tract, a GIS user could determine if there is an association between concentrations of poverty and health outcomes. Figure 4 shows census tracts in New Orleans with premature birth rates greater than or equal to 14 percent. The extent to which census tracts with high premature birth rates overlap with low-income census tracts indicates that there could be an association between premature births and poverty. Much of the literature on health outcomes suggests that poverty tends to have a significant impact. This association often has been explained in terms of access-to-health-care issues. In other words, poverty, race, and age may be important determinants of the health of a population.

Child lead-screening programs also provide an excellent source of data for a community health profile. The relationship between the environment and health outcomes may be illustrated by the connection

between high levels of lead in children and the presence of lead-based paint chips in the environment (13). The data from lead-screening programs have shown that high blood levels of lead in children may result from contaminated soil around homes and local play areas. Other environmental sources are aerosols and dust from flaking paint or building demolition. High exposures also have been linked to home renovation projects (14). Much of the renovation consists of sanding and scraping, which often generates an aerosol of dust and paint chips that may be inhaled or ingested by a child. In addition, exposure may occur in neighborhoods close to major transportation routes, on playgrounds in neighborhoods that have high levels of lead in the soil, and from play equipment painted with lead-based paint. Many studies have associated high levels of lead in the blood to exposures from lead-based paints and automobile emissions (15). Starting in the 1980s, lead has been banned as an additive in gasoline for passenger vehicles, but lead-based fuels have continued to be used in farm vehicles and some public transit vehicles until the 1990s, thus remaining potential contaminants in both urban and rural areas (16).

Other possible sources of lead include construction sites, imported clothing, cue chalk, glazed pottery, antique glassware, leaded crystal, ground paprika, proximity to a lead smelter, proximity to a radiator repair site, lead-soldered cans, lead pellets and fishing weights, miniblinds, and eye cosmetics (17–28).

Health data drawn from a GIS provide a means of displaying community or neighborhood dynamics. From this profile, potential problems may be identified. To determine if a link exists between an environmental source and a pattern of public health outcomes, users must collect more detailed information on the population and on specific environmental conditions, but a GIS serves as an initial tool for problem identification and hypothesis building, often directing prospective, retrospective, and cross-sectional investigations.

**FIGURE 3**

**Premature Birth Rates in New Orleans (1988 - 1993), by Census Tract**

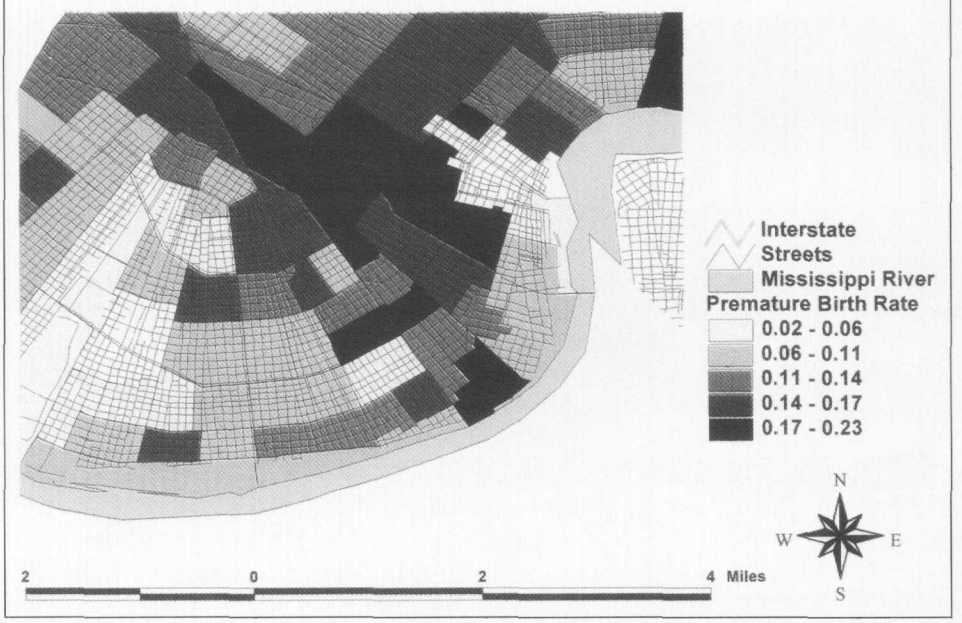
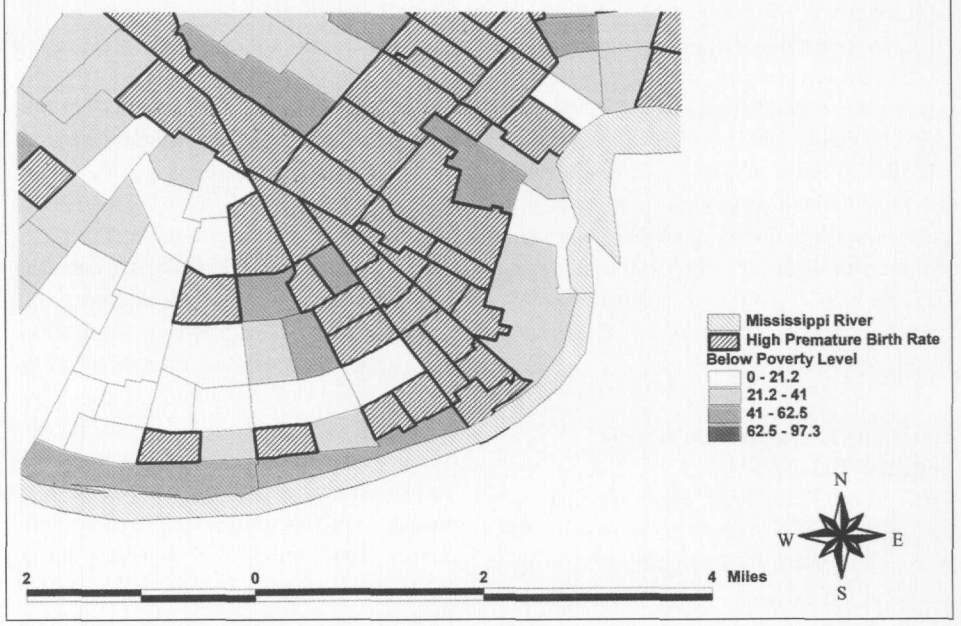



**FIGURE 4**

**Census Tract Information on Premature Birth Rates, Layered over Data on Poverty Levels**




### Issues in the Use of Health Data

An assessment of child lead-screening programs reveals a critical issue in the use of health outcome data to screen for risk and develop community profiles: Some environmental data have clearer links to public health than do others. So researchers have to be careful about assuming unjustifiably that a given health outcome has been caused by an environmental source.

In some cases, environmental sources may be clearly and directly linked to a health outcome. The causes of lead poisoning in children have been researched extensively. Thus, high levels of lead in a child's blood are known to result from a direct exposure to lead in the environment, although the source of the lead may vary. A GIS can show the locations of potential sources of lead such as radiator repair sites and lead-smelting operations; the mapping capability thus provides a

## FIGURE 5

**Sample Questions from the Environmental Health Basic Exposure History Form**

**ABOUT YOURSELF**

- What is your age?
- Do you smoke? If no, does anyone else in your household smoke in the home?
- Do you have asthma? If no, does anyone else in your household have asthma?

**ABOUT YOUR HOME AND HOUSEHOLD**

- Was your home built before 1978? (After 1978, lead-based paint was banned from the market)
- Has your home ever been tested for lead?
- Have you or anyone else in your home been tested for lead poisoning?
- How do you heat your home?
- Do you currently have any problems with cockroaches or other pests in your home?
- Which best describes your primary source of drinking water coming into your home?
- Do you have a home workshop or studio where you work with chemicals or metals?
- Do you have any hobbies or things you often do in your spare time that involve contact with any of the following: (paint strippers, glues, art materials, varnishes, welding materials, or mercury)?
- Do you grow your own fruits or vegetables?
- Do you eat locally caught fish?
- Has your home ever been checked for radon gas?

**ABOUT YOUR WORK**

- What is your current or most recent occupation or job title?
- Are you exposed to any of the following hazards at work?
- Do you work with lead or other metals at work?

**ABOUT YOUR COMMUNITY**

- Are there any local point sources of pollution, e.g., factories, incinerators, trash-transfer stations, chemical plants, auto or truck repair shops, in your community that might directly impact your health?
- Do you live near a heavily traveled roadway with traffic congestion?
- Do you swim in a natural body of water (other than a swimming pool)?

means of examining a potential relationship between a source and a health outcome.

Even where a strong link occurs, however, the health outcome may be influenced by individual lifestyle, genetic factors, or other sources not evident from a map of the neighborhood. It may not be possible to establish a link between a specific environmental source and a health outcome without extensive examination of an individual's medical and exposure history. In such cases, users may hypothesize that specific health outcomes are associated with environmental factors, but may not be able to demonstrate a direct relationship.

## The Louisiana Environmental Health Exposure Project and the Environmental Health Exposure Form

In an effort to assist medical providers and the public health community in understanding how the environment may affect individual health, the U.S. Environmental Protection Agency (U.S. EPA) provided Louisiana State University with a grant to develop an environmental exposure interview form and a GIS. The form, created in collaboration with the Association of Occupational and Environmental Clinics, provides clinic representatives with sets of questions to be posed to an adult member of a household. The first part of the form asks for information on the general environment of the household, including the age and type of the home, proximity to pollution sources in the community, and the source of drinking water. More specific questions relating to the household involve the numbers and ages of children, type of heating, pets in the home, nature of family members' work, individual diets or medicines consumed, and home-based industries or hobbies such as pottery making, stained-glass setting, or smelting of fishing weights and muzzle-loader bullets. Figure 5 shows sample questions from the "Personal Environmental Health Basic Exposure History Form."

Software also was created to provide health care providers with an easy way of entering basic exposure records into a database. The software allows the user to view, edit, sort, print, and save a record. Records may then be matched to an address with U.S. EPA's mapping software, LandView III (including Marplot) (14). Other GIS programs also could be used. Patient characteristics derived from responses to the exposure form may be compared with the information in other map layers, such as specific health outcome and environmental data. Individual-exposure data obtained from the form provide an additional source of information for use in developing a community profile.

The data obtained from the form may not be sufficient to fully determine the specific relationship between environmental pollution sources and health outcomes, but can provide information that assists in establishing such relationships. Examining the causes of disease requires a detailed epidemiological investigation, including evaluation of specific individual exposures and other behavioral, social, and environmental risk factors. The exposure form is a first step in alerting health care providers and the public health community to potential problems in a community.

The form presents a health care provider or the public health community with the opportunity to obtain additional information on individual risk factors and environmental sources related to public health outcomes in a community. The questions on the form relate to environmental indicators that allow screening for local environmental exposure. Thus, the form provides a means of creating a community risk-screening profile for environmental health.

### A Hypothetical Survey

A hypothetical survey was created, and addresses were selected for an area in New Orleans. A sample set of records was created with the exposure-history-form software, and the information was plotted to addresses in the city of New Orleans. Responses to the survey form may be screened to further develop information on a local community. Although the responses and addresses are hypothetical, Figure 6 shows that a GIS can be used to compare responses to survey questions. In this example, households that have members with asthma are compared with households that have no member with asthma. The GIS allows the user to determine if there is a spatial relationship in the responses. If spatial relationships were found, further questions would need to be addressed.

## Conclusions

Risk screening uses many tools, including statistics, GIS, and databases. On an individual level, the risk of disease is influenced by genetics, behavior, income, and the home and outside environments. While known risk factors for individual disease can be identified, it is far more difficult to link health outcomes to specific environmental sources.

The type of assessment that may be done with a GIS is limited. Although extensive data on environmental quality are included in many GIS programs, little information is available on the actual levels at which urban residents are exposed to pollutants in their environment. Individual exposure information is essential in assessing community health risks and conducting epidemiological investigations into the relationship between environmental pollutants and disease.

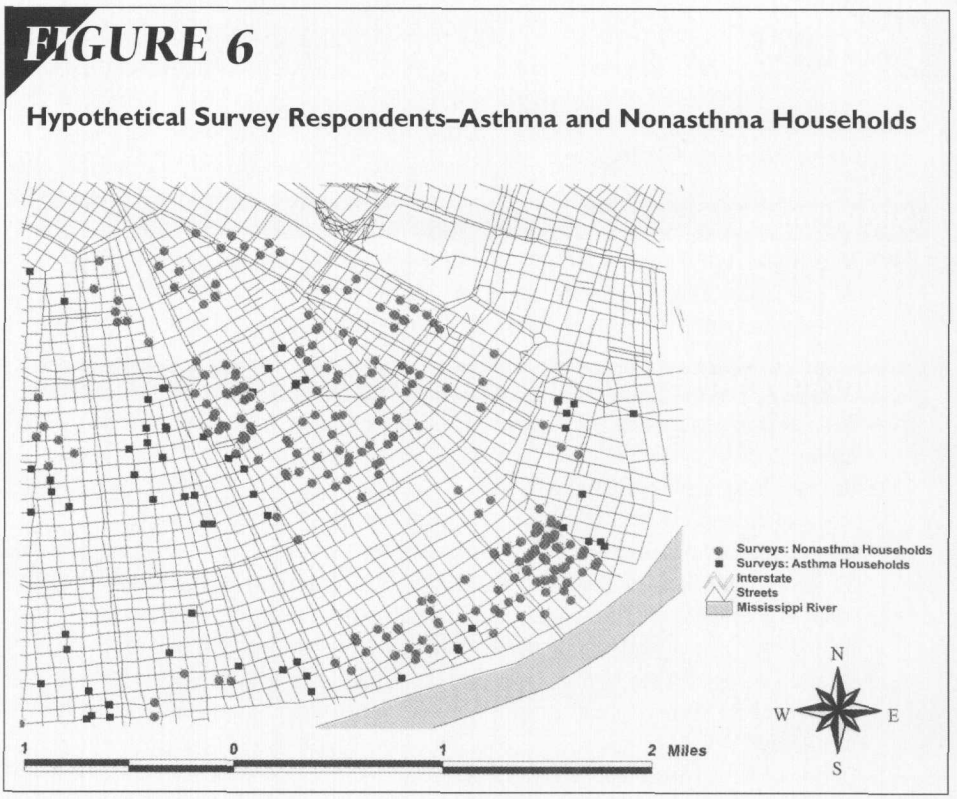
Nevertheless, simply looking at health outcome data together with specific environmental sources, such as U.S. EPA–regulated industrial sites, can be misleading. Environmental health risk screening involves the application of multiple scientific disciplines to an investigation of the relationship between environmental factors and human health. This process reflects a complex interaction between social, economic, health, and environmental factors.

Health outcome data may be obtained for risk screening use in a GIS. Data on birth and mortality rates may be created for census tracts and used in comparisons with Bureau of the Census household and housing information. The geographic boundaries of census tracts provide an excellent basis for community profiles.

Businesses that use hazardous substances may be identified from U.S. EPA databases or from the local phone directory. Digital phone directories also may be sorted according to the Standard Industrial Classification Code (SIC). Some digital phone directories allow the user to select listings by SIC and to export records with geographic latitude and longitude coordinates. A GIS may open these records.

The Louisiana Birth Certificate Database provides some health outcome information related to individuals. Records may be sorted by age, sex, occupation, and census tract. Nevertheless, the use of such information in risk screening and the preparation of a community health profile is a complex undertaking and can result in misleading observations. A specific health outcome indicator such as premature births could have some relationship to one or more environmental sources. It could, however, also be highly influenced by personal lifestyle, health condition, age, and even genetics. Thus, it may not be possible to derive the specific effects of the environment and personal factors on an individual's death from the Louisiana Birth Certificate Database. More detailed examination of the patient's health records may be required. Even with that kind of detailed examination, direct links between the environment and an individual's death may be in question.

General relationships between the environment and health outcome data can, however, be observed through risk screening, along with suggestions for follow-up analysis and studies. In addition, procedures for the use of health outcome data in risk screening should be developed and distributed along with the data. With the community profile and the environmental health exposure form, health care providers and public health agencies have powerful tools for collecting additional data that can be used in environmental health risk screening.

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